Upper Missouri River
Riparian Proper Functioning Condition (PFC)
Assessment Report

Upper Missouri River Breaks National Monument

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BLM

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U.S. Department of the Interior

Bureau of Land Management

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Executive Summary

The objective of this report is to summarize riparian conditions along the Missouri River following completion of a Proper Functioning Condition (PFC) assessment in 2010. The assessment was completed on public land administered by the Bureau of Land Management (BLM) within the Upper Missouri River Breaks National Monument (Monument). The Monument was established on January 17, 2001, when President Clinton issued a Proclamation under the provisions of the Antiquities Act of 1906. The Proclamation states the area contains a spectacular array of biological, geological, and historical objects of interest. From Fort Benton to the Charles M. Russell National Wildlife Refuge, the Monument spans 149 miles of the upper Missouri River, the adjacent Breaks country, and portions of Arrow Creek, Antelope Creek, and the Judith River.

The Missouri River was divided into six individual reaches and a functional rating determined based on evaluations conducted at 73 sites. All six reaches were found to be in proper functioning condition. The results of the assessment indicate herbaceous riparian-wetland plant communities (sedge, rush, bulrush) are playing a key role in ecological function along the upper Missouri River. Many of the sites examined on public land are dominated by diverse and robust herbaceous riparian-wetland vegetation. Woody plant communities were less common than herbaceous plant communities, but cottonwood and willow were present where conditions are suitable for their establishment. Suitable sites for recruitment of woody species are naturally limited by the narrow, confined floodplain where disturbance from floods and ice scouring precludes woody plants.

An important issue affecting riparian condition across all reaches of the upper Missouri River is flow attenuation. Flow regulation from upstream dams has decreased the frequency of high flows typically associated with cottonwood recruitment. The combination of flow attenuation along with the colonization of communities of riparian-wetland vegetation has resulted in widespread narrowing of the channel and has actually over-stabilized the river. It is important to remember that time is a key factor, and in some cases it could take years before woody species thrive on a particular site. In addition, the germination and subsequent establishment of woody vegetation does not occur each year but is commonly tied to infrequent episodic events.

Noxious weeds and non-native and invasive plant species were widespread throughout the river corridor. Noxious weeds were present on 93% of the sites evaluated and non-native species were found at 99% of the locations. Russian olive (*Elaeagnus angustifolia*), its establishment a growing concern in river riparian areas, was more common in the upper half of the study area and nearly absent in the lower section. Reed canarygrass (*Phalaris arundinacea*) occurred on 66% of the sites. Sites likely contain a combination of the native form of reed canarygrass and an introduced variety, the latter more invasive and aggressive. The distribution and density of reed canarygrass seemed to be influenced by the season of livestock use. Observed occurrence of reed canarygrass was low in grazed areas. Throughout the river corridor, there is concern that the expansion of noxious weeds and non-native and invasive species into areas currently dominated by desirable riparian-wetland vegetation could affect riparian function in the future and modify values like wildlife habitat, livestock forage production and water quality.

Beaver impacts to woody riparian species on the upper Missouri River were found to be substantial. Even though beaver are a natural component of the river, populations have increased in recent years and their effects seem to be compounded by flow regulation. Regulated flows on the upper Missouri River limit the density and distribution of woody species on public land. At many of the evaluation sites, woody species, mainly young plants, were repeatedly sheared off by beaver impacting their growth and survival. Mature cottonwood trees are also being damaged by girdling and often cut down. This is occurring river wide and is more pronounced where there are fewer cottonwood forests.

Livestock grazing can adversely affect the condition and functional rating of riparian areas along the river. However, relative to the dominant drivers of riparian condition (flow regulation, geology of the landscape, erosion/deposition processes and disturbance from ice), healthy riparian areas are being maintained under current grazing management strategies and the negative effects from grazing are minor and localized.

One of the key messages to take away from this assessment is maintaining the riparian-wetland resources on the upper Missouri River within the Monument for the future will require a basin wide approach. The assessed portion of the upper Missouri River is located below a drainage area that extends to the Idaho border; in fact, the drainage area at the Virgelle stream gage is 34,379 square miles. There are a tremendous amount of activities outside the control of BLM that occur within the basin and could influence the condition of the upper Missouri River. Working with BLM's partners on issues that affect water availability and river flows, working with neighboring landowners on invasive plant control, and continuing livestock grazing management strategies that are compatible with management of riparian areas will be necessary for future management of the riparian-wetland resources within the Monument.

Introduction

Purposes and Objectives

With designation as a National Monument, many thought the area would be managed differently, perhaps changing, reducing and eliminating existing land uses and adding more emphasis to protecting ecologic, scientific and historic resources. This is especially true for the Missouri River. There is a great deal of disagreement about the loss of cottonwood forests, recruitment of woody species, the effects of altered flow regimes and the current condition of riparian habitat along the river. BLM's management of the river has been challenged with claims that riparian conditions are less than satisfactory and their recovery and management has been severely impacted by livestock grazing. Livestock grazing along the river is clearly the most contentious issue within the Monument.

In 2008, the Lewistown Field Office requested the National Riparian Service Team (NRST) to assist BLM with problem solving, training, assessment, monitoring and grazing management strategies that are compatible with healthy riparian areas. Team members and staff have expertise in hydrology, ecology, fisheries, wildlife, range management, soils and geology, social sciences, conflict management, public affairs and communication. A key purpose for seeking NRST's help was assisting the BLM with an on-the-ground condition assessment to determine the health and functionality of riparian areas along the river.

The purpose of the proper functioning condition assessment was to:

1. Complete an evaluation of riparian areas along the river following the BLM standard PFC assessment process.

2. Determine the functional rating for BLM administered lands within each reach.

3. Document site potential and the factors influencing a site's development.

4. Document the physical site conditions needed for woody species recruitment (cottonwoods, willows). Are woody species occurring where conditions exist for their recruitment and survival? What impacts were observed during the field assessment (ice, beaver, high flows, sediment, wildlife, and livestock) and how is it affecting woody species establishment, growth and survival?

5. Engage interested publics and stakeholder groups in joint fact finding and the assessment process.

6. Identify issues that will guide future monitoring efforts.

Study Area

The upper Missouri River is one of the most outstanding features of the Monument. This important river system provides a connection to the past and contains unique archaeological, historical and ecological resources. The Proclamation states, "Remnants of this rich history are scattered throughout the Monument, and the river corridor retains many of the same qualities and much of the same appearance today as it did then."

Congress designated 149 miles of the Upper Missouri as a component of the National Wild and Scenic River System in 1976 calling it an irreplaceable legacy of the historic American West. Congress further stated that the river, with its immediate environments, possesses outstanding scenic, recreational, geological, fish and wildlife, historic, cultural, and other similar values. Located between Fort Benton and US Highway 191 in north-central Montana, the river flows generally west to east through Chouteau, Blaine, Fergus, and Phillips counties. The lower 10 miles of the Upper Missouri National Wild and Scenic River are located within the Charles M. Russell National Wildlife Refuge and is managed by the US Fish and Wildlife Service.

Land Uses

Grazing by domestic livestock is the dominant agricultural use within the study area. Grazing in the Missouri River Breaks began in the early 1880's (Mackie, 1970). Cattle are the most common grazing animal, although sheep were present historically but declined rapidly because of market conditions and high levels of predation in the breaks. Horses were once a problem in the 1930's and 1940's. Abandoned by homesteaders leaving the area, their numbers grew and "horse gathering" was a source of income for local ranch families (local ranchers, personal communication). Currently, there are 93 livestock operators grazing public land within the Monument. The area is divided into 113 grazing allotments with approximately 38,000 Animal Unit Months (AUMs) of forage available for livestock grazing (USDI, BLM 2008).

Recreation activities are the other principle use of resources within the Monument. Activities available to the public are very diverse with opportunities in both upland areas and along the Missouri River. Most of the visitor use is associated with the Missouri River. Visitors can boat the length of the Upper Missouri National Wild and Scenic River, starting at Fort Benton to the end at James Kipp Recreation Area. The area is remote and provides a glimpse of what Lewis and Clark saw 200 years ago. Riparian cottonwood groves provide sites for most of the developed and primitive campgrounds.

Previous Investigations and Background

This is the first effort in applying the PFC protocol to the upper Missouri River; however, inventories monitoring and research has been occurring since the late 1980's. Hansen (1989) inventoried, classified and discussed management options for riparian sites along the upper Missouri River. Based on Hansen's findings, BLM has been monitoring both herbaceous and woody plant communities since 1990. Sites are monitored annually or every three to five years. How often the studies are repeated is based on the site's potential and the expected rate of change. On some sites, nearly 20 years of data has been collected.

The BLM has partnered with the scientific community since the 1990's for research projects involving riparian communities along the upper Missouri River. The U.S. Geological Survey (USGS) and BLM have been studying the factors controlling cottonwood recruitment and regeneration and the impacts from livestock grazing to cottonwood seedling establishment and mortality (Auble et. al, 2005, 2010; Auble and Scott, 1998; Bovee and Scott, 2002; Scott and Auble, 2002; Scott et. al, 1997). The Montana Natural Heritage Program in partnership with the BLM (Kudray et. al, 2004), studied the critical habitat components of riparian forests in the river corridor and the environmental factors that influence them. Presently, the BLM is partnered with the University of Montana (Merigliano et. al, not yet published) to sample mature riparian forests to establish a relation between site conditions (i.e. landform, soil texture, depth to the water table) and the expected vegetation the site would support.

Methodology

PFC is a qualitative interdisciplinary team (ID Team) assessment that considers hydrology, vegetation, and erosion/deposition (soils) attributes and processes to assess the condition of riparian-wetland areas. This provides a key synthesis of existing information that is foundational to determining the overall health of a riparian-wetland system (USDI, 1998). The PFC assessment was completed in accordance with BLM Technical Reference 1737-15 (USDI, 1998) by an ID Team of specialists from Montana BLM staff, NRST, and a contractor. The members of this team have considerable expertise in riparian ecology, vegetation, hydrology, wildlife, range management, and soils. The upper Missouri River PFC assessment consisted of: (1) substantial pre-work, which included review of existing documentation; (2) field evaluation of all BLM administered lands along the Missouri River within the Monument; and (3) development of final PFC checklists, report, and general management recommendations.

In review of existing documentation, ID Team members met for an assessment pre-work meeting with NRST specialists, USGS riparian ecologist, and a University of Montana research professor. The purpose of the pre-work meeting was to gain a common understanding of what is already known and review existing documentation, agree on preliminary reach breaks and document potential and capability for each reach, and determine field work logistics.

The ID Team based preliminary reach breaks on geomorphic and vegetative characteristics, including landform, geology, sinuosity, channel slope, channel shape and pattern, tributary influence, and entrenchment. Riparian plant communities, not coincidentally, are commonly similar across geomorphic reaches, which further strengthened the rationale behind the location of the reach breaks. Potential and capability descriptions were written for each reach in terms of physical channel characteristics and riparian-wetland vegetation.

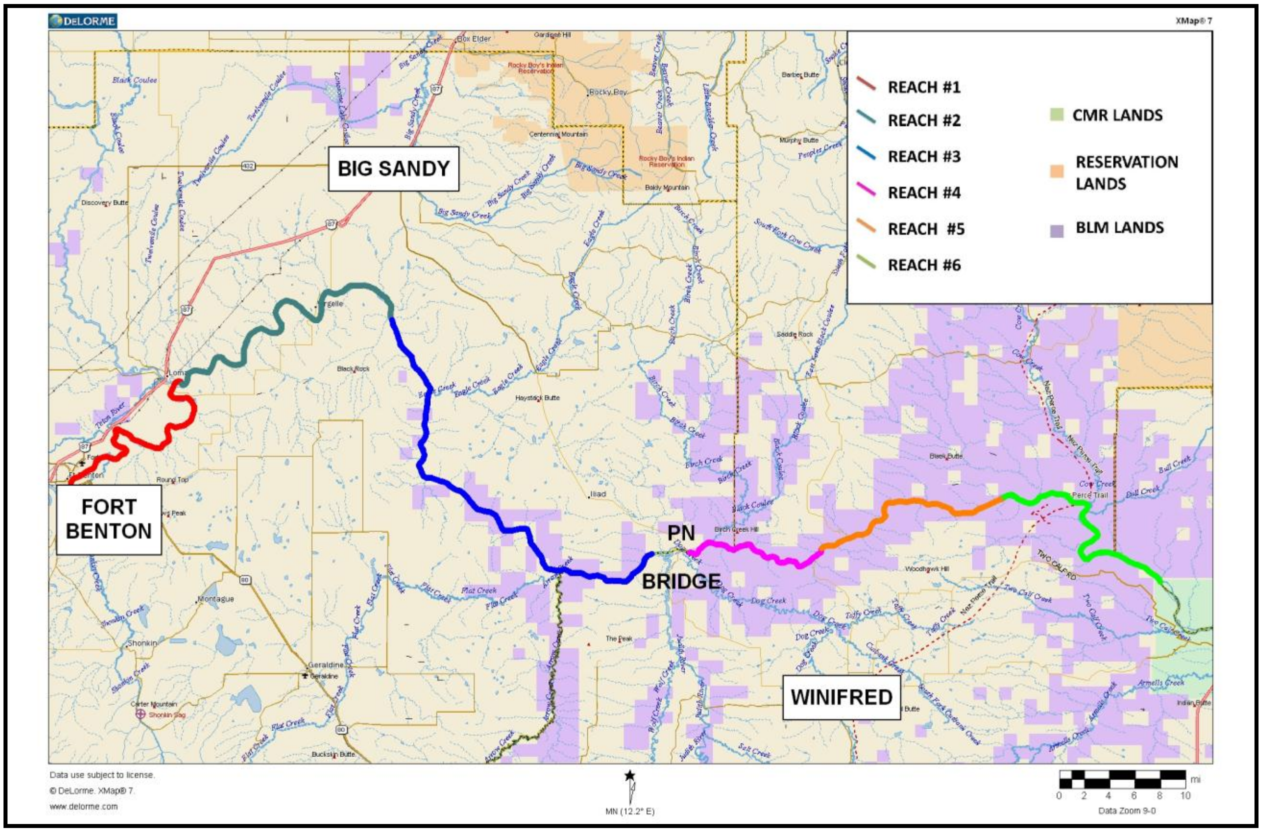

Figure 1 – The upper Missouri River in the Monument was broken into six reaches for evaluation.

