2011

Cottonwood Management Plan/Programmatic Environmental Assessment Proposed Implementation of a Cottonwood Management Plan Along Six Priority Segments of the Missouri River

U.S. Army Corps of Engineers

Finding of No Significant Impact

Cottonwood Management Plan/Programmatic Environmental Assessment
Proposed Implementation of a Cottonwood Management Plan Along
Six Priority Segments of the Missouri River

Project Summary

The U.S. Army Corps of Engineers (Corps) proposes to preserve existing stands and reestablish new stands of plains cottonwood (*Populus deltoides*) at selected public/government lands along the Missouri River in accordance with the Cottonwood Management Plan (CMP). The Proposed Action is the implementation of the CMP. The goal of the plan is to be a living document that preserves, creates, or restores cottonwood habitats along the Missouri River and meets the requirements of the USFWS 2003 Amended Biological Opinion (BiOp) concerning the bald eagle (*Haliaeetus leucocephalus*). The principal immediate focus of the CMP includes measures in the following segments:

- Segment 4: Garrison Dam to Lake Oahe Headwaters near Bismarck, North Dakota (RM 1389.9 – RM 1304.0)
- Segment 6: Oahe Dam to Big Bend Dam (RM 1072.3 – RM 987.4)
- Segment 8: Fort Randall Dam to Niobrara River (RM 880.0 – RM 845.0)
- Segment 9: Niobrara River to Lewis & Clark Lake, including the Lake (RM845.0 – RM 811.1)
- Segment 10: Gavins Point Dam to Ponca, Nebraska (RM 811.1 – RM 753.0)
- Segment 13: Platte River mouth to Kansas City, Missouri (RM 595.5 – RM 367.5)

The programmatic Environmental Assessment (EA) evaluated the potential impacts of cottonwood management along the Missouri River; however, site-specific environmental review, in the form of EAs, are anticipated in the future prior to implementation of the techniques suggested in the CMP in any segment.

Alternatives

Three alternatives were considered in the environmental assessment: (1) No Action Alternative, (2) Implementation of the CMP with Limited Strategies, and (3) Implementation of the CMP (Proposed Action).

Proposed Action

The Proposed Action is the implementation of the CMP with the option of using all strategies. Implementation strategies include 1) Protection of existing cottonwood stands, 2) Restoration of hydrologic/geomorphic processes for cottonwood regeneration, 3) Artificial propagation of cottonwoods, and 4) Modification to management policies to protect/restore cottonwoods. Many of the techniques would be used in combination in order to be most successful.

Summary of Environmental Impacts

The programmatic EA evaluates the environmental consequences of the implementation of the CMP along the six priority segments. Site specific EAs will be developed to analyze the implementation of the strategies at specific sites. The implementation of the CMP will create long-term, beneficial impacts to the Missouri River by developing fluvial features, such as side channels, oxbow lakes, and backwaters that will create suitable areas for cottonwood establishment. The creation of these fluvial features will restore the historical geomorphology within the currently channelized portions of the river. Connecting the river to these habitats is critical to fish and wildlife species, including many native fish species. Creation of these habitats and flow manipulation will reduce the rate of bed degradation and improve areas with low water tables. The establishment or reconnection of side channels, oxbow lakes, and backwaters will establish new habitat for riparian and wetland vegetation to grow. In addition wetland and riparian habitat will be protected by discouraging land clearing, and purchase of conservation lands or easements.

The implementation of the CMP will create long-term, beneficial impacts by minimizing erosion and improving sedimentation processes along the riverine reaches. Bank erosion will be minimized through discouraging the clearing of cottonwoods along the river and through the establishment of new cottonwood communities along the highly eroded riverbanks. The establishment of these new communities will help protect the riverbanks from further erosion. Implementation of the CMP is also expected to improve the water quality of the river since development of the riverbanks will be discouraged and livestock grazing will be minimized. Both strategies will reduce the amount of nitrogen, phosphorus, and other pollutants entering the system. The beneficial impacts to water quality will further promote the aquatic resources of the Missouri River, including fish and invertebrates. Potential adverse impacts to groundwater, including a decrease in groundwater levels if pumping is used, may occur if irrigation of the agricultural fields is needed to benefit the growth of the cottonwood communities along the river. An additional adverse impact to water resources may result from the use of herbicides to clear invasive species or the use of fertilizers to promote cottonwood growth.

Beneficial impacts to wildlife are also expected from the implementation of the CMP. The preservation and establishment of cottonwood trees through plantings, discouragement of clearing, and easements will provide habitat for many species including the bald eagle. The creation of the side channels, oxbow lakes, and backwaters will also provide additional habitat for waterfowl, amphibians, reptiles, fish, invertebrates, and small mammals. Adverse impacts to wildlife species such as rodents and white-tailed deer that typically feed on cottonwood trees may occur. The implementation of the CMP will include the control and prevention of rodent and deer herbivory of cottonwood stands.

The implementation of the CMP will have negligible impacts to socioeconomic resources. The Corps and other entities may purchase lands or easements and create voluntary property buyout programs.

Impacts to site specific resources will be determined during the NEPA process on a segment/site basis. Consultation with the USFWS, Native American tribes, and the State Historical Preservation Officer with respect to threatened and endangered species and cultural resources will occur prior to implementation of any management strategies.

Mitigation Measures

To minimize the impacts to groundwater from irrigating agricultural lands, an Irrigation Water Management Plan will be implemented to promote and encourage efficient use of the water. To reduce impacts to water quality from the use of herbicides and fertilizers, nonpersistent herbicides and fertilizers will be used and will be applied only in accordance with label and application permit directions. To minimize the impacts to rodent and deer populations that typically feed on cottonwood trees, the Corps will provide access to alternative grazing and shelter. If deer exclosures are installed, a Deer Management Plan based on habitat targets for the designated site will be prepared and implemented.

Public Availability

The Draft Cottonwood Management Plan/Programmatic Environmental Assessment was made available to the public on February 12, 2010 for a 30-day review period ending on March 12, 2010. An electronic copy of the document was available on the Missouri River Recovery Program (MRRP) website. Letters announcing the availability of the document for public review were sent to the Cottonwood Management distribution list and an email was sent to members of the MRRP website emailing list. Several requests were received for an extension to the comment period. The comment period was then extended until April 15th. Additional requests were received for a second extension; therefore, the comment period continued until May 23, 2010. Comments were received and addressed within the CMP/EA. As required by Stipulation 22 of the Programmatic Agreement with the Omaha District, the Corps sent a separate consultation letter and compact disc containing the revised CMP/EA to all individuals on the Programmatic Agreement list and five additional tribes within the Kansas City District on November 10, 2010. Individuals receiving the letter had an additional 30 days to review and comment on the CMP/EA. No comments were received.

Conclusion

After evaluating the anticipated environmental, economic, and social effects of the proposed action, it is my determination that the implementation of the Cottonwood Management Plan does not constitute a major Federal action that would significantly affect the quality of the human environment; therefore, preparation of an Environmental Impact Statement is not required.

Date 11 Feb 11

Robert J. Ruch
Colonel, Corps of Engineers
District Commander, Omaha District

U.S. Army Corps of Engineers

COTTONWOOD MANAGEMENT PLAN / FINAL PROGRAMMATIC ENVIRONMENTAL ASSESSMENT

Proposed Implementation of a Cottonwood Management Plan Along Six Priority Segments of the Missouri River

December 2010

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ACHP	Advisory Council on Historic Preservation
AIRFA	American Indian Religious Freedom Act
AMP	Adaptive Management Process
ARPA	Archeological Resources Protection Act
BA	Biological Assessment
BGEPA	Bald Eagle and Golden Eagle Protection Act
BiOp	Biological Opinion
BOR	U.S. Bureau of Reclamation
BSNP	Bank Stabilization and Navigation Project
C	Channelized
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CMP	Cottonwood Management Plan
Corps	U.S. Army Corps of Engineers
CRP	Conservation Reserve Program
DEM	Digital Elevation Models
E-Team	Ecosystem Evaluation Team
EA	Environmental Assessment
EAMP	Ecology Monitoring and Assessment Program
EC	Engineering Circular
EIS	Environmental Impact Statement
EO	Executive Order
ERDC	Engineer Research Development Center
ESA	Endangered Species Act
ESH	Emergent Sandbar Habitat
EWRP	Emergency Wetland Reserve Program
EXHEP	Expert Habitat Evaluation Procedures
EXHGM	Expert Hydrogeomorphic Approach to Wetland Assessment
FONSI	Finding of No Significant Impact
FQA	Floristic Quality Assessment
FSA	Farm Service Agency
ft	Feet
GIS	Geographic Information Systems
HEAT	Habitat Evaluation and Assessment Tools
HEP	Habitat Evaluation Procedures
HGM	Hydrogeomorphic Wetland Assessment
HSI	Habitat Suitability Index
InVEST	Integrated Valuation of Ecosystem Services and Tradeoffs
IR	Inter-Reservoir
IWR	Institute for Water Resources
LCPI	Land Capability Potential Index
LCRMSCP	Lower Colorado River Multi-Species Conservation Program

LUCIS	Land Use Conflict Identification Strategy
LULC	Land Use/Land Cover
KAF	thousand acre-feet
kcfs	Thousand Cubic Feet per Second
KR	Kansas River Tributary Reservoirs
kWh	Kilowatt Hour
m	Meter
MAF	Million Acre-Feet
MBTA	Migratory Bird Treaty Act
MCDA	Multi-Criteria Decision Analysis
MNRR	Missouri National Recreational River
MoREAP	Missouri River Monitoring and Assessment Program
MRERP	Missouri River Ecosystem Restoration Plan
MRRIC	Missouri River Recovery Implementation Committee
MRRP	Missouri River Recovery Program
MW	Megawatt
NAGPRA	Native American Graves Protection and Repatriation Act
NDIRC	North Dakota Intertribal Reinternment Committee
NEPA	National Environmental Protection Act
NFWR	National Fish and Wildlife Refuge
NHPA	National Historic Preservation Act
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NRCS	Natural Resources Conservation Service, U.S. Department of Agriculture
NRHP	National Register of Historic Places
NWI	National Wetlands Inventory
NWR	National Wildlife Refuge
ORD	Office of Research and Development
PA	Programmatic Agreement
PC	Preservation Criterion
PMIP	Planning Models Improvement Program
POC	Point of Contact
R&H	Reservoirs and Headwaters
R&PC	Restoration and Preservation Criterion
RC	Restoration Criterion
RHA	Rivers and Harbors Act
RM	River Mile
ROD	Record of Decision
ROI	Region of Influence
RPM	Reasonable and Prudent Measure
SDGFP	South Dakota Game, Fish and Parks
SHPO	State Historic Preservation Office
SSURGO	Soil Survey Geographic
SWH	Shallow Water Habitat
System	Missouri River Mainstem Reservoir System

TCP	Traditional Cultural Properties
TELSA	Tool for Exploratory Landscape Scenario Analyses
THPO	Tribal Historic Preservation Office
TY	Target Year
UC	Unchannelized
UMRFFS	Upper Missouri River System Flow Frequency Study
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WRDA	Water Resources Development Act
WRP	Wetland Reserve Program
WSRA	Wild and Scenic Rivers Act

CHAPTER 1. PURPOSE AND NEED

1.1 Introduction

The Missouri River originates in the Rocky Mountains of south-central Montana and flows approximately 2,341 miles through seven states, ending at its confluence with the Mississippi River near St. Louis, Missouri. The plains cottonwood (*Populus deltoides*) was once the dominant floodplain vegetation in the Missouri River ecosystem (Corps 2006a). Natural cottonwood regeneration has largely ceased along the Missouri River following the construction of the Missouri River Mainstem Reservoir System (System) and Bank Stabilization and Navigation Project (BSNP). The reduction in the number of young cottonwoods to replace older cottonwoods concerns biologists because a variety of plant and wildlife species, including some protected species, are associated with cottonwoods.

Bald eagles (*Haliaeetus leucocephalus*) depend on the adjacent cottonwood forest for nesting, roosting, and wintering habitat along the Missouri River. Past and ongoing U.S. Army Corps of Engineers (Corps) operations to serve Congressionally authorized project purposes, including flood control, have restricted overbank flooding causing the reduction of existing stands and new cottonwood establishment. The degradation of cottonwood forests will likely continue in the future and result in additional impacts to bald eagles. In response, the Corps and the U.S. Fish and Wildlife Service (USFWS), in partnership with tribal nations, states and other agencies, are working to restore a portion of the Missouri River's natural form and function in order to recover Missouri River species provided protection under the Endangered Species Act of 1973 (ESA). The Missouri River Recovery Program (MRRP) implements the USFWS 2003 Amended Biological Opinion (BiOp) on the Corps operation of the System, BSNP, and Kansas River Tributary Reservoirs (KR) Projects. Pursuant to Section 5018 of the Water Resources Development Act of 2007 (WRDA 2007) the Corps, in consultation with the Missouri River Recovery Implementation Committee (MRRIC) is preparing a long-term and comprehensive Missouri River Ecosystem Restoration Plan (MRERP). The MRRIC includes representatives from Basin Tribes, states, and a diverse range of basin stakeholders. When complete, the MRERP will identify management actions to recover federally protected Missouri River species, mitigate losses of terrestrial and aquatic habitat, and prevent future declines of species. The Cottonwood Management Plan (CMP) is part of the MRRP. Ultimately, this plan may also inform the long-term MRERP.

The MRRP incorporates the requirements of the Missouri River BSNP Fish and Wildlife Mitigation Project on the Lower River (Mitigation Project) with the actions required by the 2003 Amended BiOp (Appendix A). The Mitigation Project was authorized by Section 601(a) of the Water Resources Development Act (WRDA) of 1986 (Public Law 99-662). Title VI of the 1986 WRDA authorizes the Mitigation Project in accordance with the plans and subject to the conditions recommended in the Missouri River BSNP Final Feasibility Report and Final Environmental Impact Statement (EIS) for the Fish and Wildlife Mitigation Plan (Corps 1981). The intent of the originally authorized Mitigation Project was to restore, preserve, and develop 18,200 acres of existing public lands and acquire and develop 29,900 acres of non-public land. A total of 48,100 acres of land in the four affected states, Iowa, Nebraska, Kansas, and Missouri, would be acquired, restored, preserved, and developed for the Mitigation Project. Allocations of the acreage by affected states are presented in the report entitled *Missouri River Bank Stabilization and Navigation Fish and Wildlife Mitigation Project, Reaffirmation Report* (Corps 1990). In the WRDA of 1999 (Public Law 106-53) Congress authorized the acquisition and development of an additional 118,650 acres for the Mitigation Project, increasing the total acreage to 166,750 acres. The key recovery initiatives for the MRRP include habitat construction and restoration, hatchery support, flow modification, and an integrated science program that informs an overall adaptive management strategy. The CMP is part of the habitat creation recovery initiative of the MRRP.

1.2 Proposed Action

There are many ongoing efforts within the MRRP to restore and protect habitat in the Missouri River basin, including the Cottonwood Habitat Program (the subject of this report) (Corps 2007a). The Corps proposes to preserve existing stands and reestablish new stands of cottonwoods at selected public/government lands along the Missouri River in six segments of the river identified by the USFWS as priority segments. The Proposed Action includes the implementation of a CMP. The goal of this plan is to be a living document that preserves, creates, and/or restores plains cottonwood habitat along the Missouri River and meets the requirements of the USFWS 2003 Amended BiOp (USFWS 2003) (Appendix A).

The CMP prioritizes the preservation and the re-establishment of cottonwoods along the Missouri River. Site selection and prioritization would be achieved through a decision making strategy and once sites were selected, they would be evaluated with the cottonwood community model to evaluate which measures would gain the most habitat lift. After those initial alternatives are chosen, costs would be assessed to implement those alternatives and each plan would be run through the Institute of Water Resources (IWR), Corps Planning Suite to determine which alternatives are the most cost effective plans. The CMP also identifies strategies for implementing the plan including land acquisition, easements, management policies, and timelines. The period of analysis is 100 years because of the life cycle of the cottonwood trees. The life of the project would last until 2110.

In addition to describing the proposed CMP, this document evaluates the potential environmental impacts of the implementation of the CMP and the No Action Alternative. This integrated Environmental Assessment (EA)/CMP evaluates impacts and satisfies requirements established by the National Environmental Policy Act (NEPA) of 1969 and the Corps' NEPA implementation regulations found in the Code of Federal Regulations (CFR), 33 CFR Part 230. Although this programmatic EA evaluates the potential impacts of cottonwood management along the Missouri River, site-specific environmental review, in the form of EAs, would be anticipated in the future and prior to implementation of these strategies. Site specific EAs would be tiered to this Programmatic EA. The site specific EAs would include consultation and environmental review of the specific techniques implemented at selected sites along a priority segment.

1.3 Background

Historically, the Missouri River was a fully functioning, highly dynamic, geofluvial, riverine system. The river consisted of a meandering channel dynamically migrating across a heavily braided floodplain that supported a riparian mosaic characterized by a diverse array of forests, wetlands, backwater channels, oxbow lakes, chutes, and intermittent prairie habitats. Cottonwood was the dominant vegetation in the wide floodplain forests of the pre-regulated river, providing important riparian habitat to a variety of wildlife species, including the bald eagle (Corps 2006).

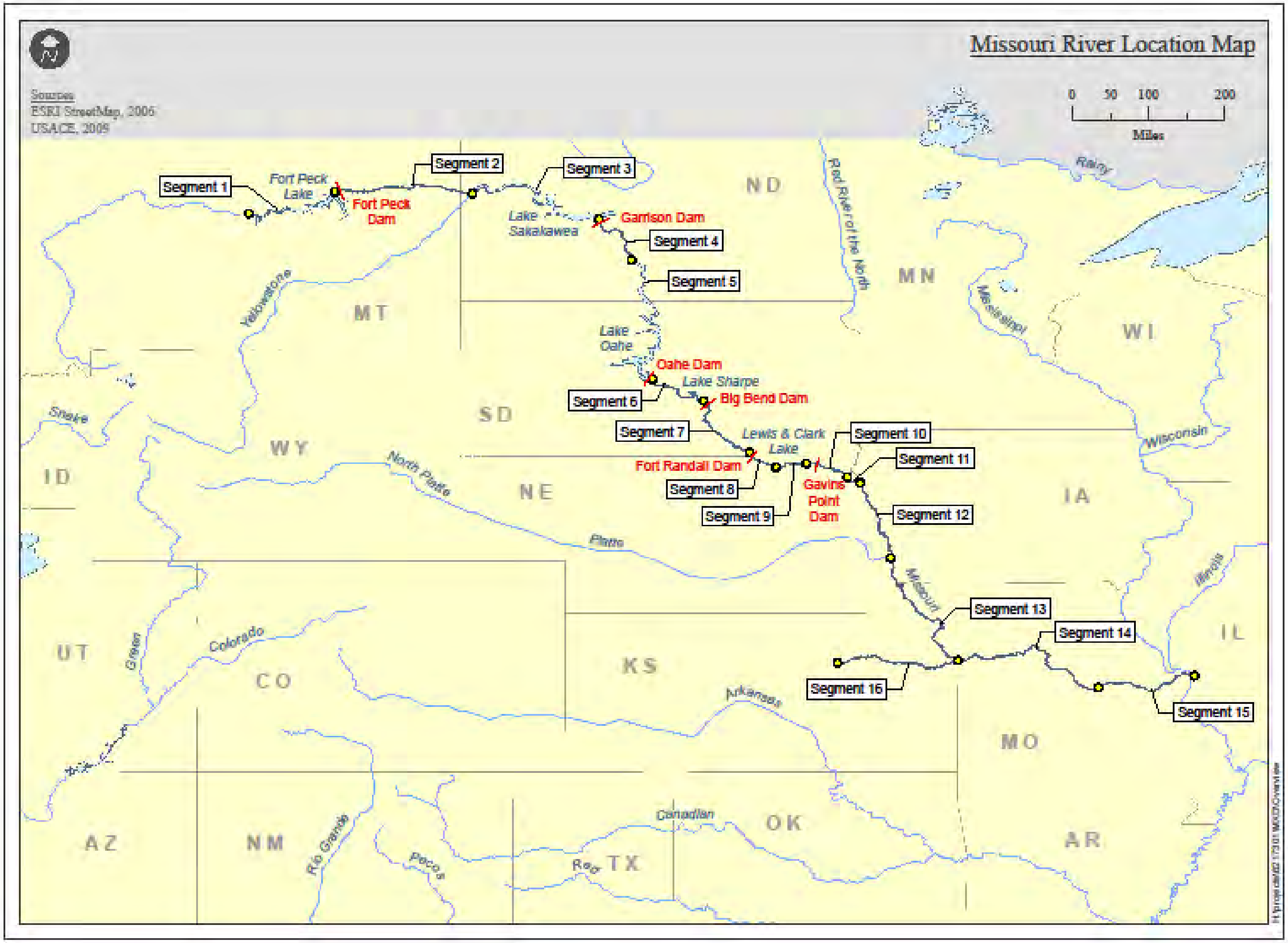
The current system consists of six dam and reservoir projects (Figure 1-1). These projects were constructed and are operated and maintained by the Corps for the Congressionally authorized purposes of flood control, navigation, irrigation, hydropower, water supply, water quality, recreation, and fish and wildlife. The recurrent, devastating flooding of the Missouri River and the 1930 to 1941 drought led to the construction of the dams on the Missouri River, beginning with the construction of Ft. Peck Dam in the 1930's. Construction of Ft. Peck Dam commenced in 1933 by Executive Order (EO) and under authorization by Congress for the relief of unemployment. Construction was completed under authorization by Congress in the Rivers and Harbors Act (RHA) of 1935. Although originally authorized primarily for navigation and flood control, the Fort Peck Power Act of 1938 authorized construction of hydropower facilities.

Following the construction of Ft. Peck Dam additional dams were planned under the Pick-Sloan Plan developed from the combined efforts of the U.S. Bureau of Reclamation (BOR) and the Corps. The Pick-Sloan Plan, authorized by the Flood Control Act of 1944, called for the Corps construction of five more mainstem dams and many tributary dams in the Missouri River basin. Dams were to be constructed by both the Corps and the BOR. The plan also authorized the multipurpose operation of the System. The five additional dams are Garrison, Oahe, Big Bend, Fort Randall, and Gavins Point. The dams form six major reservoirs on the Missouri River: Fort Peck Lake, Lake Sakakawea, Lake Oahe, Lake Sharpe, Lake Francis Case, and Lewis and Clark Lake.

As a technique to improve conditions for river navigation, Congress authorized the Corps to channelize the Missouri River below Sioux City, Iowa in the mid 1950's. Congress also authorized the Corps to construct bank stabilization structures along the riverbanks to protect private property in the upper reach of the river. Much of this diverse and extensive floodplain forest in the lower Missouri River had been cleared before significant regulation of the river occurred. Extensive areas of the woodlands in the floodplain were removed to provide fuel for steamboats during the nineteenth century, and more recently for agriculture (NRC 2002). As a result of the changes to hydrology and subsequently to the floodplain, the lower Missouri River riparian vegetation has declined compared to its historical extent (Bragg and Tatschl 1977). These anthropogenic changes have had a cumulative effect on the natural hydrology of the river, including altering and regulating the flow, narrowing the width of the river, and separating the river from its natural floodplain (NRC 2002). The extent of changes to the Missouri River floodplain vegetation and their cause vary greatly among the reaches of the river. Ecologists have voiced general concerns regarding the loss in wildlife habitat value due to the reduction of riparian forests in the system, and specifically with the loss of plains cottonwood along the banks of the Missouri River (Corps 2006).

The cottonwood provides material, cultural, and spiritual benefits to Native Americans. For the inhabitants of the Missouri River Valley, these sheltering trees emerged from Mni Sose and covered the floodplain and low terraces, providing fuel, and wood, and a lush habitat for plants and animals. The leaves and heartwood form symbols that reach deeply into Lakota spiritual traditions, and the trunk forms the sacred center of the Sundance ceremony.

Figure 1-1. Missouri River Location Map and Mainstem Reservoir System



The Corps strives to balance many, sometimes competing uses of the river system: flood control, navigation, irrigation, hydroelectric power generation, municipal and industrial water supply, water quality, recreation, and fish and wildlife habitat, including endangered species habitat, through its *Master Water Control Manual*, or Master Manual (Corps 2006b). The Corps provides the primary operational management of the Missouri River and is, therefore, responsible under the ESA to take actions to conserve listed species in areas within its authorities. Section 7(a) (2) of the ESA states that each federal agency shall, in consultation with and with the assistance of the Secretary (Interior), insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species.

As a result of the Operations of the System, related Operations of the KR, and the Operations and Maintenance of the Missouri River BSNP, the Corps requested on April 3, 2000 that the USFWS formally consult under the ESA. The Corps prepared two biological assessments (BAs), which ultimately determined that their current river operations may affect listed species, including the endangered pallid sturgeon (*Scaphirhynchus albus*), the endangered least tern (*Sternula antillarum athalassos*), and the threatened piping plover (*Charadrius melodus*) (Corps 2006a).

In response to the BAs, the USFWS reviewed project plans and completed one BiOp in 2000 (USFWS 2000a) and an amendment to the BiOp in 2003 for the three projects combined (USFWS 2003). The 2003 Amended BiOp advised the Corps that the operation of the System, KR and BSNP projects, under past and present operating criteria and annual plans, have severely altered and continue to alter the natural hydrology, the riverine, wetland, terrestrial floodplain habitats, and the fish and wildlife resources of these ecosystems. After reviewing current conditions of each listed species, the environmental baseline for the action area, the effects of the Corps' proposed actions for the projects, and the cumulative effects, the USFWS concluded that the Corps actions, as proposed, would likely jeopardize the continued existence of the least tern, piping plover, and pallid sturgeon, but would not likely jeopardize the continued existence of the bald eagle (USFWS 2000a). When a conclusion of "no jeopardy" is reached, the requirements of the federal action agency are to minimize, to the extent practical, the take of listed species that is anticipated to occur, given that the project has already been determined to not jeopardize the species.

The 2003 Amended BiOp (which incorporates the sections of the USFWS 2000 BiOp applying to the bald eagle by reference) included Reasonable and Prudent Measures (RPMs) to minimize the "take" of bald eagles under Section 7 of the ESA, including the elements of this proposed action. These RPMs include the following:

1. Map and evaluate the current health of the cottonwood forests that provide or may provide wintering, non-breeding, and breeding habitat for bald eagles on the Missouri River. This mapping also shall identify which stands will be experiencing overbank flooding under proposed operations. The baseline level of mortality and tree vigor of

cottonwood forests shall be measured and used for comparison against future levels of mortality. A sub-sampling scheme may be set up for measurement purposes after an initial inventory.

2. For cottonwood and other riverine forest areas that are not experiencing regeneration, a management plan shall be developed that will allow for natural regeneration, periodic seed germination, and seedling establishment at a sufficient rate such that regeneration is maintaining pace with or exceeding mortality. Those areas that lack regeneration are those areas that no longer experience overbank flooding. The majority of these areas would occur in Segments 2-10 (Figure 1-1). The regeneration scheme may require planting of young trees and/or incorporation of measures to protect seedlings from adverse factors for some time after planting. This report may be generalized for the entire river so that it may be stepped down for the Corps project lands and other public and private lands where the Corps may be involved with Section 404/10 activities or other authorizations and funding.

3. Fund and implement actions in accordance with developed management plans on the Corps project lands, and where appropriate, in partnership with adjacent landowners, ensure that no more than 10 percent of the cottonwood forest habitat identified in RPM 1 above, that is suitable for bald eagles, is lost as eagle habitat during the study life.

The 2003 Amended BiOp also emphasized the importance of a more sustainable cottonwood forest along the Missouri River to benefit other native species that rely on the floodplain forest community. Subsequent to the 2003 Amended BiOp, the USFWS removed (de-listed) the bald eagle from the list of threatened and endangered species under the ESA (71 FR 8238, February 16, 2006). The Bald and Golden Eagle Protection Act (BGEPA) now provides the primary protection for the bald eagle. The bald eagle is also protected under the Migratory Bird Treaty Act (MBTA).

The BGEPA (16 U.S.C. 668-668c) was enacted in 1940 and has been amended several times since then. The BGEPA prohibits unregulated take of bald and golden eagles (*Aquila chrysaetos*) and provides a statutory definition of "take" that includes "disturb." The word "disturb" means to agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available: 1) injury to an eagle, 2) a decrease in its productivity by substantially interfering with normal breeding, feeding, or sheltering behavior, or 3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior." In addition, most states have their own regulations and/or guidelines for bald eagle management. Some states may continue to list the bald eagle as endangered, threatened, or of special concern. The bald eagle is listed as a state threatened species in South Dakota and as a species of conservation concern in North Dakota and Missouri.

The MBTA was enacted in 1918. A 1972 agreement supplementing one of the bilateral treaties underlying the MBTA had the effect of expanding the scope of the MBTA to cover bald eagles and other raptors. The MBTA and the BGEPA protect bald eagles from a variety of harmful actions and impacts. In addition to the BGEPA and the MBTA, the USFWS recently developed National Bald Eagle Management Guidelines to advise landowners, land managers, and others who share public and private lands with bald eagles when and under what circumstances the protective provisions of the BGEPA may apply to their activities.

When the bald eagle was listed under the ESA, incidental takes under the BGEPA were typically addressed by BiOps under the ESA. With the delisting, the BGEPA becomes the primary law for incidental takes and new permits from the USFWS may be required. In most instances, the USFWS is continuing the RPMs presented in the BiOps under the ESA to address incidental takes under the BGEPA. However, not all incidental takes under the ESA are considered incidental takes under the BGEPA. For example, unlike the ESA, habitat loss does not constitute a take under the BGEPA. The Corps is reviewing material to determine if their actions constitute a take under the BGEPA. Once that review is complete, the Corps will consult with USFWS to request a permit under the BGEPA or to request a finding. Regardless, the Corps recognizes federal laws protecting the bald eagle, and that restoration of cottonwood forest is an integral component of the current MRRP. Additionally, the Missouri River cottonwood forest community is being studied as a part of the Corps collaborative development of a long-term MRERP.

1.4 Purpose and Need for the Proposed Action

The purpose of the CMP is to guide management actions along the Missouri River to provide a diverse age-class of cottonwood stands, to the extent possible, over the natural range of cottonwood forests. A successful plan is one that would allow the regeneration of cottonwoods in the long-term. The Corps proposes to prevent the loss of this important component of the Missouri River ecosystem by developing and implementing a CMP. This plan suggests ways the Corps and other entities can protect cottonwood stands that are currently valuable to the bald eagle as well as establish new cottonwood stands to keep the riparian habitat along the river a viable forest community and to restore the degraded or inundated riparian habitat that currently exists.

The need is for the establishment and preservation of early successional forest along the Missouri River. The proposed action is needed because bald eagles that use the mainstem of the Missouri River depend on adjacent cottonwood forests both for nesting and wintering habitat. With continued operation of the Missouri River, cottonwood forests will continue to degrade and be lost as bald eagle habitat. Wintering eagles have been documented on the Missouri River for many years. Wintering eagles use cottonwood forests for roosting, foraging, and perching. Bald eagles continue to favor certain cottonwood forests adjacent to tailrace areas below the mainstem dams that also support large numbers of wintering waterfowl and fish resources. Some of those wintering areas such as the Karl Mundt National Wildlife Refuge (NWR) have been designated by the USFWS as essential bald eagle wintering areas. Additionally, although eagle population studies have revealed that both reproduction and survival are important, changes in survival rates seem to have more effect on the population than similar changes in reproduction rates (Grier 1980). Population modeling predicts that eagle populations with lower reproduction but adequate survival might do better than other populations with higher reproduction but poor survival. Adult eagles must prepare themselves for the next breeding season, and subadults and immatures must survive stressful environmental conditions. Therefore, maintaining and/or improving winter survival is crucial to eagle recovery (USFWS 1983).

The Proposed Action would not only provide habitat for the bald eagle, but the creation of riparian floodplain systems as a benefit to other wildlife and aquatic resources that utilize similar habitat along the Missouri River.