Table 1 – Reach break descriptions

Reach	River Miles (0 – Fort Benton, 139 – CMR Boundary)
Reach #1 (Fort Benton to Marias River)	River Miles 0 to 22
Reach #2 (Marias River to Lonetree Coulee)	River Miles 22 to 49
Reach #3 (Lonetree Coulee to Above PN Bridge)	River Miles 49 to 86
Reach #4 (Below PN Bridge to Stafford Ferry)	River Miles 89 to 102
Reach #5 (Stafford Ferry to Sturgeon Island)	River Miles 102 to 119
Reach #6 (Sturgeon Island to CMR Boundary)	River Miles 119 to 139

Not only was the completion of the assessment important for BLM's management of riparian areas along the upper Missouri River, but allowing stakeholders and interested parties the opportunity to participate and engage in discussion with ID Team members was also a primary goal. Creation of awareness and transparency of the process was necessary because although not everyone may be in agreement on the proposed management of these lands, at least a common understanding of the decision-making rationale would be known. For that reason, pre-assessment community workshops were held in Lewistown, Winifred, and Fort Benton the week of June 14, 2010. The public, including interested parties and livestock grazing permittees, was invited to participate during the major portion of the field work conducted between July 6 and July 16, 2010. Following the assessment, the results were presented to the public at meetings in Big Sandy and Winifred, March 15 and 16, 2011.

To characterize the riparian-wetland vegetation during the assessment, the ID Team divided the riparian-wetland area into three zones. Zone 1 is from the scour line (the lower limit of sod-forming or perennial vegetation) to bankfull discharge (the stream discharge generally considered to be the single discharge that is most effective for moving sediment, forming or removing bars, and forming or changing bends and meanders, all of which result in the average morphological characteristics of channels). Although other channel forming processes, such as ice drives, can be responsible for channel morphology on the upper Missouri River, a distinct morphologic and vegetative break occurs at the discharge that coincides with roughly the 2-year return interval flow. The bankfull discharges, which are associated with the top of Zone 1, increase directly with drainage area. Along upper study reaches (e.g., those above Judith Landing), bankfull discharge is approximately 23,000 cfs and increases to 25,000 cfs along the lower study reaches.

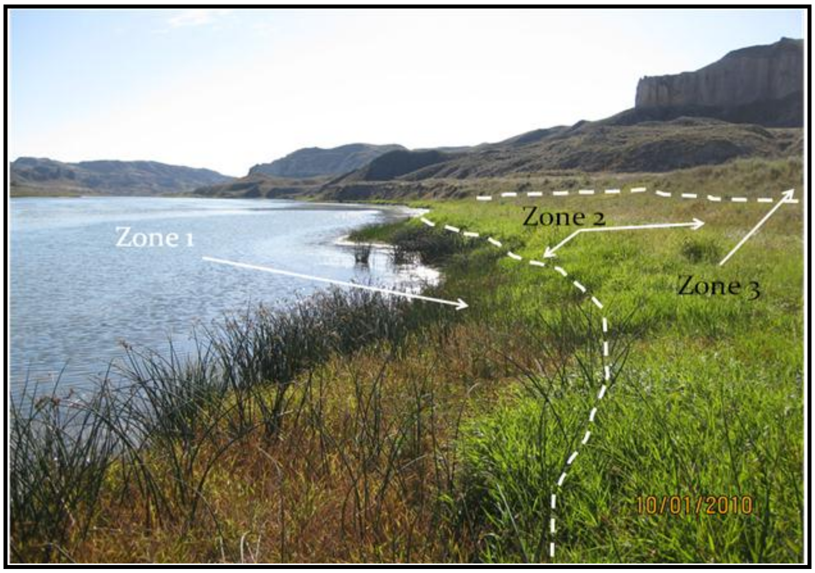

Figure 2 – Three zones were used for vegetation characterization.

Zone 2 is located between the bankfull discharge and the area inundated by what was historically the 10-year return interval flow. Flow regulation has shifted the frequency of this event from what was once an approximately 10-year return interval to roughly a 20-year return interval. This inundating discharge corresponds roughly to 45,000 cfs at Fort Benton, approximately 60,000 cfs from Virgelle to Judith Landing, and up to 70,000 cfs on the lower study reaches below Judith Landing.

Zone 3 is from the top of Zone 2 to the uplands. This zone is infrequently flooded but may contain relic riparian species such as mature cottonwoods that were established at lower elevations before the surface was moved higher through sediment accretion.

For the PFC Assessment July field work, predetermined stops were chosen for each reach based on sites that were representative of larger reaches of river, geomorphic and vegetative characteristics, unique or critical areas, grazing allotments, and reach breaks. The ID Team collected vegetation information on 73 sites at 42 locations within Zones 1 and 2. At each stop, the inundating discharges, flood frequency curves, and zone locations were reviewed as necessary. These were just the predetermined stops, the ID

Team actually stopped over one hundred times to take photos, discuss conditions, or validate that the predetermined stops were representative of larger reaches of river. At each site the plant species present were recorded by surveying (walking) through the sampling area. Also, the ID Team noted the dominant plants encountered in Zones 1 and 2. Dominance was used to describe plants having a canopy cover greater than 25% or when only a single plant occurred within an assessment area. If the canopy cover of two or more plants made up most of the assessment area, and they were of about equal value, each was noted as a dominant plant. Photo points were established at each site. Notes characterizing vegetation composition, structure and condition were kept along with the amount of bare ground, the amount of the bank covered by vegetation, human-caused bare ground, livestock and wildlife use, impacts from flooding and ice, and shrub and tree age classes. The USDA Plant Database (http://plants.usda.gov/) was a key source used for listing the scientific and common name of the plants. ID Team familiarity and local knowledge was the principle method for identifying plant species. Technical floras (Appendix B) were also used and Matt Lavin, Montana State University botanist, assisted in the identification of some sedges.

The vegetation section of the PFC checklist focuses on the kind, age class, species diversity and amount of *"riparian-wetland"* vegetation present along a reach within Zones 1 and 2. The term "*riparian-wetland"* refers primarily to facultative wetland and obligate plants or those that usually or almost always occur in wetland areas. It is important to note that even though plains cottonwood (*Populus deltoides*) , and green ash (*Fraxinus pennsylvanica*) are considered facultative plants, meaning they are equally likely to occur in wetland or non-wetland areas, for this assessment they were considered together with other riparian-wetland vegetation and used by the ID Team for completing the PFC checklist. Both plants, and especially plains cottonwood, were found within Zones 1 and 2 and are important in determining the processes and functionality of the upper Missouri River.

At the completion of the reach evaluation, a functional determination was made placing the reach into one of three categories, proper functioning condition (PFC), functional at risk (FAR), or nonfunctional (NF). Riparian-wetland areas can function properly before they reach their potential. Potential is defined as the highest ecological status a riparian-wetland area can attain given no political, social, or economic constraints, and is often referred to as the potential natural community (PNC) (USDI, 1998). The PFC definition does not mean potential or optimal conditions for a particular species have to be achieved for an area to be considered functioning properly. The ID Team evaluated all reaches relative to potential to identify which sites had the potential to support riparian-wetland attributes.

The PFC checklist for each reach has been finalized, and along with the plant lists and photographs, has been posted to BLM's Lewistown Field Office website (http://www.blm.gov/mt/st/en/fo/lewistown_field_office.html). Copies are also available at the Lewistown and Havre BLM offices. Each reach summary contains administrative information, a reach description, vegetation, stream and hydrologic information, plant lists, a topographic map of the segment and photographs. The assessment findings are summarized in this report.

Riparian Ecology of the upper Missouri River

The upper Missouri River in the Monument is a geologically and ecologically unique area. Visitors to this part of the river see lush riparian vegetation, tall cottonwood trees, willows, wildlife, and spectacular views knowing little about how the river functions in order to produce these values. Because stream and riparian function is based on the interaction between soil, water, and vegetation, understanding the riparian ecology of the river is paramount to determining how, why, and where vegetation occurs along the upper Missouri River.

Soils and Organic Matter

The structure and composition of riparian-wetland soil has a significant effect on hydrology and the kind of vegetation that can be supported on a site. Soils and the organic matter therein greatly influence nutrient cycling, and plant establishment and growth. Because the upper Missouri River experiences frequent high flow events and ice scour, soil movement and development is an active process and sites can change from well vegetated to bare soil with a single event. Because the river transports a large amount of sediment and organic matter, these high flow events deposit a considerable amount of material on streambanks and riparian zones.

Organic matter refers to the carbon compounds in a soil. Organic matter is created by plants (roots, leaves, and stems), microbes, and other organisms, and play vital roles in nutrient, water, and biological cycles. Organic matter consists of highly decomposed and partially decomposed material, and fresh organic residue. Organic matter in a soil is also affected by vegetation, which acts as a filter by slowing the water and removing sediments and suspended organic matter. Depositional events often bury some or all of the plants on a site which increases organic matter as the plant material decays.

Organic matter is important because it can hold up to eight times its weight in moisture, which increases the water-holding capacity of soils and extends the growing period of plants by prolonging the time before plants reach their wilting point (Brady and Weil, 1996). In addition to organic matter, plant roots also affect soils as they increase water infiltration, help stabilize the soil, improve pore spaces, increase total volume, and improve water storage.

Figure 3 – Soils within a fluctuating water table show evidence of being saturated and being exposed to oxygen (i.e. the rust color).

Soils along the upper Missouri River vary widely in texture and generally consist of silts, sands, and clays (Hansen, 1989); these are primarily derived from sandstone and shale parent material common in the area. More specifically, soils across the riparian zone range from sandy clay loams (20-35% clay) to silty clay loams (27-40% clay). Clayey soils can be a limiting factor for the establishment and long term seedling survival of willow and cottonwood, especially when the clay content exceeds 25%. An increase in organic matter generally makes all soils more amenable for seedling germination and plant survival, but this is especially important for clay soils.

In sandy soils, soil pores are relatively large; consequently soil moisture drains rapidly, and plant-available water is less than 10% (typically 5% to 8%) by volume. Organic matter can more than double plant-available water. For example, a sandy soil with 5% organic matter can hold nearly 30% plant-available water by volume or a 4 to 6 fold increase over a sandy soil with no organic matter (Hudson, 1994). Without organic matter, sandy soil can be droughty and cottonwood establishment could be very limited due to low water-holding capacities.

Figure 4 – Sediment and organic material are stabilized by plants recolonizing the site.

Because soil composition and structure strongly influences plant growth, plant vigor is an effective indicator of soil conditions. When the above ground portion of plants exhibit good cover and vigor, it generally means the below ground portion has a vigorous root system that can quickly re-sprout and provide surface cover. This is especially true of rhizomatous species like woolly sedge (*Carex lanuginosa*), sandbar willow (*Salix exigua)*, hardstem bulrush (*Schoenoplectus acutus*), and three-square bulrush (*Schoenoplectus pungens)*. Plant vigor and length of growing season are very important for the stabilization of newly deposited alluvium and re-vegetation of ice scour areas.

Where the potential for vegetation exists, herbaceous plant communities are the most dominant cover type along the upper Missouri River. The persistence and reproductive health of these plant communities is influenced by soils and the amount of organic matter therein.

Riparian-Wetland Vegetation

Knowing how plants are adapted to the environments on the upper Missouri River is key to understanding the riparian ecology of the river. Vegetation on the riverbanks and in the riparian zone is exposed to periodic high flows/flooding, erosion and deposition, ice drives/scour, wildlife impacts (most notably big game and beaver), livestock grazing, and occasionally fire.

The degree of valley bottom and channel confinement and the height of the riverbanks are major factors influencing the presence and extent of riparian vegetation. Confined reaches with riverbanks that are high and steep with little or no floodplain do not have the potential to develop extensive riparian-wetland communities. This is an expected feature of the box-shaped channel found along the upper Missouri River. Therefore, this discussion on vegetation primarily focuses on areas where the channel confinement produces banks that are low and gently sloping enough to support at least a narrow band of riparian-wetland plant communities.

The presence and reproductive strategies of riparian-wetland plants in riparian areas are primarily tied to where they grow in relation to the elevation of the stream or river. On the upper Missouri River, because the zone from the scour line (lower limit of vegetation) to bankfull experiences the most disturbance, vegetation in this area plays an important role in river function. Riverine systems typically have a wide range of hydrologic conditions from permanently saturated to saturation for only part of the growing season. This strongly influences the distribution of plant species that occur on the various surfaces within and adjacent to the river channel. To characterize these differences, the US Fish and Wildlife Service developed the National List of Vascular Plant Species that Occur in Wetlands (USDI, 1993). This reference provides a wetland indicator rating for each species based on how often it occurs in wetlands but does not rate plants on tolerance of depth and duration (Hoag, 2007). The rating categorizes plants as obligates (99% in wetlands), facultative wetland (66% in wetlands), facultative (50-50 wetlands/uplands), facultative upland (66% in uplands), and upland (99% in uplands). The term "riparian-wetland" is generally reserved for obligate wetland and facultative wetland plants.

Plants have developed several traits to accommodate high energy flows, ice scour, large depositional events, and a lack of oxygen in the soil – all of which are common on the upper Missouri River. These traits include flexible stems (that yield to high flows and ice), aerenchyma tissue (cells which allow plants to take in oxygen and exchange gases in completely saturated conditions), rhizomes (underground stems), adventitious buds (growth buds that develop in places other than at the end of a twig or in leaf axils), stolons (above ground stems), and large, deep root systems.

In particular, because the Missouri River processes and deposits a considerable amount of sediment, plants must have the ability to effectively grow through sediment deposition. The time it takes vegetation to stabilize newly deposited sediments or revegetate disturbed areas is often related to the mass and strength of the roots; species with massive, strong, and vigorous roots will grow through sediment and occupy a site faster than those with lesser root systems. Other important considerations affecting site recovery include the growth rate of individual plant species and the frequency of repeated disturbance.

Plants differ in their ability to help stabilize streambanks (Hansen et al. 1995; Dunaway et al. 1994; Kleinfelder et al. 1991). In order to better understand and communicate the role of vegetation in stream function, Winward (2000) provides a definition for plants that provide effective streambank stabilizing properties – these plants are defined as "stabilizers." Stabilizers are plant species that become established along edges of streams, rivers, ponds, and lakes and have rooting characteristics that aid in bank stability and floodplain development. Although they generally require hydric settings for establishment, some may persist in drier conditions once they have become firmly established. They commonly have strong, cord-like rhizomes as well as deep fibrous or woody root masses. They are able to buffer streambanks against the erosive forces of moving water. Most of the deep rooted sedges and rushes and many willow and cottonwood species are good bank stabilizers.

Figure 5 – An excellent condition woolly sedge community is protecting the banks in Reach 4.

Bank stability ratings for plant communities are addressed in Winward (2000) and for individual plant species in Burton et al. (2011). Both of these documents rate plant communities and individual plants (respectively) on a scale of 1 to 10 based on their ability to stabilize banks when compared to anchored rock and logs (bare ground is a 1 and anchored rock and logs are a 10). Annuals and tap rooted species typically rate a 3 whereas most rhizomatous obligate species like sedges and rushes rate between 7 and 9.

Herbaceous Riparian-Wetland Plants

Herbaceous plants are the most dominant cover type or group along the riverbanks and riparian zones adjacent to the upper Missouri River. This is because herbaceous plants are better adapted to tolerate flooding, depositional events, and ice drives/scour than most woody plants. This is particularly true for the zone from the scour line to bankfull. In addition, because beaver are widespread on the upper Missouri River, herbaceous plants are less affected by beaver impacts than shrubs or trees.

The most dominant herbaceous species on the riverbanks and in the wetter portions of the riparian zone are grass-like plants that include woolly sedge, three-square bulrush, hardstem bulrush, needle spikerush (*Eleocharis acicularis*), common spikesedge (*Eleocharis palustris*), reed canarygrass, and alkali cordgrass (*Spartina gracilis*). The most dominant forbs and grasses in the drier zones (above the riverbank zone) include white (*Melilotus alba*) and yellow sweet clover (*Melilotus officinalis*), wild licorice (*Glycyrrhiza lepidota*), black medic (*Medicago lupulina*), dandelion (*Taraxacum officinale*), western yarrow (*Achillea millefolium*), quackgrass (*Agropyron repens*), and smooth brome (*Bromus inermis*). Because most of the forbs and grasses along the river are not considered riparian-wetland plants, occur in the drier zones adjacent to the river, and do not drive river function, they will not be discussed in considerable detail.

Many grass-like wetland species such as sedges and rushes have well developed aerenchyma tissue. Aerenchyma tissue allows the plants to survive and flourish in anaerobic conditions (without oxygen) and provides herbaceous wetland plants with an advantage over upland plants. This adaptation allows oxygen to travel through the leaves and stems to the roots. As excess oxygen is released from the roots to the soil, it oxidizes iron to produce rust colored mottles after the soil dries out (Wilson et al., 1999). Aerenchyma tissue is present in some woody riparian plants (e.g. willows); however, it is not as well developed as it is in herbaceous riparian plants.

Almost all of the grass-like plants in the wetter zones of the upper Missouri River are rhizomatous (can reproduce via underground stems). This is an important trait because it allows for a quicker recovery of surface leaves and stems after defoliation than from seeds. In addition, most of the rhizomatous plants found on the upper Missouri River have strong root systems important for stabilizing streambanks. Some rhizomatous species can have 10 or more miles of root in a 12” X 12” X 18” block of soil (Manning et al., 1989).

Some riparian speciesare better competitors because they are more efficient at extracting nutrient concentrations from organic matter and above ground vegetative material and transferring it to roots and shoots. Sedges have the ability to transfer up to 80% of the nitrogen and phosphorus from their dying leaves to growing shoots, and their roots can also remove phosphate ions from organic compounds in the soil (Wilson et al., 2008). Sedges, rushes, and some grasses are well adapted to utilize high amounts of organic material and, as discussed earlier, the Missouri River deposits have a considerable amount of organic matter.

Reed canarygrass is an aggressive plant found on the upper Missouri River that can become dominant in riparian areas because it has been observed as cespitose (clumped), rhizomatous, and stoloniferous. Stolons can also achieve similar results as rhizomes in increasing the extent of the parent plant but to a lesser extent.

Emergent Plants (Herbaceous)

Emergent plants are herbaceous aquatic plants that occur on saturated soils or on soils covered with water for most of the growing season. Examples of emergent plants along the upper Missouri River include hardstem bulrush, common spikesedge, needle spikerush, and three-square bulrush. Plants found at the edge of river sometimes creep out into the shallows like common spikesedge and needle spikerush but usually remain close to the bank. Although some emergent species are also found moving up the bank, they primarily remain in the saturated areas at or below bankfull. This continuously flooded shoreline area is a transition zone from the river to the bank where both emergent plants and other obligate and facultative wetland plants occur.

Figure 6 – Hardstem and three-square bulrush established at the river's edge. The photograph was taken September 2010.

The function of emergent plants is to prevent the re-suspension of fine bottom sediments using strong, interlocking root systems. They also capture fine sediments that settle in the river margins that builds substrate for other wetland plants. Some emergents like hardstem and three-square bulrush are considered "stabilizers" and defined above. Emergents can reproduce by seed or roots but primarily spread by rhizomes allowing them to colonize into areas where seed establishment is very difficult.

Woody Riparian-Wetland Plants

Willows

Three species of willow occur along the upper Missouri River, yellow willow (*Salix lutea)*, peach-leaf willow (*Salix amygdaloides)*, and sandbar willow (*Salix exigua*). Willows are important in helping to bind the soil and buffer the effects of moving water. Their larger roots become intertwined with the finer fibrous roots of the herbaceous stabilizer species to increase streambank stability. Generally, the size and mass of willow roots closely correspond to the above ground biomass. Woody species do not have well developed aerenchyma tissue and thus do poorly in anaerobic soils.

Although willows and cottonwoods do not have strongly developed aerenchymous tissue, they have adventitious buds on stems that allow damaged branches that become buried to produce roots and stems. Both willow and cottonwood plants that were established from buried beaver cuttings commonly occur along the upper Missouri River.

Sandbar willow is the only willow along the river that spreads by roots and once established can quickly occupy a site. Sandbar willow is dominant on some gravel bars, at the mouths of some side channels and draws, and on small islands. Sandbar willow is more adapted to frequent disturbances than other willows found on the upper Missouri River because it sprouts from root suckers (or "rhizomes") and the stem structure is flexible. This allows it to bend with high flows and recover quickly from ice damage and depositional events. Other willows and cottonwoods are generally only flexible when young while sandbar willow maintains its pliability even when mature. Once established, it can be very efficient in trapping sediment and bank building. However, sandbar willow is vulnerable to disease because each plant is connected to the parent stem.

The age of individual willow plants is sometimes difficult to determine because willows and cottonwoods, have the common characteristic of periodic stem die back followed by initiation of new stems. The process is not well understood and new and vigorous shoots can be found growing in most willow plants all the time. This die back does not occur at the base of the plant or the roots but occurs primarily in the limbs and shoots. This allows the plant to stay alive through several stem replacement events and the base of the willow to stay alive for centuries. Yellow and peachleaf willow can be a single or multiple-stem plant. The die back cycle for the tree/shrub group is around 12-18 years; however, the main stem generally does not die back each time. Consequently, the main stems can remain alive during several die backs of the secondary stems (Winward, 2008). Although sandbar willow is rhizomatous, it also experiences a die back cycle and appears to cycle in clones or individual stems one at a time (similar to the sequence that occurred during the original sprouting). The normal cycling of willow stem regeneration creates a diversity of stem age classes whereas impacts from ice, beaver, and fire commonly shear or damage most of the stems on a site thereby creating more even aged stands.

Figure 7 – Yellow and peachleaf willow recycling stems. Note the dead limbs with understory of young branches.

Concerns have been raised at times regarding the lack of willow along the upper Missouri River. One factor that limits widespread willow communities is the inability of sprouts and seedlings to compete with herbaceous vegetation on recent deposits (where established herbaceous plants are covered with sediment) and/or the site is saturated for long periods of time. Established herbaceous communities that are covered with deposits will usually reoccupy the site much more quickly than willows. Once mature, willows can withstand competition from most other vegetation except shading from cottonwoods which can reduce vigor or eliminate willows over time. Willows tend to compete better with herbaceous plants on sites that have somewhat coarser soils and are better drained. Provided they can out-compete the herbaceous plants on the site, willows are generally adapted to disturbed sites and commonly become established on new sediment deposits at mouths of draws, cut banks, and gravel or sand bars. For willows to become established they must be able to grow and develop quickly enough to remain in the water table.

Another limiting factor, as has been mentioned, is the inability of woody plants to withstand mechanical damage from high flow events and ice (other than sandbar willow). If the cycle of physical disturbance is frequent plants that survive become multi-stemmed, short, and unhealthy.

Cottonwoods

Two species of cottonwood occur along the upper Missouri River, plains cottonwood and narrowleaf cottonwood (*Populus angustifolia*); however, narrowleaf cottonwood generally only occurs in the upper reaches.

Bare, moist sites suitable for cottonwood recruitment are most often met through flow induced channel change (Auble et al. 2005). Mature cottonwood produces an estimated several million seeds; however, less than 1% of the landscape is suitable for germination and long-term establishment. The plants compensate for this by releasing seeds over a six-week period from early June to mid-July. Favorable sites for cottonwood establishment are the same as those required by willow except cottonwoods prefer coarser deposits like sand and gravel. These sites must be moist, barren, newly deposited alluvium, and be in open areas so they have ample sunlight (Hansen, 1989). Germination usually occurs within 8-24 hours and successful establishment depends on the water table remaining in the rooting zone of the seedling (the seedling root needs to keep pace with the declining water table).

Figure 8 – Cottonwood seedlings growing in newly deposited sediments in July 2010.

There is a critical elevation where the seedbeds are high enough to avoid flooding mortality or ice scour but low enough to allow the new seedlings to reach the permanent water table (Hansen, 1989). This is in large part why it is estimated that only 1 in a million seedlings survive to become a mature cottonwood tree (Auble, 2005).

The mature cottonwood trees on the upper Missouri River generally have established at surfaces greater than 1.5 -1.75 meters above late summer water levels (Scott and Auble, 2002). Seedling root growth must keep up with declining water tables through the summer (Mahoney and Rood 1998; Scott et al., 1993), and the rate of stream stage decline should not exceed 2.5 cm (1inch)/day (Mahoney and Rood, 1998). Furthermore, survival is low when the stage declines are greater than one meter the first year.

These requirements are rarely met on the upper Missouri River and desiccation is an issue in the higher bank positions.

However, alluvial groundwater declines alone may not be the dominant limiting factor affecting cottonwoods on the river. As discussed earlier, organic matter in the soil can increase available water and extend the time that roots can continue to grow. The presence of large amounts of organic material may be a key to establishment of cottonwoods after large flow events. This is one possible explanation why cottonwoods have established over time at elevations above the river that normally preclude them.

Hansen (1989) describes four depositional sites which are suitable for the recruitment of pioneering species such as plains cottonwood and willow species. They are point bars, side bars, mid-channel bars, and delta bars. Through the unconstrained reaches, all of the fore mentioned features exist. Meandering and channel narrowing are important processes for the establishment of woody vegetation. This results in vegetation community patterns that are spatially variable and usually not even-aged. Establishment surfaces of mature trees are often well below present ground surface and near channel bed elevation. Strong left-bank, right-bank asymmetry in ages corresponds to meander pattern (Scott et al., 1997). Small portions of constrained channels result in vegetation community patterns of small numbers of linear, even–aged stands and establishment surface of mature trees well above channel bed elevation (Scott et al., 1997). More diverse representation of woody riparian vegetation, in terms of age-class and distribution, are evident in back channels, mid-channel bars, and depositional zones.

Because of the climate of northcentral Montana, which includes very cold temperatures, snow, and rapid warm up from “Chinook” winds, mechanical ice drives occur. The influence of this process on riparian vegetation is substantial. However, the effect is less noticeable in the unconstrained portion of the river relative to the constrained reaches. In the unconstrained portions, recruitment of trees is less dependent on large flood pulses because with lateral movement and sediment aggradation, established trees are removed from the zone where they receive more frequent physical disturbance (Scott and Auble, 2002).

Historical observations by Lewis and Clark indicate the river contained sparse and discontinuous stands of cottonwood trees (Coues, 1893). Current amounts of cottonwood forest are similar to that of 1890, and there has been recruitment of trees associated with the major flow events since that time (unpublished USGS data – in review and subject to revision). Much of the recruitment of cottonwood forest has been associated with channel narrowing (such as abandoned back channels filling in), which is probably a one-time response, and without a change in flow regime, the amount of cottonwood forest will decrease. Although cottonwood can be affected by livestock grazing/ungulate browsing, it is interesting to note that successful recruitment of cottonwood trees occurred in the past during periods of heavy grazing pressure. For example, grazing pressure was heavier during most of the 1900s than it is today (BLM Grazing Records).

Figure 9 – Cottonwood sprouting from heavy beaver use. Note dead plants scattered throughout and the nearly solid stand of leafy spurge.

Other Woody Species

The green ash/chokecherry (*Prunus virginiana*) habitat type is a major type in the Great Plains Region of Central and Eastern Montana. It occurs along streams, rivers, lakes, springs, and ponds throughout the region occupying terraces, fans, or floodplain positions (Hansen, 1989). The tree layer of this type may also include box elder (*Acer negundo*) but currently plains cottonwood generally dominates stands of this type (Hansen, 1989).