1.4.1 Project Area

The Missouri River is the nation's longest river. It runs through seven states, including Montana, North Dakota, South Dakota, Nebraska, Iowa, Kansas, and Missouri. The Missouri River drains one-sixth of the United States and encompasses 529,350 square miles, including 9,700 square miles in Canada (USFWS 2000a).The Missouri River originates from Hell Roaring Creek in the Rocky Mountains of south-central Montana and flows 2,619 miles ending at its confluence with the Mississippi River near St. Louis, Missouri (Figure 1-1). Today, the river is highly regulated and has been modified throughout much of its length. For purposes of describing a river, river miles (RMs) are used. RMs are defined as miles calculated from the mouth of the river or, for upstream tributaries, from the confluence with the main river.

For the purposes of this report, the Missouri River includes RM 2,341 at the confluence of the Madison, Jefferson, and Gallatin Rivers in Montana through RM 0 at the confluence with the Mississippi River.

While the region of concern includes the entire Missouri River, the USFWS identified in the 2003 Amended BiOp several moderate and high priority segments of the Missouri River (Figure 1-2) that will be the principal focus of the CMP, including:

- Segment 4: Garrison Dam to Lake Oahe Headwaters near Bismarck, North Dakota (RM 1389.9 – RM 1304.0)
- Segment 6: Oahe Dam to Big Bend Dam (RM 1072.3 – RM 987.4)
- Segment 8: Fort Randall Dam to Niobrara River (RM 880.0 – RM 845.0)
- Segment 9: Niobrara River to Lewis & Clark Lake, including the Lake (RM845.0 – RM 811.1)
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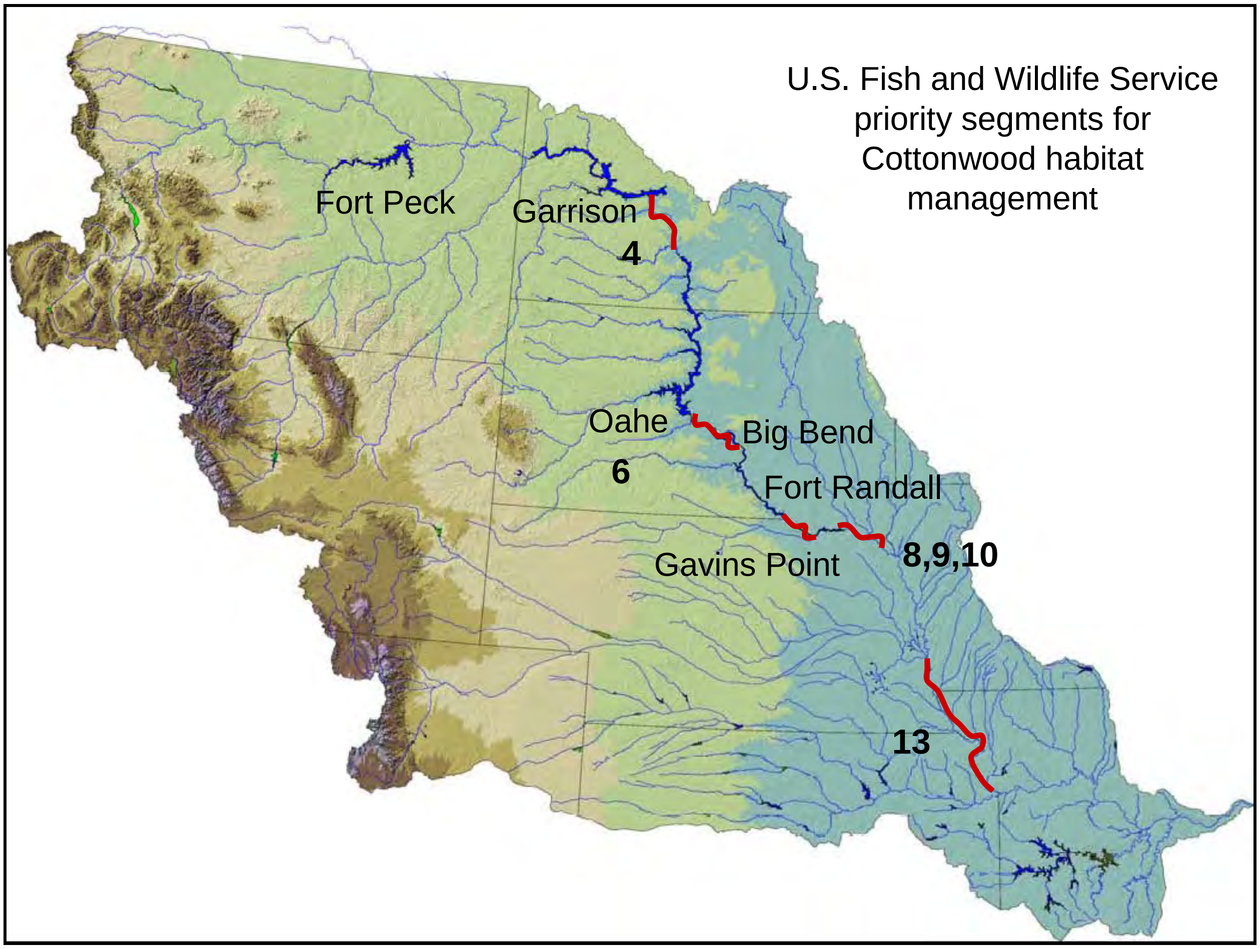
- Segment 13: Platte River mouth to Kansas City, Missouri (RM 595.5 – RM 367.5)

Existing conditions are summarized by the individual segment (when applicable and information is available), as described by the both the Corps (2004) and the USFWS for each resource.

Figure 1-2. USFWS Priority River Segments Identified in the 2003 Amended BiOp



Source: Rabbe 2004

1.4.2 Regulatory Authority

The CMP will meet the requirements of the USFWS 2003 Amended BiOp. Specifically, the USFWS determined that the System, KR, and BSNP projects would result in the incidental "take" of bald eagles in the form of harm, through long-term habitat loss that may impair essential behavior patterns of bald eagles. Although the bald eagle has been delisted by the U.S. Government, it continues to be protected by other federal laws, including the BGEPA, the MBTA, and the Lacey Act (USFWS 2008a). The BGEPA provides for the protection of the bald eagle and the golden eagle by prohibiting the take, possession, sale, purchase, barter, offer to sell, transport, export or import, of any bald or golden eagle, alive or dead, including any part, nest, or egg, unless allowed by permit (16 U.S.C. 668(a); 50 CFR 22). Many actions that would be considered as likely to incidentally "take" bald eagles (from harassment, harm or habitat alterations) under the ESA would fall under the definition of "disturb" in the BGEPA. The USFWS prepared the National Bald Eagle Management Guidelines to help landowners, land managers and others to meet the intent of the BGEPA (USFWS 2008b). In addition to meeting the requirements of the 2003 Amended BiOp, this plan is in compliance with Section 2010 of the WRDA of 2007.

Protection of the bald eagle provided by the Lacey Act will also continue, making it a federal offense to take, possess, transport, sell, import, or export nests, eggs and parts that are taken in violation of any state, tribal or U.S. law (USFWS 2008a). The MBTA is a federal law that protects the bald eagle and carries out the United States' commitment to four international conventions with Canada, Japan, Mexico and Russia. Those conventions protect birds that migrate across international borders and the MBTA prohibits the taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts, and nests except as authorized under a valid permit (50 CFR 21.11).

Although the removal of trees is not a violation of the BGEPA, the impacts resulting from forest removal can be a violation if the loss of the tree(s) kill(s) an eagle, or agitates or bothers an eagle to the degree that it results in injury or interferes with breeding, feeding, or sheltering habits substantially enough to cause a decrease in productivity or nest abandonment, or create the likelihood of such outcomes. Specifically, this would be true if the trees were located within a traditional communal roost site or were the primary perch trees used by eagles in an important foraging area (USFWS 2008a). In this plan, protection and restoration of cottonwood forests for use by the bald eagle will be discussed as individual implementation strategies or measures that can either be applied as stand-alone techniques or that can be applied in conjunction with a variety of other suggested techniques to meet the goals and objectives of the study.

1.4.3 Compliance with NEPA

As a major federal action that may affect the quality of the human environment, it is necessary to evaluate the CMP under the NEPA. This EA evaluates the potential impacts, positive and negative, of the CMP at the programmatic level. If the decision is made to proceed with the CMP, additional review under NEPA is anticipated to further evaluate alternatives and the potential impacts of those alternatives at both the segment and site level. The 2003 Amended BiOp identifies six priority segments within the Missouri River for cottonwood management. It is currently planned that EAs would be prepared for each segment to evaluate and rank potential sites within the segment. These segment level EAs would evaluate alternatives within each segment for achieving the overall goal of the CMP and would be tiered to and linked to this programmatic EA. The goal of the CMP is to provide a single, comprehensive and integrated planning and management strategy to guide the efficient and effective preservation and restoration of critical cottonwood community structure and function in the Missouri River Basin as described in RPM-2 (page 1-5).

Following completion of segment-level EAs, final environmental clearance for specific sites would be required, either as a categorical exclusion to the NEPA or an EA, depending on anticipated impacts for each site. In addition, evaluation of permits under Section 10 of the RHA and Section 404 of the Clean Water Act would be completed during the site specific NEPA process. Those activities that may require appropriate mitigation measures would be determined and analyzed during the NEPA process. Consultation with American Indian Tribes and compliance with Section 106 of the National Historic Preservation Act (NHPA) would also be completed during the site specific NEPA process.

1.5 Objectives of the Proposed Action

A clear statement of goals and objectives is needed to establish measurable targets and to drive development of criteria to assess the success of an activity. For purposes of this effort, a goal is considered a description of generally agreed upon desired outcomes, and is by its very nature generally defined in broad contexts. Goals are clarified by objectives and endpoints. Objectives are the specific, doable tasks needed to achieve the goal. Objectives identify effect, subject, location, timing, and duration. Targets (endpoints or performance criteria) are readily observable, usually quantifiable, events or characteristics that can be aimed for as part of a goal or objective. Targets are a subset of the broad set of indicators, which are prior identified system characteristics that can provide feedback on progress toward goals and objectives. Criteria are specific targets (often thresholds) that indicate when explicit, goals and objectives have been met. Here, criteria are also discussed in terms of ways to assess or think about goals and objectives. Goals, objectives, targets, and criteria were developed for the CMP with legal and regulatory mandates in mind and with an awareness of the complexity of relationships amongst the species, ecosystems, and ecological processes that future management actions would affect.

Regeneration of cottonwoods, historically the most abundant and ecologically important species on the river's extensive floodplain, has largely ceased along the Missouri River. Extensive recruitment currently occurs only in downstream reaches that were flooded in the 1990s and in upstream reaches above the large dams (NRC 2002). In 1992, W.C. Johnson stated that model calculations predict that without changes to the current management regime, cottonwood forests in segment 4 will essentially be lost as a significant community on remnant floodplains in less than a century (Johnson 1992). The cottonwood forests that remain on the floodplain between and immediately below dams are unlikely to be sustained by the current low river meandering rates. This is likely the same for cottonwoods along other segments of the river since cottonwood regeneration is limited similarly by flow regulation.

1.5.1 Program Level

A hierarchy of planning activities for this effort mandates a series of ever-increasing complexity and detail when considering the goals and objectives of these actions. In other words, there are very general goals and objectives that have been developed at the programmatic level. These were further refined for the CMP. As the study progresses and particular segments and sites are mapped, evaluated, and restored/preserved, the goals and objectives become increasingly more detailed. Below, the Program, Priority Segments and CMP goals and objectives are detailed.

Goal

The goal of the Cottonwood Management Program is to develop a management plan that will allow for natural regeneration, periodic seed germination, and seedling establishment at a sufficient rate such that regeneration is maintaining pace with or exceeding mortality.

Objectives
The objectives of the Cottonwood Management Program include:

1) Characterize the current state of the cottonwood community in the priority segments (4, 6, 8, 9, 10, and 13) by mapping the existing stands and determining their age class in compliance with RPM-1.
2) Assess the ecosystem health of these communities through the application of readily available tools and technology in compliance with RPM-1.
3) Develop a cottonwood management plan for the priority segments to inform planning and decision-making for the priority segments in compliance with RPM-2.
4) Fund and implement actions in accordance with developed management plans on Corps project lands, and where appropriate, in partnership with adjacent landowners in the priority segments in compliance with RPM-3.

1.5.2 Segment Level

The evaluation of baseline and future conditions of priority segments (4, 6, 8, 9, 10, and 13) will be assessed for each segment as the team inventories and evaluates the unique conditions within each segment. Although goals and objectives will vary slightly among these segments, broad goals and objectives can be identified here. Quantifiable performance measures or success criteria will be established early on as each segment is assessed.

Goal
The goal is to evaluate the condition of existing cottonwood communities within each segment and develop a suite of ecological strategies for conserving them through preservation, compensatory mitigation, recovery, and restoration activities that will maintain pace or exceed mortality.

Objectives
The objectives at the segment level include:

1) Quantify the baseline and No Action conditions of the cottonwood communities in the segment.
2) Develop, compare and select designs to extend and enhance the segment's native cottonwood communities and restore destroyed native cottonwood communities while creating greater stand diversity in terms of stand age, size and composition along the Missouri river (and its tributaries).
3) Prioritize areas, programs and projects for implementation to achieve stated mitigation, recovery, and restoration goals and objectives.
4) Promote ecosystem heterogeneity by creating, restoring, or preserving backwater habitats throughout the project area.
5) Implement measures to reestablish fluvial processes in the segment, including high flow/ side channel creation, transport of sediment, and bank improvements in an effort to recreate hydraulic connections between the historical floodplain and the river consistent with operational constraints.

6) Protect, extend and enhance areas of potential habitat for rare or imperiled species identified by federal, state ,or tribal governments within the segment.
7) Develop and implement a long-term operations and maintenance strategy (including adaptive management), which incorporates long-term monitoring and ecological response thresholds for proposed restoration/preservation features.
8) Coordinate and integrate project implementation and monitoring with other, ongoing restoration and research efforts in the segment before, during and after implementation;
9) Create opportunities for educational or interpretive features, while integrating recreational features that are compatible with ecosystem integrity.
10) Continue to engage the public in the restoration of the ecosystem by garnering input and involvement throughout planning and implementation.
11) Avoid and/or minimize conflicts with other recovery efforts in the Missouri River Basin by coordinating efforts with those study teams and establishing heuristics (rules-of-thumb) to mediate conflicts if they do arise.
12) Implement measures to reestablish riparian communities in the segment, including river bank stabilization and modifications to enable natural regeneration as well as planting of cottonwoods.

The performance measures (number of acres to restore, to what condition, and in what time frame) and adaptive management thresholds (indications of failure and response times) of the individual segment restoration and preservation studies will be defined for each segment dictated by the baseline conditions of the segment and the estimated mortality and localized stressors (urban sprawl, agricultural conversion, invasives, water supply, etc.) that are likely to jeopardize the extant cottonwood communities over the life of the project (100 years).

1.5.3 Cottonwood Management Plan

The goals and objectives of the CMP were developed to specifically address the RPM-2:

> For cottonwood and other riverine forest areas that are not experiencing regeneration, a management plan shall be developed that will allow for natural regeneration, periodic seed germination, and seedling establishment at a sufficient rate such that regeneration is maintaining pace with or exceeding mortality. Those areas that lack regeneration are those areas that no longer experience overbank flooding. The majority of these areas would occur in Segments 2-10 (Figure 1-1). The regeneration scheme may require planting of young trees and/or incorporation of measures to protect seedlings from adverse factors for some time after planting. This report may be generalized for the entire river so that it may be stepped down for the Corps project lands and other public and private lands where the Corps may be involved with Section 404/10 activities or other authorizations and funding.

Goal

The goal of the CMP is to provide a single, comprehensive and integrated planning and management strategy to guide the efficient and effective preservation and restoration of critical cottonwood community structure and function in the Missouri River Basin in compliance with RPM-2.

Objectives
The objectives of the CMP are as follows:

1) Characterize the overall system (including the key drivers and stressors).
2) Describe the plan's development process and identify critical stakeholders and decision makers involved in the plan's development.
3) Characterize the existing cottonwood community in the Missouri River basin.
4) Describe the mapping and evaluation of the ecosystem (focused primarily on the critical segments).
5) Describe an approach to identifying, prioritizing, and selecting potential preservation/restoration sites.
6) Present potential preservation and restoration strategies to redress the declining conditions of the ecosystem across the system.
7) Provide details regarding the study's adaptive management strategy.

To estimate the pace of cottonwood regeneration and mortality and determine suitable bald eagle habitat, extensive field studies are currently being or have been conducted within the priority segments. The data from these studies will be documented and assessed using a newly developed cottonwood community index-based model that was created based under the USFWS Habitat Evaluation Procedures (HEP) (USFWS 1980a-c) to generate estimates of potential ecosystem response quantitatively. Potential restoration strategies are described in this report and organized by a larger activity, goal, and technique. These strategies (or measures) are described in Chapter 2. The cottonwood community HEP model will evaluate the anticipated effectiveness of various restoration strategies for creating new cottonwood habitat, with a goal of maintaining and increasing cottonwood habitat within the Missouri River basin.

Following the implementation of these measures, a monitoring program will be implemented to determine if the goals and objectives are being met, specifically if cottonwood habitat is being maintained and restored as a result of this program. Adaptive management has been incorporated into this program. If monitoring data indicate initial efforts are unsuccessful, or inadequate, adaptive management provides the flexibility to incorporate new data and information and adjust the program accordingly. Adaptive management will be used during the life of the project (100 years) and ensure that the goals and objectives are met.

1.6 Related and Influential Corps NEPA Documents

1.6.1 Programs

In creating this management plan, the project team looked at other projects that are ongoing on the Missouri River and took them into account. Other programs under the MRRP include the Emergent Sandbar Habitat (ESH) program, Shallow Water Habitat (SWH) program, water quality monitoring, least tern and piping plover population monitoring, and Missouri River flow modifications.

The ESH program builds and manages sandbars for the protected interior least tern and piping plover. Sandbars can be created and maintained by mechanically building new areas, clearing existing vegetation, or modifying river flows during the year. The Corps has been managing System releases for years during the tern and plover nesting season to minimize the take of nests, eggs, and chicks. The SWH program is involved in restoring approximately 20 percent of the shallow water habitat along the Missouri River below Gavins Point (Corps 2008). The SWH may be restored through channel widening, side channel chutes, or manipulation of existing aquatic habitat. Water quality monitoring was developed to monitor the status and trends of ambient water quality parameters throughout the river basin. The data will be used to assess pallid sturgeon recovery, shallow water habitat development, and ecosystem recovery. The least tern and piping plover population monitoring includes monitoring the production of young birds and an annual adult census of the birds on the Missouri River. Technical criteria for a bimodal spring pulse release from Gavins Point Dam, required by the 2003 Amended BiOp were included in the Missouri River Mainstem Reservoir System Master Water Control Manual (Master Manual) in 2006. The bimodal pulse is intended to provide a spawning cue for the endangered pallid sturgeon.

Projects that may influence the CMP and are considered in the analysis of cumulative effects are described below. The purpose of describing these projects is to ensure that: project scopes and objectives are not duplicated, proposed projects do not offset or compete with each other, and that appropriate agencies are aware of any future large scale projects for the Missouri River.

1.6.1.1 *Missouri River Fish and Wildlife Mitigation Project (Mitigation Project) / Supplemental Environmental Impact Statement* (The Kansas City and Omaha Districts of the Corps, March 2003).

The primary purpose of the Mitigation Project is to mitigate the habitat lost as a result of the Missouri River BSNP. The previous BSNP Fish and Wildlife Mitigation Project, authorized by the WRDA of 1986 was modified by the WRDA 1999 to include the acquisition and development of 118,650 acres in the Missouri River floodplain and tributaries to restore or preserve fish and wildlife habitat of the Lower Missouri River floodplain ecosystem. The Supplemental EIS analyzed three alternatives including a Preferred Action, No Development alternative, and the No Action alternative. The preferred action included the acquisition and development of an additional 118,650 acres to restore or enhance aquatic and terrestrial habitat on individual sites purchased from willing sellers. The project study area is located along 734 miles of the Missouri River from Sioux City, Iowa to the mouth of the river near St. Louis, Missouri. This 734-mile corridor encompasses an area of more than 2,180,000 acres. Project activities could also occur on tributary floodplains. Specific analyses considered a defined Region of Influence (ROI) as the floodplain of the Lower Missouri River, or for some resources (e.g., socioeconomics) the 46 counties contiguous to the Lower Missouri River in Nebraska, Iowa, Kansas, and Missouri. It would be envisioned that the CMP would be utilized in this program to the fullest extent possible.

1.6.1.2 *Draft Programmatic Environmental Impact Statement for the Maintenance and Creation of Emergent Sandbar Habitat on the Upper Missouri River* (Omaha District of the Corps, proposed draft July-Aug 2007)

The Corps District has prepared a Draft Programmatic EIS that evaluates potential effects to the natural, physical, and human environment that may result from implementation of a program for the mechanical maintenance and creation of ESH within the free-flowing reaches of the Upper Missouri River from Ft. Peck, MT downstream to near Sioux City, IA. The ESH maintenance and creation program is necessary for the Corps to meet fledge ratio and adult population goals established in the 2003 Amended BiOp for two federally protected bird species, the endangered interior least tern and threatened piping plover.

1.6.1.3 *Missouri River Final Environmental Impact Statement, Master Water Control Manual Review and Update* (Northwestern Division of the Corps, March 2004)

The Missouri River Mainstem Reservoir System Master Water Control Manual establishes the technical criteria for the Corps operation of the System. In response to concerns regarding the operation of the System during the first prolonged drought experienced by the Basin since the filling of the System in 1967, the Corps initiated a review of the Master Manual in 1989. This review was conducted under the authority of Corps regulation ER11-2-240a with consideration of other applicable laws, including the Flood Control Act of 1944, ESA, and the Corps trust and treaty responsibilities to American Indian Tribes. Following publication of the Final EIS the Master Manual was revised in 2004 to include more stringent criteria to conserve more water in the upstream reservoirs during prolonged droughts. Following a public process convened by the U.S. Institute for Environmental Conflict Resolution, the Master Manual was again revised in 2006 to included technical criteria for bimodal spring pulse System releases from Gavins Point Dam as required to fulfill the 2003 Amended BiOp. An EA which was tiered to and linked to the Final EIS was prepared to address specific criteria of the bimodal spring pulse operation. Bimodal spring pulse System releases are intended to benefit the endangered pallid sturgeon.

In its Record of Decision (ROD) for the Master Manual Review and Update, the Corps embraced an overall adaptive management strategy for implementation of the 2003 Amended BiOp.

1.6.1.4 *Final Environmental Assessment and Finding of No Significant Impact for Intermediate Endangered Species Habitat Improvement by Vegetation Removal in North Dakota, South Dakota, and Nebraska Segments of the Missouri River* (Omaha District of the Corps, July 2005)

The project proposed to remove vegetation on 76 sandbars located within three stretches of the Missouri River in order to increase habitat for federally-listed avian species. The federally-endangered interior least tern and the federally-threatened piping plover were specifically targeted for habitat restoration in this project. These avian species nest on bare sandbars in the Missouri River and along reservoir shorelines. Their nesting habitat has been reduced due to the loss of sandbar scouring by heavy spring flows and/or ice, which has allowed vegetative encroachment on the sandbars. This project involved clearing vegetation using herbicides approved for aquatic application by the U.S. Environmental Protection Agency (USEPA), using either an imazapyr-based or a glyphosphate-based product, followed by monitoring and evaluation of the usefulness of this clearing method of habitat creation for terns and plovers. The sandbars targeted for avian habitat improvement are located between RMs 756 and 805 in the 59-mile stretch of the Missouri National Recreational River (MNRR) between South Dakota and Nebraska, RMs 832 and 870 in the Lewis and Clark Lake and the 39-mile area of the MNRR between South Dakota and Nebraska; and RMs 1284 and 1380 in North Dakota downstream from Garrison Dam. A total of approximately 1,248 acres of land would be treated on these sandbars.

1.6.1.5 *Final Environmental Assessment for the Restoration of Emergent Sandbar Habitat in the Lewis and Clark Lake Delta, Missouri River, South Dakota and Nebraska* (Omaha District of the Corps, October 2005)

These NEPA documents evaluated ESH restoration downstream from the sedimentation delta at Lewis and Clark Lake in Nebraska and South Dakota. The Corps proposed to restore approximately 225 acres of ESH in two separate complexes, pursuant to implementation of the 2003 BiOp Amendment. This project included the excavation of material from the lakebed. This material was placed atop submerged sandbars to elevate them and make available nesting and foraging habitat for interior least terns and piping plovers, two federally listed species. In addition, construction equipment was used to shape created sandbars, making them more attractive to the birds.

1.6.2 Other Programs Related to the Missouri River

Numerous other related actions will be considered in this CMP/EA to evaluate the cumulative effects of these and the proposed action on affected resources (see Cumulative Impacts Section, Chapter 4). Other related actions include:

South Dakota Bald Eagle (Haliaeetus leucocephalus) Management Plan

As a result of bald eagle increases in the state, the South Dakota Game, Fish and Parks (SDGFP) is taking a proactive position regarding eagle management to ensure that the species continues to thrive in South Dakota (Aron 2005). A bald eagle management plan has been drafted that identifies long-term goals for bald eagles in South Dakota and management actions designed to achieve those goals. As examples, two of the goals include maintaining known bald eagle winter roost sites with no-net-loss in acreage of cottonwood forest cover and cottonwood regeneration. Cottonwood regeneration includes planting a 4:1 replacement ratio of four cottonwood seedlings for any mature tree removed along the Missouri River in SDGFP-owned areas, developing a planting schedule to retain the currently existing cottonwood acreage at winter roost sites; downstream of Oahe, Fort Randall, and Gavins Point dams and identifying and initiating planting at potential sites where cottonwoods can be regenerated on the transferred lands at reasonable expense. The SDGFP proposes regeneration of cottonwood through altering river flows and planting efforts.

Land Acquisition at the Big Muddy National Fish and Wildlife Refuge (NFWR)
The Big Muddy National Fish and Wildlife Refuge (NFWR) established in 1994, currently has eight approved units totaling 10,400 acres located in eight counties of Missouri along the Missouri River that have been purchased and committed to conservation land. The USFWS has approval through Congress to allow the refuge to acquire up to 60,000 acres of floodplains and adjacent lands on the lower Missouri River between Kansas City and St. Louis, Missouri. Many landowners were interested in selling their Missouri River bottomland following the floods of 1993. The USFWS was originally authorized to acquire these lands from willing sellers with funding from Emergency Supplemental Appropriations, but continues to acquire land from willing sellers with Land and Water Conservation Funds.

Emergency Wetland Reserve Program (EWRP) and Wetland Reserve Program (WRP)
The Natural Resources Conservation Service (NRCS) in consultation with the Farm Service Agency (FSA) and other federal agencies has been working with the states of Missouri, Kansas, Nebraska, and Iowa to protect flood-created habitats and floodplain wetlands through the EWRP and the WRP, which provide a payment to landowners for easements on these areas. States were authorized to begin a continuous sign-up as of October 1, 1996 for the WRP. As of 1994, about 13,503 acres of floodplain lands in Missouri, Kansas, Iowa, and Nebraska have been determined eligible for the EWRP and WRP programs. Roughly 83 percent of these lands are in the State of Missouri and 15 percent in Iowa (USFWS 2000a). The most recent Farm Bill significantly increased funding for the Conservation Reserve Program (CRP) and WRP programs.

1.7 Relevant Government and Public Involvement

Because of the expanse of this project and the Missouri River, a regional approach is essential to develop a meaningful, long-term CMP. Therefore, the Corps is committed to working in partnership with Basin Tribes, federal, state, and local agencies, academia, and the MRRIC to effectively manage cottonwoods along the Missouri River. Development of this plan involved the cooperation of multiple agencies and individuals at various levels of participation, henceforth referred to as the Cottonwood Management Team. The Corps is the lead agency and is responsible for all aspects of developing the CMP/EA, including selecting a preferred alternative and preparing a Finding of No Significant Impacts (FONSI) if no major environmental concerns are determined.

The Cottonwood Management Team for this study included cooperating agencies, tribes, and institutions that have agreed to provide expertise and data on pertinent topics of the plan throughout the planning process. Since 2002, agency workshops and meetings have been conducted to gather information and request input from Cottonwood Management Team members, as well as other experts. Organizations represented on the Cottonwood Management Team are listed on Table 1-1.

Table 1-1. Cottonwood Management Team

Type of Agency	Agency Name	Division/Program (if applicable)
Federal Agencies	National Park Service	Research/Great Plains Cooperative Ecosystem Studies Unit, Missouri National Recreation River (MNRR)
		Missouri National Recreational River
	U.S Army Corps of Engineers	Engineer and Research Development Center (ERDC)
	Natural Resources Conservation Service	
	Missouri River Futures	
	U.S. Fish and Wildlife Service	Boyer Chute National Wildlife Refuge (NWR)
		DeSoto NWR
		Karl Mundt NWR
	U.S. Geological Survey (USGS)	
Native Tribal Governments	Lower Brule Sioux Tribe	Wildlife Department
State Agencies	Lewis & Clark Natural Resources District	
	Nebraska Forest Service	
	North Dakota Forest Service	
	South Dakota Division of Resource Conservation	
Universities and Academic Institutions	Benedictine College	
	South Dakota State University	
	University of South Dakota	Missouri River Institute
Nonprofit Agencies	The Nature Conservancy	
	Izaak Walton League	

Since 2002, the Cottonwood Management Team has organized many meetings and workshops to discuss different elements of the project. Descriptions of the Cottonwood Management Team meetings and workshops completed or planned to date are described below. Appendix B includes the Cottonwood Management Team workshop documentation.

June 2002 Cottonwood Model Workshop – A project kickoff meeting and scoping workshop were held in 2002. The entire Cottonwood Management Team was invited. The majority of the participants at the 2002 meeting were from Nebraska and South Dakota.

April 2005 Cottonwood Restoration Meeting – The Corps wrote *Draft Criteria for Regenerating Plains Cottonwood (Populus deltoides) along the Missouri National Recreational River* (Corps 2004b) and solicited input on the report from the Cottonwood Management Team. A subset of the 2002 team was invited to the April 2005 workshop, which was geared towards discussing cottonwood regeneration methods. The type of sites considered ideal for cottonwood regeneration methods of planting and protecting installed cottonwoods to ensure their success, and costs associated with regenerating cottonwoods were identified along the 59-mile wild and scenic stretch of the MNRR between RMs 753 and 811 (between Ponca State Park, Nebraska and Yankton, South Dakota).

May 2006 Model Development Workshop for Cottonwood Riparian Community – The 2006 model development workshop was highly technical in content and, therefore, a group of technical experts from the Cottonwood Management Team were invited to participate. The workshop was held from May 2-4, 2006 in Yankton, South Dakota.

August 2007 Missouri River Cottonwood Management Plan Programmatic Environmental Assessment Scoping Workshop & Habitat Modeling Workshop – A three-day workshop was held in Yankton, South Dakota from August 21 – 23, 2007. The entire Cottonwood Management Team was invited and representatives from Nebraska, South Dakota, Missouri, Iowa, Kansas, and North Dakota participated, reflecting the larger scope of the CMP/EA which covers all prioritized reaches of the Missouri River. The purpose of this workshop was to discuss the status of the ongoing vegetation studies and the development of the CMP/EA, as well as to describe the habitat model and how it would be used to support the CMP and decision-making process for implementation strategies. At this meeting, Team members had an opportunity to contribute their specialized knowledge about cottonwood restoration and riparian studies for consideration in the CMP and habitat model.

February 2008 Habitat Evaluation Procedures Analysis for Cottonwood Riparian Community Workshop – A three-day workshop was held with the Cottonwood Management Team in Vermillion, South Dakota from February 20 – 22, 2008 that included: a detailed discussion of the USFWS's HEP (including defining the model input variables); a review of the basic rationale that was developed by the Corps Engineering Research Development Center (ERDC) based on the results from the August 2007 meeting, and a discussion of the criteria that were used to assess priority cottonwood study sites. The team was updated on the vegetation sampling process that is being conducted to quantify the vegetation characteristics by stand age class.