Figure 10 – Chokecherry growing on an upper terrace. Note cottonwood in the background and silver sagebrush in the foreground.

As sediment aggrades and depositional features mature, the potential exists for drier riparian species. According to Hansen (1989), as the alluvial material matures, there is a corresponding change in soil parameters, which provides a more suitable environment for tree species such as green ash and boxelder. Hansen (1989) describes a successional path of pioneer species such as plains cottonwood and sandbar willow followed by an understory of green ash, boxelder, chokecherry, and red-osier dogwood (*Cornus stolonifera*). Rivers which are free to move back and forth across their floodplain result in stands of vegetation in various stages of succession (Hansen, 1989). Suitable conditions for understory development are more frequently met in the unconstrained reach than the constrained reaches of the upper Missouri River. Typical stream characteristics of unconfined streams, such as point bars and cutbanks and their associated patterns of woody riparian species are present in certain areas on the upper Missouri River. However, most of the river in the Monument is within a confined channel with limited meanders and are therefore dominated by herbaceous vegetation.

Mature green ash, chokecherry, and box elder, occur both as a separate cover type and intermixed with mature cottonwood. A variety of herbaceous species comprise the understories in these cover types. Most of the plants in the saturated and seasonably wet sites are either seedlings, young, or re-sprouts from ice and beaver damage. The mature and mid age trees generally occur on elevated terraces which receive limited disturbance and have perched water tables or the plants are large enough in stature to be connected to a deeper water table. These elevated flat terrace sites are sloped back toward the canyon walls and appear to have been created either by slumps or berms from large historic ice drives or a combination of the two processes. Because of this feature, these sites are then able to capture run off and create a perched water table. Several of these sites are dominated by clay soils washed down with upland runoff, were wetter than adjacent upland sites, and some have standing surface water.

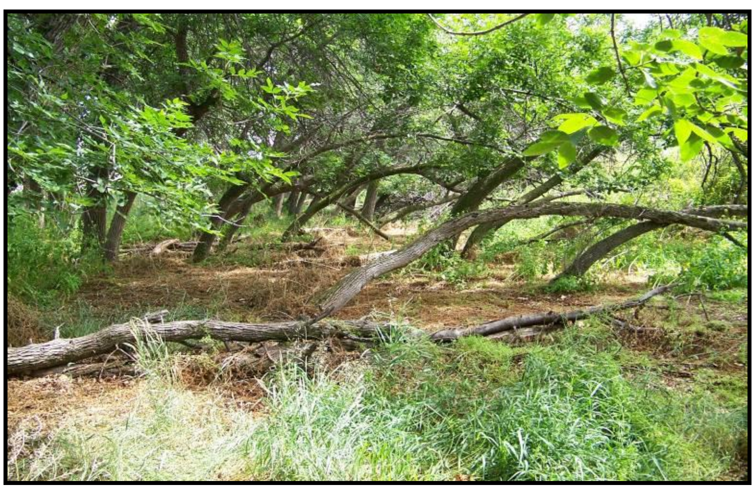

Figure 11 – This figure shows an upper terrace with green ash and box elder. The bent trees appear to be growing toward sunlight.

Noxious Weeds and Invasive Plants

Like many drainage basins in the West, noxious weeds and invasive plants are a large problem in the upper Missouri River basin. As documented by Kudray et al. (2004), non-native plants present the most serious and immediate threat to this ecosystem.

Streams are disturbance systems that erode, transport and deposit sediment from uplands, banks and beds. This disturbance process not only provides an effective seed bed for riparian species, but also for noxious weeds and invasive species. In the absence of weeds, natural succession pathways generally includes pioneering plants like willow, cottonwood, and herbaceous species to colonize the open ground, and a series of more complex plant communities would replace each other over time.

In stream systems, seeds are dispersed both by air and by water. Research over the past 25 years has shown that water borne dispersal is beneficial to weeds. The spread of weeds is controlled by the requirements for regeneration, environmentally cued dispersal, channel morphology, flow regimes, substrate, elevation to water table, and the seed bank (Merritt and Whol, 2002). However, seed dispersal via water (hydrochory) allows weeds to populate areas that are not accessible from other dispersal agents. It has been shown that at the population level, hydrochory may increase the effective size and longevity of weed populations, and control their spatial configuration. Dispersal by water may even influence community composition resulting in definite landscape patterns (Nisson et al., 2010). This certainly appears to be the case for the Monument. Species like yellow sweetclover and leafy spurge (*Euphorbia esula*) can often be seen as nearly solid linear bands in areas where there is a transition from wet to dry soil.

Figure 12 – Yellow sweetclover is dominant in Zone 2 in some locations.

There are several species of noxious weeds and invasive plants on the river that dominate many sites. Some, like smooth brome and Russian olive were planted many years ago while others were introduced with other seeds and feed grains. Leafy spurge, one of the most competitive and damaging noxious weeds, is a creeping perennial that reproduces from seed and vegetative root buds. It has a taproot that can reach depths of 15 feet and rhizomes that spread out primarily in the top 24 inches of the soil. The roots also have a vast storage of nutrients that allows it to recover from control attempts making it one of the harder weeds to kill. Leafy spurge occurs mostly in the zones above bankfull.

Reed canarygrass occurs in all of the Monument river reaches but is much more prominent in the upstream reaches. It has a range of rooting characteristics from cespitose (clumped) to rhizomatous. It is often referred to as an introduced cultivar that was developed to stabilize eroding stream banks; however, a study done by Merigliano and Lesica (1998) determined it was a native. Herbarium specimens collected in Montana, Idaho, and Wyoming prior to 1900 revealed that it was present on some river systems. Reed canarygrass is a very aggressive plant that has been observed on continually saturated sites but occurs along the upper Missouri River on areas that are seasonally flooded. It is large in stature and stands up to six plus feet tall. Once reed canarygrass leaves and stems become coarse is used lightly by ungulates. Reed canarygrass can build very deep layers of thatch which impedes the establishment of other species. It occurs in many of the woolly sedge, hardstem bulrush, and sandbar willow plant communities.

Other noxious weeds prevalent along the upper Missouri River include Canada thistle (*Cirsium arvense*), perennial pepperweed (*Lepidium latifolium*) and Russian (*Acroptilon repens*) and spotted knapweed (*Centaurea stoebe*).

Discussion of Assessment Results

Hydrology, Deposition and Erosion

Landscape Setting of upper Missouri River Reaches

Reaches 1 and 2 are located within the older, pre-glacial Missouri River channel. Relative to the constrained, postglacial river channel, the upper Missouri River upstream of Coal Banks has relatively high sinuosity, wide valleys, and rapid channel migrations (Scott et al., 1997). As such, the floodplain is broader than the constrained portions of the Missouri River with alluvial floodplains. It is important to note that Reaches 1 and 2 are characterized by relatively wider valley bottoms, greater channel sinuosity, and greater rates of lateral channel migrations compared to constrained reaches of the upper Missouri River.

Figure 13 – Decision Point is located in the pre-glacial channel at the mouth of the Marias River (bottom of Reach 1 and top of Reach 2).

Reaches 3, 4, 5, and 6 are located in the post-glacial river channel. According to Scott et al. (1997), these reaches exhibit low sinuosity and are constrained by a narrow valley. Scott and Auble (2002) described the postglacial channel as a series of entrenched meanders inhibited by exposures of sandstone and shale badlands. Very little channel migration has occurred within the past 100 years (Scott et al., 1997).

Figure 14 – Reach 5 is located in the post-glacial channel. Very little floodplain exists.

Although Reaches 1 and 2 are both in the pre-glacial valley, the pre-glacial valley was divided into two reaches. Reaches 1 and 2 are different due to the influence of the Marias River (located at the top of Reach 2). However, more importantly, Reach 2 is more of a transition reach than Reach 1. When the Missouri River was pushed into the post-glacial channel downstream of Reach 2, downcutting would have occurred in the upstream direction until vertical equilibrium was reached. Once equilibrium was reached, the channel would have widened until it no longer had the sediment transport capacity or competence to move sediment through the system, and deposition occurred. In Reach 2, much of this deposition has occurred as mid-channel bars and islands. These features provide important energy dissipation and locations for riparian values to be obtained as this is where floodplain development is occurring.

Figure 15 – Mid-channel bars provide important floodplains within Reach 2.

Throughout Reaches 1 and 2, BLM administered lands are typically those areas least desirable for agricultural type purposes. As such, they are commonly located in steep terrain or on the outside of the meander bends of the river. Although Reaches 1 and 2 may have high potential for floodplain development and riparian-wetland species, floodplain development is not necessarily imminent or predictable. For example, the BLM land on the outside bend of the river would have very little potential for floodplain development because shear stress is highest on the outside of a meander. On the other hand, once the river begins to migrate in the opposite direction, it could have very high potential.

Figure 16 – The outside bends of the river have very low potential for riparian development.

With the constrained, post-glacial valley reaches, Reaches 3 and 5 were separated from Reaches 4 and 6 by the degree of confinement. Reach 4 has several mid-channel bars and islands such as Council Island, Holmes Council Island, and Iron City Island. Although small in relation to the river, there are also some small unconstrained zones within Reach 4 such as Coal Bottom and Ford Bottom. Granted, potential floodplain development is still very small, but it is still more than the extremely limited floodplain potential in Reaches 3 and 5.

Reach 6 is a transition reach before a geomorphic break, occurring near the Charles M. Russell National Wildlife Refuge Boundary, where the valley widens substantially because of the river-level exposure of Bear Paw Shale. The width of flood-prone areas does increase in Reach 6 relative to other constrained reaches of the upper Missouri River, and depositional features do increase in the downstream direction. Sinuosity within Reach 6 begins to increase and gradient decreases along with associated shear stresses that move substrate materials. That combined with an ever increasing sediment load as the river moves through the breaks results in depositional features that are far more common than along other constrained reaches of the upper Missouri River. Delta bars, mid-channel bars, and lateral bars are abundant.

In contrasting Reach 6 to Reach 3, where less sinuosity and steeper gradient give the river the capacity to move most materials entering the river from side drainages, the increased sinuosity and smaller gradient of Reach 6 allow for depositional zones to be found near smaller tributaries. Therefore, increased potential exists for floodplain and riparian values within Reach 6.

Figure 17 – Reach 3 and Reach 6 have different geomorphic and vegetative characteristics. At left, a confined Reach 3 is dominated by an herbaceous riparian-wetland plant community. The right figure shows a somewhat less confined Reach 6, which has more depositional sites dominated by woody, sandbar willow communities.

Hydrology/Deposition & Erosion PFC Checklist Discussion

An important consideration in the PFC assessment process is whether the floodplain above bankfull is inundated in "relatively frequent" events. The two ways of looking at that question are whether or not there has been a change in the channel morphology that would prevent high flows from accessing the floodplain such as channel downcutting or widening and/or whether there has been a change in flow regime such that formerly flood-prone areas are no longer inundated.

In regards to channel morphology, Rosgen C channels are found in Reach 1 and a very small portion of Reach 2. Rosgen C channels are low gradient, meandering, point-bar with riffle/pool morphology (Rosgen, 1996). Rosgen C channels are often found in broad valleys with terraces, in association with floodplains and alluvial soils, which is in line with these reach's potential based upon the geomorphic setting. They can be slightly entrenched with a well-defined meandering channel.

Reaches 3, 4, 5, and 6 are Rosgen F channels. Most of Reach 2 is an F-channel type, and portions of Reach 1 are as well. Rosgen F-type channels can be described as entrenched, meandering, riffle/pool channel on low gradients with high width/depth ratios (Rosgen, 1996). Rosgen F channels are often found on entrenched landforms in highly weathered material, which once again matches what would be expected based upon the geomorphic setting. One noteworthy difference between F-channel and C-channel types is the entrenchment ratio, which is the flood-prone width divided by the bankfull width. C-channel types have an entrenchment ratio generally greater than 2.2, whereas F-channel types typically have an entrenchment ratio less than 1.4 (Rosgen, 1996). The entrenchment ratio strongly influences the vegetation patterns on the upper Missouri River.

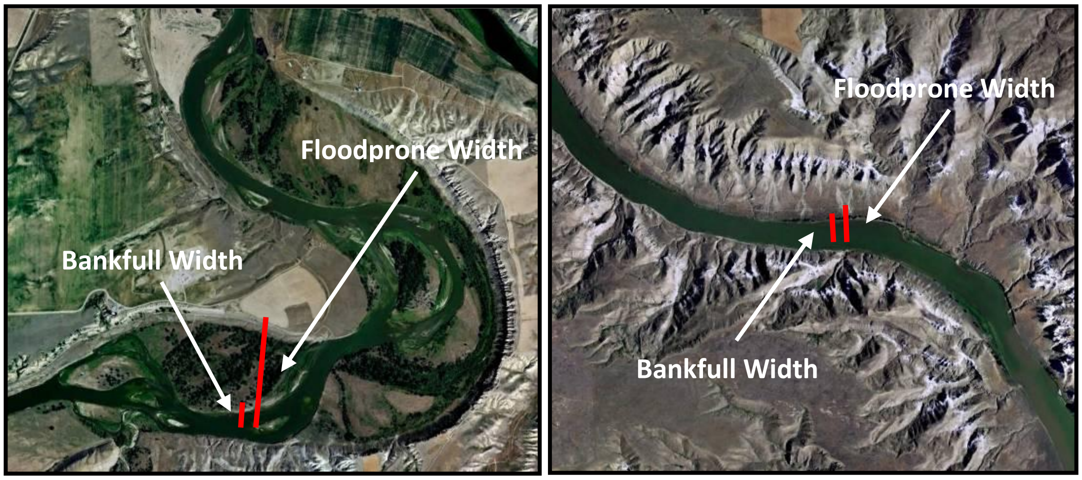

Figure 18 – The Rosgen C and Rosgen F channels on the upper Missouri River have different entrenchment ratios and vegetation patterns (images from Google Earth, 2010). The left figure shows a C channel in Reach 1, and the right figure shows an F channel in Reach 3.