October 2008 Site Visits to Segment 10 Priority Areas – A three-day site visit along Segment 10 was conducted by several members of the Cottonwood Management Team, including preparers of the CMP/EA. The purpose was to evaluate and refine draft restoration measures and other implementation strategies described in Chapter 2 of this CMP/EA that might be applicable to this segment.

November 2008 HEP Analysis for Baseline Results and Without-Project Trends Workshop – A four-day workshop was held in Vermillion, South Dakota from November 18 to 21, 2008 for the Cottonwood Management Team to discuss the HEP Analysis for the cottonwood riparian community, specifically the baseline results and without-project trends. Refinements to the model were recommended and a status update on the CMP and field data evaluation was provided at this meeting. Findings of the field studies which included the historic change in understory species, historic land use changes, and declines in cottonwood recruitment were presented. The Land Capability Potential Index (LCPI), a tool used to understand the potential "wetness" of an area, to better estimate the potential for cottonwood regeneration was also presented.

March 2009 Cottonwood Community Habitat Model Workshop **–** A five-day workshop was held in Vermillion, South Dakota from March 30 through April 3, 2009. This workshop focused on reviewing Segment 10 with-project design alternatives.

Future Scheduled Workshops **–**Future workshops will be held to finalize the modeling effort for Segment 10. After the modeling effort for Segment 10 is complete, similar workshops will be conducted for the other priority reaches.

American Indian Tribal Coordination

The Corps is very aware of its responsibilities to American Indian tribes and their unique status as dependent sovereign nations. There are 28 American Indian tribal reservations located within the Missouri River basin. Thirteen of the 28 tribal reservations are located directly on the Mainstem Reservoir System and lower 811 miles of the Missouri River, while others are dispersed within tributary stream basins. The U.S. Government's relationship with federally recognized tribes is not only defined by law and regulation but also is deeply rooted in the Nation's history. Federally recognized tribes are dependent sovereign nations, and tribal governments are sovereign entities with rights to set their own laws and priorities, to develop and manage tribal and trust resources, and to be involved in federal decisions or activities that have the potential to affect these rights. Federally recognized tribes have a legal relationship to the United States through treaties, Acts of Congress, executive orders, or other administrative actions that are independent of States. The tribes, as sovereign nations, retain inherent powers of self-government. Accordingly, the Corps has previously acknowledged in the *Missouri River Master Manual* (Corps 2004a) that the operation and maintenance of the Missouri River can and does significantly affect tribal trust assets and, therefore, the Corps has a legal and trust responsibility to the tribes affected. These responsibilities are described in the President's Memorandum on Government-to-Government Relations with American Indian tribal governments signed on April 29, 1994, and the Department of Defense's American Indian and Alaska Native Policy signed by the Secretary of Defense on October 20, 1998. In the course of developing the CMP/EA, the Corps has attempted to ensure that it has met its legal and trust responsibilities, both procedurally and substantively, with American Indian tribal governments. The following tribes were invited to participate during the Cottonwood Management Team Meetings:

- Rosebud Sioux Tribe/Sinte Gleska University
- Winnebago Tribe of Nebraska
- Lower Brule Sioux Tribe
- Cheyenne River Sioux Tribe
- Oglala Sioux Tribe

The tribes and agencies listed within the Programmatic Agreement with the Corps Omaha District were sent letters on November 12, 2010 offering the opportunity to comment on the CMP/EA for 30 days (Appendix C). In addition to the tribes and agencies listed within the Programmatic Agreement, five tribes within the Kansas City district were also given this opportunity. No comments were received.

Public Involvement

The Draft CMP/EA was made available to the public on February 12, 2010 for a 30-day review period ending on March 12, 2010. An electronic copy of the document was available on the Missouri River Recovery Program (MRRP) website. Letters announcing the availability of the document for public review were sent to the Cottonwood Management distribution list and an email was sent to members of the MRRP website emailing list. A copy of the notice of availability and distribution list can be found in Appendix C. Several requests were received for an extension to the comment period. The comment period was then extended until April 15th. Additional requests were received for a second extension; therefore, the comment period continued until May 23, 2010. Comments were received from eleven individuals. Copies of the letters and emails are located in Appendix C along with a table that presents the Corps responses to the comments.

1.8 Decision That Must be Made

This EA discusses alternatives for implementing the CMP along the Missouri River, specifically at river segments prioritized by the USFWS in the BiOp. The EA documents a general environmental analysis conducted by the Corps for cottonwood protection and reestablishment and includes a discussion of:

1. Purpose and need for action
2. Alternatives, including the Proposed Action
3. Affected environment
4. Environmental consequences

The three alternatives that were considered in this analysis are:

- Alternative 1 No Action Alternative
- Alternative 2 Implementation of the CMP with Limited Strategies
- Alternative 3 Implementation of the CMP (Proposed Action)

Based upon the analysis documented in this EA, a decision concerning the objectives of the proposed action and the requirements of the USFWS BiOp would be made and an Alternative would be selected which best meets the objectives. The chosen alternative would be compatible with past restoration efforts along the Missouri River. The decision to choose an alternative as the preferred alternative would be based upon compliance with and the authority granted by the federal laws and regulations previously described and with Corps policy. The federal, state, local, and tribal regulations that this project complies with are discussed in more detail in Section 1.10.

1.9 Scope of the Environmental Assessment/CMP

NEPA requires that a federal agency prepare an EA whenever it proposes a federal action that may affect the quality of the human environment. To ensure an awareness of environmental effects that may be caused by the implementation of the CMP, NEPA requires that the EA include a brief discussion of the need for the action, or appropriate alternatives if there are unresolved conflicts concerning alternative uses of available resources, of the environmental impacts of the alternatives, and a list of the agencies, interested groups and the public consulted.

This CMP/EA has been prepared to define the Action Alternatives, to identify the environmental consequences of the Action Alternatives, and to determine if a FONSI is appropriate. This determination will be based on the impact analysis of Proposed Action and alternatives to the Proposed Action.

The impact analysis in this CMP/EA will examine the environmental consequences associated with the Proposed Action, Alternatives, and the No Action alternative. The following issues are addressed in this document:

- Physical Resources
- Sediment and Erosion
- Water Resources
- Biological Resources
- Socioeconomic Resources
- Cultural Resources

For the purposes of this report, the study area includes the mainstem of the Missouri River and the associated floodplains. While elements of the Proposed Action are located throughout the entire Missouri River Basin and the mainstem, the intent of the Proposed Action is to concentrate on improving habitat conditions in the six priority stream reaches of the Missouri River, as identified by the USFWS in the 2003 Amended BiOp (Figure 1-2).

Existing conditions are discussed by individual river segment (when applicable and information is available) for each resource. The description of existing environmental conditions provides a general understanding of potential planning issues and establishes a broad benchmark by which the magnitude of potential environmental impacts of the alternatives can be compared. Although this CMP/EA evaluates the potential impacts of cottonwood management along the Missouri River, site-specific environmental review, in the form of supplemental EAs, would most likely be required to implement these strategies.

This EA has been prepared to ensure compliance with NEPA of 1969, as amended, the regulations of the President's Council on Environmental Quality (CEQ) for NEPA compliance, and the Corps' NEPA Regulations (33 CFR 240) and provide adequate baseline or "affected environment" chapters for segment specific EA's.

1.10 Applicable Regulatory Requirements and Required Coordination

The following are a list of applicable regulatory requirements and required coordination for this project.

The National Environmental Policy Act of 1969

Public Law 91-190 establishes a broad national policy to improve the relationship between humans and their environment, and sets out policies and goals to ensure that environmental considerations are given careful attention and appropriate weight in all decisions of the federal government.

Federal Statutes

- The American Indian Religious Freedom Act
- Antiquities Act of 1906, as amended
- Archaeological and Historic Preservation Act of 1974, as amended
- Archaeological Resource Protection Act of 1979, as amended
- Bald and Golden Eagle Protection Act of 1940, as amended
- Clean Air Act of 1972, as amended
- Clean Water Act of 1972, as amended
- Endangered Species Act of 1973
- Farmland Protection Policy Act
- Federal Water Project Recreation Act of 1965, as amended
- Fish and Wildlife Coordination Act of 1958, as amended
- Fishery Conservation and Management Act
- Flood Control Act of 1944
- Historic Sites Act of 1935
- Land and Water Conservation Fund Act of 1965
- Migratory Bird Conservation Act of 1928, as amended
- Migratory Bird Treaty Act of 1918, as amended
- National Historic Preservation Act of 1966, as amended
- National Historic Preservation Act Amendments of 1980
- Native American Graves Protection and Repatriation Act
- Noise Control Act of 1972, as amended
- North American Wetlands Conservation Act
- River and Harbor Act of 1899
- River and Harbor and Flood Control Act of 1962, Section 207
- Water Resources Development Acts of 1986, 1988, 1990, 1992, and 1996
- Water Resources Planning Act
- Watershed Protection and Flood Prevention Act of 1954, as amended
- Wild and Scenic Rivers Act of 1968, as amended
- Wilderness Act

Executive Orders

- Protection and Enhancement of Environmental Quality (EO 11514)
- Protection and Enhancement of Cultural Environment (EO 11593)

- Floodplain Management (EO 11988)
- Protection of Wetlands (EO 11990)
- Compliance with Pollution Control Standards (EO 12088)
- Prime and Unique Farmlands (Memorandum, CEQ, 11 August 1980)
- Environmental Justice (EO 12898)
- Protection of Children from Health and Safety Risks (EO 13045)
- Recreational Fisheries (EO 12962)
- Environmental Effects of Major Federal Actions (EO 12114)
- Indian Sacred Sites (EO 13007)
- Consultation and Coordination with Indian Tribal Governments (EO 13175)
- Responsibilities of Federal Agencies to Protect Migratory Birds (EO 13186)
- Facilitation of Cooperative Conservation (EO 13352)

Other Federal Policies

- Council on Environmental Quality Memorandum of August 11, 1980: Analysis of Impacts on Prime and Unique Agricultural Lands in Implementing the National Environmental Policy Act
- Council on Environmental Quality Memorandum of August 10, 1980: Interagency Consultation to Avoid or Mitigate Adverse Effects on Rivers in the Nationwide Inventory
- Migratory Bird Act Treaties and other international agreements listed in the Endangered Species Act of 1973, as amended, Section 2 (a)(4)

Cooperative Agreements

- Programmatic Agreement for the Operation and Management of the Missouri River Main Stem System for Compliance with the National Historic Preservation Act, as amended, 2004

CHAPTER 2. ALTERNATIVES

This chapter describes the alternatives considered for evaluation in this EA. The development of the CMP and Habitat Model are also described in this chapter.

2.1 Introduction and Incorporation of Data Collection

To ensure compliance with the recommendations from the 2003 Amended BiOp prepared by the USFWS as per RPM 1, the Corps is currently evaluating and mapping the ecosystem integrity of existing cottonwood forests that may provide wintering, non-breeding, and breeding habitat for bald eagles along six priority segments (4, 6, 8, 9, 10, and 13) of the Missouri River (Corps 2006a). The data will be used to establish the existing (baseline) conditions, to identify sites for potential cottonwood restoration and/or preservation, and to allow for the comparison of present-day conditions to forecasted future conditions following implementation of measures.

The baseline data are being used to assess the current status of cottonwood forests along the Missouri River, including their composition, structure, biotic integrity, areal extent, and age distribution. This includes field vegetation sampling data and information derived from geographic information system (GIS)-based mapping of the extent and age of cottonwood and riparian forests along all six priority reaches (4, 6, 8, 9, 10, and 13). Analysis is also being completed on two additional reference segments of the river in Montana: Segment 2, Fort Peck Dam to Lake Sakakawea headwaters near Williston, North Dakota (RM 1771.5 to 1568.0) and a Wild and Scenic reach below Fort Benton (RM 2073.4 to 1917), which has the closest approximation of the Missouri River under an unregulated flow regime.

2.1.1 Vegetation

The GIS-based efforts include mapping the age of existing stands of trees based on photo-interpretation methods. The land cover type data were collected for the entire length of each study segment. In addition to the cottonwood data layers, GIS point data of existing and historical bald eagle nest locations will be used for planning purposes. These data are considered sensitive and will not be presented to the public. Additionally, data from other Missouri River Recovery programs, specifically location of past, existing, and proposed ESH sites, were acquired during the data collection process (Point of Contact [POC]: Tim Fleeger, Corps, Omaha District).

The detailed vegetation analysis mapping and data collection effort along the Missouri River has been completed for incorporation in the habitat model currently being developed by ERDC.

The objectives of the data collection activities included the following:

1. **Determine present-day land use/land cover (LULC)** within the historic Missouri River floodplain, including the distribution of cottonwood forest and early successional cottonwood sites.
2. **Determine historic land cover patterns and forest distribution** along the Missouri River, particularly baseline pre-dam conditions, and changes from these historic pre-dam

patterns to present-day patterns.

3. **Determine the present-day successional stage and age distribution** of riparian woody vegetation patches, particularly those containing cottonwood.
4. **Determine the plant species composition and structure** within existing cottonwood stands, across the successional gradient from sapling stands to old growth stands.
5. **Determine the characteristics of the plant species** occurring in the cottonwood stands evaluated under number 4 above, in terms of their affinity for wetland habitats and their affinity or dependence on undisturbed natural habitats (i.e., the floristic "quality" of the vegetation).

The initiation of the pilot study on vegetation composition within four cottonwood stands began in August 2006. The summers of 2007 - 2009 were the main field seasons for vegetation sampling and GIS work commenced in April 2007. Currently, results on vegetation have been reported for all segments on the MNRR in South Dakota and Nebraska (Dixon et al. 2010). Additionally, two reference areas were sampled - Segment 2 and the Wild and Scenic reach of the Missouri River in Montana.

A detailed description of the methods and results of the GIS mapping and vegetation sampling efforts is included in the 2007, 2008, and 2009 *Annual Reports* by Dixon et al. (2009 and 2010) and is presented as Appendix D of this report. As vegetation sampling is completed, annual reports are submitted to the Corps to describe the status and trends as well as provide data and conclusions that will be used by Cottonwood Management Team in the Cottonwood Community Model.

2.1.2 Hydrology, Soils, and Topography

To characterize the current hydrologic regime, spatially-explicit data were collected across Segment 10 and stored in an ArcGIS geodatabase. Projection for all ArcGIS shape files and geodatabases was NAD 1983 UTM Zone 14N. The objectives of this data collection activity include the following:

1. **Determine mean elevation of ground water level** (meters [m]) for the last 10 years using groundwater contouring developed by the Missouri River Institute (Mr. Tim Cowman) based on contouring and Digital Elevation Models (DEMs).
2. **Develop a Land-Capability Potential Index (LCPI)** map for Segment 10 and correlate this to existing and potential cottonwood community patterns and distributions. The LCPI was developed by the USGS to serve as a relatively coarse-scale index to delineate broad land capability classes in the valley of the Lower Missouri River. The index integrates fundamental factors that determine suitability of land for various uses, and may provide a useful mechanism to guide land-management decisions. The LCPI was constructed from integration of hydrology, hydraulics, land-surface elevations, and soil permeability (or saturated hydraulic conductivity) datasets.

The LCPI required the collection of the following information, which was developed by the U.S. Geological Society (USGS) for this report (Jacobson et al. 2007; Jacobson 2008):

a. **Water-surface elevations** of different frequency occurrence, using data from the Corps Upper Missouri River System Flow Frequency Study (UMRSFFS). This study calculated flood frequencies for USGS gauging stations using standardized methods. These calculations provided discharges for the 1, 2, 5, 10, 25, 50, 100, 250, and 500-year recurrence floods (equivalent to annual probabilities of 100, 50, 20, 10, 4, 2, 1, 0.4, and 0.2 percent) under current (2007) reservoir regulation.
b. **Land-surface elevations** to assess how surface water interacts with the ground surface. The primary land-surface elevation dataset was compiled by the Corps for the UMRSFFS. This dataset was supplemented with a bathymetric dataset for the Missouri River that was collected as part of the same project.
c. **Soil drainage classes** served as a measure of the ability of the soil to retain water during saturated conditions. Drainage classes conceptually integrate saturated hydraulic conductivity of the soil and underlying geologic materials, and to some extent, contain information related to surface topography (Soil Survey Staff 1993). Seven standard soil-drainage classes were identified from the NRCS Soil Survey Geographic (SSURGO) database maps for each county within the study area (NRCS 2003-2006).
d. **Terrain units** were used to provide a complementary assessment of local topographic conditions that might influence floodplain ecological processes. Terrain units were based on relative topographic position of points in the landscape. A benthic terrain mapping approach was used to classify the landscape into convex-up areas (crests, such as natural bar forms, floodplain ridges, levees, and road embankments), concave-up areas (depressions, such as river channels, floodplain swales, and drainage ditches), and areas without appreciable concavity or convexity. Areas lacking topographic variability are classified according to whether they are sloping or flat, based on applying a threshold slope angle.

The results of these analyses for Segment 10 are currently being incorporated into a cottonwood community-based index model for the study by ERDC.

2.1.3 Spatial Context

To characterize the current landscape setting, spatially-explicit data were collected across Segment 10 and stored in an ArcGIS geodatabase. Projection for all ArcGIS shape files and geodatabases was NAD 1983 UTM Zone 14N.

The objectives of this data collection activity include the following:

1. **Determine the total acres of habitat types** within Segment 10 using LULC mapping provided by Dr. Dixon above (described in Section 2.1.1 Vegetation).
2. **Determine the predominant land use that surrounds the cottonwood forest community** by categorizing the vegetative LULC mapping developed by Dr. Mark Dixon into useful response categories: Natural vs. Pastoral vs. Urban.
3. **Determine the mean distance between habitat patches** by measuring distances between habitat polygons using the Patch Calculator developed by ERDC

(http://el.erdc.usace.army.mil/elpubs/pdf/em07.pdf) on the LULC mapping developed by Dr. Dixon.

4. **Determine the relative interspersion of supporting (non-forested/shrub) habitats** using the LULC mapping provided by Dr. Dixon above and running ArcInfo's Spatial Analyst toolset (Neighborhood Statistics and Variety) to determine the relative mosaic pattern established.
5. **Determine the average patch size** using the LULC data provided by Dr. Dixon above.
6. **Calculate the proportion of the forest that is dominated by cottonwood** using the LULC mapping provided by Dr. Dixon above.
7. **Calculate the proportion of the forest that is dominated by cottonwood poles and saplings** using the LULC mapping provided by Dr. Dixon above.

The results of these analyses for Segment 10 are currently being incorporated into a cottonwood community-based index model for the study by ERDC.

2.2 Development of the Cottonwood Community Habitat Model

The intent of this section is to provide a brief description of the model and describe the process the team undertook to complete this effort. Draft model documentation (containing details surrounding the development and applications for the model on a pilot project) is currently under development (Draft Report will be submitted to the District for review in March 2010), and readers interested in the details surrounding this effort should refer to this document when it becomes available.

2.2.1 Model Purpose and Contribution to the Planning Effort

Planning, management, and policy decisions surrounding the cottonwood recovery effort require information on the status, condition, and trends of these complex ecosystems and their components at various scales (e.g. local, regional, watershed and system levels) to make reasonable and informed decisions about the planning management and conservation of these sensitive and/or valued resources. One well accepted solution in other regions of the country has been to develop index models that assess ecosystems at varying scales. By definition, index models are comprehensive, multi-scale, grounded in natural history, relevant and helpful, able to integrate terrestrial and aquatic environments, flexible, and measurable (Andreasen et al. 2003). Determining the value of diverse biological resources under the CMP requires a method that captured the complex biotic patterns of the landscape, rather than merely focusing on a single species habitat or their suitability requirements within the study area. Therefore, a decision has been made to assess ecosystem benefits using a community-based (functional) model rather than employing a series of species- or guild-based models. And, as such, planning decisions will subsequently be made based on the results of the model applied within the well received and respected HEP framework (USFWS 1980a-c). Designed to predict the response of habitat parameters in a quantifiable fashion, HEP is an objective, reliable, and well-documented process used nationwide to generate environmental outputs for all levels of proposed projects and monitoring operations in the natural resources arena. When applied correctly, HEP provides an impartial look at environmental effects, and delivers measurable products to the user for comparative analysis. Habitat Suitability Index (HSI) models can be tailored to a particular situation or application and adapted to meet the level of effort desired by the user. Thus, a single model (or a series of inter-related models) can be adapted to reflect a site's response to a particular design at any scale (e.g., species, community, ecosystem, regional, or global dimensions). Several agencies and organizations have adapted the basic HEP methodology for their specific needs in this manner (Inglis et al. 2006; Gillenwater et al. 2006; Ahmadi-Nedushan et al. 2006; and others).

As part of the process, a multi-agency, multi-disciplinary expert team (a subset of the CMP team) referred to as the Ecosystem Evaluation Team (E-Team) has been established to design, calibrate, and apply the model using field and spatial data gathered from reference sample sites in the segments identified in the BiOp. The model development objectives are to:

1) Identify the natural history and stressors relative to restoring and maintaining the cottonwood community,
2) Construct a draft index model for cottonwood habitat suitable for bald eagle use,
3) Review, test, and revise the model through application (i.e., calibrate and verify),
4) Perform a sensitivity analysis on the results to determine the uncertainty of the outcomes, and
5) Propose validation options using independent datasets.

The model has been designed to characterize the baseline conditions (in a quantitative manner) of the community, and the HEP method guides the forecasting of future conditions (i.e., changes in fundamental ecosystem processes) under various recovery alternatives. The HEP assessment has been designed to evaluate the future changes both in quantity (acres) and quality (community habitat suitability) of aquatic, wetland and terrestrial ecosystems simultaneously. Outputs are calculated in terms of annualized changes anticipated over the life of the project (a.k.a. period of analysis, in this case 100 years).

2.2.2 Model Reference, Structure, and Composition

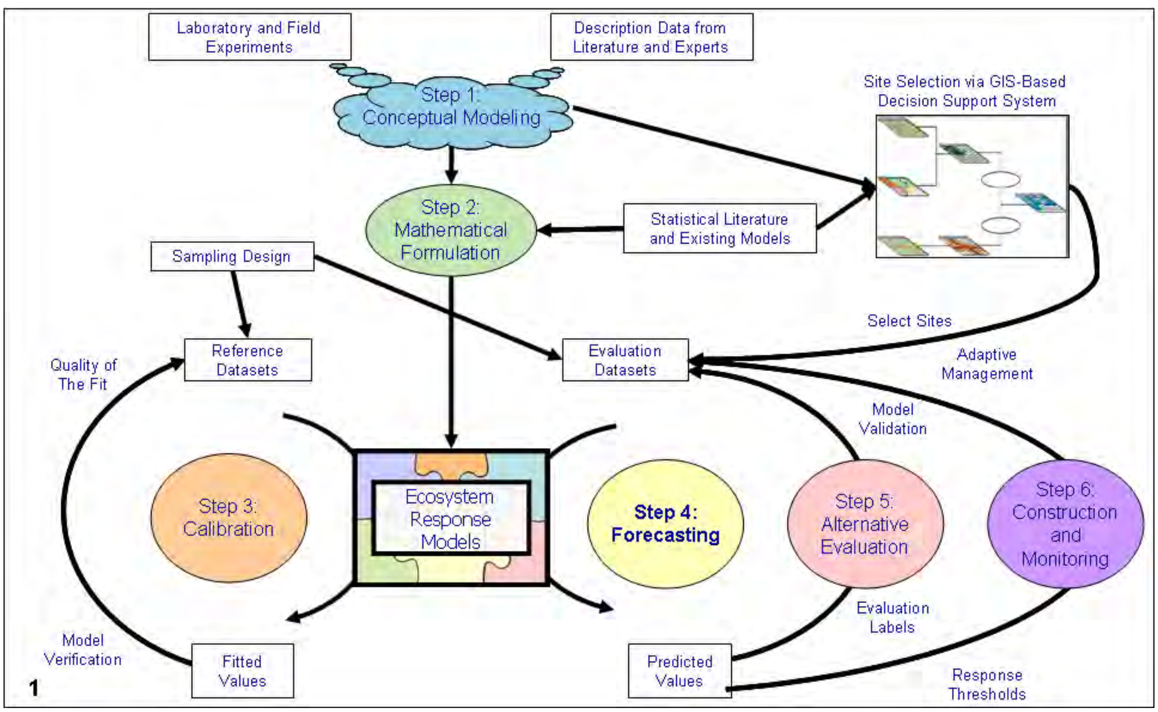
A series of workshops were held over the course of the study effort to develop a model and characterize baseline conditions of the study area prior to plan formulation and alternative assessment for the study. In the first workshop, the E-Team was briefed on the project scope and opportunities by the District planners. Land and water management activities (e.g., hydrologic alterations, urban development and agricultural production) were identified as the system's key anthropogenic drivers. The stressors (i.e., physical, chemical, and biological changes to system structure and function) were identified and grouped into five categories: 1) hydrologic alteration, 2) geomorphic and topographic alteration, 3) climate change, 4) urban encroachment and agricultural use, and 5) exotic species introductions. Each stressor altered ecosystem integrity[1] within a water, soils, habitat and/or landscape context. For example, hydrologic alterations to the channel have caused changes not only in flooding frequency and duration, but have altered

[1] We prescribe to the Society of Ecological Restoration's (2001) definition of ***ecosystem integrity*** here, which has been defined as "the state or condition of an ecosystem that displays the biodiversity characteristic of the reference, such as species composition and community structure, and is fully capable of sustaining normal ecosystem functioning."

ecosystem function and structure across the basin. Urban encroachment has exacerbated these problems by reducing infiltration, increasing storm water runoff, and increasing disturbance regimes system-wide. These changes have ultimately led to opportunities for exotic species invasions reducing spatial complexity on a landscape scale. The direct and indirect effects of these alternations are as obvious as they are numerous – reduced hydrologic pulsing, reduced sediment transport, fragmentation, and loss of biodiversity.

For purposes of this effort, a systematic framework was developed that coupled the traditional Corps planning process with an index modeling approach derived from a sound conceptual understanding of ecological principles and ecological risk assessment that characterized ecosystem integrity across spatial and temporal scales, organizational hierarchy, and ecosystem types, yet adapted to the project's specific environmental goals. Ideally, the development of conceptual models involves a close linkage with community-index modeling, and produces quantitative assessment of systematic ecological responses to planning scenarios (Figure 2-1).

Figure 2-1. Overview of the Successive Steps (1-6) of the Community-Based Index Model Building and Application Process for Ecosystem Restoration, Where Two Data Sets (One for Calibration and One for Alternative Evaluations) are Used (adapted from Guisan and Zimmerman 2000)[1]



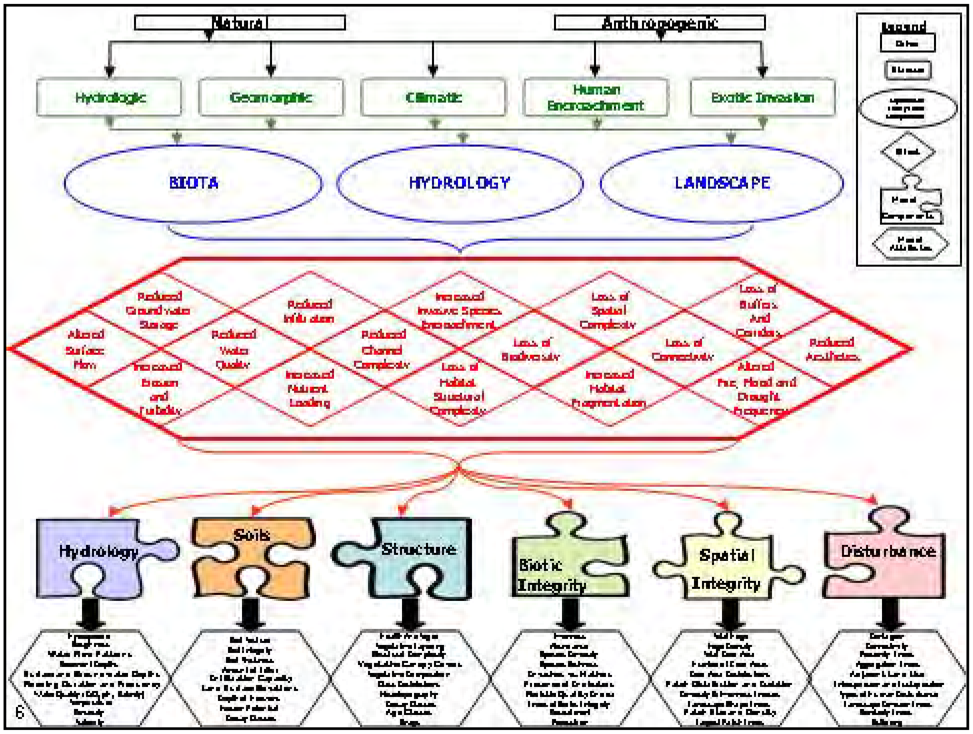
Source: Burks-Copes et al 2010

[1] It is important to note here that the same models used to evaluate alternatives should be used in the future to monitor the restored ecosystem and generate response thresholds to trigger adaptive management under the indicated feedback mechanism. As such, the Districts can use the models developed early-on in the process to adaptively manage the system over the long-term.

Under this modeling paradigm, conceptual modeling led to the choice of an appropriate scale for conducting the analysis and to the selection of ecologically meaningful explanatory variables for the subsequent environmental (index) modeling efforts.

As a first step in the index model development process, ERDC developed a conceptual model to illustrate the relationships between these system-wide drivers and stressors and attempted to highlight the ecosystem responses to these pressures across the entire watershed (Figure 2-2).

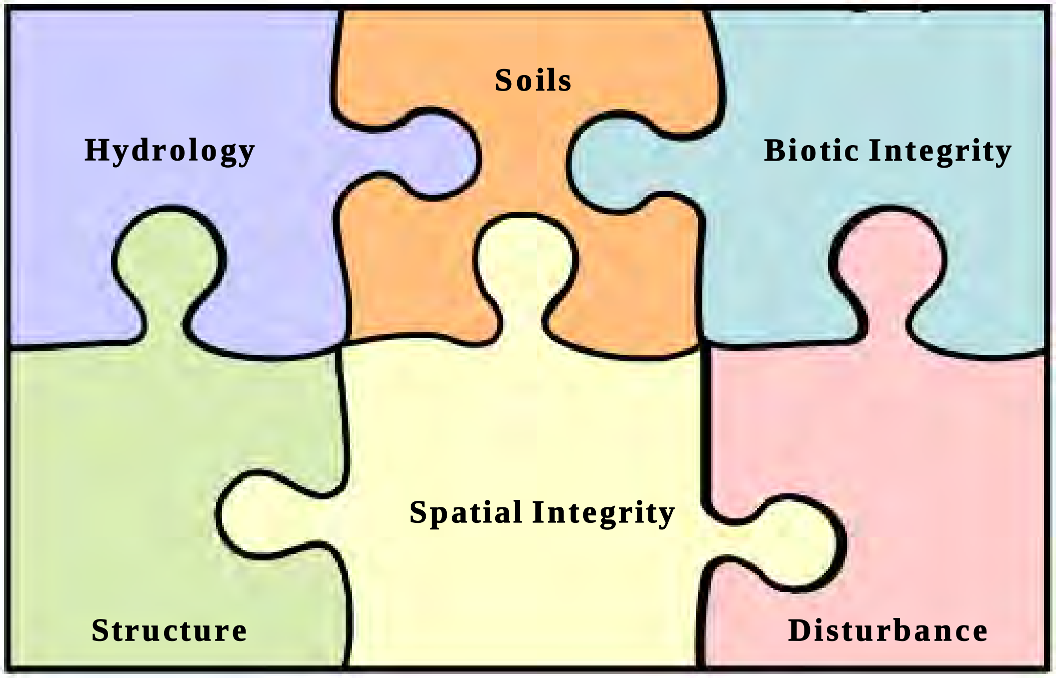
Figure 2-2. A Conceptual Model for the Cottonwood Community Modeling Effort



Source: Burks-Copes et al 2010

Conceptually speaking, the “Significant Ecosystem Components” (water, soils, habitat, and landscape) were characterized by parameters responsive to project design. These parameters or variables (hydroperiod, vegetative cover, disturbance, etc.) were grouped in a meaningful manner to quantify the functionality of the community in the face of change based on expert opinion and scientific literature. The effort to combine the variables in mathematical algorithms could then be viewed as community index modeling under the HEP paradigm. For purposes of organization, the community based index model was constructed from combinations of components – an analogy used was one of puzzle building. The individual model components were represented as “pieces” of the ecosystem puzzle, that when combined captured the essence of the system’s functionality (Figure 2-3).

Figure 2-3. Within the Conceptual Modeling Building Framework, the Various Model Components (Color-Coded for Organization Purposes) are Pieced Together to Capture the Essence of Community Functionality Using the Ecosystem Puzzle Analogy



Source: Burks-Copes et al 2010

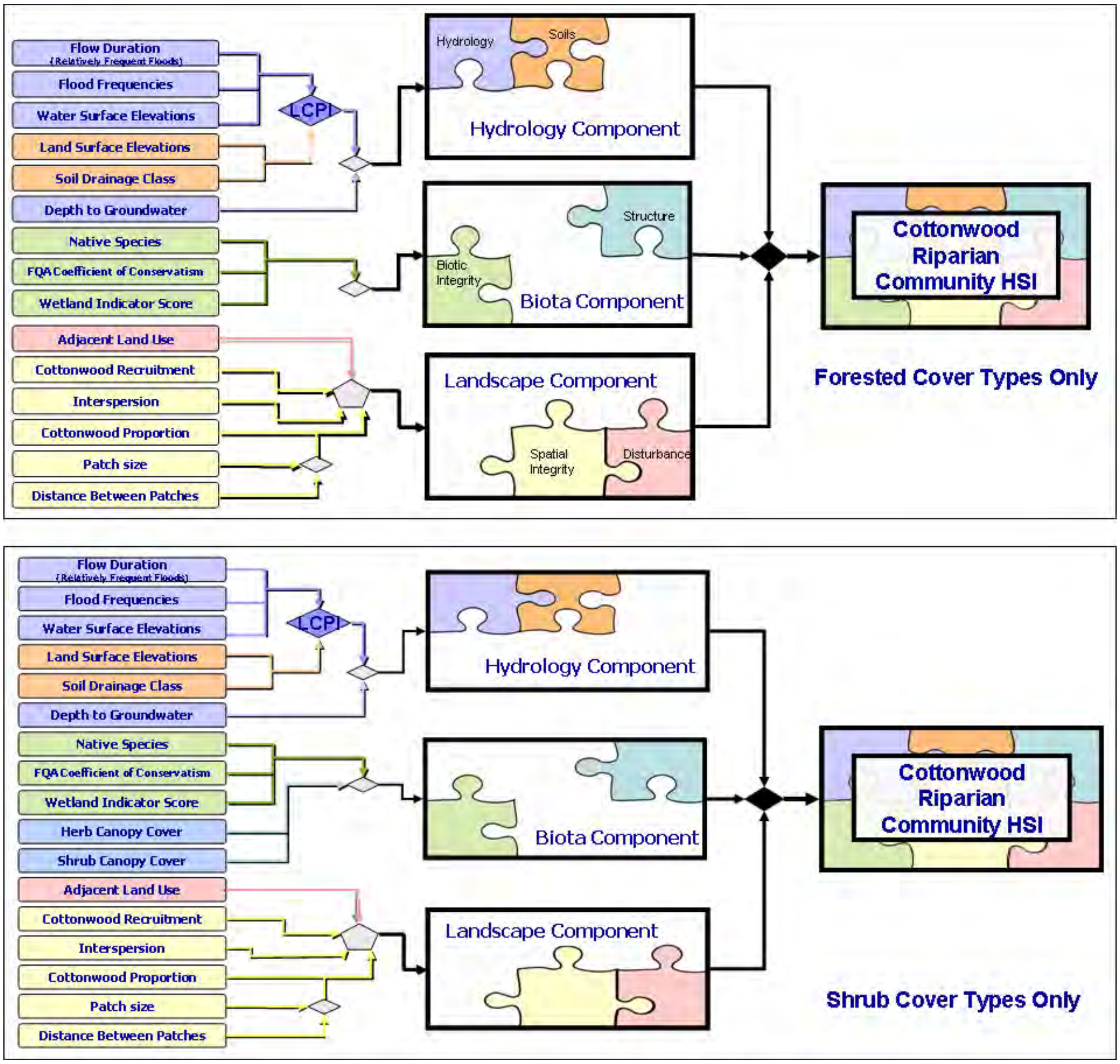
Vegetation communities in the area ranged from riparian forests, shrublands, meadows, wetlands (i.e., marshes), and the river itself. Out of this effort, a draft model for the cottonwood community arose. Subsequent refinement of the model has led to the identification of contributing ecosystem components, and a description of associated variables (with suggested sampling protocols) that are being used to measure ecosystem restoration/preservation benefits. The accuracy and utility of the proposed model is being "tested" (e.g., verified) with specific field and planning exercises on the District's ongoing study. The application will more than likely lead to small modifications of the model over the course of the study to accommodate broader planning specifications.

Over the course of several workshops, three model components (i.e., Hydrology, Biotic Integrity, and Spatial Context) were identified by the E-Team as the key functional indicators necessary to characterize the ecological integrity[1] of this unique community (Figure 2-4). Model components were combined in a meaningful manner mathematically to characterize the existing reference conditions found in the watershed on an age basis (Forest = >25 years old; Shrubs = < 25 years

[1] The E-Team prescribes to the Society of Ecological Restoration's (2001) definition of ecosystem integrity here, which has been defined as "the state or condition of an ecosystem that displays the biodiversity characteristic of the reference, such as species composition and community structure, and is fully capable of sustaining normal ecosystem functioning."

old), and to capture the effects of change under proposed design scenarios. Reference sites in this instance refer to multiple sites in a defined geographic area (the reference domain) that were selected to represent a specific type of ecosystem (i.e., Midwest riparian forests and wetlands along the Missouri River). Reference sites are most commonly described as natural settings – lacking human disturbances (Hughes 1994; Bailey et al. 2004; Chessman and Royal 2004; Intergovernmental Task Force on Water Quality Monitoring 2005). Reference-based conditions are therefore the range of physical, chemical, and biological values exhibited within the reference sites. When reference sites are characterized as undisturbed ecosystems, reference conditions exhibit at a range of values that reflect the spatial and temporal variability that commonly occur in natural ecosystems (Swanson et al. 1993; Morgan et al. 1994; White and Walker 1997; Landres et al. 1999). When reference sites include altered or disturbed ecosystems (as is the case in most urban-based ecosystem restoration efforts), the reference conditions exhibit a wider range of values that reflect both natural variability and variability due to human activities. In these instances, optimal conditions or "virtual" references can be established using a variety of techniques including literature values, historical data, paleoecological data, and expert opinion (Society for Ecological Restoration International 2004; Ecological Restoration Institute 2008). Regardless of how reference conditions are established, ecosystem restoration evaluations can use the reference-based approach as a template for model development, restoration planning, and alternative analysis.

Figure 2-4. Model of the Cottonwood Community HEP Model



Source: Burks-Copes et al 2010

Seventeen individual variables have been mathematically combined to characterize these functional components for the two age classes (Figure 2-4). For example, The *Biota Component* is captured by measuring the vegetative diversity (i.e., Floristic Quality Assessment (FQA) coefficient of conservatism, native species presence/absence, and wetland indicator scores) and structure (herbaceous and shrub canopy coverage) of the community. The *Hydrology Component* is captured by measuring depths to groundwater, flow durations, flood frequencies, land/water surface elevations, and soils characteristics via the LCPI (described previously). The *Landscape Component* is captured by measuring patch dynamics (i.e., patch size, distance between patches, patch heterogeneity/mosaic, cottonwood dominance, and age class structure). The model has been customized to characterize both cottonwood dominated and other riparian or non-cottonwood habitats. The model has also been tailored to treat mature and immature stands of forests somewhat differently (i.e., the mathematical relationships inside the *Biota Component* are derived uniquely dependent on age class setting).

2.2.3 Model Calibration, Verification, and Validation

Calibration here refers to the use of known (reference) data on the observed relationship between a dependent variable and an independent variable to make estimates of other values of the independent variable from new observations of the dependent variable. Model verification refers to a process by which the E-Team confirms by examination and/or provision of objective evidence that specified requirements of the model have been fulfilled with the intention of assuring that the model performs (or behaves) as it was intended. Sites deemed to be highly functional communities, according to experts, should produce high index scores. Sites deemed dysfunctional (by the experts) should produce low index scores. Validation refers to the process of establishing objective yet independent evidence that the model specifications conform to the user's needs and intended use(s). The validation process questions whether the model is an accurate representation of the system based on independent data not used to develop the model in the first place. Validation can encompass all of the information that can be verified, as well as all of the things that cannot -- i.e., all of the information that the model designers might never have anticipated the user might want or expect the product to do. For purposes of this effort, validation refers to independent data collections (bird surveys, floristic quality outputs, water quality surveys, etc.) that can be compared to the model outcomes to determine whether the model is capturing the essence of the ecosystem's functionality.

The reference condition described earlier defined the measurement scale and the state toward which the E-Team desired to move the system. In this instance, the reference-based approach employed "reference standard ecosystems" to establish optimal conditions (HSI = 1.0) that served as benchmarks or standards of comparison for the existing and future conditions. Locating "degraded" reference sites was essential to calibrating the model. These "degraded" reference conditions represented the other end of the measurement scale and represented the ecological systems that were clearly degraded and socially unacceptable (HSI – 0.0). Once the data were collected and entered into spreadsheets, average values and standard deviations were calculated per variable. These were reported on a "cover type-by-cover type" basis for each reference site in the segment. The averages (and standard deviations) were also calculated on a reach-by-reach basis and reported out with the site statistics. To develop curves for each variable, ERDC relied heavily on the input of the team's expert opinions and data gathered from cottonwood-dominated sites. However, the model was verified by comparing the results of the analysis against expected outcomes – the model had to differentiate between poorly functioning sites (non-cottonwood dominated settings) and optimal sites (fully functioning settings identified by the experts as high quality). In addition, several sets of data were withheld from the initial calibration to independently "test" the model's response to new conditions. The model will likely need to be recalibrated when it is "ported" up or downstream for the next segment evaluations. Although not addressed at this time, a sensitivity analysis is a potential activity for the future evolution of this process. Also, a series of wildlife population and vegetative surveys currently being conducted could provide data to validate this model in the near future.

2.2.4 Model Applications: Without-project Forecasting

It was the general consensus of the E-Team, that the future Without-project conditions of the study area (and the surrounding community) were certain to reflect some losses in ecosystem function (i.e., quality) and presence (i.e., quantity) when faced with the pressures of continued hydrologic alterations (i.e., continued disconnection from the hydrologic pulse perpetuating the cyclical life cycle of the system's cottonwood community), increased population growth (and urban sprawl), and escalated conversion to drier species communities. In essence, the future system was assumed to have a very different character than the current system – the gallery forest was likely to disappear and be replaced with a more dry riparian character. The E-Team addressed these issues in several workshops over the course of the study, and developed a set of heuristics (rules-of-thumb) to forecast both the changes in quantity and quality to generate a "No Action" scenario for the study. The following rules were developed:

1) **Urban Sprawl:** Urban centers were assumed to grow outward from their boundaries based on past trends and an assumption that density would increase over time at a constant, but cumulative rate of 10 percent.

2) **High Conflict Areas:** Additional areas that are not protected by an easement or owned in fee title by federal, state, or possibly tribal is at risk of development. These areas were considered to become urbanized by 2015.

3) **Stabilized Banks:** The E-Team made the additional assumption that riverside property would likely be "valuable" property in terms of development in the future, and as such, the stabilization of banks would likely encourage this urbanization movement.

4) **High Erosion Zones:** Highly unstable banks were assumed to erode inland at a rate of 50m every 10 years and moderately unstable banks would erode inland at a rate of 25m every 10 years (pers. comm. Tim Cowman, Missouri River Institute, 2008). However, the dynamic conditions of the river indicated these erosions patterns would not be regular enough to forecast with any deal of certainty beyond the first 10-year increment of the study (i.e., Target Year [TY] 6, or 2015).

5) **Agricultural Conversions:** Although the E-Team agreed that some agricultural land conversion would happen based on the past trends described in Dr. Mark Dixon's report on historic land cover changes, it was determined that many of the landowners would

likely resist conversion of any remaining riparian forests because they would likely conserve these for hunting purposes (Dixon et al. 2010). Therefore, no agricultural conversions were considered at this time.

6) **Federal/State Lands:** An aggressive program to secure easements was undertaken in 2008 and are in the process of being secured, so these areas (and all previous fee title and easements) were assumed to be protected from the urbanization and agricultural activities described in the above sections. Therefore, these new easements were erased from the conversion layers. However, not all easements restrict agricultural activities.

7) **Succession:** The E-Team developed a simple succession rule to "age" stands over the period of analysis. The following rules were applied:

    a. All habitats would simply "age" and move up into the above age classes unless:
        i. They were cottonwoods older than 114 years, then they would convert to later successional non-cottonwood stands (riparian communities); or
        ii. They were considered riparian shrubs – they would not succeed, but remain in place (although their ages would increase).
    b. Sandbars along the shoreline would recruit cottonwoods in the first year of the analysis, but these would not be considered viable until the fifth year of the study.

2.2.5 Model Applications: With-project Designs and Forecasting

Appendix E of this CMP/EA presents a suite of potential implementation strategies (or measures) that can be considered singly or packaged together into various alternatives for a particular priority cottonwood restoration site. The anticipated results from implementation of these alternatives can be evaluated using the model to assess the net habitat improvement expected over time. It should be noted that some of the measures that may not be appropriate for federal participation or that have low potential for cottonwood restoration benefit and may not yield any quantifiable results, may not be suitable for evaluation in the model.

The E-Team will be implementing a proactive strategy to formulate recovery plans specifically tailored to focus on recovery alternatives at a site level on a segment basis. The potential implementation strategies will be broken into preservation or conservation initiatives. These initiatives will be identified as either dependent or independent "features" or "activities." By definition, these elements are considered the smallest components of the alternative plans. Features are typically structural elements while activities are often nonstructural actions performed continually or in a periodic fashion to support the restoration investment. Combinations of these features, referred to as management measures, will thus become the building blocks from which the alternative plans will be made.

The first step will be to evaluate the benefits of the proposed alternatives by developing acreage forecasts over the life of the project for each alternative. It is important to note that the successional trends envisioned by the E-Team in the Without-project conditions will be retained in these restoration/preservation plans, in order to capture the cyclical nature of the Missouri River's cottonwood community.

The E-Team will be developing projected future conditions for the With-project design scenarios through a process of expert elicitation using Turning Point software technologies (http://www.turningtechnologies.com/groupresponsesystemsupport.cfm) and facilitated by the ERDC researchers. In essence, the experts will be asked to quantify the ecosystem's response to proposed alternatives on a variable-by-variable basis for every cover type at the site. These forecasts will be compiled, and the means of the scores will be applied to the SI graphs and the model results will be calculated using the Habitat Evaluation and Assessment Tool (HEAT) software. A pilot study has been initiated to "test" the model's utility in quantifying the benefits under this protocol at three sites in Segment 10 in the summer of 2009, and the full analysis will be performed on Segment 10 in the future.

2.2.6 Incorporation of Future Data, Models, and Recommendations

The Corps' intention has been to develop an index model that can be used in the future to evaluate and compare similar communities in the region, and to evaluate the benefits of proposed project management plans. The community model development process is anticipated to be iterative - as new information becomes available under the iterative Corps planning paradigm the CMP anticipates revising the model. The following areas of research are considered important to improving veracity of the information "feeding" the community index model.

1) **Channel Migration Modeling –** The inherent dynamic riverine setting in which this particular riparian community exists suggests that critical information such as thalweg movement and sediment deposition will be necessary to accurately predict patterns of cottonwood recruitment at the landscape level. To date, no migration modeling has been accomplished, and as such, the E-Team has simply estimated recruitment based on historical patterns and expert opinion. A first step in garnering the necessary information is to model the channel's migration and pinpoint these critical areas of potential establishment in a spatially-explicit environment.
2) **Succession Modeling –** Succession, a fundamental concept in ecology, refers to the more-or-less predictable and orderly changes in the composition or structure of an ecological community. The cottonwood community along the Missouri River is subject to this regular change in age class. Rates of cottonwood recruitment (i.e., river channel or sandbar to woody vegetation), rates of cottonwood loss from clearing for agricultural and residential land use and river channel migration, and senescence of aging stands will all influence the future area and age distribution of the forest. Altered species composition and successional trajectories related to flow regulation will influence the future structure and composition of these forests. Cottonwood forest area, age distribution, and species composition will influence landscape-level patterns of biodiversity. At the moment, the E-Team has developed a simple rule-based technique to spatially capture the conversions. However, the lack of a channel migration model has impeded the process – the lack of "new establishment zones" makes the rule-based approach unidirectional and at this point indicates that no recruitment can occur without artificial intervention. A valuable next step in this study would be to develop a landscape transition / forest succession model to forecast the implications of current successional trajectories and land conversion rates on long-term dynamics of cottonwood forests in the landscape. Several successional models are being investigated that would receive input from the channel migration model and

map the areas of successional change. These include a *Recruitment Box Model* (Mahoney and Rood 1998), the *Tool for Exploratory Landscape Scenario Analyses (TELSA)* (http://www.essa.com /tools/telsa/index.html), and *Vegetation Dynamics Development Tool* (http://www.essa.com/tools/vddt/index.html).

3) **Land use Conversion Modeling –** Although the E-Team has developed a rather straightforward rule-based method to forecast future land trends along the Missouri River, there are even more sophisticated systems to forecast and map predicted trends at the landscape scale readily available. The E-Team is considering investigating one such technique: the *Land Use Conflict Identification Strategy (LUCIS)* which uses ArcInfo Model Building to link ArcGIS tools in a structured visual environment that will facilitate the development of complex land-use models without requiring the user to learn programming languages. LUCIS employs a Multi-Criteria Decision Analysis (MCDA) strategy to explore optimal suitability for three broad land-use categories (agriculture, conservation, and urban) and compare them to identify where conflict among them exists.

4) Ecosystem Service Modeling – Government officials, conservation professionals, farmers, and other land owners in this region make decisions about how to use their land all the time. Yet, never before have any of these groups had a systematic way to demonstrate the future costs and benefits of their decisions for people and the environment in this region. The E-Team proposes to apply spatially explicit models to quantify and map the delivery, distribution, and economic value of ecosystem services. They are exploring the use of several GIS-based toolboxes developed by The Natural Capital Project called Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) (http://www.naturalcapitalproject.org/InVEST.html) to measure the potential ecosystem system services produced as a by-product of the proposed alternative scenarios. This tool would then help the E-Team visualize the impacts of potential decisions, identifying tradeoffs and compatibilities between environmental, economic, and social benefits.

5) Climate Change – One threat to the Missouri River cottonwood community is a change in precipitation and/or temperature patterns stimulated by global climate change that in turn disrupts the extremely sensitive hydrologic regime of the system. Risk and uncertainty surrounding current predicted climate patterns suggests that any planning activity intent on adaptively managing dynamic systems over the long-term must take into account a series of potential future scenarios under a broad range of climate regimes. Currently, the E-Team is using a somewhat static "No Action" scenario that incorporates urban growth as a land use conversion factor, but ignores potential threats to hydrological regime caused by global climate change. The E-Team would like to pursue a series of activities that would capture varying future forecasted conditions using climate envelope models (http://wikiadapt.org /index.php?title=Decision_Climate_Envelopes) tied to biome shift models (http://www.earthscape.org/r1/wwf04/wwf04.doc; http://www.aibs.org/bioscience-press-releases/resources/03-07.pdf. In addition, because 70 percent of the Missouri River flow is generated by snowpack in the Rocky Mountains where the headwaters are found (pers. communication Mark Dixon, Univ. of South Dakota, April 2009), the impacts of water supply and dam operations are also relevant to these activities and would provide another suite of alternative actions to adaptively manage under these changed regimes. The E-Team would like to pursue hydrologic scenario modeling and formulate alternatives (with Risk and uncertainty incorporated into the approach) to better plan for these potential future scenarios. These alternatives would be incorporated in to future site-specific EA's.

In addition to these research themes, the application of the index model can be made more robust by improving the outputs of the analysis. Two specific actions could be taken to improve the current model effort:

1) **Automating the GIS analyses –** Several GIS-based analyses are performed in the application of the model, and these should be automated using ArcInfo's Model Builder to streamline the process and reduce handling errors.
2) **Model Validation –** Although model calibration and verification are currently being undertaken in the model development process, model validation (i.e. determining whether the model is an accurate representation of the cottonwood ecosystem based on independent data) should be undertaken. A series of plant and animal (multi-faunal) surveys would need to be conducted over a series of several years (3-5 yrs at a minimum) to determine whether the community model is indicative of species richness (one measure of ecosystem function).

2.2.7 Planning Model Certification

The Corps Planning Models Improvement Program (PMIP) was established to review, improve, and validate analytical tools and models for Corps Civil Works business programs. In May of 2005, the PMIP developed Engineering Circular (EC) 1105-2-407, Planning Models Improvement Program: Model Certification (Corps 2005). This EC requires the use of certified models for all planning activities. It tasks the Planning Centers of Expertise to evaluate the technical soundness of all planning models based on theory and computational correctness. EC 1105-2-407 defines planning models as,

> " *. . . any models and analytical tools that planners use to define water resources management problems and opportunities, to formulate potential alternatives to address the problems and take advantage of the opportunities, to evaluate potential effects of alternatives and to support decision-making.*"

Clearly, the community-based index model developed for this effort must be either certified or approved for one-time use. The Omaha/Kansas City Districts will initiate this review in 2010.

For purposes of model certification, it is important to note that the model must be formally certified or approved for one-time-use, but the methodology under which it is applied (i.e., HEP) does not require certification as it is considered part of the application process. HEP in particular has been specifically addressed in the EC:

> "*The Habitat Evaluation Procedures (HEP) is an established approach to assessment of natural resources, developed by the US Fish and Wildlife Service in conjunction with other agencies. The HEP approach has been well documented and is approved for use in Corps projects as an assessment framework that combines resource quality and quantity*

over time, and is appropriate throughout the United States." (refer to Attachment 3, page 22, of the EC)

ERDC is using the newly developed HEAT to automate the calculation of habitat units for this effort (Burks-Copes et al. 2008). This software is not a "shortcut" to HEP modeling, or a model in and of itself, but rather a series of computer-based programming modules that accept the input of mathematical details and data comprising the index model, and through their applications in the HEP or the Hydrogeomorphic Wetland Assessment (HGM) processes, calculates the outputs in responses to parameterized alternative conditions. The HEAT software contains two separate programming modules – one used for HEP applications referred to as the EXpert Habitat Evaluation Procedures (EXHEP) module, and a second used in HGM applications referred to as the EXpert Hydrogeomorphic Approach to Wetland Assessments (EXHGM) modules. ERDC is using the EXHEP module to calculate outputs for this effort. ERDC is pursuing certification of HEAT through a separate initiative, and hopes to have this tool through the process in the next year barring unforeseen financial and institutional problems. ERDC will be using the Institute for Water Resources (IWR) Planning Suite to run the cost analyses for this effort as well, and this software was certified in 2008.

2.3 Site Selection Criteria

Each potential preservation or restoration project varies by site in physical and ecological characteristics, scale, scope, and objectives. Careful analysis of the landscape (geomorphic valley form, stream type and vegetation community type) should take place before any plans are drawn to verify the feasibility of the project as a whole. That said, it has been documented that the early successional stages of cottonwood forest are declining along the Missouri River and without preservation or restoration efforts, it has been predicted that the area of cottonwood forests is likely to decline substantially within the next 100 years (Johnson 1992). When looking to identify the areas where preservation or restoration is most needed, certain criteria can be used to differentiate between high priority restoration or preservation sites and the rest of the landscape.

Appropriate criteria for differentiating among potential project sites needs to focus upon site characteristics that will favor cottonwood survival and the potential contribution of an individual site to the integrity of the cottonwood community at the landscape level.

The criteria presented below was developed for Segment 10 (Pilot Study). The criteria for other river segments may differ based on differing segment-specific conditions. It is the CMP Model Development Team's intent to automate this process as much as possible – potentially via the development of a GIS-based toolbox that can be used and customized for each segment.

2.3.1 Pilot Study – Segment 10 Site Selection Criteria

For the Segment 10 Pilot Study, the Cottonwood Management Team used an approach that assembled an "expert panel" of individuals from different areas of expertise. These experts are typically not policy makers or agency executives. These individuals are those who work most closely to the actual problems and are integrally involved in formulating, describing, and developing solutions. Much work has been completed by the Cottonwood Management Team to examine the issues of protection and restoration of cottonwood forests along the Missouri River. This work has yielded a list of potential criteria that were used to select sites within Segment 10, some of which may also be used as criteria for other segments to be evaluated later. The following criteria have been developed and labeled as either a restoration criterion (RC), a preservation criterion (PC), or both restoration and preservation criterion (R&PC):

1. **Depth to water table (RC)** - Cottonwoods are phreatophytes, or plants that have adapted to arid environments by growing deep roots that acquire moisture at or near the water table. This criterion addresses the fact that cottonwoods require close proximity to groundwater to establish and persist.
2. **Targeted site locations (R&PC) –** preservation and/or restoration of cottonwoods within the MNRR boundary is a priority and site location target. If a site is identified within the MNRR boundary, landowner cooperation could be encouraged through the availability of program funding.
3. **Cooperation with tern and plover restoration sites (R&PC) –** The Corps tern and plover program seeks out landscape preservation opportunities immediately adjacent and in close proximity to constructed sandbars to prevent human development and impacts of encroachment. In order to cooperate with other Corps conservation programs, cottonwood preservation and restoration sites that are located on sand bars in the river could be omitted entirely and all preservation initiatives could be targeted along river banks and outside of ESH areas. Adjacency to mainland, including sidebars, may be beneficial from a preservation standpoint. The size of an appropriate avoidance buffer will be determined in coordination with the ESH program.
4. **Sites that overlap with existing or potential backwater restoration (RC)** - It is desirable to select sites that overlap with another Corps or other entity's restoration project to optimize mobilization and planning costs/efforts. If appropriate restoration sites or potential areas for protecting existing cottonwoods could be located adjacent to lands that are already protected, a more contiguous protected area will result. If possible, restoration locations should be adjacent to natural resource areas under long-term protection by resource agencies or other organizations. Combining related projects can provide value-added benefits and could potentially be cost-shared with the adjacent protected areas. However, careful screening to locate new restoration sites should be exercised so the most appropriate location is determined for cottonwood seedling establishment, regardless of the use of adjacent lands. Some program rankings in the U.S. Department of Agriculture (USDA) are given additional points for close proximity to other 'reserved' land. Therefore, USDA program rankings could be considered in these types of projects.
5. **Adjacent to existing young cottonwood stands (RC) –** If the site is adjacent to existing young (sapling, pole and young age classes) cottonwood stands, the likelihood of gaining a seed source over time is increased as well as reducing fragmentation. Young stands indicate areas where accretion is occurring, a condition that is favorable to the establishment of cottonwood stands.
6. **Sites subject to periodic inundation (RC) –** If the site is likely to periodically be inundated this would enable the establishment of cottonwoods, which require a flooding component. Flow regulation and channelization substantially changed the Missouri

River's historic hydrologic and geomorphic regimes and the natural variability in flows along many rivers has been modified by water management activities. Not only have high flows been reduced in many areas, but low flows have increased considerably. The post-dam floodplain environment is severely missing overbank flooding, which only occurs on the lowest terraces.

7. **Sites that are not likely to erode away in the near future (R&PC) –** Sites that have the potential to erode away in the near future would not be targeted for cottonwood preservation sites. Erosion patterns over the last 15 years will be used to avoid areas that are likely to experience significant bankline loss in the near future. *This criterion is based on a 5-10-year time window, with no long-term predictions of future stream geomorphology.*
8. **Sites that could provide landscape connectivity (R&PC) –** Landscape connectivity involves the linkage of habitats, species, communities and ecological processes at multiple spatial and temporal scales and can add to the size of existing cottonwood/ riparian forest patches, thus decreasing fragmentation. Habitat patches that are isolated or fragmented from similar patches by great distances or inhospitable terrain are likely to have fewer species than less isolated patches.
9. **Sites that are at risk from development or land use changes (R&PC) –** If the area is likely to be developed for commercial or agricultural use or if agricultural expansion is a possibility, the site should be preserved. Municipal Master Plans, zoning maps, and census data (past, current and future trends analysis), as well as local knowledge of an area can be used to determine development potential or changes in land use.
10. **Site are positioned near a seed source (RC) –** There is a higher likelihood that there will be heavier seed fall on the area (i.e., less work to restore the sites) if sites are positioned close to seed sources.

Following application of the site selection criteria to determine suitable locations for implementation projects, sites have been ranked based on the scores achieved and the weighting established for each criterion by the Cottonwood Management Team. Other factors that need to be considered when prioritizing sites include: prioritization rankings of sites in other priority segments and the regional effect that would result from implementation of one or more projects in the different segments; owner willingness; degree to which site conditions are worsening and in need of action; and other possible data gaps yet to be identified. An additional consideration is that several criteria have a time component where the benefits achieved may be short term (now to ten years), medium term (ten years to twenty years), or long term (beyond twenty years).

The primary focus of the site prioritization will therefore be based upon those sites that can provide the largest area and greatest amount of cottonwood community habitat benefits in the future. These sites will then be assessed using the cottonwood community habitat model. This will further refine the planning and decision-making process for sites to pursue as potential restoration sites.

2.4 History and Process Used to Formulate the Alternatives

The 2003 Amended BiOp established the need for a CMP for the Missouri River. As described earlier, this EA evaluates the potential impacts of a CMP for the Missouri River at the programmatic level.

An agency workshop was conducted to gather information from resource agencies interested and involved in the project. At the three-day agency workshop in Yankton, South Dakota, the team presented proposed protection and restoration measures and requested input from resource agencies, including federal and state agencies, universities and academic institutions, tribal governments, and nonprofit agencies. It was agreed that because the CMP was to address the entire Missouri River over a 100-year period, it needed to be as broad and flexible as was reasonable, providing a toolbox of measures that could be implemented in a variety of habitat types and could be adaptable to changing conditions over the life of the project.

In considering alternatives for this environmental assessment, the team discussed if there were reasonable alternatives to the CMP. Because of the need for the CMP to be broad and flexible, the team concluded that at the programmatic level, the range of reasonable alternatives included the No Action, the implementation of the CMP using all implementation strategies, and the implementation of the CMP focusing only on the protection and propagation of the cottonwoods.

If the decision is made to implement the CMP, more detailed alternatives would be developed in the analysis at the segment and site level.

2.4.1 Minimum Mission/Project Objectives

Development of the objectives was completed with legal and regulatory mandates in mind and with an awareness of the complexity of relationships between the species, ecosystems, and ecological processes that future management actions would affect. The major objective of this report is to fulfill the requirements of the USFWS 2003 Amended BiOp. Specifically, the results of the ERDC Habitat Model and Adaptive Management will be incorporated into this CMP/EA.

The objectives of the CMP/EA include the following:

- Cottonwood regeneration will maintain pace with or exceed mortality, and
- No more than 10 percent of cottonwood forest habitat that is suitable bald eagle habitat will be lost during the project life.

If the decision is made to implement this CMP, objectives will be further defined for each segment, based on the conditions of the cottonwood community within the segment.

2.5 Detailed Description of No Action Alternative

2.5.1 Alternative 1 – No Action Alternative

Under the No Action Alternative, the CMP proposed for the Missouri River would not be adopted and the associated projects would not be implemented. As a result, the natural resources that currently exist along the Missouri River, specifically cottonwoods but including bald eagles, would not be managed on a comprehensive and long-term planning basis. Benefits to the bald eagle population from habitat improvement would not occur.

2.6 Detailed Description of the Proposed Action and Alternatives

The Corps proposes to preserve existing stands and reestablish new stands of cottonwoods at selected sites along the Missouri River. The Proposed Action and Alternative includes implementation of a CMP that describes a process to prioritize the preservation and the reestablishment of cottonwoods along the Missouri River. Prioritization would be achieved through the incorporation of a model that evaluates a set of alternatives and site priorities for protecting the bald eagle. The CMP also identifies strategies for implementing the plan including land acquisition, easements, management policies, and timelines.