Evidence exists that the fore mentioned channel types would be present at potential although the bankfull widths would have been greater, resulting in smaller entrenchment ratios. Comparisons of detailed maps from the 1890s (Missouri River Commission Map), 1950s, 1980s and 2006 imagery indicate a decrease in channel width as a result of channel narrowing (unpublished USGS data, in review and subject to revision). However, the decrease in channel width versus flood-prone width would not have been large enough to change the channel classification into a channel type that is different from what the channel type is today. Table 2 shows river channel width in the 1890s, 1950s, and 2006 (unpublished USGS data, in review and subject to revision). The width in meters is the amount of river channel area, including bare sites within the active channel, normalized to the river reach length. The upper reach used by USGS roughly coincides with BLM Reaches 1 and 2, and the middle reach corresponds with BLM Reaches 3, 4, 5, and 6.

Table 2 – Observed changes in river channel widths (m) (unpublished USGS data, in review and subject to revision)

USGS River Reaches	1890s	1950s	2006
Upper Reach (Fort Benton to Coal Banks (River Mile 0 to 46)	226	200	169
Middle Reach (Coal Banks to Grand Island (River Mile 46 to 139)	229	206	184
Lower Reach (Grand Island to Fort Peck Reservoir – on CMR National Wildlife Refuge)	266	212	172

The channel has also been vertically stable. During the periods of record, the stage-peak discharge relations at the Fort Benton (1890-2010), Virgelle (1935-2010), and Landusky (1934-2010) gages have not drastically changed. The stage-peak discharge relation at Landusky has been less consistent than Virgelle or Fort Benton with more active scour and fill processes. However, the Landusky gage is located in a more dynamic valley bottom with a greater percentage of sand-sized particles in the substrate, so this would be expected. The point is that none of the three stream gages located on the upper Missouri River indicates recent downcutting. Although a stable stage-discharge relation accompanied by channel narrowing would point toward a deeper channel, it may not be an indicator of vertical instability as much as the channel reaching a new equilibrium. The key message is that flows of equivalent magnitude inundate similar elevations.

Two significant dams regulate flows on the upper Missouri River, Canyon Ferry Dam on the Missouri River and Tiber Dam on the Marias River. Although the frequency of flood pulses and the timing of a snow-melt dominated hydrograph have not changed, the magnitude of large peak flows has been reduced from 40% to 50% as a result of regulation (Bovee and Scott, 2001). For the assessment, Log Pearson type III curves were fit to the pre and post Tiber Dam (1956) peak discharges to estimate pre and post Tiber Dam flood frequency. Granted, the period of record prior to dam construction was shorter than the post dam or total periods of record. Still, the results were as expected with a shift in the flooding frequency.

Nevertheless, the answer to whether or not floodplains are inundated in "relatively frequent" events was still answered "yes" on all of the checklists because the shift in flooding frequency of "relatively frequent" events such as 2- to 5-year return intervals is less than the shift in flooding frequency of much larger events. Much larger events still may be important for ecological processes such as cottonwood recruitment, but the assessment considers frequent events. Furthermore, soil characteristics indicating that the soils undergo periodic saturation were prevalent in Zones 1 and 2 on all reaches of the river.

In the constrained reaches, most of the obligate riparian-wetland vegetation occurs on low-flow deposits within the active channel, which is a fairly common scenario on very large rivers. Although the development of these sites may not occur at potential or be present under a more active flow regime, livestock grazing management on the upper Missouri River is not precluding development of these areas.

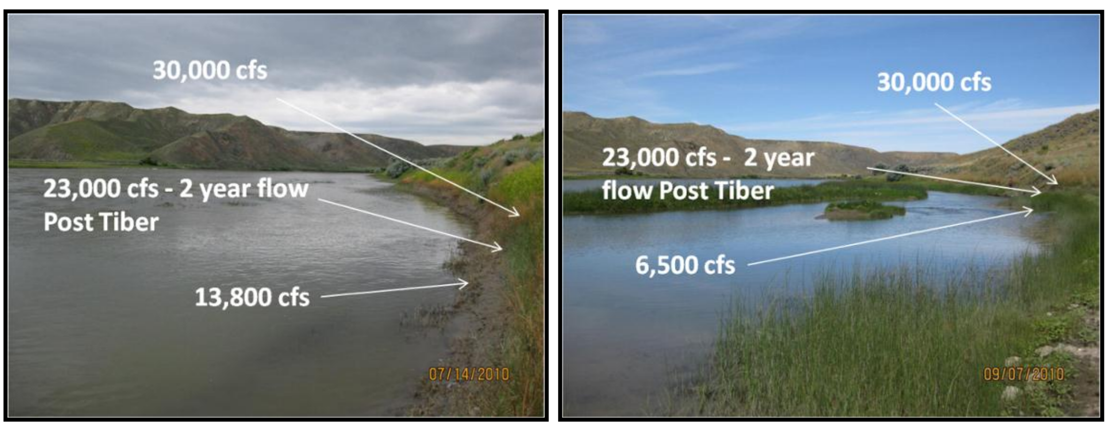

Figure 19 – High flows inundate very little bank distance in highly confined Reach 3. Arrows point to the same bank position. Notice the building site of riparian-wetland vegetation that occurs below the 2-year return interval discharge. Perhaps more noteworthy is that the difference in 13,800 cubic feet per second (cfs) and 30,000 cfs only inundates a few feet of bank distance. This area is frequently battered by disturbance from ice and river flows.

Consideration of the channel and flow characteristics of the upper Missouri River is imperative because they control the different vegetation patterns within the reaches. Note that this PFC assessment was not a cottonwood survey, but using cottonwood as an example of the thought processes followed by the ID Team, bare moist sites suitable for cottonwood recruitment are most often met through flow induced channel change (Auble et al., 2005). Hansen (1989) describes four depositional sites which are suitable for the recruitment of pioneering species such as plains cottonwood and willow species. They are depositional sites such as point bars, side bars, mid-channel bars, and delta bars. Through the unconstrained Reaches 1 and 2, all of the fore mentioned features exist. Meandering and channel narrowing are important processes for the establishment of woody vegetation.

In the constrained reaches of the upper Missouri River, the potential area for cottonwood establishment is much smaller, which is evident by the linear bands of trees. Large flood pulses are necessary to establish trees in high enough bank positions that they are relatively safe from future flows and ice. In Reaches 3, 4, 5, and 6, unconstrained zones within the larger constrained zones do occur. They can be found near tributary junctions, channel islands, and overflow channels (Scott and Auble, 2002). In these unconstrained portions, recruitment of trees is less dependent on large flood pulses because with the lateral movement and sediment aggradation, established trees are removed from the zone where they receive more frequent physical disturbance (Scott and Auble, 2002). Mid-channel bars, or islands, provide very important functions and values within the highly confined F-channel types of the upper Missouri River. Whereas the main river is laterally very static, islands are very dynamic and are constantly moving within the channel. As such, they function as small, unconstrained areas. Because floodplain development is limited on the main channel streambanks, islands provide important flood-prone areas within the highly constrained reaches of the upper Missouri River.

For the most part, the channel characteristics on the upper Missouri River are in balance with the landscape setting. The river features are appropriate for the valley type they are in, which was discussed in great detail above. A key consideration though is that there has been substantial urban and agricultural development since 1890 (unpublished USGS data, in review and subject to revision), primarily in Reaches 1 and 2. As urban and agricultural development increases on the floodplain, these constraints may not allow for channel meandering processes common in Reaches 1 and 2 to continue at the same rate or in equivalent amounts. Furthermore, a decrease in fluvial disturbances associated with dams and further being limited by development on the floodplain would most certainly decrease the lateral migration rates. This effect would be less noticeable in Reaches 3, 4, 5, and 6 than in Reaches 1 and 2 because for one, the river is naturally not laterally migrating much in the confined reaches, and two, the larger percentage of BLM land in these reaches would preclude substantial urban floodplain development.

Riparian-wetland area can widen by expansion of riparian-wetland vegetation into upland areas associated with a rising water table or by the river channel narrowing and new floodplain colonizing with riparian-wetland vegetation. A shift from wetter conditions in the mid- to late 1800s combined with the effect of flow regulation has resulted in a process of channel narrowing (Scott and Auble, 2002). This has resulted in riparian species such as cottonwood becoming established on sites that were previously within the active channel. The channel will not be capable of narrowing indefinitely, and this may be a one-time response as the channel approaches a new equilibrium.

Those areas where floodplain development was occurring, such as delta bars at the mouths of tributaries and islands, were occupied by with riparian-wetland vegetation. These zones are small relative to the reach, but would be leading to small increases in the size of the riparian-wetland area. A crucial detail though is if the upper Missouri River returns to more active disturbance processes, which would be closer to the natural state and potential, there would actually be less riparian-wetland vegetation in many of these areas.

Figure 20 – Riparian-wetland area expanding in Reach 4.

In the PFC checklist, there are two closely related items that do not necessarily require the same response, but they absolutely should not contradict each other. They are that the upland watershed is not contributing to riparian-wetland degradation and that the stream is in balance with the water and sediment being supplied by the watershed. Obviously on a river the size of the upper Missouri, substantial impacts exist within the watershed above it, but the PFC checklist does not ask whether there are impacts above the reach being evaluated. It asks whether or not those impacts are causing riparian-wetland degradation.

The existing channel morphology and channel forming process do not indicate a large change in the amount of water or sediment supplied by the watershed. This does not imply that each reach has the same supply/transport relationship. Reach 1 had higher percentages of gravel and cobble, while Reach 6 had greater percentages of fine-grained sediments in the substrate. There are two reasons for this, supply and transport capacity. As the river passes through the Missouri Breaks, the supply of fine sediment increases, and the transport capacity of the river to move sediment decreases. An example of this can be given by contrasting confined Reaches 3 and 6. Reach 3 has a sinuosity approaching one, and it takes a very large tributary to provide enough sediment to overcome the river's ability to move it. So, there is very little floodplain development. Reach 6 has a somewhat greater sinuosity and shallower gradient, plus a tremendous amount of source material, so it is more conducive to floodplain development. Although different, both conditions are as expected for the respective reaches based upon their potential, and both received "yes" answers that they were in balance with the water and sediment supplied by the watershed.

Figure 21 - Reach 3 and Reach 6 have different sediment transport characteristics. The left figure shows sediment supplied by a side tributary easily transported by the river in Reach 3. In contrast, the right figure shows Reach 6, which has an even greater sediment supply and decreased capacity to move it. Both conditions are as expected relative to each reach's respective potential.

The transport characteristics of the confined reaches have been discussed a fair amount in this report, and it may appear contradictory to have a transport reach that has/is experiencing channel narrowing because one would not expect much deposition in a transport reach. Sediment supply/transport relations are complex, and these are relative characteristics. Reach 3 has characteristics that are more conducive to sediment transport compared to Reach 6 although they both exhibit characteristics that are more like a transport reach than a depositional reach. So, use of these terms was not intended to make a conclusive determination whether a reach is transport or supply limited. It was solely intended to describe the physical processes affecting each reach's potential and existing condition.

Although there are large landform controls on the river channel on the upper Missouri River, vegetation, primarily herbaceous vegetation, is a strong driver for the conditions that are currently present on the river. The floodplain and channel characteristics are adequate to dissipate energy, and any new floodplain or point bars are revegetating with riparian-wetland vegetation. A shift from season-long grazing (May-October) to more active grazing management on the river has allowed for the expansion of dense, obligate riparian-wetland herbaceous communities. Even though expansion of these communities has been facilitated by a decrease in fluvial disturbance, they are responding as one would expect given the change in flow regime. A more natural upper Missouri River would actually have more disturbance, more bare banks, and greater sediment yield than current conditions.

The increased roughness because of the vegetation further accelerates deposition resulting in energy loss in the channel because of added friction. Most areas are dominated by herbaceous vegetation, particularly in the confined reaches of the river, but depositional areas on BLM lands were also well vegetated with riparian vegetation, including cottonwood and willow. Because these species are currently established on low elevation surfaces that are subject to frequent disturbance from floods and ice, they may never become mature individuals. However, they do provide a functional role because these species are generally the first to establish on depositional sites of coarser material. Therefore, the floodplain and channel characteristics are adequate to dissipate energy and point bars are revegetating with riparian-wetland vegetation.

Figure 22 - Floodplain and channel characteristics are adequate to dissipate energy. The left figure shows a depositional site in Reach 1 vegetating with sandbar willow and narrowleaf cottonwood. The right figure shows a narrow floodplain in confined Reach 5 dominated by an herbaceous riparian-wetland plant community.

Even though there are affects to the hydrology and erosion/deposition on the upper Missouri River, they were not large enough to result in any “no” answers for those sections of the PFC assessment The primary reason is that the channel attributes and function are within a relative range of conditions appropriate for each reach’s potential. Especially if one considers the important limiting factor of flow regulation on the upper Missouri River, the river channel, floodplain, and associated vegetation are responding appropriately.

Vegetation

Surface ownership of lands bordering the Missouri River varies. From Fort Benton to the boundary of the Charles M. Russell National Wildlife Refuge 45% of the bank miles are administered by the Bureau of Land Management. Reaches 4, 5 and 6 have the greatest amount of public land bordering the river; 81%, 82% and 72% respectively. Refer to Appendix A for maps which include land ownership for each reach.

Vegetation plays a prominent role in determining the functional rating in the PFC assessment process. In evaluating the sites, the ID Team often stressed “the species tell the story.” To function properly, the site needs to have the right kind of vegetation, in the right amount and in a healthy condition to protect the river bank, resist erosion and filter and capture sediment. The kind, location (position), extent, density, functional role, growth/reproductive strategies, and vigor of vegetation relative to the site’s potential were all factors the ID Team considered in determining the functional rating along each reach.