The CMP presents a suite of potential implementation strategies (or management measures) that could be employed to protect and restore cottonwood communities. Some of the suggested measures will require initial refinement at the reach level before being applied more widely to the river system, as originally recommended in National Research Council (NRC) (2002). The implementation strategies are organized under the following categories: 1) Protection of Existing Cottonwood Stands, 2) Restoration of Hydrologic/Geomorphic Processes for Cottonwood Regeneration, 3) Artificial Propagation of Cottonwoods, and 4) Modification to Management Policies to Protect/Restore Cottonwoods. A summary of the implementation strategies are presented in Section 2.7.

Under each of the four categories of Implementation Strategies, general goals have been established, and several specific techniques, which are described in detail in Appendix E, have been recommended to achieve these goals. Important sources and references have been properly cited in each technique, as this CMP/EA is a summary of numerous scientific studies, plans, and programs that have been previously authored or implemented. It is important to note that this plan attempts to present the entire suite of possible implementation strategies regardless of constraints such as costs and feasibility. Many of these measures are not mutually exclusive, some of these measures overlap, and many measures should be considered in conjunction with other measures to be most successful, as described at the bottom of each box in Other Strategies to Consider (Appendix E).

The implementation strategies described below were developed to address a range of issues along the Missouri River in the six priority segments. These six priority segments are characterized into four river environments, which are described below and summarized in Table 2-1:

- ***Reservoirs and Headwaters (R&H):*** Segment 6 (Lake Sharpe); Segment 9 (Niobrara River to Lewis and Clark Lake, including Lewis and Clark Lake)
- ***Inter-reservoir (IR):*** Segment 4 (Garrison Dam to Lake Oahe Headwaters near Bismarck, North Dakota); Segment 6 (Oahe Dam to Lake Sharpe Headwaters); Segment 8 (Fort Randall Dam to Niobrara River)
- ***Unchannelized (UC):*** Segment 10 (Gavins Point Dam to Ponca, Nebraska)
- ***Channelized (C):*** Segment 13 (Platte River to Kansas City, Missouri) (USFWS 2000a)

Table 2-1. Summary of Priority Segment River Environments

Priority Segment	River Environment			
	Reservoir and Headwater	Inter-reservoir	Unchannelized	Channelized
4		X		
6	X	X		
8		X		
9	X			
10			X	
13				X

When developing the implementation strategies, the intent was to choose general measures that would capture the different environments of each of these segments and that could be applied within any of the six segments.

Segment 13 is the only channelized segment and the issues and site-specific conditions are therefore unlike any of the other segments. For example, cottonwood growth and recruitment may not currently be an issue in Segment 13 and all 48 of the sample sites were submerged under 2 to 10 feet (ft) of water during the flooding in late June 2008 (Bowen 2008). However these recruitment sites would need to be protected from clearing or other vegetation management that removes the young trees. Additionally in Segment 13, the Missouri River floods levee to levee every spring near Atchison, Kansas, which is not characteristic of the other five priority segments. However, even though the segments may differ in site-specific conditions, the plan provides both general and detailed implementation strategies that can be applied, in most cases, in combination with other measures to meet the goals and objectives of this plan for all six priority segments. Note that the applicable segment where each of these measures can be applied is described at the bottom of each box in Potential Study Locations (Appendix E).

2.6.1 Alternative 2 – Implementation of the CMP with Limited Strategies

Alternative 2 would include the implementation of the CMP with a limited range of strategies. This alternative would focus on preserving and protecting existing cottonwoods and planting or propagating new cottonwood stands. Implementation strategies included under Alternative 2 are 1) Protection of Existing Cottonwood Stands and 2) Artificial Propagation of Cottonwoods (defined in Section 2.7). Table 2-2 includes a brief summary of the implementation strategies, general goals, and specific techniques proposed to be implemented. Detailed information on the specific techniques is presented in Appendix E. Many of these techniques would be used in combination with one another in order to be most successful; however not all techniques would be necessarily implemented.

Table 2-2. Brief Description of Implementation Strategies Presented in Alternative 2

Implementation Strategies	General Goal	Specific Technique
Protection of Existing Cottonwood Stands	Establish Land Conservation Measures	Discourage Development Near the River
		Discourage Cottonwood Clearing Near the River
	Purchase or Accept Lands Near the River	Purchase Lands or Create a Voluntary Property Buyout Program
		Pursue an Applicable Easement
		Bequests for Conservation and Donations
	Use Funding Programs to Protect Cottonwoods	Use Short-Term Conservation Loan Funds
		Use Tax Incentives and State Programs
		Use Existing Programs
		Use Forest Legacy Program Funds
		Use Conservation Cost-Sharing Programs
	Prevent Competition to Existing Cottonwood Stands	Control and Prevent Domestic Livestock Grazing on Existing Cottonwoods
		Control and Prevent Deer Grazing on Existing Cottonwoods
	Reduce Mortality to Existing Cottonwood Stands	Conservation of Surface Water and Alluvial Groundwater to Maintain Existing Cottonwoods
Artificial Propagation of Cottonwoods	Plant or Propagate New Cottonwood Stands	Harvest Cottonwood Seeds
		Plant Cottonwood Seeds
		Plant Rooted Cottonwood Seedlings (A) / Saplings (B)
		Plant Small Unrooted Cottonwood Cuttings (Live Stakes)
		Disk Land for Cottonwood Habitat
	Protect New Cottonwood Stands	Remove and Control Invasive Vegetation
		Control and Prevent Rodent/Ungulate Herbivory to Existing Cottonwoods
		Maintain Plantings through Short-Term and Long-Term Management

2.6.2 Alternative 3 (Proposed Action) – Implementation of the CMP

Alternative 3, the Proposed Action, would include the implementation of the CMP using all strategies. Implementation strategies included under Alternative 3 would include 1) Protection of Existing Cottonwood Stands, 2) Restoration of Hydrologic/Geomorphic Processes for Cottonwood Regeneration, 3) Artificial Propagation of Cottonwoods, and 4) Modification to Management Policies to Protect/Restore Cottonwoods. Table 2-3 provides a brief summary of the implementation strategies, general goals, and specific techniques proposed to be implemented under Alternative 3. Detailed information on the specific techniques is presented in Appendix E. Alternative 3 provides a toolbox of a broad range of techniques which would allow the Corps to choose appropriate measures to implement at specific sites. Many of these techniques would be used in combination with one another in order to be most successful; however, not all techniques would necessarily be implemented.

Table 2-3. Brief Description of Implementation Strategies Presented in Alternative 3

Implementation Strategies	General Goal	Specific Technique
Protection of Existing Cottonwood Stands	Establish Land Conservation Measures	Discourage Development Near the River
		Discourage Cottonwood Clearing Near the River
	Purchase or Accept Lands Near the River	Purchase Lands or Create a Voluntary Property Buyout Program
		Pursue an Applicable Easement
		Bequests for Conservation and Donations
	Use Funding Programs to Protect Cottonwoods	Use Short-Term Conservation Loan Funds
		Use Tax Incentives and State Programs
		Use Existing Programs
		Use Forest Legacy Program Funds
		Use Conservation Cost-Sharing Programs
	Prevent Competition to Existing Cottonwood Stands	Control and Prevent Domestic Livestock Grazing on Existing Cottonwoods
		Control and Prevent Deer Grazing on Existing Cottonwoods
	Reduce Mortality to Existing Cottonwood Stands	Conservation of Surface Water and Alluvial Groundwater to Maintain Existing Cottonwoods
Restoration of Hydrologic and Geomorphic Processes for Cottonwood Regeneration	Create Fluvial Processes Suitable for Cottonwood Establishment	Create Side Channels, Reconnect Old Oxbow Lakes and Establish Backwater Areas
		Allow or Create In-Channel Sandbars to Naturally Revegetate with Cottonwoods
	Floodplain Activities	Lower the Bench
		Eliminate Structural Limitations Along the River
Artificial Propagation of Cottonwoods	Plant or Propagate New Cottonwood Stands	Harvest Cottonwood Seeds
		Plant Cottonwood Seeds
		Plant Rooted Cottonwood Seedlings (A) / Saplings (B)
		Plant Small Unrooted Cottonwood Cuttings (Live Stakes)
		Disk Land for Cottonwood Habitat
	Protect New Cottonwood Stands	Remove and Control Invasive Vegetation
		Control and Prevent Rodent/Ungulate Herbivory to Existing Cottonwoods

Implementation Strategies	General Goal	Specific Technique
		Maintain Plantings through Short-Term and Long-Term Management
Modification to Management Policies to Protect/Restore Cottonwoods	Strategic Recommendations	Land Preservation Education and Information Exchange
		Encourage Irrigation Water Management Plans to Benefit Cottonwood Stands
		Establish a Focus Group to Educate the Public about Carbon Credit Programs
		Collaborate with Established Conservation Trees Work Group
	Management Recommendations	Federal Use of Mitigation Projects to Require Cottonwood Plantings
		State Use of Mitigation Projects to Require Cottonwood Plantings

2.7 Implementation Strategies

The following is a discussion of the implementation strategies presented in Alternatives 2 and 3.

2.7.1 Protection of Existing Cottonwood Stands

Due to the near-term and substantive threat to the cottonwood communities along the Missouri River, the protection and conservation of established cottonwood stands is a critical element of the program in the early years of implementation. Using the site-selection criteria developed for this plan, locations of existing cottonwood stands under threat of conversion to another land use will be identified. As described earlier, criteria for preservation sites focus primarily on characteristics that favor cottonwood survival and integrity of the cottonwood community at the landscape level.

2.7.2 Restoration of Hydrologic and Geomorphic Processes for Cottonwood Regeneration

Degradation of the river channel disconnects the river from its floodplain which makes it more difficult for the river to overflow its banks and affects the floodplain water table. When the water table is lowered, it effectively drains water from oxbow lakes, wetlands, and other important features and may cause stress to cottonwood trees through a declining water table. Side channels and backwater areas provide slower-moving waters critical for the reproduction, shelter, and feeding of fish species as well as the recruitment of cottonwood stands. Existing side channels and backwater areas of the Missouri River have been greatly reduced, thereby eliminating important habitat. The water, sediment, and nutrients previously spread across the floodplain by overbank flows and the meandering river are now primarily restricted to the main channel or contained in the system's reservoirs. In order to enhance the hydrologic connectivity of the river and floodplain and to create processes suitable for cottonwood establishment, oxbow lakes could be reconnected, existing side channels could be enhanced or new overbank side channels could be created that would flood at high flows.

The degradation of the river channel and reservoir shorelines over time has also led to an increase in river bench height. Most of the areas available for cottonwood planting are on relatively high benches that do not frequently flood or receive the adequate moisture needed for the initial stages of cottonwood development. Lowering the bench along the river and reservoirs would increase connectivity between the river and floodplain. Cottonwood seedlings could be planted or natural recruitment would occur. In addition to the degradation of the river, the structural alterations, including the straightening of channels, bank stabilization, and construction of wing dams, were designed to constrict flows to the main channel and to prohibit channel meandering has also lead to the river/floodplain disconnect. The removal of structural limitations would create unconstrained corridors that provide room for the river to meander in an erosion zone that is integral to promoting cottonwood establishment. These activities would be most successful if timed accordingly with the cottonwood seed dispersal in June and July.

2.7.3 Artificial Propagation of Cottonwoods

The preferred methodology of establishment of cottonwoods is natural regeneration; but where that is not possible, planting is a valid alternative to encourage the establishment of cottonwoods in appropriate locations for long-term survival and growth. There has been extensive research conducted to determine the criteria for the successful establishment of riparian cottonwood seedlings. Because there is no carryover seed bank from previous years, cottonwood seeds dropped from mature trees must either land directly or be carried by the river to suitable sites for establishment. In addition, there is a very limited period of seed dispersal and viability (June through July), that further restricts the process (Schreiner 1974). Natural regeneration in the segments that contain reservoirs is typically low, since there is little to no water flow. In these areas, regeneration of cottonwoods would be through artificial propagation.

Successful cottonwood recruitment occurs when seed release and seed dispersal occur after peak flow and during the receding limb of the hydrograph. It is important that the timing of seed release coincide with the receding stream, which exposes moist sites that are suitable for seedling establishment. Seed release can be out of phase with flooding, and therefore, cottonwood recruitment would not occur. There is a need for moderate flood events for successful establishment and it has been determined that a 1 in 5 to a 1 in 10 year flood event is associated with cottonwood recruitment, although these numbers are estimated and will be dependent upon the river and the actual river segment. The stream stage should be declining to expose saturated sites for initial seedling establishment during the period of seed-dispersal and streambanks above the base stage should be exposed at this time. The timing of seed dispersal can be somewhat variable, depends on the geographical location and may last for a couple of months. Therefore, the local phenology of seed release for a given segment must be established rather than assuming uniform dispersal timing along the entire river. Additionally, the precise elevation range of the streambanks that is suitable for cottonwood recruitment will depend on the stage-discharge relationships and sediment texture along with the location of the river segment.

There are several additional general or associated practices that would be considered as part of or immediately following implementation of the Artificial Propagation of Cottonwoods described above:

- **Choosing Appropriate Cottonwood Ecotypes with Genetic Diversity –** Research has indicated that planting trees that are genetically diverse will result in increased diversity of other species in the dependent community. A benefit of genetically diverse stands of trees in dominant riparian communities is increased plasticity to varying environmental perturbation including disease, insect outbreaks, and climate change. It is important to be cognizant of patch heterogeneity to avoid planting a homogenous stand of cottonwoods. In addition, to preserve genetic diversity and ensure that the plants used in revegetation projects are adapted for local conditions, it is important to use local ecotypes of native species. Ecotypes are populations of a plant species that are genetically adapted for a given set of conditions. Knapp and Rice (1996) have indicated that the use of appropriate ecotypes can significantly improve the success of a restoration project. For example, the Lower Colorado River Multi-Species Conservation Program (LCRMSCP) has undertaken a cottonwood genetics study to genetically screen remaining stocks of Fremont cottonwood (*Populus fremontii*) trees in existing stands and to select genetically distinct trees to plant, monitor, and observe how genetic differences may be expressed in terms of growth, reproduction, and survival in a typical restoration site, and genetic traits that influence superior habitat quality. These genetic traits will likely be important for long-term survival and for maintaining habitat quality and health throughout the life of the program.

- **Establishment of an On-Site Cottonwood Plant Nursery for Stock –** If vast amounts of native cottonwoods are required for planting, a locally-created on-site nursery may be an option to ensure that a mix of genetically known plant stock is available for future restoration activities, especially if a large plant supply does not currently exist and the purchasing of individual plants would be costly (LCR MSCP 2007a). A nursery would provide a consistent and readily accessible source of plant materials for additional restoration sites and for future conservation areas. Cottonwoods could be planted 20 ft apart (based upon their center), smaller trees could be planted 10 ft on center, and a cover crop could also be planted, as long as the cover plant does not compete with the cottonwood seedlings. A contractor could be hired for propagating, delivering, and mass planting the native trees as well as regular irrigation, which would be required until the seedlings are established. The cottonwoods could then be transplanted on an as-needed basis to restoration sites that have been carefully chosen based on habitat requisites for cottonwoods. If available, the Corps may contract local nurseries capable of producing conservation grade trees for distribution and planting.

- **Plant Associated Species with Cottonwoods to Ensure Structural Diversity –** Prior to twentieth century human-induced environmental changes, the Missouri River's vegetation was characterized as having high biodiversity both within forest communities and across the floodplain. Natural vegetation communities along the Missouri River historically featured forests with a wide variety of species. Future riparian floodplain plantings should replicate these native plant species. The dominant floodplain trees were cottonwood, green ash (*Fraxinus pennsylvanica var. lanceolata*), box elder (*Acer negundo*), and American elm (*Ulmus americana*). Subdominant trees included peach-leaved willow (*Salix amygdaloides*) and bur oak (*Quercus macrocarpa*). Common shrubs and woody vines included dogwood (*Cornus stolonifera* or *Cornus drummondi*) wolfberry (*Symphoricarpos occidentalis*), poison ivy (*Rhus radicans*), chokecherry (*Prunus virginiana*), juneberry (*Amelanchier alnifolia*), woodbine (*Parthenocissus inserta*), and fox grape (*Vitis vulpina*) (Johnson et al. 1976). Johnson et al. (1976) determined that these forests formed a successional series of ecological communities dominated by a cottonwood-willow association formed on fresh alluvium on low benches and on the higher benches, dominated by ash, box elder, and elm. In addition to cottonwood and willow, later successional species were more diverse on the lower portions of the Missouri River than in northern reaches of the river. For example, box elder, silver maple (*Acer saccharinum*), red mulberry (*Morus rubra*), and several elms replaced cottonwood and willow and formed an intermediate successional stage. The mature forest included several species of oaks (*Quercus* spp.), hickories (*Carya* spp.), black walnut (*Juglans nigra*), basswood (*Tilia americana*), hackberry (*Celtis* spp.), and sycamore (*Platanus occidentalis*). The native species described above, which historically dominated the Missouri River floodplains, should be planted in conjunction with cottonwood restoration measures to ensure structural diversity of the shorelines and the higher benches outside of the floodplain. Generally, ecosystems containing many different plant species are not only more productive, they are better able to withstand and recover from climate extremes, pests and disease over long periods of time.

- **Control and Prevent Domestic Livestock Grazing on Existing Cottonwoods** (as described in detail in Appendix E, BOX 11)

- **Control and Prevent Deer Grazing on Existing Cottonwoods** (as described in detail in Appendix E, BOX 12)

2.7.4 Modification to Management Policies to Protect/Restore Cottonwoods

The following Modifications to Management Policies to Protect/Restore Cottonwoods are discussed in Appendix E:

- Land Preservation Education and Information Exchange
- Encourage Irrigation Water Management Plans to Benefit Cottonwood Stands
- Establish a Focus Group to Educate the Public about Carbon Credit Programs
- Collaborate with Established Conservation Trees Work Group
- Federal Use of Mitigation Projects to Require Cottonwood Plantings
- State Use of Mitigation Projects to Require Cottonwood Plantings

2.8 Alternatives Considered but Eliminated from Further Consideration

Additional goals and techniques were identified for cottonwood management; however, they were dismissed from further analysis because they are not consistent with the technical criteria included in the Master Manual. These goals and techniques included channel restoration activities such as implementing a flow regime outside of that delimited by technical criteria in the Master Manual, increasing sediment supply and transport, and partial or full removal of dams.

Flow regulation and channelization substantially changed the Missouri River's historic hydrologic regimes and geomorphology. The primary change was that the extreme high and extreme low flows were lost from the hydrograph downstream of each mainstem dam. Not only have high flows been reduced in many areas, but low flows have increased considerably. Therefore, the current annual hydrograph exhibits far less flow variability, specifically, in the reaches directly below the dams where the spring and summer rises no longer occur in many stretches. Flooding is important in the establishment of cottonwoods, but is absent on the historic floodplain under post-dam flow management in reaches where the channel has incised downstream of dams. In these areas, flooding now only occurs on lower surfaces or the lowest terraces. While flood deposition processes are essential to the establishment of riparian cottonwoods in the Missouri River and could provide a focus for management prescriptions aimed at maintaining riparian cottonwoods, public safety, and social and economic impacts are key considerations affecting the feasibility and implementability of such proposals.

Native plants such as the cottonwood that occupy floodplain environments have requirements that are coordinated with the natural seasonality of river flows. Therefore, the loss of the natural pattern has impeded growth and reproduction. Natural cottonwood communities thrived under dynamic hydrologic conditions. Active channel migration associated with floods created new point bars and mid-channel bars suitable for cottonwood generation (Johnson 1992; Scott et al. 1996; and Johnson 2000). Regulated flow regimes have been associated with disruption of cottonwood regeneration because of loss of geomorphologically effective flows and alteration of seasonal timing. Therefore, restoration of flow regimes has been advocated as a direct mechanism to restore cottonwood communities and was considered for this plan (Auble et al. 1994; Auble and Scott 1998; NRC 2000; NRC 2004).

A flexible flow regime could include delivering larger peak flows in the river system to restore more natural flood pulses to improve cottonwood regeneration. It has been suggested that for cottonwood recruitment and establishment to occur, the following flexible flow scenarios should occur: 1) a programmed or allowed flood, 2) a spring rise for increase flows and pulses, 3) a reduced summer flow or minimum flows, and 4) sustained fall maintenance flows or 5) ramping flows for growth. Smaller seasonal flows have also been associated with successful regeneration of cottonwoods because their timing is synchronized with the cottonwood life cycle (Mahoney and Rood 1998; Kalischuk et al 2001). Predictable floods during cottonwood seed dispersal deposit seeds at an elevation above the water surface where seedlings have sufficient soil moisture to germinate and are minimally exposed to scour by seasonal ice. Recession of spring natural floods is at a rate that allows root growth to keep pace and assure access to the water at depth.

Naturalization of the flow regime on the Lower Missouri River is highly constrained by authorized purposes and socioeconomic concerns (Jacobson and Galat 2008). While return to the full dynamics of the natural flow regime is unlikely because of the socioeconomic benefits of authorized purposes, some flexibility has been implemented recently (since 2006). In response to jeopardy biological opinions the Corps implemented bimodal spring pulsed flows specifically to support recovery of the endangered pallid sturgeon (USFWS 2003; Corps 2004; Corps 2006). The timing, magnitude, duration, rate of change, and conditions for curtailing or pro-rating the flow pulses are detailed in technical criteria. The resultant pulsed flows were determined to be within flow scenarios evaluated in the Missouri River Master Manual NEPA process, and therefore could be implemented under the Master Manual (Corps 2006). Within the Master Manual limits, specific criteria are revised annually and seasonally in accordance with system storage and downstream flow conditions. Pulsed flows are timed to prevent disruption of nesting by piping plovers and interior least terns.

Flow pulses allowed under the technical criteria are generally insufficient to transport large quantities of sand, build sandbars, and promote bank erosion; dynamic geomorphic processes that would be necessary to restore cottonwood communities to pre-regulation levels (Corps 2003). Moreover, a naturalized flow regime would not be effective in restoring dynamic geomorphic processes where banks have been stabilized and where sediment supply is limited, thereby limiting the potential geographic extent of restoration (Jacobson et al. 2009). Flow pulses under the technical criteria may be sufficient, however, to support successful germination of cottonwoods on the limited areas of new floodplain being within the banks of the pre-regulated river RM 753-811(Elliott and Jacobson 2006). Bare sandbar areas suitable for cottonwood regeneration are created to a limited extent under the prevailing flow and sediment regimes; similar sandbars could be created by mechanical means; and rare events like the 1997 flood may create extensive areas. Although discharges necessary to create extensive bare sandbar areas are not within the authorized technical criteria, variations in flow timing, sequence, and rate of decline may be possible within the limits explored in the Master Manual NEPA process. Flexible flow manipulations within those limits could be important and cost-effective in optimizing cottonwood regeneration in segment 10. The potential may exist for flow modifications that will promote cottonwood regeneration without conflicting with flows designed to promote sturgeon, piping plover, and interior least tern reproduction.

The restoration of flows within the river cannot be considered without the restoration of the sediment supply in the river as well; these two elements are not mutually exclusive, but dependent upon one another for the successful recruitment of cottonwoods in riparian areas. An increase in sediment supply would engage and enhance sandbar development. Pioneer cottonwood and willow communities would develop within the erosion zone on newly formed point bars.

Dams along the Missouri River mainstem block flow, raise water heights, inundate surrounding terrestrial habitats, and slow the velocity of flowing water in rivers (Stanley and Doyle 2003). The partial and/or full removal of the large and small dams along the Missouri River and tributaries would allow sediments and debris that would normally remain suspended in the water column to continue to move downstream instead of settling out and collecting within reservoirs. Following dam removal, riparian vegetation along reservoir margins may eventually die due to the water table decline (Shafroth et al. 2002). This mortality is accompanied by the prompt colonization of newly exposed sediments. Sediments mobilized by channel formation processes in the reservoir are transported downstream, where they settle on channel beds and banks. Because taking out dams creates "new" habitat, and because sediments are amenable to plant growth, dam removal may be a valuable tool for riparian restoration (Shafroth et al. 2002). The establishment and survival of cottonwood in the drawdown zone suggests that the particular nature of the transition from decades of continuous inundation to a terrestrial condition may leave a legacy signature in the vegetation community at least on the decades to century time scale corresponding to the lifespan of cottonwood.

In order to implement the hydrologic and geomorphic techniques for cottonwood establishment discussed above (increased flows, increased sediment, and dam removal), the Master Manual would need to be revised which would require a change in legislation. Therefore, this plan will not look at the above techniques.

2.9 Comparison Summary (Matrices/Charts)

Table 2-4 compares the impacts associated with Alternative 1, the No Action Alternative and the Action Alternatives (implementation of the CMP), Alternatives 2 and 3.

Table 2-4. Comparison of Alternatives

Resource	No Action Alternative	Alternative 2 – Implementation of the CMP with Limited Strategies	Alternative 3 (Proposed Action) – Implementation of the CMP
Physical Resources and Current Operations	• Continuation of long-term, adverse impacts to the physical resources of the Missouri River.	• No impact to physical resources and current operations.	• Long-term, beneficial impacts to the geomorphology of the Missouri River.
Sedimentation and Erosion	• Long-term, adverse impacts due to the continuation of erosion along the riverbanks. • Long-term, adverse impacts to sedimentation within the reservoirs.	• Long-term, beneficial impacts to erosion and sedimentation processes along the riverine reaches.	• Long-term, beneficial impacts to erosion and sedimentation processes along the riverine reaches.
Water Resources	• Long-term, adverse impact to hydrology and water quality due to future development along the river.	• Long-term, beneficial impact to water quality due to the control of runoff and livestock. • Short-term, minor, adverse impacts to water resources from use of pesticides.	• Long-term, beneficial impact to water quality due to the control of runoff and livestock. • Short-term, minor, adverse impacts to water resources from irrigation and use of pesticides.
Wetland and Riparian Vegetation	• Long-term, adverse impacts to vegetation due to the restriction of overbank flooding.	• Long-term, beneficial impacts to wetland and riparian vegetation due to the establishment of cottonwood trees and conservation of surface waters.	• Long-term, beneficial impacts to wetland and riparian vegetation due to the establishment of cottonwood trees and conservation of surface waters. • Long-term, beneficial impacts to vegetation due to the creation of new habitat and new cottonwood forests.

Resource	No Action Alternative	Alternative 2 – Implementation of the CMP with Limited Strategies	Alternative 3 (Proposed Action) – Implementation of the CMP
Wildlife Resources	• Long-term, adverse impact to wildlife including the bald eagle.	• Long-term, beneficial impacts to wildlife due to the preservation of existing cottonwood habitat and creation and availability of new cottonwood habitat. • Long-term, beneficial impact to the bald eagle. • Short-term, adverse impacts to rodents, ungulates, and white tailed deer that would typically feed on cottonwoods trees.	• Long-term, beneficial impacts to wildlife due to the preservation of existing cottonwood habitat and creation and availability of new cottonwood habitat and side channels, oxbow lakes, and backwater channels. • Long-term, beneficial impact to the bald eagle. • Short-term, adverse impacts to rodents, ungulates, and white tailed deer that would typically feed on cottonwoods trees.
Aquatic Resources	• Long-term, adverse impacts to aquatic resources due to the continued degradation of habitat.	• Long-term, beneficial impacts to aquatic resources due to the improvement of water quality.	• Long-term, beneficial impacts to aquatic resources due to the improvement of water quality and creation of additional habitat.
Socioeconomics	• No impacts to socioeconomics.	• Long-term, negligible impacts to the economy due to the conversion of agricultural land to conservation land. • Short-term, beneficial impacts to land owners and small businesses.	• Long-term, negligible impacts to the economy due to the conversion of agricultural land to conservation land. • Short-term, beneficial impacts to land owners and small businesses.
Cultural Resources	• No impact to cultural resources.	• Impacts would be determined with future consultation.	• Impacts would be determined with future consultation.

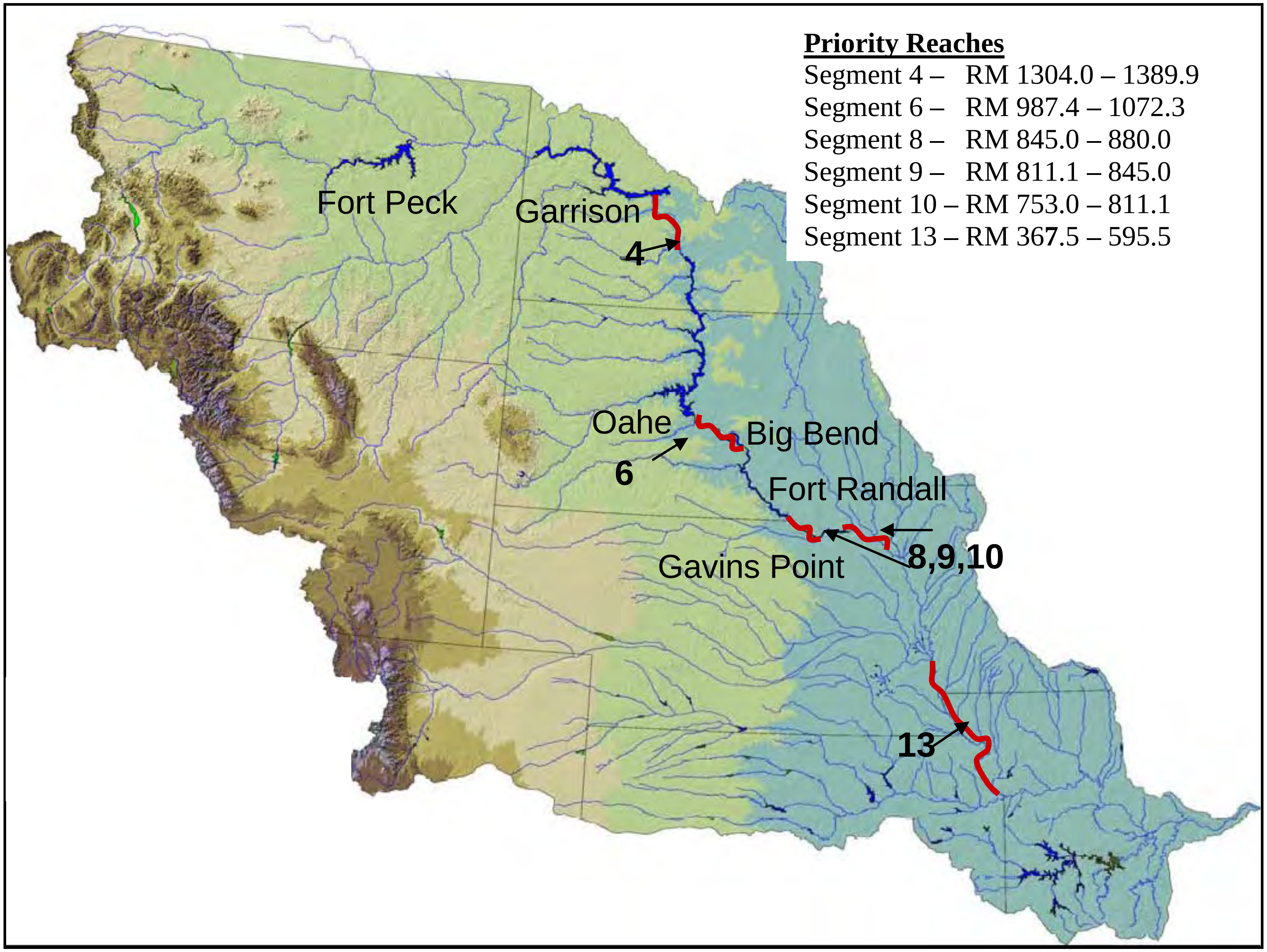
CHAPTER 3. AFFECTED ENVIRONMENT

3.1 Introduction

The study area of the overall Missouri River Restoration includes the mainstem of the Missouri River and the associated floodplains (Figure 1-1). While elements of the proposed action and alternatives are located throughout the entire Missouri River Basin and the mainstem, the intent of the Cottonwood Management Plan is to concentrate on improving habitat conditions in six priority river segments of the Missouri River, as defined by the USFWS in the 2003 Amended Biological Opinion (USFWS 2003) (Figure 3-1). Therefore, existing conditions are described based on priority river segments when information is available, otherwise the existing conditions are generally described for the entire Missouri River.