The ID Team documented 107 vascular plant species in riparian Zones 1 and 2 along the Missouri River. Appendix B lists the scientific and common names for the plant species recorded. No Threatened and Endangered or special status plant species were found at any of the assessment sites.

Herbaceous communities dominated most sites found on public land along the Missouri River. Of the 73 sites evaluated, 77% of Zone 1 and 63% of Zone 2 were dominated by grass-like plants (sedges, rushes, and bulrushes), grasses and forbs.

There were differences in species composition among reaches, plants were present in varying amounts depending on site characteristics such as soil type, width of flood-prone area and bank steepness, but generally Zone 1 contained a diverse mix of native herbaceous riparian-wetland plant species. Along the river's edge, referred to as the scour line, pioneering species such as common spikesedge and needle spikerush were common. Both species are often the first to establish along the shoreline, are rhizomatous (helping to stabilize the bank), grow fast and spread quickly. Other dominant plants present in Zone 1 included woolly sedge, hard-stem bulrush, three-square bulrush, alkali cordgrass and reed canarygrass. Woolly sedge, a mat-forming plant that can colonize an entire river bank, did not occur on public land in Reaches 1 and 2, was only found in trace amounts in Reach 3, but was often dominant on many sites in Reaches 4, 5 and 6. The riparian-wetland plants were well established mid- to late successional species that have important bank-stabilizing qualities indicated by their extensive and deep root systems.

With increasing distance from the river and into Zone 2, the area is flooded less frequently and supports a different group of plants more adapted to somewhat drier conditions. Zone 2 is also impacted by high flows, sedimentation and ice drives creating extensive areas of disturbance which was reflected by the amount of non-native plants and invasive weed species. Common grasses and forbs included alkali cordgrass, creeping meadow foxtail (*Alopecurus arundinaceus*), Kentucky bluegrass (*Poa pratensis*), quackgrass, smooth brome, black medic, cocklebur (*Xanthium strumarium*), silverweed cinquefoil (*Potentilla anserina*), rough horsetail (*Equisetum hyemale*), wild licorice and yellow sweetclover. Among the non-native plants, quackgrass and smooth brome were the most common. Yellow sweetclover was extensive on many sites and was frequently associated with areas disturbed by ice.

The lack or small amount of tree and shrub species occurring in Zones 1 and 2 was not surprising. Tree and shrub species were present but consisted of scattered plants, usually single-stemmed saplings and seedlings, totaling only a small percentage of the canopy cover. For one, it is difficult for willows and cottonwoods to become established in herbaceous riparian-wetland sites due to the lack of bare areas for seedling establishment and the competition for sunlight and nutrients. Also, woody species located along the bank in Zones 1 and 2 are subjected to frequent disturbance from ice and water and are periodically buried with sediment during high flows. These effects were intensified on sites where there were only a few woody plants present.

Reed canarygrass occurred on 66% of the sites. Reed canarygrass is a cool-season perennial grass, an aggressive competitor that invades a site and displaces native vegetation. It commonly reproduces by rhizomes, can grow into dense mats, and tolerates frequent and prolonged flooding. Questions have been raised about whether all the forms of reed canarygrass found along the Missouri River are native or an introduced variety. Merigliano and Lesica (1998) determined reed canarygrass was widely established in river systems in Montana, Idaho and Wyoming well before European settlement. Lewis and Clark listed the plant in their journals. In the Unites States, cultivation of Eurasian strains began in New England around the 1830's when farmers were interested in improving forage production and quality (Harrison, et al., 1996). There are no easy traits for differentiating between the native plants and European cultivars (White, et al., 1993). Cross breeding has likely occurred and the reed canarygrass plants we now see along the Missouri River may be the more invasive and aggressive form. The ID Team noted a strong connection between the distribution and density of reed canarygrass and the season of livestock use. Reed canarygrass has been frequently observed to become dominant on ungrazed or lightly grazed sites (Paine and Ribic, 2002). Reed canarygrass occupied more area in the floodplain, and was often the dominant herbaceous species on those sites excluded from livestock grazing and sites with late summer or fall grazing. This pattern changed when the timing of livestock use was earlier in the summer or when periodic use occurred during the summer.

In total for Reaches 1 through 6, the ID Team documented 21 sites with woody plant species occurring in Zones 1 and 2, 58% of the sites observed. Reaches 1 and 6 had the highest amount of woody plant communities on BLM land. These two reaches are somewhat less confined and contain more sites on public land suitable for woody species establishment. Tributary junctions and back channel areas were the most common feature containing extensive woody plant communities. Sandbar willow was noted as the dominant woody species. Plains cottonwood and yellow willow were commonly found but only in trace amounts. The ID Team noted that the survivability of woody plants within Zones 1 and 2 has been greatly reduced due to damage from ice, scouring during high flows, deposition of large amounts of sediment and removal of stems by beaver.

Noxious Weeds and Invasive Species

Many of the species recorded during the assessment were non-native plants and invasive weed species. Kudray and others (2004) in their study of riparian forest along the Upper Missouri National Wild and Scenic River inferred that non-native plants and invasive weed species were the most serious and immediate threat to this ecosystem. Our assessment results support their findings. Noxious weeds were prevalent in Zones 1 and 2, present on 93% of the sites evaluated, with leafy spurge, Canada thistle, perennial pepperweed and Russian and spotted knapweed as the most common. These varied in distribution and density depending on the amount of disturbance from ice and flooding in Zones 1 and 2 and the depth to the water table. Leafy spurge was closer to the river whereas spotted knapweed occupied drier areas that were disturbed and on coarser textured soils. Russian knapweed and perennial pepperweed were more common in Zone 2.

Non-native species, principally quackgrass, Kentucky bluegrass, creeping meadow foxtail, yellow sweetclover, red top (*Agrostis gigantean (alba*)) and smooth brome, were found on 99% of the sites evaluated. The occurrence of non-native plants was more common in Zone 2 more than likely resulting from repeated disturbances caused by ice, high flow events and sedimentation.

Russian olive was more common on public land in Reaches 1, 2 and 3, occurring on 13 of 45 sites, and was nearly absent in Reaches 4, 5 and 6, only present on 4 of 28 sites. Our observations while traveling down river also indicate, regardless of ownership, that Russian olive was much more evident along the river in the upper reaches.

Since the mid-1980s, BLM has been actively using an integrated weed management (IWM) approach to control invasive weeds within the Upper Missouri National Wild and Scenic River. The BLM uses a combination of practices and treatment strategies designed for each weed species and management area. Preventing new weed species from entering the Missouri River ecosystem and maintaining “weed free areas” is the most practical and effective means of weed management. Working closely with counties and private landowners has been essential to deal cooperatively with noxious weeds infestations in areas of mixed ownership. Recently, efforts have been directed toward eliminating Russian olive by focusing on the lower reaches where the amount of public land is higher and its occurrence and density is much lower.

Grazing Management

As part of the PFC process, at least one site in every grazing allotment was evaluated and the number of stops and sites depended on the size of the allotment. As expected, small tracts of public land had one evaluation site whereas larger, more complex grazing allotments may have had several. Although some grazing allotments showed evidence of livestock impacts to an evaluation site, the ID Team concluded these areas were small, isolated and did not affect the functional rating for the reach.

Cattle's grazing in riparian-wetland areas along the Missouri River has been a major issue since the 1960s reaching a much higher level of concern over the past decade following designation of the Monument. The diverse interest and competing uses have resulted in a great deal of conflict and controversy. Consequently, grazing within the Monument became the principle reason the BLM, working with the National Riparian Service Team, decided to assess riparian conditions along the Missouri River.

Currently, there are 43 grazing allotments (194,130 acres) along the Missouri River between Fort Benton to the CMR boundary. They range in size from 34 to 45,000 acres of public land and provide 19,670 animal unit months (AUMs) of forage. Prior to 1993, nearly every river bottom had continuous hot-season grazing (grazed continuously through the summer and fall months).

Over the past 15 to 20 years, BLM has implemented and evaluated a variety of management changes to maintain and improve riparian conditions on nearly all of the grazing allotments. There is no "one-size-fits-all" approach in designing and implementing grazing management strategies for use in riparian areas. Often times it's not a rigid rotation system but simply controlling when cattle graze a riparian area and for how long. It is important to understand that the area observable while floating along the river may only be a very small part of the grazing allotment. Some have several acres of riparian habitat but several thousand acres of upland areas. These provide habitat for a variety of wildlife species and other recreation activities. A successful management program must consider the entire grazing allotment and the resources in the riparian zone near the river and upland areas away from the river.

Constant involvement of the grazing permittees and their commitment to a grazing management strategy is essential to a successful program. There are many examples of grazing management practices that BLM has successfully used to improve riparian conditions. These include adjusting the timing, duration and frequency of livestock use, reducing the stocking rate, and implementing rotation systems that avoid continuous hot season grazing. There are multiple practices and approaches that have been effectively used at different times and locations to manage livestock grazing in riparian areas.

The use of exclosures and riparian pastures has been effective in controlling livestock use in small areas. Options are used when allowing livestock to graze a riparian area which include only grazing certain times of the year or one in every three or four years.

Many other "grazing tools" have also been used to help implement changes in riparian area management. The most successful projects have been those that influence livestock distribution. Off-site water developments, prescribed burning, the use of supplements (mostly salt and molasses lick tubs) and fencing have all been used to restrict livestock use in riparian areas and draw livestock away from the river.

In 2008 the Hay Coulee Grazing Allotment was designated as a resource reserve allotment providing 10,000 acres of public land and 1,500 AUMs for grazing on a temporary basis. Grazing permittees can apply to use the Hay Coulee Grazing Allotment to rest areas and pastures within their own grazing allotment. The Hay Coulee Grazing Allotment is located in the Monument, but it is not within the Missouri River corridor.

Future management of livestock grazing along the upper Missouri River needs to move towards an adaptive management approach rather than rigid and inflexible grazing schedules. Developing objectives for an area, implementing a sound management strategy, monitoring and continually making changes to improve conditions are keys to maintaining and improving resource conditions.

Wildlife

Herbaceous and woody riparian communities provide the single most important habitat for the largest number of insect and wildlife species within the Monument. These communities provide seasonal and year-round habitat for amphibians, reptiles, resident and migratory birds, including raptors and waterfowl, and mammals from small shrews and mice up to elk and historically grizzly bear. Yet this critical habitat comprises less than 1% of the entire habitat within the monument (USDI, BLM 2008a), and not all of this habitat occurs along the UMNWSR.

Plant communities in various successional stages along the Missouri River provides important habitat. Bare or nearly bare, eroded or depositional areas provide nesting and loafing habitat for the spiny soft-shelled turtle, a BLM Designated Sensitive Species (USDI, BLM 2004), and nesting and foraging habitat for waterfowl and shorebirds, including killdeer and terns. Herbaceous emergent and riparian vegetation provides habitat for birds, small mammals, and reptiles and amphibians, including Northern leopard frog (BLM Designated Sensitive Species). Areas with dense communities of cattail, large rush species, or stands of sandbar willow are used by numerous bird species for foraging and nesting, with nests of many species woven into stiff upright stems less than four feet above the ground.

Although Zone 3 is dominated by upland communities (some of which are abandoned riparian communities), it contains the most limited and important vegetation along the river including several woody species, which exist as individuals, small scattered individuals, or dense deciduous forest. Species include cottonwoods, boxelder, green ash, willows, chokecherry, current (*Ribes*), red-osier dogwood, prairie rose (*Rosa woodsii*), western snowberry (*Symphoricarpos occidentalis)* and others species. This habitat is important or critical for many mammals, reptiles, amphibians, resident and migratory bird species, including cavity nesters and raptors (hawks, owls, eagles), and is a highly preferred food source for beaver (Lesica and Miles, 2004). These woodland communities provide important stopovers or travel corridors for many small migratory birds to rest and feed during spring and fall migrations. Mature cottonwoods along the river provide roosting and nesting trees for an expanding population of bald eagles (BLM Designated Sensitive Species).

Of concern for future wildlife use of riparian areas is the presence and dominance of non-native vegetative species. While there are concerns over Russian olive and salt cedar (*Tamarix ramosissima)* becoming established, herbaceous invasive species are currently dominating many sites. Rapid invasion of gravel and sand bars, reduction in vegetative species diversity, reduced diversity and populations of native invertebrates, change in physical structure (stiff upright stems and leafs to limp stems and leaves forming mats), and change in susceptibility to fire, are all currently occurring. These changes are already taking place and impacts to reptiles, amphibians, birds, small mammals and other less obvious species is likely occurring as well.

Assessment Results Summary

In summary, all six reaches were rated by the ID Team in properly functioning condition (PFC). The key attributes and processes responsible for the PFC rating were adequate riparian-wetland species diversity, age class, vigor, cover of riparian-wetland plants with moderate to high stability ratings on the streambanks, stable streambanks, and channel attributes and functions within the range of conditions appropriate for each reach.

As mentioned in the Methodology section of the report, riparian-wetland areas can function properly before they reach their potential. Potential is defined as the highest ecological status a riparian-wetland area can attain given no political, social, or economic constraints, and is often referred to as the potential natural community (PNC) (USDI, 1998). Each reach was evaluated against its ecological potential to ensure the accuracy of the PFC assessment. Having a reasonable knowledge of the attributes and processes that are possible within each reach ensures that the system will be gauged against what it can actually produce.

After completing each reach, the ID Team not only placed the reach into a functioning condition category, but using the collective experience of the team, estimated how close a particular reach was to achieving its potential natural community. This is expressed using an estimated percentage of potential or PNC. Though there are issues associated with a decrease in disturbance regime on the upper Missouri River, the primary reason for departure from potential was invasive and noxious plant species. Noxious and invasive plant species typically have different plant characteristics than native vegetation, such as potential biomass production and erosion control potential, that can affect riparian function.