The following description of environmental conditions provides a general understanding of planning issues and establishes a broad benchmark against which the magnitude of potential environmental impacts of the alternatives can be assessed. The *Missouri River Final Environmental Impact Statement*, *Master Manual Review and Update* is the primary source of the description of existing environmental conditions (Corps 2004a).

Figure 3-1. USFWS Priority River Segments Identified in the 2003 Amended BiOp.



3.1.1 Missouri River

The Missouri River drains one-sixth of the United States and encompasses 529,350 square miles, including 9,700 square miles in Canada (USFWS 2000a). It flows approximately 2,341 miles from its headwaters at the confluence of the Gallatin, Madison, and Jefferson Rivers in the Rocky Mountains at Three Forks, Montana, to its confluence with the Mississippi River at St. Louis, Missouri. The primary tributaries are the Yellowstone, Marias, Niobrara, James, Platte, and Kansas Rivers (USFWS 2000a). It has been estimated that 35 percent of the Missouri River is currently impounded, 32 percent has been channelized, and 33 percent is unchannelized (MRNRC undated, circa 1999).

Areas upstream of the dams in Montana (above RM 1882.7) are the least-impacted portion of the Missouri River. Areas downstream of Montana include the six federal, mainstem reservoirs that have submerged about a third of the former river under permanent pools (Berry and Young 2001). Remnants of the former river exist below some of the dams, but are subject to highly modified flow regimes. Areas of the river south of Sioux City, Iowa consist largely of a constricted, rock-lined, single channel (Berry and Young 2001). The primary authorization is to maintain a 9-ft deep by 300-ft wide navigation channel from Sioux City to the mouth, and secondary authorizations include the stabilization of the river banks. Empirical physical and hydrological data suggests that the river north of Sioux City is characterized by low velocity, shallow and deep depths and clear water, while areas south of Sioux City has high velocity, deep depth, and poor water clarity (Berry and Young 2001).

3.2 Physical Resources and Current Operations

The Missouri River Basin drains four physiographic provinces, including the Rocky Mountain System, Great Plains, Central Lowlands, and Interior Highlands Provinces (Berry and Young 2001). Seventy-one percent of the Missouri River basin is largely in the semi-arid Great Plains physiographic province. Parts of the basin are in three other provinces: 11 percent in the Rocky Mountains (western basin), 17 percent in the Central Lowlands (eastern and lower basin), and about 2 percent in the Interior Highlands (south, lower basin). Average annual precipitation is about 17 inches in the Great Plains, about 31 inches in the Rocky Mountains, and over 35 inches in the Interior Highlands. Tributary water quality and quantity differ among provinces, and influence conditions in the mainstem of the Missouri River (Berry and Young 2001). The basin’s elevation drops from 14,000-ft at its northwestern boundary to about 400 ft where it meets the Mississippi River (MRNRC undated, circa 1999).

The riverine reaches north of Sioux City are relatively sinuous and semi-braided, and have retained many of the islands, backwaters, and side channels characteristic of pre-dam geomorphology. There is little overbank flooding and sediment deposition in the reaches resulting in channel degradation and greatly reduced rates of island and sandbar creation. The construction of dikes and levees south of Sioux City provided a narrow, sinuous channel with few islands, backwaters, or side channels (Hallberg et al. 1979; Kallemeyn and Novotny 1977 as stated in Corps 2004a). As a consequence of channel work and bed degradation, drainage has improved on the floodplain and accreted lands have been reclaimed for agricultural purposes. Only a few oxbow lakes and isolated backwaters remain, passively maintained by groundwater seepage or surface inflow, or actively maintained by pumping of groundwater or surface water. Although still important resources, the separation of these isolated oxbows and backwaters from the river channel has reduced their functional value as habitat.

Priority River Segments

Segment 4 (Garrison Dam to Lake Oahe Headwaters near Bismarck, North Dakota) – RM 1389.9 to 1304.0 (Figure 3-2)

Segment 4 is limited upstream by Garrison Dam and downstream by Lake Oahe. Garrison Dam is located at RM 1390 in central North Dakota. The earth-filled dam is 11,300 ft long and 180 ft high. Within this reach, the river is restricted to one main channel with very few side channels, old channels, or oxbow lakes. Significant tributaries include the Knife River near Stanton, North Dakota, and the Heart River just upstream of the Lake Oahe delta and downstream of Mandan, North Dakota.

Segment 6 (Oahe Dam to Big Bend Dam, including Lake Sharpe) - RM 1072.3 - RM 987.4 (Figure 3-3)

This river segment is relatively straight and confined to one channel. Oahe Dam is located at RM 1072 near Pierre, South Dakota. The earth-filled Oahe Dam is 9,300 ft long, excluding the spillway, and 200 ft high.

Big Bend Dam is located at RM 987 in central South Dakota. Big Bend Dam is also an earth-filled dam and 10,570 ft long and 78 ft high. Lake Sharpe is 80 miles long and covers 61,000 acres when full. Its gross capacity is 1.9 million acre feet (MAF). The 8-unit power plant produces 1.1 billion kilowatt hour (kWh) per year. Because Lake Sharpe is so close to Oahe Dam, it receives very little sediment inflow from the mainstem of the Missouri River; however, a delta formed by sediment from the Bad River, a major right-bank tributary, extends from Pierre (RM 1067) to the DeGrey area (RM 1037). In addition, there are smaller deltas associated with several tributary creeks. Lake Sharpe remains at a nearly constant pool elevation, even in drought periods.

Segment 8 (Fort Randall Dam to Niobrara River) – RM 880.0 to 845.0 (Figure 3-4)

Segment 8 is limited upstream by Fort Randall Dam and downstream by Lewis and Clark Lake. Fort Randall Dam is located at RM 880 in southeastern South Dakota. Fort Randall Dam is an earth-filled dam 10,700 ft long and 140 ft high. The 36 miles of river from Fort Randall Dam (RM 880) to the Lewis and Clark Lake delta/Niobrara River (RM 844) is designated as the MNRR under the Wild and Scenic Rivers Act (WSRA) because of the relatively undeveloped, scenic beauty (Berry and Young 2001). The banks along this river segment tend to restrict flow to one main channel.

Segment 9 (Niobrara River to Lewis and Clark Lake, including Lewis and Clark Lake) - RM 845.0 - RM 811.1 (Figure 3-4)

There are a few side channels and backwaters at the lower end of the Lewis and Clark Lake delta. The Missouri and Niobrara Rivers annually contribute sediment to Lewis and Clark Lake creating a delta that currently extends from near Verdel, Nebraska (RM 844), to about 3 miles downstream of Springfield, South Dakota (RM 833). The Niobrara River is responsible for approximately 60 percent of the sediment input. Physical attributes of Segment 9 from the

Niobrara River downstream to the headwaters of Lewis and Clark Lake (RM 845 to 825) include a confluence with a major tributary, aggrading stream bed, and turbidity (Drobish 2005).

The Lewis and Clark Lake is currently 18 miles long due to the delta encroachment on the open lake and covers 31,000 acres when full. Its total capacity is 0.5 MAF. The 3-unit power plant produces 0.7 billion kWh of energy per year. Construction began in 1952, and the project was operational in 1955. Power generating units came on line in 1956 and 1957.

Segment 10 (Gavins Point Dam to Ponca, Nebraska) – RM 811.1 - RM 753.0 (Figure 3-5)
Gavins Point Dam is located at RM 811 on the Nebraska-South Dakota border near Yankton, South Dakota. Gavins Point Dam is an earth- and chalk-filled dam 8,700 ft long and 45 ft high. Downstream of Gavins Point Dam, the Missouri River flows un-impounded to its mouth. The 58-mile stretch of river between Gavins Point Dam (RM 810) and Ponca (RM 753) is designated as the MNRR under the WSRA. It is also the only river segment downstream of Gavins Point Dam that has not been channelized by dikes and revetments. This portion of the river is a meandering channel with many chutes, sandbars, islands, and variable current velocities. Snags and deep pools are also common. Although this portion of the river includes bank stabilization structures, the river remains fairly wide. Because river sediment is captured above Gavins Point Dam, extensive bed degradation has occurred in the river below the dam. Gradual armoring of the riverbed has reduced the rate of channel degradation. Approximately 27 percent of the banks have been stabilized to curtail erosion. Channel degradation and siltation of shallow areas have contributed to the loss of marshes, backwaters, and chute habitats. However, the Gavins Point reach resembles the natural river more than any other reach.

Segment 13 (Platte River to Kansas City, Missouri) – RM 595.5 - RM 367.5 (Figure 3-6)
This river segment has been modified over its entire length by an intricate system of dikes and revetments designed to provide a continuous navigation channel without the use of locks and dams. This channel is an authorized federal channel by the Corps. Authorized channel dimensions are achieved through supplementary releases from the large upstream reservoirs and occasional dredging and maintenance. The lowest velocities are found in eddies that form behind dikes, occasionally in front of the next downstream dike, and along channel margins, particularly on the inside of bends in the river.

Figure 3-2. Segment 4 (Garrison Dam to Lake Oahe – RM 1389.9 to RM 1304.0)

Figure 3-3. Segment 6 (Oahe Dam to Lake Sharpe – RM 1072.3 to RM 1067 and Lake Sharpe – RM 1067 to 987.4)

Figure 3-4. Segment 8 (Fort Randall Dam to Niobrara River – RM 880.0 to 845.0) and Segment 9 (Niobrara River to Lewis and Clark Lake Delta – RM 845.0 to 811.1)

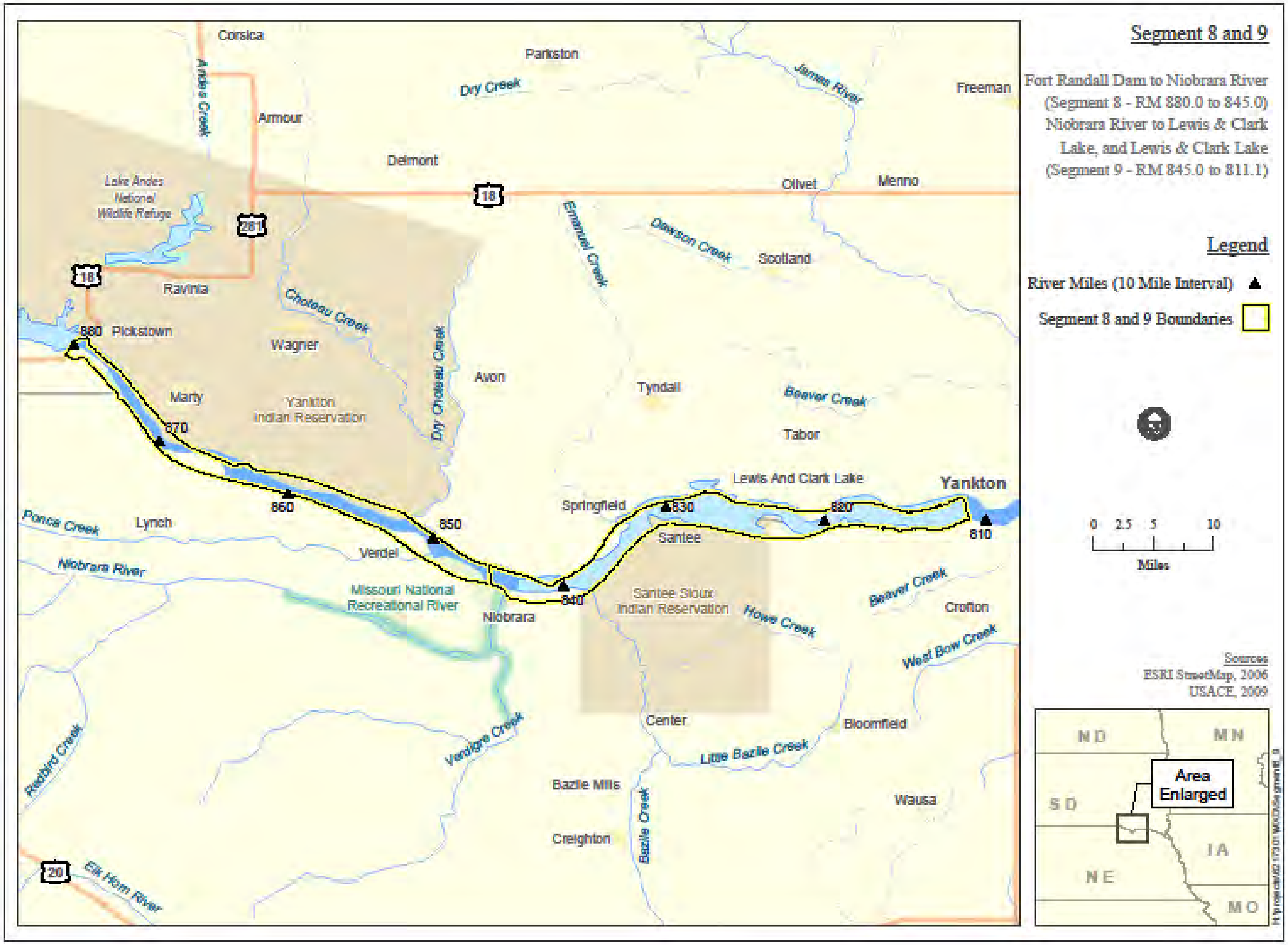


Figure 3-5. Segment 10 (Gavins Point Dam to Ponca, Nebraska – RM 811.1 to 753.0)

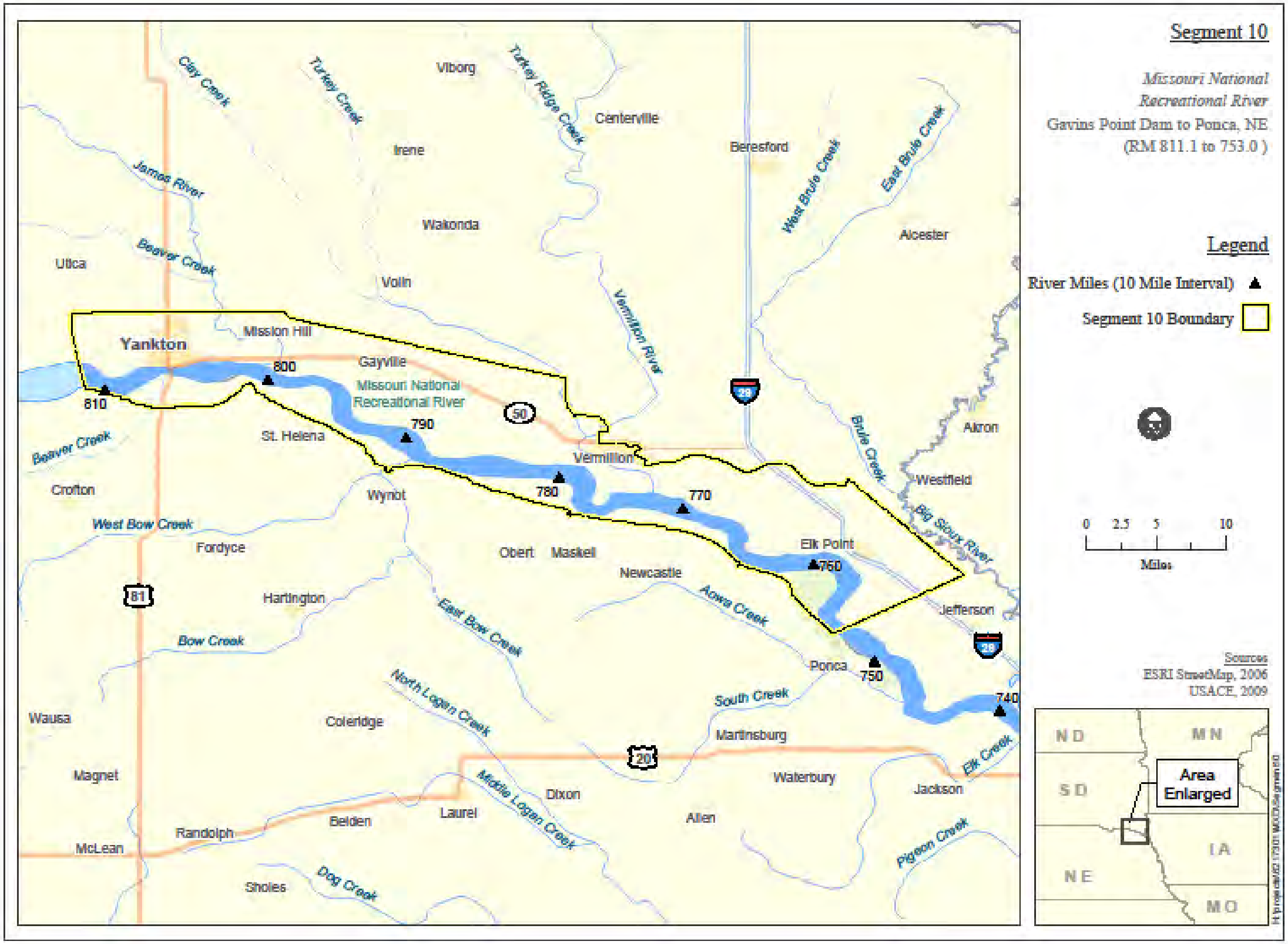
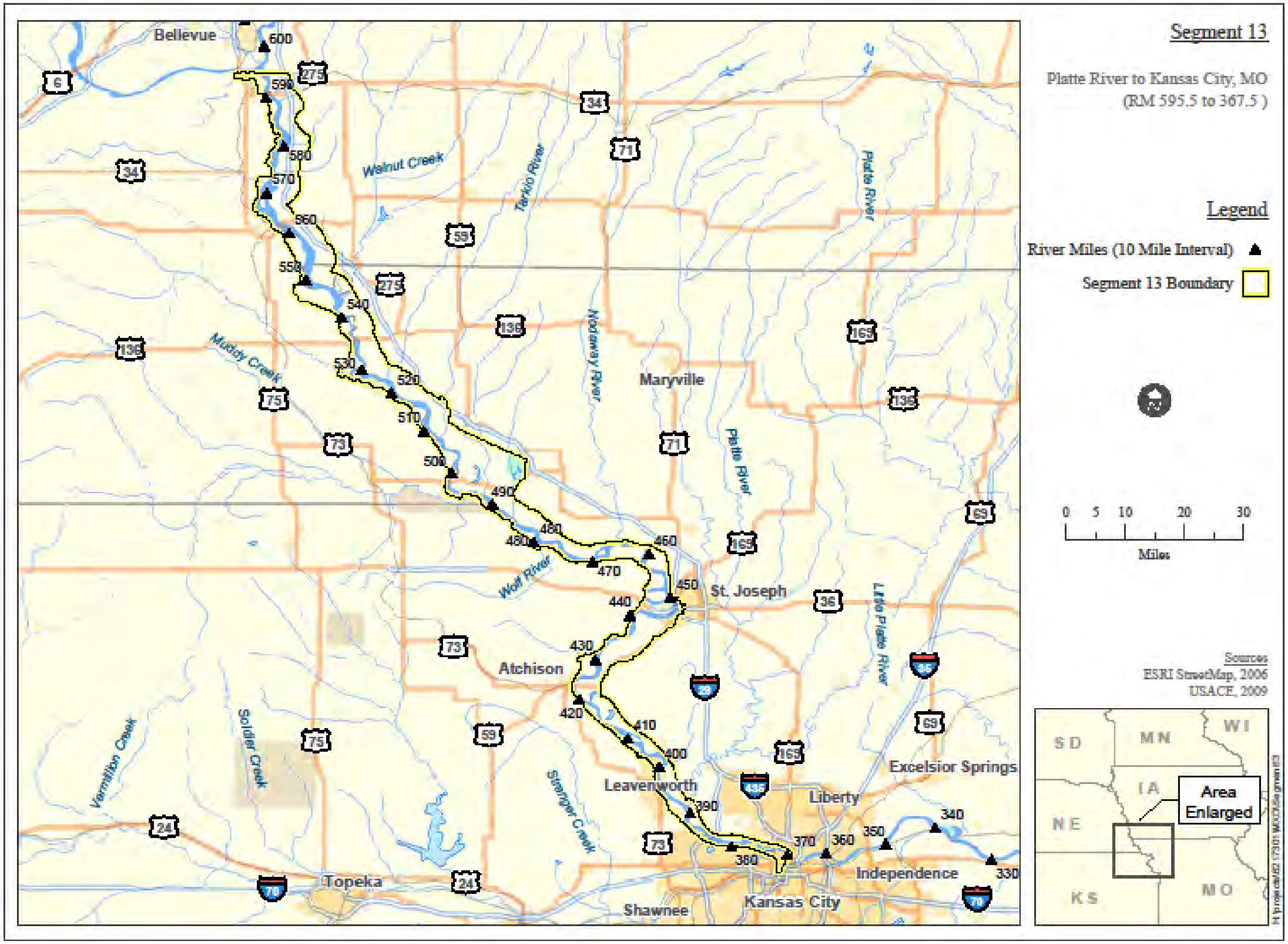


Figure 3-6. Segment 13 (Platte River to Kansas City, Missouri – RM 595.5 to 367.5)



3.3 Sedimentation and Erosion

All priority segments are located in the Great Plains portion of the Missouri River basin, where the slope is generally gentle. Land surface is a mixture of glacial material, river sediments, and wind-blown sediment. Soils are a mixture of clay, silt, sands, and gravels. Bedrock is generally composed of shales and sandstones. Because of these soil features, shorelines and the bottoms of lakes and river reaches are highly erodible. Water action from waves, currents, and ice breakup and freezeup cause erosion.

Shoreline and riverbank erosion continue to cause a threat to the establishment of cottonwood communities. The riverine reaches of the Missouri River and its tributaries flow through highly erodible sediments. Sediments from upstream and tributary sources are deposited in the upper ends of the reservoirs. As a result, the channels below the dams are subject to erosion as the clear water released from each dam picks up sediment and transports it downstream. This process results in a deepening and progressive armoring of the riverbed. Missouri River channel degradation has contributed to head cutting not only at the mouths of tributaries, but also up many of the tributaries. This head cutting has led to increased erosion, aquatic habitat degradation, reduced fish access up some of the impacted tributaries, and increased public expenditures to maintain infrastructure. Without overbank and sediment-laden flows, new high banks are not formed in the reaches immediately below the dams. Fewer flood flows have led to less erosion of the banks and sandbars.

The mainstem reservoirs act as catchment basins for the sediment loads carried by the Missouri River. Approximately 0.09 MAF of sediment enters the mainstem reservoirs annually. The loss of storage capacity to date is about 5 percent of the total system capacity. Sediment is deposited slightly below the prevailing pool level. All six mainstem lakes have large deltas formed at their headwaters. These large sediment deposits continue to grow, although they are confined to the upper reaches of each reservoir or to its tributary arms.

In general, downstream from Omaha (RM 595), tributaries provide a sufficient level of coarse sediments to limit riverbed erosion, but degradation continues to be a problem in isolated locations. One of these locations is the Kansas City reach. Where degradation occurs, water levels decline, thus affecting resources, such as wetlands, along the river that depend on a water source from the river. Non-flood flows and degradation mean less formation of river-dependent water bodies, such as oxbow lakes. Erosion of the channel bed may also lead to additional bankline erosion in areas where the banks are unprotected. The mouths of tributaries are also susceptible to degradation where the main river's channel has been degraded.

Priority River Segments

Segment 4 (Garrison Dam to Lake Oahe Headwaters near Bismarck, North Dakota) – RM 1389.9 to 1304.0 (Figure 3-2)

Degradation of the riverbed below Garrison Dam (RM 1390) occurs primarily in the first 35 miles below the dam. Grain size has increased over the years in the 25 miles below Garrison Dam, indicating a gradual armoring of the channel. The riverbed 25 to 50 miles below the dam continues to degrade. Little or no new accretion has occurred after 1953 because flood peaks were eliminated or reduced by the flood control capacity of the upstream mainstem reservoirs.

Segment 6 (Oahe Dam to Big Bend Dam, including Lake Sharpe) - RM 1072.3 - RM 987.4 (Figure 3-3)

From Oahe Dam to Lake Sharpe, the tailwater of Oahe Dam declined less than 1 foot in elevation through 1982. It has since been relatively stable. Bank erosion is not a problem because protective measures have been constructed.

Wind-driven waves and ice along the mainstem reservoirs have created a pattern of systemic bank erosion and shoreline recession that dumps acres of silt into the water annually. At Lower Brule Sioux Reservation, for example, the average loss ranges from 8 to 12 feet of shoreline a year. This pattern has created a dead zone of eroding cliffs and wave-washed beaches that prevents the redevelopment of a riparian habitat suitable for the growth of cottonwoods and other river species.

Lake Sharpe sediment deposition begins in the upper end of the lake at RM 1062, 10 miles below Oahe Dam and extends downstream to RM 1020, 37 miles above Big Bend Dam. Within this reach, the Bad River is the major source of sediment. Deposition is estimated to be about 4 thousand-acre feet (KAF) per year. Loss of capacity has been limited to about 8 percent of the permanent pool. The cities of Pierre and Fort Pierre, South Dakota, located on opposite sides of the river near the mouth of the Bad River, are within the deposition reach. Both communities experience a high water table and risk flooding due to the decrease in the channel capacity.

Segment 8 (Fort Randall Dam to Niobrara River) – RM 880.0 to 845.0 (Figure 3-4)

The tailwater area of Fort Randall Dam from RM 880 to 860 has experienced up to 6 ft of degradation of the bed and widening of the channel from 1953 to 1986. The rate of erosion has decreased over this period. Streambank erosion since closure of the dam in 1953 has averaged about 40 acres per year compared to a pre-dam rate of 135 acres per year. The river has coarser bed material above than below RM 870, indicating some armoring of the channel below the dam. Less erosion of the bed and streambanks occurs downstream from the tailwater area.

Segment 9 (Niobrara River to Lewis and Clark Lake, including Lewis and Clark Lake) - RM 845.0 - RM 811.1 (Figure 3-4)

At the mouth of the Niobrara River (RM 843.5), a delta of sediment has built up near the Ponca Tribal Lands and Santee Sioux Tribal Lands. The delta has formed as a result of the lack of large flood flows to transport sediment downstream. Sediment is deposited in the Lewis and Clark Lake delta from the mouth of the Niobrara River downstream to RM 827. Over half of the sediment comes from the Niobrara River.

Segment 10 (Gavins Point Dam to Ponca, Nebraska) – RM 811.1 - RM 753.0 (Figure 3-5)

There has been a gradual erosion of the riverbed below Gavins Point Dam to Ponca, Nebraska, since 1955. The extent of erosion is highest (about 10 ft) in the reach immediately below the dam. The bed material in this reach has also become progressively coarser than in the lower reach, thus indicating gradual armoring of the channel bed over time. The rate of riverbed erosion has diminished since 1980. Streambank erosion has also occurred below Gavins Point

Dam. The rate of erosion declined after 1955. Rates of erosion since closure in 1956 have averaged 157 acres per year between Gavins Point Dam and Ponca State Park, compared to a pre-dam rate of 202 acres per year. Rates of erosion have declined somewhat since 1975. Streambank erosion problems are generally confined to the river above Ponca because the banks are stabilized below Ponca (RM 753).

Segment 13 (Platte River to Kansas City, Missouri) – RM 595.5 - RM 367.5 (Figure 3-6)
Except at Kansas City, coarse materials from the tributaries downstream from Omaha keep most of the downstream reaches of the Missouri River from degrading.

3.4 Water Resources

Differing weather patterns and the resulting runoff in the basin are the primary factors governing the amount of water in storage and the release of water from the mainstem reservoirs. The broad range in latitude, longitude, and elevation of the Missouri River basin and its location near the geographical center of the North American continent result in a wide variation in climatic conditions. Average annual precipitation ranges from as little as 8 inches in the northern Great Plains to as much as 40 inches in the higher elevations of the Rocky Mountains and in the southeastern portion of the basin. Floods occur on the Missouri River and its tributaries most often in the late spring during the snowmelt season, but floods can also occur during occasional high summer or fall rainfall levels. The basin is also marked by periods of drought, most notably the nearly decade-long droughts of the 1930s and 1950s, and the drought from 1987 to 1993.

Total annual runoff varies considerably from year to year due to large variations in precipitation. Runoff, as measured at Sioux City with adjustments for depletions, has varied from a low of about 11 MAF per year to nearly 50 MAF per year over the period of record from 1898 to 1997. The median runoff at Sioux City is 24.6 MAF. About 30 percent of the runoff enters above Fort Peck Dam, 45 percent enters between Fort Peck and Garrison Dams, about 9 percent enters between Garrison and Oahe Dams, 4 percent enters between Oahe and Fort Randall Dams, 6 percent enters between Fort Randall and Gavins Point Dams, and 6 percent enters between Gavins Point and Sioux City. Runoff from below Sioux City to St. Louis averages about 41 MAF (1898 through 1997), which accounts for 63 percent of the runoff in the basin. From August 1992 to July 1993, runoff above Sioux City was 31.1 MAF, while runoff below Sioux City was 85.8 MAF. The runoff below Sioux City was 209 percent of normal and reflected the beginning of the "Great Flood of 1993."

The objective of System flood control is to regulate the mainstem lakes to prevent Missouri River flows from contributing to flood damage in the reaches downstream from dams. Regulation of individual lakes is coordinated to prevent damaging releases from a particular lake. Movement of water through the System is controlled by demands on storage and depletions. Runoff is stored temporarily in the mainstem reservoirs and released throughout the year. The amount of water in storage usually peaks in July and then declines until late in winter when the cycle begins again. Multiyear droughts cause smaller runoff volumes and gradually declining water levels in the lakes. Flood control is typically accomplished by storing peak flows of the plains snowmelt and rainfall season from late February to April and the mountain snowmelt and rainfall period from May through July. Regulation provided by the six mainstem lakes and by upper basin tributary reservoirs has nearly eliminated flood flows on the Missouri River from Fort Peck Dam downstream to the mouth of the Platte River below Omaha. Below the Platte River, flood flows still occur due to high local precipitation and runoff from downstream uncontrolled tributaries.

Priority River Segments

Segment 4 (Garrison Dam to Lake Oahe Headwaters near Bismarck, North Dakota) – RM 1389.9 to 1304.0 (Figure 3-2)

Under the current water control program, releases from Garrison Dam are generally lowest in the spring and fall and highest in the summer and winter. Releases in non-flood periods may reach 40 thousand cubic feet per second (kcfs), while minimum daily average releases may be as low as 9 to 10 kcfs. Monthly average releases from Garrison Dam, normally in the range of 18 to 22 kcfs in December, are usually increased to the 22 to 30 kcfs range in January and February to accommodate peak power demands and help balance the water in the system. Releases are normally reduced to about 20 kcfs by mid-March as the demand for power declines. In drought periods like the 1987 to 1993 drought, winter releases may be cut back in March and April to 10 to 15 kcfs to conserve water. In the spring and fall, average monthly releases during droughts are also limited to 10 to 15 kcfs, the minimum level necessary to provide hydropower and to protect water supply intakes, water quality, irrigation needs, recreation, and fish and wildlife.

To discourage terns and plovers from nesting near the water during the mid-May through August nesting period, daily releases are usually fixed at a constant rate in the 19- to 26-kcfs range with hourly peaking limited to 6 hours a day near 30 kcfs. This encourages the birds to nest at higher island elevations where the nests are less vulnerable to inundation from late summer higher daily average navigation releases. During large system inflow years, large flood control evacuation release rates are necessary and nesting flow restrictions are lifted.

Flood Control – The reach extending from Garrison Dam to Lake Oahe Dam contains 34,600 acres of agricultural land subject to flooding (Table 3-1). For flood damage estimating, the value of wheat was assigned to this land. There are 3,500 residential buildings subject to flooding along this reach, with a total building and contents value of $312 million. There are 260 nonresidential buildings with a total value of $580 million. The area most subject to flooding is near Bismarck, North Dakota.