Table 3 – Estimated Percent Similarity to PNC

Reach #	Percent Similarity to PNC
1	75 to 85
2	< 5
3	40
4	10
5	50
6	30

One of the goals of the assessment was to address Montana Department of Environmental Quality (MDEQ) water-quality concerns on the upper Missouri River and provide beneficial information to be used during their total maximum daily load (TMDL) process. The upper Missouri River is listed as water-quality impaired by MDEQ for a number of different causes and sources, depending on which reach of the river is being discussed. However, some of the consistent causes and sources related to streamside management include sedimentation/siltation from streambank modifications/destabilization and alteration in streamside vegetative cover and physical substrate habitat alterations from agriculture or grazing in riparian or shoreline zones.

The fore mentioned causes and sources of impairment on the upper Missouri River were not corroborated based upon this assessment. Well documented, widespread channel narrowing on all reaches of the upper Missouri River is indicative of a system that is trapping and storing sediment, not a source of sediment/siltation. Streambanks are very well stabilized, in fact, actually over stabilized given the colonization of riparian-wetland vegetation and change in fluvial disturbance regime. Livestock grazing in riparian or shoreline zones is not a source of unstable streambanks, alteration in streamside covers, or physical substrate habitat alterations.

As mentioned earlier, this assessment was not a cottonwood inventory, but no report on the upper Missouri River would be complete without a discussion on the status of riparian forest. In the table below, the upper reach used by USGS roughly coincides with BLM Reaches 1 and 2, and the Middle Reach corresponds with BLM Reaches 3, 4, 5, and 6. The width of riparian forest in meters is the amount of forest area in square meters divided by the river reach length in meters. This facilitates comparison between reaches.

Table 4 – Amount of riparian forest (m) (unpublished USGS data, in review and subject to revision)

USGS River Reaches	1890s	1950s	2006
Upper Reach (Fort Benton to Coal Banks (River Mile 0 to 46)	48	75	92
Middle Reach (Coal Banks to Grand Island (River Mile 46 to 139)	32	27	32
Lower Reach (Grand Island to Fort Peck Reservoir – on CMR National Wildlife Refuge)	274	158	173

Much of the increase in riparian forest in the Upper Reach can be attributed to an increase in invasive Russian olive. There is the possibility of Russian olive becoming the dominant or co-dominant tree on the upper Missouri River (personal communication, G. Auble (USGS)). Russian olive can affect vegetation composition and structure and can change the site's potential. Russian olive has significant effects on riparian forests. According to Lesica and Miles (2001), Russian olive can displace native trees and shrubs and form monotypic stands that alter ecosystems.

In the Middle Reach, Russian olive is relatively absent, and current amounts of cottonwood forest are similar to those documented in 1890. The process of channel narrowing that has been occurring since the late 1800s has resulted in establishment of cottonwood trees as existing back channels have filled in. This increase in trees has mitigated the effects of the loss of trees from higher surfaces. It is important to note that the channel will not be capable of narrowing indefinitely, and this may be a one-time response as the channel approaches a new equilibrium. Without a change in flow regimes on the upper Missouri River, the amount of cottonwood forest will decrease on all reaches although this effect will be somewhat less noticeable in the unconstrained portions of the river.

Table 5 – 2006 cottonwood forest age class distribution (unpublished USGS data, in review and subject to revision)

USGS River Reach	2006 Cottonwood Forest Age Class Distribution (Percent)				
	< 10 years	10 to 25 years	25 to 50 years	50 to 114 years	> 114 years
Upper Reach (Fort Benton to Coal Banks (River Mile 0 to 46)	2	5	31	44	18
Middle Reach (Coal Banks to Grand Island (River Mile 46 to 139)	2	7	31	35	25

Given that cottonwood is a flood and disturbance dependent species, spatial and temporal variability in the recruitment of trees means that there is no reasonable expectation of constant total area or stable age distributions (unpublished USGS data, in review and subject to revision). The decrease in the magnitude of fluvial disturbances on the upper Missouri River is associated with both climatic shift and dams. A shift from wetter conditions in the mid to late 1800s combined with the effect of flow regulation has resulted in a process of channel narrowing (Scott and Auble, 2002). This has led to the establishment of cottonwood trees. However, as mentioned in the previous paragraph, without a change in disturbance regime on the upper Missouri River, the amount of cottonwood forest will likely decrease.

An essential consideration in the flow related discussion on the upper Missouri River is not just the flows themselves but floodplain development. Urban encroachment on the floodplain precludes the river's ability to perform an important river function, which is flooding. Flow releases out of Canyon Ferry Dam are particularly limited by urban encroachment by the city of Great Falls and by housing developments on the Missouri River between Great Falls and Helena. Although not to the same extent as Canyon Ferry Dam, flows out of Tiber Dam on the Marias River are also limited by development.

Furthermore, it is not just the flood itself that is important for river processes, it is the effect of periodic disturbance that shifts rivers around and creates new sites for maintenance of riparian-wetland vegetation and channel characteristics. Urban development has increased substantially since 1890 (unpublished USGS data, in review and subject to revision), primarily in Reaches 1 and 2. As floodplain development increases, it may not allow for channel meandering processes, which are responsible for the prevalent cottonwood forest within these reaches, to continue at the same rate or in equivalent amounts.

Conclusion

Interpretations and Management Opportunities

During the past 25 years, much attention has been focused on the charismatic riparian species on the upper Missouri River, such as cottonwood and other woody riparian species, which do have important values. However, there hasn't been much focus on the biggest driver of function and condition, which is the dominant, late-successional sedge/rush communities. Perhaps facilitated by the decrease in disturbance on the upper Missouri River, these plant communities are vigorous, robust, and diverse in composition and age-class. These plants on the upper Missouri River have massive and extensive root systems and are able to produce tremendous growth following scour by water and ice. The plants are inundated by water for long periods of time on an annual basis. They grow in soils with very high clay composition and are buried by sediment deposition almost yearly. They do all this in a very short growing season. Plants in poor condition are not capable of doing this.

A plausible explanation for these productive herbaceous communities is the effect of organic matter. The healthy, obligate, riparian-wetland vegetation on the upper Missouri River not only traps a tremendous amount of organic matter, but it becomes organic matter itself. Organic matter in the soil increases the water-holding capacity of the soil by staggering proportions thereby increasing the growing season and the amount of riparian-wetland area in places that are not under the immediate influence of river flows. Organic matter also breaks up the pore spaces in compacted soils increasing the water availability to plants that maybe ordinarily would not grow in soils with very high clay contents. The soils and water availability determine potential and which plants can be where.

All reaches of the upper Missouri River were evaluated as being in PFC because of healthy plant communities of streamside vegetation and channel attributes and functions within a relative range appropriate for each reach. Serious issues include how flow management and invasive plant species and noxious weeds will affect condition and function of riparian-wetland resources on the upper Missouri River in the future. Livestock grazing influences the condition of vegetation, but it is not a limiting factor, which is not to say that livestock grazing management should not continue to be carefully managed, or that there are not small, localized areas that could benefit from improved management.

The upper Missouri River has a vast watershed, and the activities that occur within that watershed affect the condition of riparian-wetland resources on BLM lands within the Monument. This means that sustainability of the riparian-wetland resources within the Monument is dependent, in part, upon many factors which are outside the control of the BLM. What does this mean for BLM? Sustaining the riparian-wetland resources within the Monument for the future will require BLM to work with partners, cooperators, other local, state, and federal agencies and neighboring landowners. An obvious management opportunity is working with partners and other agencies on management of river flows. The riparian-wetland areas on the upper Missouri River would benefit from any measure to shift river flows toward a more natural flow regime. To some extent, this is happening already. At the time of this report, the BLM and the Bureau of Reclamation are working towards a Memorandum of Understanding (MOU) that would establish a working group to pursue this. Water management on the upper Missouri River is complex. Large dam operation is mostly controlled by the federal Bureau of Reclamation and U.S. Army Corps of Engineers. The State of Montana, through various agencies, is responsible for permitting the use of water, water quality, and fish and wildlife. Obviously, there is also the local county, city, and private property interests and management of streamside zones and floodplains within their jurisdictions, not to mention private companies like Pennsylvania Power and Light – Montana that generate power from river flows. So, clearly this is not only a complex management opportunity, but also a multi-jurisdictional one.

Housing development on floodplains is a big issue that is outside the control of the BLM. Urban development on the floodplain of the Missouri River and its tributaries not only affects the river's ability to function in those particular areas, but it also decreases the opportunities for future management of river flows. Floodplains are by definition areas prone to flooding. BLM should support, encourage, and work with the State of Montana, local conservation districts, counties and cities on educating citizens on which types of developments are or are not appropriate in floodplains.

Aggressive and invasive plant species and noxious weed management is problematic on rivers. Rivers like the upper Missouri River have sites that are continually disturbed. These areas are perfect for invasive plant species. Second, the transport mechanism of seeds from upstream sources is always present. BLM is aggressively working on invasive plant and noxious weed control on public land with a number of chemical, biological, and mechanical control methods. BLM is also working with cooperators such as local weed districts, county weed crews, and grazing permittees on noxious weed control. BLM lands on the upper Missouri River are intermingled with private and State land. Treating invasive plants on only one land ownership is of limited value. The treatment and control of invasive plants and noxious weeds needs to continue across boundaries.

The effect of beaver is important for future consideration. In the constrained portions of the river, nearly every woody species was removed by beaver at some point. Breck et al. (2003) stated that beaver herbivory will need to be considered in plans to enhance cottonwood populations along regulated rivers. Because of the limited potential for woody plant establishment in the constrained reaches (due to river processes), beaver (combined with shearing by ice) are inhibiting seedlings and saplings from maturing into more large statured plants on many sites. Beaver are a natural component of river systems, but in flow regulated systems, their effect is compounded. Not only is there a decrease in the regeneration of woody species associated with flow regulated systems, but a stabilized flow regime provides easier denning for beaver. Lesica and Miles (1999) speculated that flow regulation enhanced beaver denning habitat. They suggest that flooding is an important cause of beaver mortality and den abandonment and thus reduces the density of beavers on rivers that flood.

Breck et al. (2003) cited numerous authors in stating that "flow modification due to the diversion of water and operation of large dams is partially responsible for a drastic decline in cottonwood recruitment along many of these rivers." They also stated "on flow regulated rivers, cottonwood recruitment can be spatially restricted and that in turn could lead to a situation where trees are more vulnerable to beaver herbivory." Breck et al. (2003) reported that beavers decreased tree density and made individual trees more susceptible to herbivory. Lesica and Miles (1999) reported that plains cottonwood was prevented from developing a mature canopy because the low density caused by flow regulation allowed beavers to suppress the recruitment into larger size classes.

Restricted flows on rivers can reduce cottonwood recruitment, and move cottonwood and willow establishment closer to or in the river channel on islands (Breck et al. 2001). Lesica and Miles (2004) documented 90% beaver use of cottonwoods within 50 meters of the river channel, but only 21% on cottonwoods located farther away. Breck et al. (2003) stated that with additional woody establishment along channel margins “beaver could limit cottonwood establishment in such a case, because the new recruitment areas will be close to the river and the absolute abundance of cottonwood will probably remain low.” This is certainly true for many sites along the upper Missouri River.

The fact that livestock grazing was not identified as a major issue does not mean that livestock grazing management will never change or that there will not be opportunities for improved grazing management in the Monument. Assessments by themselves generally should not be used to change livestock management unless there are very strong indicators of resource problems. Two essential questions in regards to future livestock grazing management are whether BLM’s livestock grazing are maintaining the dense, obligate-wetland vegetation in streamside zones, and whether livestock is the factor precluding woody species recruitment on sites where it would be expected. As mentioned previously, the upper Missouri River is over stabilized, which has allowed for colonization of streamside communities of stabilizing obligate and facultative wetland herbaceous vegetation. If the upper Missouri River returns to a more active disturbance regime there may be less of these areas. BLM needs to ensure that livestock grazing is not the factor in removing or precluding development of these areas. At the time of the assessment, livestock grazing was not precluding woody species recruitment at sites where it was expected given the disturbance history of the river. This doesn’t mean that livestock grazing has never influenced vegetation on the upper Missouri River, but livestock use on woody species, particularly in unconstrained areas, was light. The ID Team did evaluate sites where deer and bighorn sheep use on woody species was high. These issues will be discussed further in the monitoring section below.

Monitoring

Assessments are part of a process that includes monitoring and management. The assessment results and management opportunities have been discussed, but how does one track the condition of riparian resources on the upper Missouri River and the effect of management changes upon them? Monitoring on a river the size of the Missouri is problematic because the strategy for monitoring needs to be commensurate with the size of the area that the question is applicable to. For example, how the extent and status of riparian forest on the upper Missouri River are changing is a river scale question, whereas woody species use levels are an allotment scale question. Furthermore, many existing monitoring protocols would need to be modified to work on a river the size of the upper Missouri River.

The BLM has been monitoring several hundred sites based upon Hansen’s 1989 inventory of riparian areas on the upper Missouri River for 20 plus years. This monitoring has been primarily qualitative in nature and will continue in the future. Since the completion of the PFC assessment the ID Team has been working on modifying the existing monitoring form to make certain its use is applicable in the future. However, because it is qualitative, the existing monitoring is not always capable of distinguishing the different factors affecting condition and trend.   Some adjustments to BLM’s monitoring strategy will be necessary to properly address the issues identified by the assessment.

In continuation of this process, the ID Team, with the assistance of the NRST team leader, a USGS research ecologist, and a BLM state office program lead, has begun developing a strategy for monitoring the upper Missouri River. To begin the discussions, the ID Team divided the questions into river, reach, and allotment (site) scale questions based upon the assessment results. All monitoring should address the questions and have the capability of detecting change. The river, reach, and allotment (site) scale questions are shown in Table 6. An individual monitoring technique is not required for each question, as one technique may address several questions; but the BLM needs to ensure that monitoring can answer the questions listed below. Some questions are applicable at more than one scale.