Table 3-1. Agricultural Acres and Crop Distribution Subject to Flooding by River Segment

Reach	River Segment	Agricultural Acres	Crop Distribution (percent)		
			Corn	Soybeans	Wheat
Garrison	Segment 4	34,600	0	0	100
Big Bend	Segment 6	0	0	0	0
Fort Randall	Segments 8 and 9	2,200	28	17	55
Gavins Point	Segment 10	1,900	28	17	55
Omaha to Kansas City	Segment 13	664,500	50	50	0

Source: from Corps 1998 as stated in Corps 2004a

Segment 6 (Oahe Dam to Big Bend Dam, including Lake Sharpe) - RM 1072.3 - RM 987.4 (Figure 3-3)

Oahe Dam water releases have a seasonal pattern. During the navigation season, water releases generally range from 22 to 34 kcfs to meet downstream demands for navigation, but flows may be higher or lower during floods or droughts. During the fall, releases from Oahe Dam are reduced to 22 to 30 kcfs to provide capacity in Lake Francis Case for winter releases from Oahe used to generate power. Hourly releases fluctuate from 0 to 58 kcfs for peaking power generation. Winter releases average 20 to 30 kcfs in non-drought years and 15 to 20 kcfs in drought years. There is no minimum release requirement from Oahe Dam, although weekend releases of 3 kcfs are provided during the daytime hours of the recreational fishing season. The channel capacity below Oahe Dam is approximately 60 kcfs for open-water conditions but may be as low as 25 kcfs under severe winter ice conditions.

Flood Control – The reach extending from Oahe Dam to Big Bend Dam does not contain any agricultural land subject to flooding (Table 3-1). There are 271 residential buildings subject to flooding along this reach, with a total building and contents value of $24 million. There are nine nonresidential buildings with a total value of $3 million. The areas most likely to flood are Pierre and Fort Pierre, South Dakota.

Segment 8 (Fort Randall Dam to Niobrara River) – RM 880.0 to RM 845.0 (Figure 3-4)

Releases from Fort Randall Dam vary considerably during the year and these fluctuations cause bank erosion and affect water intakes. Maximum hourly releases for hydropower generation are 45 kcfs. The minimum hourly release is zero kcfs, except during the spring game fish spawning season, when the desired minimum hourly release is 15 to 20 kcfs. In the navigation season, spring through fall monthly average releases are usually 20 to 36 kcfs to meet navigation targets downstream. During extended droughts, spring through fall, monthly average releases may drop to as low as 3 to 15 kcfs, even in years when navigation is supported. Monthly average releases may also drop to 3 to 15 kcfs if there is too much water downstream, as occurs during flood years. In winter, releases are generally kept in the 8 to 17 kcfs range to meet non-navigation service levels downstream. At above-normal storage levels, winter releases are typically about 18 kcfs or even higher following large floods. During drought years, winter releases are generally 8 to 10 kcfs.

During the mid-May to mid-August nesting season of terns and plovers, hourly releases are increased to 36 kcfs for 6 hours to encourage the birds to nest at higher island elevations where the nests are less vulnerable to inundation from late summer higher daily average navigation releases. This peak release permits average daily releases to be increased as needed to continue to meet the navigation requirements when the inflows from tributaries to the river decrease. The 36 kcfs peak is less than power plant capacity. During large system inflow years, large flood control evacuation rates are necessary and nesting flow restrictions are lifted. There is also a 15 to 20 kcfs hourly minimum flow to protect fish spawning from mid-April through June.

Flood Control – The reach extending from Fort Randall Dam to Gavins Point Dam contains 2,200 acres of agricultural land subject to flooding (Table 3-1). Corn and soybeans are the primary crops grown on this land. There are 62 residential buildings subject to flooding along this reach, with a total building and contents value of $6 million. There are four nonresidential buildings with a total value of $1 million.

<u>Segment 9 (Niobrara River to Lewis and Clark Lake, including Lewis and Clark Lake) - RM 845.0 - RM 811.1 (Figure 3-4)</u>
Lewis and Clark Lake water elevation and storage levels vary little within and between years. The water level is drawn down from elevation 1,207 ft toward the base of the annual flood control and multiple use zone (elevation 1,204.5 ft) of each spring and the lake is allowed to fill before fall into the flood control and multiple use zone. The lake is operated at elevation 1,206 ft during the tern and plover nesting season and it is allowed to rise to elevation 1,207 ft just before each fall.

Flood Control – The reach extending from Fort Randall Dam to Gavins Point Dam is discussed in the section above.

<u>Segment 10 (Gavins Point Dam to Ponca, Nebraska) – RM 811.1 - RM 753.0 (Figure 3-5)</u>
Releases from Gavins Point Dam generally fall into three categories: navigation, flood control, and non-navigation releases. In the navigation season, which generally runs from April 1 through November 30 at the mouth, releases from Gavins Point Dam are generally 25 to 35 kcfs. In the winter, releases are in the 10 to 20 kcfs range. In wet years with above-normal upstream inflows, releases are higher to evacuate flood control storage space in upstream reservoirs. Maximum winter releases are generally kept below 24 kcfs to minimize downstream flooding problems caused by ice jams in the river.

During the 1987 to 1993 drought, summer release restrictions at Gavins Point Dam for the protection of terns and plovers resulted in not always meeting Nebraska City and Kansas City targets during August. Conversely, when the system water supply is unusually large, as in 1996 and 1997, service levels for the orderly evacuation of stored flood waters take precedence over nesting birds. Consequently, release rates from Gavins Point Dam may have to be increased to as much as 25 kcfs over and above full-service navigation flows during nesting.

Flood Control – The reach extending downstream from Gavins Point Dam to Sioux City contains 1,900 acres of agricultural land subject to flooding (Table 3-1). Corn and soybeans are the primary crops grown on this land. There are 3,705 residential buildings subject to flooding along this reach, with a total building and contents value of $254 million. There are 343 nonresidential buildings with a total value of $131 million.

<u>Segment 13 (Platte River to Kansas City, Missouri) – RM 595.5 - RM 367.5 (Figure 3-6)</u>
Full-service navigation releases from Gavins Point Dam are dependent on the demand for water at downstream navigation target points at Sioux City, Omaha, Nebraska City, and Kansas City. Operating experience since 1967 has demonstrated that flow rates of 31 kcfs at Sioux City and Omaha, 37 kcfs at Nebraska City, and 41 kcfs at Kansas City are sufficient to maintain the 9 by 300 ft navigation channel. Generally, an average navigation season release of 35 kcfs at Gavins Point Dam will provide downstream flows necessary for full service. If downstream tributary inflow above Kansas City is abnormally low, then additional water must be released from Gavins Point Dam to meet the 41 kcfs target at Kansas City. If downstream tributary inflows are high,

then the flow target at Sioux City will determine the system release rate. When system storage is low, less than full service is provided by lowering target flows by up to 6 kcfs (minimum service). In extended droughts when navigation has ended or during floods, releases may be reduced to 9 kcfs or less.

Flood Control **–** The Platte River to Kansas City reach contains 360,200 acres of agricultural land subject to flooding (Table 3-1). Corn and soybeans are the primary crops grown on this land. There are 2,168 residential buildings subject to flooding along this reach, with a total building and contents value of $95 million. There are 486 nonresidential buildings with a total value of $1.5 billion. Below the Platte River, flood control protection from the mainstem projects declines because of increased tributary inflow. In 1993, the stage at Nebraska City reached 9.2 ft above flood stage compared to the 12.2 ft above flood stage it would have reached without the projects.

3.5 Biological Resources

3.5.1 Ecology of the Cottonwoods

Cottonwood forests were historically a major component of the floodplain of the Missouri and other Great Plains rivers. Floods maintained the ecological health of these forests by providing moisture to sustain the growth of trees and wetland plants, depositing fine sediments and nutrients that enhance the fertility of floodplain soils, stimulating decomposition of leaves and woody debris, dispersing seeds of floodplain trees, and forming sediment bars that provide seedbeds for establishing new cottonwood and willow stands. In the absence of flooding and river channel migration, establishment of new cottonwood stands along meandering rivers declines, with existing cottonwood stands aging and eventually being replaced by later-successional species such as ash, elm, and box elder (Johnson et al. 1976; Johnson 1992).

Establishment of cottonwood seedlings is generally restricted to bare, moist sites protected from intense physical disturbance. These areas are typically found along the riverine reaches of the Missouri River. Three fluvial geomorphic processes including channel narrowing, channel meandering, and flood deposition, are important in producing sites suitable for establishment of cottonwoods from seeds. These processes may act alone or in combination at any given site. Their relative importance depends upon geologic and climatic factors, including flow variability, sediment load, and stream gradient (Scott et al. 1997). Cottonwood forest regeneration currently appears largely restricted to narrow shoreline zones or the upstream end of deltas.

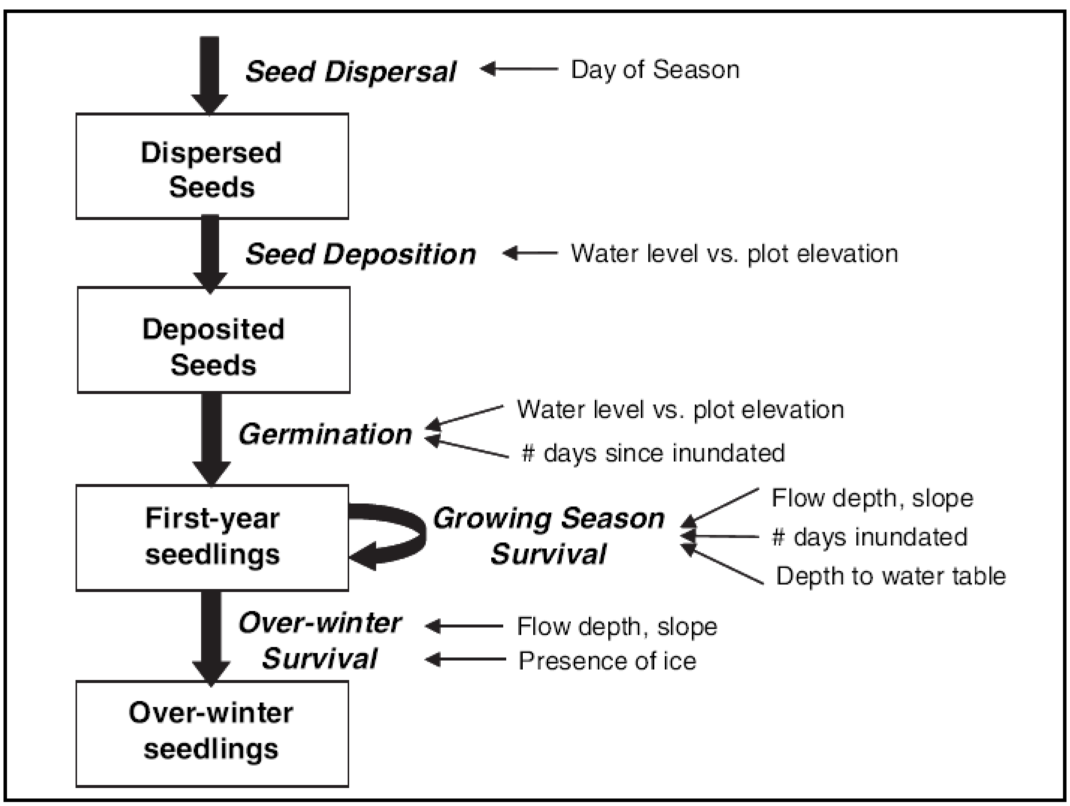
Channel narrowing involves stream abandonment of a portion of the former channel bed. This includes reduction in width of a single channel or loss of flow in one or more channels of a multiple-channel stream. Cottonwood trees established during channel narrowing are often not even-aged, since establishment could occur at any time within the period of relatively low flow. Stands usually have an irregular shape, with the longest axis parallel to the direction of flow. The establishment point of trees is low, at the elevation of the channel bed at the time the surface was abandoned by the stream (Scott et al. 1997).

Meandering channels are generally characterized by low flow variability, low gradient, low width/depth ratio, and a sediment load dominated by silt and clay. Conditions suitable for establishment occur on portions of the point bar that are sufficiently moist and safe from riverine disturbance (Scott et al. 1997). Sediment accretion and movement of the channel away from the point bar protect vegetation from flood disturbance and ice scour. Stands produced by channel meandering typically exhibit arcuate bands of even-aged trees oriented parallel to the flow at the time of establishment (Scott et al. 1997). These bands form relatively frequently, and each band occupies a small portion of the floodplain. The establishment point of these trees is at the moderate elevation of the point bar: above the channel bed but below the surface of the flood plain (Scott et al. 1997).

Floods can produce tree establishment by creating bare, moist deposits high enough above the channel bed to minimize future flow-or ice-related disturbance. Trees established on flood deposits along constrained channels occur as even-aged stands oriented along the direction of flood flow. The establishment point is high relative to the channel bed, and close to the present floodplain surface (Scott et al. 1997).

The Modified Recruitment Box Model (Figure 3-7) is an integrative model that defines the stream stage patterns that enable establishment if cottonwood seedlings (Mahoney and Rood 1998). The model is quantitative in nature and describes the streambank elevation and timing of stream stage patterns that are required for successful cottonwood recruitment.

Figure 3-7. Modified Recruitment Box Model Structure and Important Variables



(Source: Dixon and Turner 2006)

Cottonwood forests provide important roosting and nesting habitat for many birds including song birds, woodpeckers, and bald eagles. Fallen cottonwood trees into the river and backwater also create habitat for fish and macroinvertebrates.

Biologists are concerned about the future of cottonwood forests along the Missouri River and the bird species that depend on them. Most of the cottonwoods along the upper part of the river began growing before the dams were built. The river's dams have eliminated the natural flooding regime and extensively reduced the creation of areas of bare, moist soil, which provide ideal conditions for new cottonwoods to grow. The decreased frequency of overbank flooding, perhaps compounded by lowered water tables, is probably causing the reduced cottonwood vigor, branch loss, and high mortality observed in mature riparian forests. Moisture conditions resulting from the reduced frequency of spring flooding and lowered water table are likely contributing to stress already occurring as a consequence of the advanced age of most cottonwood stands. Cottonwood forests are forecast to be replaced by those dominated by green ash, box elder, and other late successional species (Johnson 1992). These future riparian forests are likely to be considerably lower in tree and bird diversity primarily because of the loss of pioneer plant species, loss of vertical structural complexity, and the loss of nesting cavities found mostly in old cottonwood trees (Johnson 1992; Rumble and Gobeille 2004). Smaller tree species support a lower diversity of bird species than tall cottonwoods. Studies have shown that cottonwood woodlands support more cavity nesting birds (i.e., woodpeckers) than green ash, juniper (*Juniperus* sp.), or bur oak woodlands. Cottonwood woodlands also have a greater diversity of bird species than shelterbelt plantings, which are rows of trees planted near farmsteads (MRRP 2007).

In 2007 through 2009 Dr. Dixon and colleagues conducted a vegetative survey of all priority segments. The overall goal of this project is to assess the current status of cottonwood forests along the Missouri River, including their composition, structure, health, areal extent, and age distribution. Data and conclusions derived from the survey will be used in the Cottonwood Community Model. The project involves (1) GIS-mapping of present-day and historic land cover, including cottonwood forest extent and age class distribution, and (2) characterization of vegetation structure, composition, wetland affinity, and floristic “quality” within cottonwood, disturbed cottonwood, and non-cottonwood riparian forest stands across a gradient of successional age classes. In 2007-2009, a total of 332 stands; 216 cottonwood, 32 disturbed cottonwood, and 74-non-cottonwood, and 10 planted cottonwood; were sampled throughout the six priority reaches and two reference reaches. Mean tree species richness per stand decreased from downstream to upstream. The age distribution of cottonwood habitats varied among the river segments. Across the segments 48 to 91 percent of the cottonwood area was greater than 50 years old (Dixon et al. 2010). The preliminary results from analysis of vegetation data collected within cottonwood, disturbed cottonwood, and non-cottonwood stands sampled in 2007-2009 for each of the six priority segments are discussed below.

3.5.2 Wetland and Riparian Vegetation

The Missouri River floodplain currently supports significant stands of riparian forest. Deltas have developed in the lakes associated with the six mainstem dams supporting additional extensive wetland complexes. The wetlands along the river and in deltas serve many important functions: wildlife habitat (waterfowl, big game, furbearers, etc.), fish breeding and foraging habitat, nutrient/sediment trapping, flood control, and recreation. Riparian forests serve as important wildlife habitat, timber sources, wind shelters for residences, and locations for recreational activities. In this section wetland and riparian vegetation are discussed. Wetlands and open water areas of the Missouri River are classified according to the USFWS's system of definitions for the National Wetlands Inventory (NWI), commonly referred to as the Cowardin System (Cowardin et al. 1979). According to the Cowardin system, all wetlands exhibit three characteristics: (1) the presence of hydrophytic (water-loving) plants; (2) predominantly undrained hydric soils; and (3) a substrate that is saturated with water or covered by shallow water for at least some portion of the growing season. Open water or deepwater habitats are defined as "permanently flooded lands lying below the deepwater boundary of wetlands" and include the reservoirs and river. The wetland classes along the Missouri River fall into four major groups, each based on dominant vegetation structure: 1. emergent—dominated by perennial or persistent herbaceous plants, 2. scrub-shrub—dominated by woody vegetation less than 20 ft tall, 3. forested—dominated by woody vegetation greater than 20 ft tall, and 4. exposed shore—less than 30 percent cover of trees, shrubs, or persistent emergents and associated with rivers, reservoirs, or lakes. For this document, the term "wetland" is used to refer to emergent, scrub-shrub, and forested classes. The term "exposed shore" refers to shoreline wetlands, both vegetated and unvegetated. "Riparian" applies specifically to the upland, or nonwetland, component of the Missouri River floodplain.

Typically occurring at higher elevations than wetlands, riparian communities are characterized by relatively dry, sandy soil and occasional intermittent flooding. Dominance of hydrophytic vegetation is used to distinguish wetland and riparian habitats. The vegetation in riparian areas may be transitional, including plants found in both upland and wetland communities. Three riparian vegetation classes were identified along the Missouri River, each defined by dominant vegetation structure: (1) grassland, (2) shrub, and (3) forest.

Floodplain and aquatic habitat includes three classes of wetlands, three classes of riparian vegetation, and river, reservoir, and exposed shoreline categories. The classes of wetland and riparian vegetation tend to occur in distinct elevational bands that parallel the river, reflecting a soil moisture gradient of increasing dryness with increasing distance from the river.

<u>Exotic and Invasive Plant Species</u>

Undesirable plants include species classified as undesirable, noxious, harmful, exotic, injurious, or poisonous under state or federal law. Some of the noxious/exotic weeds found throughout the Missouri River project area include saltcedar (*Tamarix ramosissima*, *Tamarix chinensis*, and *Tamarix parviflora*), purple loosestrife (*Lythrum salicaria*), leafy spurge (*Euphorbia esula*), field bindweed (*Convolvulus arvensis*), Canada thistle (*Cirsium arvense*), musk thistle (*Carduus nutans*), Russian knapweed (*Acroptilon repens*), absinth wormwood (*Artemisia absinthium*), spotted and diffuse knapweed (*Centaurea stoebe* ssp. *micranthos*), yellow starthistle (*Centaurea solstitialis*), Russian olive (*Elaeagnus angustifolia*), common buckthorn (*Rhamnus cathartica*) and dalmatian toadflax (*Linaria genistifolia* ssp. *dalmatica*) (USDA 2008). Both saltcedar and purple loosestrife are the most prevalent invasive plant species in some of the priority river segments and are therefore, described in more detail below.

Saltcedar – these species are a persistent pioneer that is able to survive in a wide variety of habitats. An enormous water consumer, a single large plant can absorb 200 gallons of water a day, although evapotranspiration rates vary based on water availability, stand density, and weather conditions (Hoddenbach 1987; Davenport et al. 1982). Saltcedar's high water consumption further stresses native vegetation by lowering ground water levels and can dry up springs and marshy areas. Paradoxically, saltcedar infestations may also lead to flooding, as its extensive root system can choke streambeds (Rush 1994). It frequently forms monotypic stands that replace willows, cottonwoods, and other native riparian vegetation.

Purple loosestrife – this species caused few problems until the 1930s when it became aggressive in the floodplain pastures of the St. Lawrence River (USGS 1999). Since then, it has steadily expanded its local distribution and now poses a serious threat to native emergent vegetation in shallow water marshes throughout the northeastern and north central regions. Recent records indicate that purple loosestrife is also tolerant of soils and climates beyond these regions and threatens to become a serious problem in wetlands and irrigation systems in the Great Plains. Purple loosestrife was added to the North Dakota Noxious Weed List in 1996. North Dakota State law requires all purple loosestrife plants to be removed to prevent this plant from becoming a major weed problem in the wetlands of the state.

Riparian Vegetation

Natural upland vegetation along the river north of Sioux City encompasses ponderosa pine (*Pinus ponderosa*), prairie, and plains grassland ecosystems as defined by the USDA Forest Service (from USDA 1977 as stated in Corps 2004a). Natural upland vegetation consists primarily of grasslands. The growing season is relatively short, extending from late May to early September in the northern reaches and from late April/early May to late September near Sioux City (NOAA 1990 as stated in Corps 2004a).

About 55 percent of the total acreage of aquatic habitat exists along this portion of the river (north of Sioux City) (555,195 acres total). It includes about 74 percent of the mapped wetlands, much of which (53 percent) occurs in the four major deltas. The major reaches and deltas support much greater densities of emergent marsh, scrub-shrub, and exposed shore habitat compared to areas south of Sioux City. Conversely, non-wetland riparian vegetation along this stretch represents only 36 percent of the amount in the Missouri River floodplain.

The Missouri River reservoir deltas typically support less diverse wetland complexes compared to riverine reaches because fluctuating water levels preclude the establishment of trees and species that are intolerant of long periods of inundation. The same process similarly limits development of riparian vegetation in the deltas, which currently support only 10 percent of the riparian vegetation along the entire river.

Areas south of Sioux City contain approximately 249,200 acres of floodplain and aquatic habitat. This area is characterized by a much greater density of riparian forest (119 acres/river mile) compared to areas north (39 acres/river mile), and supports much lower densities of emergent marsh, scrub-shrub, and exposed shore habitat. The floodplain also includes a much greater acreage of agricultural land (generally not considered wetland or riparian habitat).

Priority River Segments

Segment 4 (Garrison Dam to Lake Oahe Headwaters near Bismarck, North Dakota) – RM 1389.9 to 1304.0

Riparian vegetation constitutes about 47 percent of the floodplain in this segment, water about 28 percent, exposed shoreline about 16 percent, and wetlands about 9 percent. The Garrison reach supports about 25 percent of the riparian vegetation along the Upper River of the Missouri. Emergent wetlands constitute about 68 percent of the wetland acreage in the Garrison reach; most of the remainder is scrub-shrub wetland (22 percent) (Corps 2004a). Emergent wetlands generally support a mix of hydric and mesic species, including quackgrass (*Elymus repens)*, bluegrass (*Poa* sp.), and mints (*Mentha* spp.). Reed canarygrass (*Phalaris arundinacea)* dominates some areas and slough sedge (*Carex obnupta*) forms extensive stands, particularly near Bismarck, North Dakota. Cottonwood, indigo bush (*Psorothamnus*), and peachleaf willow characterize most of the scrub-shrub wetlands. This reach supports a much lower density of wetlands (38 acres/mile) than the other Upper River reaches. The large diurnal and seasonal variations in river flow for the peaking operation of Garrison Dam probably impede wetland establishment and survival, resulting in greater amounts of exposed shore. The large islands and bars, particularly those close to the dam, are periodically scoured and support little, if any, perennial vegetation. Riparian forest constitutes just over half of the riparian vegetation in this reach, commonly lining both shores. Cottonwood, American elm (*Ulmus americana*), green ash, and box elder are the most common tree species on the floodplain (from Johnson et al. 1976 as stated in Corps 2004a). Sandbar willow (*Salix interior*), peachleaf willow, and cottonwood occur along the river sandbars. The acreage of riparian forest in this reach has been greatly reduced since settlement. Canada thistle and leafy spurge are the primary threats on the exposed shorelines of Garrison Reservoir. Saltcedar also poses an immediate threat to the natural resources around the reservoir but is a more constant threat throughout the full range of reservoir levels—high, low, and normal (Corps 2007). Active and vigilant eradication efforts have slowed the rate of spread of salt cedar (USDA 2010). Tree establishment is also restricted by the vast expanses of dense brome sod and the dewatering of riparian soils from the lack of spring floods (USDA 2010).

In 2007-2009, a total of 66 tree stands were sampled. Of these, 35 stands were cottonwood, 10 were disturbed cottonwood, and 21 were non-cottonwood. Cottonwood acreage per river mile was approximately 270 acres/river mile. Approximately 85 percent of the cottonwood community in Segment 4 was considered mature (50 to 114 tears old) and old growth (greater than 114 years old) and less than 15 percent was composed of stands of less than 50 years old. Recruitment over the last 25 to 50 years was very low on this segment. In terms of overall tree stem density and basal area, values were lower in Segment 4 when compared to the other priority segments. Species richness of the herbaceous layer and average herbaceous cover in this segment were relatively high. In terms of total stand-level species richness, Segment 4 and 10 were highest of all priority segments, with an average of 35 species per stand (Dixon et al. 2009; Dixon et al. 2010).

Segment 6 (Oahe Dam to Big Bend Dam, including Lake Sharpe) - RM 1072.3 - RM 987.4

Some small wetlands are associated with backwaters created by channel structures, but this reach (RM 1072 to 1067) was not mapped and is not included in the totals for Corps (1989 and 2004a).

The majority of the delta at Lake Sharpe is shallow, open water or seasonally flooded mudflats (Corps 1989). Palustrine emergent wetlands are limited to large islands in the Bad River delta and tributary deltas. About 430 acres of emergent wetlands occur on the two largest islands and are dominated by dense stands of common reed (*Phragmites australis*), cattail (*Typha* sp.), and reed canarygrass (Corps 1989). The few scrub-shrub wetlands are largely confined to portions of these islands.

During the 2007-2009 vegetative sampling, 38 total tree stands were sampled, including 17 cottonwood, 4 disturbed cottonwood, 11 non-cottonwood, and 6 planted cottonwood. The acreage per river mile of cottonwoods was 20 acres/river mile, which is the lowest of all priority segments. Approximately 91 percent of cottonwoods were considered mature or old growth and less than 1 percent were composed of stands less than 15 years old. Segment 6 contains a high number of non-native tree species, including Russian olive, white mulberry (*Morus alba*), and common buckthorn. Shrub cover, mostly comprised of Eastern red cedar (*Juniperus virginiana*) was also high throughout the intermediate age stands in this segment. Average herbaceous cover was high in mature, old growth, and non-cottonwood stands. Total stand-level plant species richness was low with an average of 23 species (Dixon et al. 2009; Dixon et al. 2010).

<u>Segment 8 (Fort Randall Dam to Niobrara River) – RM 880.0 to RM 845.0</u>

The Fort Randall reach consists of approximately 33 percent riparian vegetation 46 percent water 19 percent wetlands, and less than 1 percent exposed shoreline. Nearly 30 percent of wetland acreage in Segment 8 is forested; most of the remainder is emergent (56 percent) (Corps 2004a). The forested wetlands are characterized by a mix of peachleaf willow and cottonwood, with some sandbar willow. Emergent wetlands generally support the typical mix of reed canary grass and common reed. Expansive areas of cattail, often mixed with softstem bulrush (*Schoenoplectus tabernaemontani*), have developed in old channels and backwaters. Extensive areas of exposed shore are limited to a few sandbars, islands, and eroded banks. Nearly all of the riparian vegetation in the Fort Randall reach is forested, dominated by cottonwood mixed with green ash, Russian olive, slippery elm, and box elder. The sparse understory typical of mature stands contains Kentucky bluegrass (*Poa pratensis*), smooth brome (*Bromus inermis*), scouring rush (*Equisetum* sp.), eastern redcedar, and roughleaf dogwood (*Cornus drummondii*) (Corps 2004a). Open areas are usually grazed or farmed.

During the 2007-2009 vegetation sampling, a total of 54 tree stands were sampled within Segment 8. Of these, 33 stands were cottonwood, 4 were disturbed cottonwood, 13 were non-cottonwood, and 4 were planted cottonwood. Segment 8 had a substantially higher proportion of younger cottonwood communities less than 50 years old (32 percent) than segment 4 (15 percent) and segment 6 (9 percent), with the majority of these between 25 and 50 years old. When compared to the other priority segments, species richness, shrub cover, and herbaceous cover was not considered high or low. The proportion of non-native trees is high in Segment 8, with Russian olive, white mulberry, and common buckhorn relatively common. Eastern red cedar was the relatively common component of the shrub layer (Dixon et al. 2009; Dixon et al. 2010).

Segment 9 (Niobrara River to Lewis and Clark Lake, including Lewis and Clark Lake) - RM 845.0 - RM 811.1

Wetlands constitute approximately 43 percent of the Lewis and Clark Lake delta, open water 42 percent, riparian vegetation about 11 percent, and exposed shoreline about 5 percent (Corps 2004a). The smallest of the four principal mainstem reservoir deltas, the Lewis and Clark Lake delta, contains about 7 percent of the wetlands and 1 percent of the riparian vegetation along the entire river (Corps 2004a). In contrast to the other major mainstem deltas, numerous backwaters, ponds, and chutes occur in the Lewis and Clark Lake delta, supporting extensive emergent wetlands (83 percent of the wetland acreage).

A reconnaissance survey in 1988 indicated that about one-half of these emergent wetlands in the Lewis and Clark Lake delta are infested with purple loosestrife, a plant that readily invades freshwater wetlands, excluding other species and degrading habitat. Purple loosestrife was first noted in Segment 9 in 1983, and an estimate indicated that approximately 3,360 acres of wetland area on the lake was infested with the plant. The pattern or distribution of the plant is mainly downstream from the confluence of the Niobrara River and seems to be heaviest on the Nebraska side of the lake. This suggests that the origin of purple loosestrife into the lake was most likely from inflows of the Niobrara River (Corps 2003b).

Emergent wetlands that are not dominated by purple loosestrife contain reed canarygrass and common reed. Cattails occupy shallow waters associated with islands, backwaters, and side channels. Because cattails can germinate in several inches of water, the current operating regime, involving spring drawdown and higher pool levels in July, has favored the establishment of near monotypic stands of this species (from Corps 1989 as stated in Corps 2004a). This operating regime, however, probably precludes establishment of scrub-shrub wetlands in many areas of the delta because sandbar willow requires recently deposited sediments that remain unflooded for the duration of the summer.

Relatively small annual drawdowns expose only limited amounts of shore substrate, although several large new islands are forming at the mouth of the Niobrara River. Studies of these islands and sediment deposition indicate that extensive aggradation has occurred in the Lewis and Clark Lake delta (from Corps 1989 as stated in Corps 2004a). Dead cottonwood trees on several islands between the mouth of the Niobrara River and Bazille Creek, and their replacement by stands of cattail and bulrush (*Scirpus* spp.), provide additional evidence of recent aggradation. Riparian vegetation occurs throughout the upper portion of the delta. Over half of the riparian vegetation is forest, occurring on large islands near the mouth of Bazille Creek, Niobrara River, and Choteau Creek. Cottonwood dominates these stands, with green ash, dogwood, and snowberry (*Symphoricarpos* sp.) typically constituting a shrub understory in mature stands. Scouring rush frequently forms a ground cover, particularly in stands growing on sandy soils. In addition to purple loosestrife, the nonnative shrub saltcedar was first discovered in 2003 at Lewis and Clark Lake. The herbicide Rodeo was used to control saltcedar at the project and prevent it from spreading (Corps 2003b).

During the 2007-2009 vegetative sampling, a total of 8 tree stands were sampled in Segment 9. Of all priority segments, Segment 9 had the least number of tree stands sampled. Of the 8 tree stands sampled, 7 were cottonwood and 1 was disturbed cottonwood. Over half of the cottonwood area consisted of trees less than 50 years old, with the majority less than 25 years. The proportion of non-native trees is high in Segment 9, with Russian olive, white mulberry, and common buckhorn relatively common. Eastern red cedar was the most common species within the shrub layer along this segment. The average proportion of species in a stand that were non-native was approximately less than 20 percent (Dixon et al. 2009; Dixon et al. 2010).