Table 6 – The river, reach, and allotment (site) scale monitoring questions

River Scale	Reach Scale	Allotment (Site) Scale
What are the extent and status of riparian forest?	What are the extent and status of invasive plant species?	What are woody and herbaceous species use levels?
What are the extent and status of invasive plant species?	What are the woody species size classes and are they recruiting where they are expected?	What are the woody species size classes and are they recruiting where they are expected?
Where are the waist high to head high cottonwoods (i.e. 1- to 2-m tall cottonwoods)?	How are water-quality concerns addressed?	Is the composition of streambank stabilizing plants in Zone 1 being maintained?
How are water-quality concerns addressed?	Is the composition of streambank plants in Zone 1 being maintained?	

The monitoring needs to be commensurate with the size of the area that the question is pertinent to. Remote sensing techniques or large scale inventories would be most appropriate for tracking river scale issues such as the extent of invasive plant species or the status and trend of riparian forest. For example, georectified aerial imagery with geographic information system (GIS) analysis would be the most appropriate way to track river channel (for water-quality concerns) and riparian forest changes. The location of critical woody species size classes (i.e. 1- to 2-m tall cottonwoods) or the extent and status of invasive species could be completed quickly with river inventories and GPS/GIS mapping. River inventories of invasive plant species were recently completed in 2010. Allotment (site) scale questions need to address issues of management activities immediately adjacent to streamside zones. What are woody species use levels, are woody species size classes occurring where they are expected, and is the composition of streambank plants in Zone 1 being maintained?

Monitoring sites for these questions need to be located in places where they can be answered. For the purpose of site scale monitoring, four sub-areas were identified by the ID Team: a steep, confined bank with little or no riparian vegetation; a confined, moderately steep bank with a narrow band of riparian vegetation (with narrow Zones 1 and 2); a confined, moderately steep bank with a narrow band of riparian vegetation (with a wider Zones 1 and 2); and unconfined reaches. Allotments need to be stratified to make sure monitoring locations are appropriate. For example, woody species use levels would be appropriate to measure in unconfined reaches because the effect of livestock grazing could be distinguished from other factors. In confined reaches, the likelihood of woody species recruiting into older age classes is low under current conditions, and the effect of livestock grazing would be difficult to differentiate from other limiting, disturbance factors. Along the same lines, tracking the composition of vegetation in streamside zones would be appropriate in the confined, moderately steep bank with a narrow band of riparian vegetation, but it would not be appropriate in the steep, confined bank with little or no riparian vegetation.

Reach scale questions could be addressed by merging the river scale and the allotment (site) scale monitoring. For example, whether invasive plant species are displacing the native streambank vegetation in Zone 1 is a reach scale question. If BLM has the river scale invasive species inventories and the allotment scale monitoring of Zone 1 plant composition, invasive plants increasing in Zone 1 should be detectable. Along similar lines, to ensure water-quality concerns are addressed, which is also a reach scale question; the BLM could use a combination of remote sensing to monitor river channel dimensions plus the Zone 1 vegetation composition as surrogates for water quality measurements to determine if BLM management activities are contributing non-point source pollutants. At the time of the assessment, they were not.

Research Opportunities

Reed canarygrass was present and recorded by Lewis and Clark on the upper Missouri River. However, nonnative cultivars of reed canarygrass, developed for erosion control, have rapidly spread along rivers and streams in the western United States. Reed canarygrass is aggressive and can displace native, desirable riparian-wetland plant species and can result in monocultures of reed canarygrass. This alters the river and stream ecosystem and function. On the upper Missouri River, reed canarygrass appears to be expanding. How fast it is expanding and what the effects will be on the river ecosystem and functions are excellent research questions.

As indicated, one of the extraordinary riparian-wetland features of the upper Missouri River is the dominant, late-successional sedge/rush communities, perhaps facilitated by the amount of organic matter in the soils. The general relationship between river dynamics (disturbance processes), organic matter, and potential vegetation has not been studied in considerable detail, and particularly not on the upper Missouri River; therefore, this would be an additional opportunity for research within the Monument.

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Appendices

A. Maps

B. Plant List and Technical Guides


DELORME
XMap® 7
PFC Reach #1
River Miles 0 (Fort Benton) to
22 (Marias River)
LOMA & MARIAS RIVER
FORT BENTON
STATE LAND
PUBLIC LAND
STOP & PHOTO
POINT LOCATIONS
MN (12.7° E)
0 ¼ ½ ¾ 1 1¼ 1½ 1¾ mi
Data Zoom 12-0

XMap® 7

MN (12.6° E)

0 ½ 1 1½ 2 mi

Data Zoom 12-0

DELORME XMap® 7

MN (12.5° E)

0 ½ 1 1½ 2 mi

Data Zoom 12-0

MN (12.3° E)

0 ½ 1 1½ 2 mi

Data Zoom 12-0

DeLorme

XMap® 7

MN (12.1° E)

mi

0 ¼ ½ ¾ 1 1¼

Data Zoom 12-0


DELORME
XMap® 7
PFC Reach #5
River Miles 102 (Stafford Ferry) to
119 (Sturgeon Island)
STURGEON
ISLAND
REACH BREAK RM 119
REACH BREAK RM 102
STAFFORD
FERRY
STATE LAND
PUBLIC LAND
STOP & PHOTO
POINT LOCATIONS
mi
0 ¼ ½ ¾ 1 1¼ 1½ 1¾
MN (12.0° E)
Data Zoom 12-0


DELORME
XMap® 7
PFC Reach #6
River Miles 119 (Sturgeon Island)
to 139 (CMR Boundary)
STURGEON ISLAND
CMR BOUNDARY
STATE LAND
CMR LAND
PUBLIC LAND
STOP & PHOTO POINT LOCATIONS
Data use subject to license.
© DeLorme. XMap® 7.
www.delorme.com
MN (11.8° E)
0 ¼ ½ ¾ 1 1¼ 1½ mi
Data Zoom 12-0

Appendix B - Plant List (All Three Zones Combined) and Technical Guides

TREES

COMMON PLANT NAME	SCIENTIFIC PLANT NAME	REACHES FOUND
Boxelder	*Acer negundo*	1-3-4-6
Great Plains Cottonwood	*Populus deltoides*	1-2-3-4-5-6
Green Ash	*Fraxinus pennsylvanica*	1-2-3-6
Narrowleaf Cottonwood	*Populus angustifolia*	1
Peachleaf Willow	*Salix amygdaloides*	1-2-3-4-5-6
Rocky Mtn Juniper	*Juniperus scopulorum*	3-4-6
Water Birch	*Betula occidentalis*	1

SHRUBS

COMMON PLANT NAME	SCIENTIFIC PLANT NAME	REACHES FOUND
Absinth Wormwood	*Artemisia absinthium*	1-3-6
Chokecherry	*Prunus virginiana*	1-2-3-4-6
Common Juniper	*Juniperus communis*	3
Falsetarragon Sagewort	*Artemisia dracunculus*	4
Golden Currant	*Ribes aureum*	1-2-3-4-6
Prairie/Woods Rose	*Rosa woodsii*	1-2-3-4-5-6
Red-Osier Dogwood	*Cornus stolonifera*	1-3-6
Rubber Rabbitbrush	*Chrysothamnus nauseosus*	2-3-4-6
Sandbar (Coyote) Willow	*Salix exigua*	1-2-3-4-5-6
Silver Buffaloberry	*Shepherdia argentea*	1-2-4
Silver Sagebrush	*Artemisia cana*	1-2-3-4-5-6
Skunkbush Sumac	*Rhus trilobata*	1
Western Snowberry	*Symphoricarpos occidentalis*	1-2-3-4-5-6
White Stem Gooseberry	*Ribes inerme*	1-2-3-4-6
Wyoming Big Sagebrush	*Artemisia tridentate ssp wyomingensis*	3
Yellow Willow	*Salix lutea*	2-3-4-5-6

BLM & MT NOXIOUS WEEDS

COMMON PLANT NAME	SCIENTIFIC PLANT NAME	REACHES FOUND
Canada Thistle	*Cirsium arvense*	1-2-3-4-6
Common Burdock	*Arctium minus*	3-6
Common Mullein	*Verbascum thapsus*	1-2-3
Field Bindweed	*Convolvulus arvensis*	1-2-3-4-6
Leafy Spurge	*Euphorbia esula*	1-2-3-4-5-6
Houndstongue	*Cynoglossum officinale*	1-2-3
Perennial Pepperweed	*Lepidium latifolium*	2-3-5
Russian Knapweed	*Acroptilon repens*	1-2-3-4-5-6
Russian Olive	*Elaeagnus angustifolia*	1-2-3-4-6
Spotted Knapweed	*Centaurea stoebe*	1-3-5

FORBS

COMMON PLANT NAME	SCIENTIFIC PLANT NAME	REACHES FOUND
Alfalfa	*Medicago sativa*	2-3-6
American Vetch	*Vicia americana*	3-6
Annual Mustard	*Sisymbrium spp.*	3-4-6
Annual Sunflower	*Helianthus annuus*	3
Arrowhead	*Sagittaria cuneata*	3-6
Asparagus	*Asparagus L.*	6
Black Medic	*Medicago lupulina*	3-4-5-6
Broom Snakeweed	*Gutierrezia sarothrae*	1-3
Cocklebur	*Xanthium strumarium*	3-4-5-6
Cudweed Sagewort	*Artemisia ludoviciana*	1-2-3-4-5-6
Curlycup Gumweed	*Grindelia squarrosa*	2-3-4-5-6
Curly Dock	*Rumex crispus*	2-3-6
Dandelion	*Taraxacum officinale*	1-2-3-4-6
Dogbane (Indian Hemp)	*Apocynum cannabinum*	2-3-4-6
False Solomon Seal	*Smilacina stellata*	1-3-6
Field Pennycress (Fanweed)	*Thlaspi arvense L.*	2-3-4-6
Fringed Sagewort	*Artemisia frigida*	1-3-4-6
Missouri Goldenrod	*Solidago missouriensis*	1-2-3-4-5-6
Hawksbeard	*Crepis spp.*	3
Milkvetch(s)	*Astragalus spp.*	3-6
Mint (Field/Wild)	*Mentha arvensis*	3-4-5-6
Poison Ivy	*Toxicodendron rydbergii (Small ex Rydb.) Greene*	2-3-4-6
Prairie Coneflower	*Ratibida columnifera*	2-3-4-5-6
Prairie Thermopsis	*Thermopsis rhombifolia*	3-4
Prickly Lettuce	*Lactuca serriola L.*	6
Purple Prairie Clover	*Dalea purpurea Vent.*	3
Red Clover	*Trifolium pratense*	5-6
Salsify	*Tragopogon dubius*	2-3-5-6
Silverweed Cinquefoil	*Potentilla anserina*	1-3-4-5-6
Showy Milkweed	*Asclepias speciosa*	1-2-3-4-5-6
Water Smart Weed	*Polygonum amphibium*	2-3-4-5
Wax Leaf Penstamon	*Penstamon nitidus*	1
Western White Clematis	*Clematis ligusticifolia*	2-3-4-6
Western Yarrow	*Achillea millefolium*	2-3-4-6
White Penstemon	*Penstemon albidus*	1
White Sweetclover	*Melilotus alba*	2-3-4-6
Wild Licorice	*Glycyrrhiza lepidota*	1-2-3-4-5-6
Yellow Columbine	*Aquilegia flavescens*	1
Yellow Sweetclover	*Melilotus officinalis*	2-3-4-5-6

GRASSES

COMMON PLANT NAME	SCIENTIFIC PLANT NAME	REACHES FOUND
Alkali Cordgrass	*Spartina gracilis*	1-2-3-4-5-6
Barnyardgrass	*Echinochloa muricata*	3
Basin Wildrye	*Leymus cinereus*	1-3
Bluegrass	*Poa sp.*	3
Bulbous Bluegrass	*Poa bulbosa L.*	1
Canada Wildrye	*Elymus canadensis*	2-3-4-5
Cheatgrass	*Bromus tectorum*	1-2-3-4-6
Creeping Meadow Foxtail	*Alopecurus arundinaceus*	1-2-3-4-5-6
Crested Wheatgrass	*Agropyron cristatum*	1-2-3-4-6
Common Reed	*Phragmites communis*	2-3-4-5-6
Foxtail Barley	*Hordeum jubatum*	2-3-4-5-6
Green Needlegrass	*Nassella viridula*	1-2-3-4-5-6
Inland Saltgrass	*Distichlis stricta*	2-3
Japanese Brome	*Bromus japonicas*	2-3-4-6
Kentucky Bluegrass	*Poa pratensis*	1-2-3-4-5-6
Needle and Thread Grass	*Hesperostipa comata*	2-3-4
Prairie Junegrass	*Koeleria macrantha*	2
Prairie Sandreed	*Calamovilfa longifolia*	1
Quackgrass	*Elymus repens*	2-3-4-5-6
Red Top	*Agrostis gigantean (alba)*	3-4-5-6
Reed Canarygrass	*Phalaris arundinacea*	1-2-3-4-5-6
Slender Wheatgrass	*Elymus trachycaulum*	3-4-5-6
Smooth Brome	*Bromus inermis*	1-2-3-4-5-6
Western Wheatgrass	*Pascopyrum smithii*	1-2-3-4-6

GRASS-LIKES

COMMON PLANT NAME	SCIENTIFIC PLANT NAME	REACHES FOUND
Alkali (Saltmarsh) Bulrush	*Schoenoplectus maritimus*	3-5-6
Baltic Rush	*Juncus balticus*	3-6
Common Cattail	*Typha latifolia*	1-3
Common Spikerush	*Eleocharis palustris*	1-2-3-4-5-6
Field Horsetail	*Equisetum arvense*	3-4-5-6
Hardstem Bulrush	*Schoenoplectus acutus*	1-2-3-4-5-6
Horsetail (Rough)	*Equisetum hyemale*	1-2-3-4-5-6
Needle Spikerush	*Eleocharis acicularis*	3
Sedge	*Carex spp.* - no seed heads present	1-4-5-6
Three-Square Bulrush	*Schoenoplectus pungens*	1-2-3-4-5-6
Woolly Sedge	*Carex lanuginosa (pellita)*	3-4-5-6

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