Segment 10 (Gavins Point Dam to Ponca, Nebraska) – RM 811.1 - RM 753.0
The Gavins Point reach resembles the natural river more than any other reach, and, compared to the other reaches, displays the greatest density of wetlands, approximately 90 acres per mile. Wetland acreage, however, has undoubtedly declined as a result of channel degradation. Riverine habitat constitutes about 56 percent of the Gavins Point reach, riparian vegetation about 23 percent, wetlands about 19 percent, and exposed shoreline about 2 percent. This reach is the second shortest riverine reach and supports only 5 percent of the wetland acreage along the entire river and 3 percent of the riparian vegetation (Corps 2004a). Wetlands in the Gavins Point reach are composed of an even mix of emergent (48 percent) and scrub-shrub (49 percent) classes. Scrub-shrub wetlands typically occur as dense stands of young sandbar willow, but less frequently inundated areas also include peachleaf willow and cottonwood. Most emergent wetlands consist of reed canarygrass or a mix of hydric and mesic species. Cattails occur in old channels, backwaters, and near islands. Areas of exposed shore are not common but occur along the entire Gavins Point reach and are associated with sandbars, eroding banks, developing islands, and areas exposed as a result of degradation of the riverbed. Riparian vegetation has been severely reduced by clearing for agriculture. Over one-half of that remaining is forested and is dominated by cottonwood with lower densities of green ash, slippery elm, Eastern red cedar, Russian olive, mulberry (*Morus* spp.), and box elder. The typically sparse herbaceous stratum beneath mature cottonwood consists mostly of scouring rush, Kentucky bluegrass, smooth brome, and switchgrass (*Panicum virgatum*). Riparian grasslands along the MNRR reach are dominated by Kentucky bluegrass, smooth brome, and other invasive grasses and weeds.

During the 2007-2008 vegetation surveys, a total of 52 tree stands were sampled, with 32 being cottonwood, 7 disturbed cottonwoods, and 13 non-cottonwood. The cottonwood forest had a high percentage of younger trees (less than 50 years of age). The proportion of non-native trees is high in Segment 10, with Russian olive, white mulberry, and common buckhorn relatively common. Overall shrub cover was particularly high in Segment 10, especially in stands greater than 50 years. Common species within the shrub cover included common buckthorn and roughleaf dogwood. Mean species richness was relatively high when compared with other segments (Dixon et al. 2009).

Segment 13 (Platte River to Kansas City, Missouri) – RM 595.5 - RM 367.5
The 164-mile Omaha (RM 610) to St. Joseph (RM 446) reach is composed of about 54 percent riparian vegetation, 31 percent water, 12 percent wetlands, and 3 percent exposed shoreline. Emergent and scrub-shrub wetlands constitute 60 and 37 percent, respectively, of the total wetland area in the reach (Corps 2004a). Reed canarygrass dominates emergent wetlands, but sedges, rushes, and rice cutgrass (*Leersia oryzoides*) are also common in this type. Scrub-shrub wetlands typically support a mix of black willow (*Salix nigra*), young cottonwood, and some sandbar willow. Most of the wetlands in the Omaha to St. Joseph reach are associated with the old bends and oxbows that have been cut off from the river by levees but remain wet because of

pumping, groundwater seepage under levees, or surface inflows. About 41 percent of the riparian vegetation is classified as riparian grassland; 54 percent of the riparian vegetation is currently forested. The largest stands of riparian forest occur in association with wetland complexes, but substantial acreage occurs as linear bands along the river banks. Forest stands are dominated by cottonwood, but green ash, sycamore, mulberry, elm, and box elder are also common.

During the 2007-2009 sampling, a total of 48 tree stands were surveyed, with 31 being cottonwood, 6 being disturbed cottonwood, and 11 being non-cottonwood. Approximately 50 percent of the cottonwood forest consisted of trees less than 50 years; only four percent of the cottonwood forest were considered old growth (greater than 114 years). Mean tree species richness per stand was highest with 6 species in Segment 13. Common tree species in the mature forests within this segment include sycamore, box elder, hackberry, green ash, American elm, red mulberry, white mulberry, and silver maple. The proportion of tree species that are non-native is considerably lower than in segments 6, 8, 9, and 10. Shrub cover within this segment was highest in sapling and pole stands, although shrub species richness was relatively low (Dixon et al. 2009; Dixon et al. 2010).

3.5.3 Wildlife Resources

The Missouri River creates and maintains important forest and wetland habitat for a wide diversity of wildlife, including at least 60 species of mammals, 301 species of birds, and 54 species of reptiles and amphibians (Dunlap and Kruse undated; Lynk and Harrell undated; USFWS 1979 as stated in Corps 2004a). Of these, six bird and two bat species occurring in the river valley are federally listed as threatened or endangered. Because much of the river's course traverses the arid Great Plains, where less than 5 percent of the land supports trees, the densities and distributions of many of these wildlife species depend on the forests and wetlands associated with the river. The diversity and abundance of wildlife reflect the mix of habitat classes occurring in the Missouri River valley: riverine, lakes and ponds, emergent, scrub-shrub, and forested wetlands; riparian forests; grasslands; and croplands. The combination of open water, wetlands, and riparian vegetation is particularly important for the large number of waterfowl that stop along the Missouri River during spring and fall migration. Wildlife of the Missouri River can be grouped into the following categories: waterfowl; shorebirds, wading birds, and waterbirds; and other wildlife. The dependence of each of these groups of species on habitats and changes in lake level and river flow is discussed in the following sections.

Waterfowl

The Missouri River is located within the North American central flyway for the migration and breeding of waterfowl. The System and the associated lakes and wetlands provide important migration stopover habitat and, in times of drought when habitat in the North and South Dakota prairie pothole region is limited, important breeding habitat. Seventeen species of ducks, three species of geese, and one swan species occur along the Missouri River (Bellrose 1976; Johnsgard 1980; and USFWS 1979 as stated in Corps 2004a). Ten of these species are relatively common. Most of the waterfowl use occurs during spring (March through April) and fall (September through November) when millions of birds reside for varying periods of time along the river while migrating between breeding and wintering areas. Most of the use during spring and fall migration occurs on the mainstem lakes and unfrozen sections of river downstream of each of the dams, while oxbows and old chutes are heavily used in areas south of Sioux City. Nesting and migration-resting habitat have been reduced by past and on-going conversion of riparian and wetland areas to agricultural uses. The availability of remaining habitat is controlled largely by river flow patterns, which maintain favorable vegetation and water depths. Although low flows in March, April, and May in the upstream reaches tend to expose more island substrate for nesting and loafing (Canada geese, mallards, and gadwall), flows must be sufficiently high to prevent land bridging and predator access. During migration, flows that are high enough to keep islands separated from the mainland but low enough to create abundant sandbars, are especially important for geese. Flow patterns also affect waterfowl nesting success and productivity by flooding nests or eliminating suitable wetland foraging or brood-rearing areas.

Shorebirds, Wading Birds, and Waterbirds

The Missouri River and its associated wetlands support approximately 61 species of shorebirds, wading birds, and waterbirds (Johnsgard 1980; USFWS 1979 as stated in Corps 2004a). Common shorebirds and wading birds that rely on shallow water and emergent wetland habitat include great blue heron (*Ardea herodias*), killdeer (*Charadrius vociferus*), sora (*Porzana carolina*), rails (*Rallidae* sp.), various species of sandpipers (*Scolopacidae* s p.), and piping plovers. The great blue heron is a colonial tree-nester that selects riparian forests for nest sites and forages on frogs and small fish in shallow water and emergent wetlands common in backwaters and chutes (Ogden 1978 as stated in Corps 2004a). All of the shorebirds and wading birds are dependent upon Missouri River hydrology for supplying sandbars, shorelines, and shallow water zones that meet nesting and foraging needs. Waterbirds found along the Missouri River that require large areas of open water for foraging include common loon (*Gavia immer*), five species of grebes (*Podiceps* sp.), American white pelican (*Pelecanus erythrorhynchos*), double-crested cormorant (*Phalacrocorax auritus*), common terns (*Sterna hirundo*), Forster's terns (*Sterna forsteri*), least terns, and several species of gulls (*Larus* sp.). These species require either sandbars or dense emergent wetland vegetation for nesting and open water for foraging.

Other Wildlife

A variety of other wildlife, rely on Missouri River habitats that are tied to Missouri River hydrology. Aquatic furbearers, such as mink (*Mustela vison*), beaver (*Castor canadensis*), and muskrat (*Ondatra zibethicus*), den near the shoreline where flood events or sudden changes in water level can destroy dens or leave them vulnerable to predation. Upland game birds are especially dependent on emergent wetlands and riparian forests. They also use dense, weedy, herbaceous vegetation that establishes on exposed shoreline sediments in the three upper reservoirs when water levels are drawn down.

Songbirds such as American goldfinches (*Spinus tristis*), yellow warblers (*Dendroica petechia*), Bell's vireos (*Vireo bellii*), and ovenbirds (*Seiurus aurocapillus*) feed and nest in young cottonwood forests. Bird species often found in older cottonwood forests include Baltimore orioles (*Icterus galbula*), mourning doves (*Zenaida macroura*), warbling vireos (*Vireo gilvus*), and Eastern kingbirds (*Tyrannus tyrannus*). Woodpeckers and black-capped chickadees (*Poecile atricapillus*) build their nests inside old or dead cottonwood trees. In the Great Plains, bald eagles nest almost exclusively in the strong branches of a cottonwood tree.

The principal big game species are white-tailed deer (*Odocoileus virginianus*), which occur along the entire river, and mule deer (*Odocoileus hemionus*), which occur primarily in Montana, North Dakota, and South Dakota (Mackie et al. 1982; Hesselton and Hesselton 1982 as stated in Corps 2004a). Both species forage, fawn, and seek winter cover in riparian and wetland vegetation. During drought years, deer feed on the vegetation established on sediments exposed by lowered lake levels. Bighorn sheep (*Ovis canadensis*) and elk (*Cervus canadensis*) occur on the Charles M. Russell National Wildlife Refuge (NWR) near the upstream end of Fort Peck Lake. Although primarily an upland species, pronghorns (*Antilocapra americana*) occasionally extend into the Montana and Dakota portions of the Missouri River floodplain. The Missouri River supports at least 17 species of hawks, falcons, eagles, osprey (*Pandion haliaetus*), and turkey vultures (*Cathartes aura*), as well as 8 species of owls. Most of these species are dependent on wetland and riparian habitat for nesting and/or foraging habitat.

Approximately 54 species of reptiles and amphibians are found in wetland and riparian areas.

<u>Federally Threatened and Endangered Species</u>

This section provides a general discussion of the federally-listed species that have the potential to occur on and along the Missouri River as of March 2004, and as stated in the *Missouri River Master Manual* (Corps 2004a). A more detailed discussion of State-listed and County-listed species would occur during consultation when individual projects are identified by river segment and site-specific NEPA documentation is prepared in the future.

The Missouri River provides breeding habitat for the federally endangered interior least tern and the federally threatened piping plover. It also provides migration habitat for the federally endangered whooping crane (*Grus americana*). The river valley potentially provides habitat for the federally endangered Eskimo curlew (*Numenius borealis*), gray bat (*Myotis grisescenses*), Indiana bat (*Myotis sodalis*), and the American burying beetle (*Nicrophorus americanus*). The Missouri River is also provides habitat for the endangered pallid sturgeon. Though no longer listed, the Missouri River also provides habitat for the bald eagle, which is still protected under BGEPA and MBTA.

Bald Eagle **-** Breeding populations were historically common along the Missouri River but declined during the 19th and 20th centuries. Bald eagle numbers, as well as nests and nest success, have increased dramatically during the past two decades (USFWS 2000a). Due to the nationwide recovery of bald eagle populations, the USFWS proposed to remove the bald eagle from the federal endangered species list in 1999 and delisted them on June 29, 2007. Bald eagles winter in various areas throughout the United States but occur in greatest numbers along large rivers in the West and Midwest. Of the approximately 12,000 bald eagles counted during the 1988 nationwide midwinter survey of the lower 48 States, about 600 were identified in the Missouri River basin (from USFWS 1990a as stated in Corps 2004a). Bald eagles nest in large trees with specific size and structural characteristics (from Stalmaster 1987 as stated in Corps 2004a). Proximity to shorelines of lakes, rivers, or seacoasts and sufficient distance from human activity also influences their selection of nesting sites. Bald eagles usually nest in the same territories each year, often using the nests repeatedly (from Stalmaster 1987 as stated in Corps 2004a). Although trees of sufficient size grow along most of the flowing reaches of the Missouri River, only limited areas in Montana and North Dakota have provided relatively successful nesting habitat (from USFWS 1990a as stated in Corps 2004a). The U.S. Fish and Wildlife Service and the North Dakota Game and Fish Commission maintains an active database of bald eagle nests in North Dakota. Approximately 23 nesting areas have been documented along the Missouri River in North Dakota (NDGFD 2007). Additionally areas within segments 8 and 10 in South Dakota and Nebraska has also have had successful nesting in recent years. The decline in North American nesting populations is attributed primarily to the loss of habitat as natural areas were developed for human occupation. Trapping and shooting, human disturbance, and poisoning by organochlorine insecticides (mid-1900s) also contributed to the decline in population. Bald eagles also commonly use the Missouri River during the spring and fall migration.

Wintering bald eagles require night roosts located in sheltered timber stands near an abundant, readily available food supply such as fish, waterfowl, or carrion (from Stalmaster 1987; USFWS 1990a as stated in Corps 2004a). Eagles concentrate below the Missouri River mainstem dams to feed on fish that are killed or crippled while passing through the turbines and waterfowl attracted to the open water. In the northern States, where natural lakes and smaller rivers freeze during winter, the Missouri River provides the only open water for wintering birds. During the past decade, wintering populations have been increasing in the continental United States, including the Missouri River; however, perching, roosting, and nesting habitats continue to decline due to the loss of mature cottonwoods along the river. As cottonwoods succumb to age, other tree species such as ash invade the stands. Conversion of riparian and wetland habitat to agricultural uses is also affecting eagle habitat. In the Great Plains, bald eagles nest almost exclusively in the strong branches of a cottonwood tree. Most regional tree species are too small to support a bald eagle nest, which can span up to nine feet wide and weigh up to a ton.

Whooping Crane **-** The endangered whooping crane is one of the rarest North American birds. There is only one wild breeding population, the Wood Buffalo-Aransas flock, which peaked at 220 birds in the winter of 2006 (Stehn 2007). The Wood Buffalo-Aransas flock winters along the Texas gulf coast and breeds in Wood Buffalo National Park in the Northwest Territories, Canada. The 80- to 120-mile-wide primary migration corridor passes the Aransas NWR until reaching the Missouri River near the confluence with the Niobrara River in north-central Nebraska. The migration corridor then follows the Missouri River into North Dakota, bending slightly to the west as it leaves the Missouri River near Garrison, North Dakota. From Garrison, the corridor continues and broadens in the Canadian portion of the flyway as it approaches Wood Buffalo National Park (from Johnson and Temple 1980 as stated in Corps 2004a). Migrating whooping cranes interrupt their journey with brief, usually 2-day, overnight stopovers, during which time the birds feed and rest.

Omnivorous and opportunistic, cranes feed in various habitats, including cropland, wet meadows, palustrine wetlands, and native grasslands (from Howe 1989; Platte River Management Joint Study 1990 as stated in Corps 2004a). The typical diet of migratory whooping cranes includes emerging winter wheat, barley, wheat, felled corn, waste milo, and various native plant and/or animal food items such as frog and toad egg masses, beetles and other insects, small fish, snakes, crayfish, and possibly snails and bivalve mollusks (from Johnson and Temple 1980 as stated in Corps 2004a). The abundance of wet meadows, which provide suitable foraging habitat for stopovers and native food species, is dependent on river hydrology, particularly patterns of flows.

As reported by W. Jobman of the USFWS in 1989, the most critical migration stopover areas are along or near the Platte River in central Nebraska; however, at least 21 sightings have been made of cranes roosting on Missouri River sandbars in eastern Montana, North Dakota, and South Dakota (Corps 2004a). Additionally, the highest number of observations has occurred in the reach downstream of Garrison Dam, but mudflats in the drawdown zones of Lake Sakakawea, Lake Audubon, and Lake Oahe are also important roosting areas (Corps 2004a).

Eskimo Curlew **-** Historically, the endangered Eskimo curlew was an abundant spring migrant in the Great Plains region, but the Eskimo curlew is now likely to be extinct. Thousands of curlews formerly visited the Plains States between early April and late May on their 8,000-mile journey between wintering grounds on the pampas grasslands of southern South America and nesting grounds on the arctic tundra of the MacKenzie Territory (from Currier et al. 1985 as stated in Corps 2004a). The last estimates place the population at approximately 50 individuals, but little is known regarding the current distribution of these birds and it is likely now extinct (from Gollop 1988 as stated in Corps 2004a). The population decline is attributed to extensive hunting of the species during the late 1800s (from Gollop 1988 as stated in Corps 2004a), although habitat changes and other human-related perturbations may have been contributing factors (from Banks 1977 as stated in Corps 2004a). Curlews stop over in tall-grass prairie habitat that occurs along their spring migration route, but they prefer wet meadows along rivers (from Swenk 1915 and Bent 1929 as stated in Corps 2004a). The level of use of the Missouri River corridor is unknown, but is probably limited to rare visits of short duration during spring migration. Fall migration follows the Atlantic coastline and completely avoids the Missouri River basin (from USFWS 1980 as stated in Corps 2004a).

Interior Least Tern and Piping Plover **-** The interior least tern and piping plover were listed as endangered and threatened species, respectively, in 1985 (from USFWS 1990a as stated in Corps 2004a). Historically, the least tern commonly bred on the Missouri River and many of its tributaries from Montana to St. Louis (USFWS, 1990a). Since the early 1980s, there has been a substantial decrease in the populations of these two species. Both of these species winter near the Gulf of Mexico (from USFWS 1990a; Haig and Oring 1985; Nichols 1989 as stated in Corps 2004a). Least terns and piping plovers typically nest in colonies on riverine sandbars isolated by water (from Faanes 1983 as stated in Corps 2004a). Their nesting habitat requirements are similar, usually consisting of river sandbars, islands, and lakeshore peninsulas, where access by mammalian predators is minimized and foraging habitat (shallow water for terns and shorelines for plovers) is nearby (from Faanes 1983 as stated in Corps 2004a). Both species nest in shallow, inconspicuous depressions in dry, open, sandy areas with less than 30 percent vegetative cover and plant heights less than 1 foot (from USFWS 1990b; USFWS, 1990c as stated in Corps 2004a).

The significant decline in tern and plover populations is attributed to loss of habitat and human disturbance (from Cairns and McLaren 1980; Russell 1983; USFWS 1990b as stated in Corps 2004a). Nesting habitat was historically created by high flows that scoured vegetation from islands and redeposited sediments to create new sandbars. In the past half century, dams and storage reservoirs have reduced peak flows and sediment loadings, allowing vegetation to encroach on islands and reducing the creation of new sandbars. Current low productivity reflects the effects of predation, weather, human disturbance, erosion and flooding of nests, and nest abandonment (from Sidle et al. 1992 as stated in Corps 2004a). Although periodic high water levels are needed to maintain good nesting habitat, timing of high inflows and releases can preclude nesting (from Sidle et al. 1992 as stated in Corps 2004a). From 1986 to 1997, piping plover numbers on the Missouri River averaged 402 adult birds. The adult census numbers ranged from a high of 618 piping plovers in 1991 to a low of 117 piping plovers in 1997. Over the same time period, the least tern census on the Missouri River averaged 589 adult birds. The adult census numbers ranged from a high of 763 least terns in 1994 to a low of 442 least terns in 1996.

The least tern and piping plover recovery plans identify population recovery goals of 2,100 adult least terns and 970 adult plovers (from USFWS 1990a; USFWS 1990b as stated in Corps 2004a). During the past several years, the USFWS and the Corps have created additional nesting habitat on several reaches of the Missouri River by removing vegetation from islands and by installing fences in shallow water to trap sediment. The Corps has also initiated programs in recent years to benefit bird reproduction, while maintaining flows to serve authorized purposes. Project discharges are increased from Fort Peck, Garrison, Fort Randall, and Gavins Point Dams when birds begin to nest in May. The releases in August also are increased but allow full service to authorized purposes. Daily peaking power limits, less than full power plant capacity, are also initiated at this time and held through the nesting season. Depending on water conditions, releases at Fort Peck and Garrison Dams may be reduced slightly in July and August to provide a nest free-board cushion should rainfall runoff materialize. During large system inflow years, large flood control evacuation rates are necessary and nesting flow restrictions are lifted. In high water years 1995, 1996, and 1997, eggs were collected and nests moved to higher elevations to prevent inundation.

Indiana Bat and Gray Bat **-** The endangered Indiana and gray bats have experienced serious population declines due to habitat loss and human disturbance. Their historical abundance and distribution are unknown because, although distinct species, these bats are similar to other, more common, bat species in the genus

The gray bat has been reported in Missouri, Illinois, Indiana, Kentucky, Kansas, Tennessee, and Alabama. About 95 percent of all gray bats appear to hibernate in only nine identified caves (from Tuttle 1979 as stated in Corps 2004a). As stated by K. Brunson of the Kansas Department of Wildlife and Park in 1992 and D. Figg of the Missouri Department of Conservation in 1992, both species are known to occur in Boone County in central Missouri and use Missouri River bluff caves for hibernation (Corps 2004a). Additionally, the abundance of insects preyed upon by both species of bats may be partially dependent on the abundance and composition of wetland and riparian communities. In Kansas, the bats occur only in the southeast corner of the State and probably not in the vicinity of the Missouri River (Corps 2004a).

The current range of the migratory Indiana bat extends from Oklahoma, Iowa, and Wisconsin east to Vermont and south to northwestern Florida (from Barbour and Davis 1969 as stated in Corps 2004a). The winter range is associated with regions of well-developed limestone caverns.

Major populations of hibernating Indiana bats occur in Missouri, Kentucky, and Indiana. Smaller hibernating populations also occur in most of the remaining eastern States. Although the winter range is large, the species is restricted to about 135 hibernacula caves (from Brady et al. 1983 as stated in Corps 2004a).

American Burying Beetle **-** The American burying beetle is listed as an endangered species due to its precipitous population decline (from Ratcliffe and Jameson 1992 as stated in Corps 2004a). Historically, this species ranged throughout the eastern United States west to Nebraska and South Dakota. Today, it is known to occur in only a few locations. The riparian and wetland forest and grasslands along the Missouri River in South Dakota, Nebraska, and Iowa potentially support isolated populations of American burying beetles; however, as stated by B.C. Ratcliffe at the University of Nebraska State Museum in 1993, no observations of the beetles have been made on the Missouri River to date (Corps 2004a). Additionally, the habitat requirements are not well understood, but the beetles apparently occur wherever small mammal or bird size carrion is available and suitable substrate for burying the carrion is present in forest or grassland habitats (from Anderson 1982 and Ratcliffe and Jameson 1992 as stated in Corps 2004a).

Pallid Sturgeon – The pallid sturgeon is listed as an endangered species primarily due to habitat loss. The pallid sturgeon is found in both the Missouri and Mississippi Rivers. The pallid sturgeon is one of the largest fish found in the Missouri River system and has a distinctive appearance, with a flattened shovel-shaped snout, bony plates, and a long reptile-like tail. Populations of pallid sturgeon are now so small that the fish are rarely seen or caught by anglers. The primary reason for their decline is believed to be habitat loss cause by man. The pallid sturgeon's habitat has been altered by the dams that modify river flows, reduce turbidity, and lower temperatures. Pallid sturgeon recovery activities are part of the MRRP. Pallid sturgeon are currently being raised in hatcheries and restocked in the Missouri River. The hatchery replenishes missing generations and preserves population structure while the ecosystem is restored. This is not a solution to saving the species, however it will help in their recovery. There are currently six hatcheries along the Missouri River.

Priority River Segments

Segment 4 (Garrison Dam to Lake Oahe Headwaters near Bismarck, North Dakota) – RM 1389.9 to 1304.0

The 90-mile reach between Garrison Dam and Lake Oahe lies at the transition zone of eastern and western bird species and therefore supports a very diverse bird community. More than 50 species of breeding birds depend on the wetland riparian habitat in the corridor, along with 17 species of reptiles and amphibians. The extensive riparian cottonwood forests that historically bordered the river have diminished since dam closure, largely as a result of the conversion of land for agricultural uses. In addition to land use impacts, cottonwood acreage will continue to diminish as mature stands age and convert to stands of mixed species. Canada geese (*Branta canadensis*) (more than 2 pairs per mile of river) rely on stable flows in this reach during mid-March to mid-May for successful nesting. As stated by M. Olsen of the USFWS, Bismarck, North Dakota in 1998, from late-October to December several hundred thousand migrating waterfowl, including over 180,000 Canada geese, use sandbars, wetlands, and croplands (Corps 2004a). Waterfowl often remain in the area until the river freezes (between November and December), and some continue to inhabit the river area below the dam all winter. Sandbar habitat for migratory waterfowl varies from 18 acres at 30 kcfs to 3,237 acres at 10.3 kcfs, with flows in most years producing between 135 and 765 acres (from Corps 1994 as stated in Corps 2004a). Shallow water areas provide night roosting for as many as 30,000 migrating sandhill cranes during September and October.

As stated by M. Olsen of the USFWS, Bismarck, North Dakota in 1998, there were eight bald eagle nests between Garrison Dam and Upper Lake Oahe in 1998 (Corps 2004a). The current nests are located in a stand of riparian cottonwoods that is 12 to 20 ft above the normal river level. Since the 1980's the North Dakota Game and Fish Department have participated in the Midwinter Bald Eagle Survey. An average of 32 bald eagles has been counted each year along the Missouri River from Bismark to Garrison Dam. The cottonwood habitat just south of Garrison Dam (in the tailrace) is particularly important winter roosting area for bald eagle (NDGFD 2007). As stated by D. Flath of the USFWS, Montana in 1998, bald eagles also winter along this reach, with total populations exceeding 100 birds (Corps 2004a).

The Missouri River below Garrison Dam is an important area for both piping plovers and least terns. From 1988 through 2000, 23 percent (1,339 of 5,899) of the piping plovers and 25 percent (1,973 of 7,867) of the least terns observed on the Missouri River and reservoirs were found here. Piping plover numbers on this part of the river have averaged 103 adult birds annually from 1988 to 2000. The adult bird numbers have ranged from a high of 261 plovers in 1995 to a low of 6 plovers observed in 1997. Least tern numbers have averaged 152 adult birds. The number of adult birds has ranged from a high of 284 terns in 1995 to a low of 41 in 1997. The continual shifting of sandbars and the dynamic nature of the vegetation on the sandbars forces the birds to relocate to new nest sites from year to year. Some of these birds have nested within the headwaters of Lake Oahe during low water periods. Predation and sandbar use by boaters and recreationists near Bismarck have been reducing tern and plover nesting success. As stated by W. Jobman of the USFWS, Grand Island, Nebraska in 1993, migrating whooping cranes have been observed to roost in this section of the river in recent years (from Howe 1989 as stated in Corps 2004a).

Segment 6 (Oahe Dam to Big Bend Dam, including Lake Sharpe) - RM 1072.3 - RM 987.4

Large numbers of waterfowl, especially Canada geese, congregate on the river downstream of Lake Oahe and on Lake Sharpe near Pierre, profiting from the mix of open river and riparian and cropland cover that characterizes the reach and adjacent lands between the two reservoirs. Much of the wetland and riparian vegetation of this reach occurs in the tailwaters of Oahe Dam in a stretch of the river that is usually ice-free in the winter. This area downstream of the dam is an important feeding area for wintering bald eagles, which prey on waterfowl attracted to the open water and shoreline cover. As stated by J. Peterson of the USFWS, Lake Andes, South Dakota, in 1998, the Missouri River in South Dakota supports as many as 400 wintering bald eagles (Corps 2004a); however, numbers have declined in recent years, possibly due to reduced perching and roosting habitat along the river in this reach. No tern or plover nesting on this reach has been reported, but peregrine falcons (*Falco peregrinus*) and whooping cranes may briefly stop over in wetlands during their migration.

Wildlife resources of Lake Sharpe are similar to those of the riverine reach immediately upstream. Unlike other mainstem lakes, water levels in Lake Sharpe remain relatively stable throughout the year. Wetland and riparian areas provide habitat for waterfowl and aquatic furbearers, mostly at the upstream end of the lake. SDGFP manages one game management area for waterfowl and upland game birds, including pheasants. Additionally, the Lower Brule Sioux and Crow Creek Sioux Reservations have departments that restore and manage habitats on tribal lands.. Few bald eagles overwinter around Lake Sharpe because of a lack of perch sites. No least tern or piping plover nesting along the shorelines has been reported.

<u>Segment 8 (Fort Randall Dam to Niobrara River) – RM 880.0 to RM 845.0</u>

This reach supports migrating and breeding waterfowl and contains two great-blue heron and double-crested cormorant rookeries. Of particular importance for migratory waterfowl are the 10 to 70 acres of sandbar habitat exposed by flows between 35 and 18 kcfs (from Corps 1994 as stated in Corps 2004a). This reach, which includes both Yankton and Santee Reservation lands and Ponca Tribal Lands, is an active wintering area for bald eagles, particularly within the Karl Mundt NWR, where from 1995 to 1997, between 150 and 200 bald eagles wintered in the 3-mile stretch below Fort Randall Dam (from USFWS 1998 as stated in Corps 2004a). The mature riparian forests, high waterfowl population, and abundance of fish provide high-quality bald eagle habitat. Six active nests were found along the river between Fort Randall Dam and Sioux City, Iowa.

This 45-mile stretch of the Missouri River did not see large numbers of either piping plovers or least terns until 1998. From 1988 through 2000, this part of the river averaged just 17 adult piping plovers. The adult numbers ranged from a high of 62 plovers in 2000 to zero plovers in 1988, 1989, 1995, and 1997. Least tern numbers on the Missouri below Fort Randall Dam averaged 33 adult birds annually. The adult numbers ranged from a high of 124 terns in 1999 to zero terns in 1988 and 1997. The long-term reduction of waterborne sediments has reduced sandbar habitat for tern and plover nesting. Cold hypolimnic water may also reduce tern and plover use of this reach by affecting forage. Whooping cranes have also been observed foraging in adjacent wetlands in this river corridor (from Howe 1989 as stated in Corps 2004a).

<u>Segment 9 (Niobrara River to Lewis and Clark Lake, including Lewis and Clark Lake) - RM 845.0 - RM 811.1</u>

This reach extends from the Niobrara River to just downstream of Springfield, and it includes extensive emergent wetland and riparian forest. Purple loosestrife has infested most of the emergent wetland. This has reduced wetland productivity as wildlife breeding habitat but still provides shelter for migratory waterfowl. The Bazille Creek Wildlife Management Area in the lake’s delta and over 3,000 acres in the Springfield and Running Water Bottoms (approximately RM 840) are managed for waterfowl. The open-water areas of the lake provide resting habitat for Canada geese and ducks, especially diving ducks. The least tern and piping plover nest on sandbars in the delta just downstream of the Niobrara River confluence and just upstream of the Santee Reservation banks. Lewis and Clark Lake typically supports a minimal number of both terns and plovers during the nesting season, although populations of both species spiked up in 1998 and 1999 following the high water year in 1997. In the 13 years of adult censuses, between 1988 and 2000 on the lake, an average of 29 piping plovers have been observed annually. The adult numbers have ranged from a high of 84 plovers in 1998 to a low of 4 plovers seen in 1995. Least tern numbers on the lake have averaged 53 adult birds. The adult numbers have ranged from a high of 120 terns in 1998 to 16 terns in 1995. Bald eagles also winter in the delta, feeding on waterfowl.

The ESH Program created 137 acres of nesting habitat for the least terns and piping plovers from September 2008 through April 2009 within the Lewis and Clark Lake Segment of the river (RM 827). Vegetation was removed on the sandbars to construct the nesting habitat. The 2009 terns and plovers monitoring indicated that 110 least terns and 63 piping plovers used the new nest sites for feeding and raising young (MRRP 2009). In 2009 and 2010, the ESH team is planning on constructing an additional 40 acres of ESH habitat at RM 842 within the Lewis and Clark Lake Segment. Construction would include removing existing vegetation and increasing the height of the sandbars to ensure habitat is available at varying river flows and elevations.

<u>Segment 10 (Gavins Point Dam to Ponca, Nebraska) – RM 811.1 - RM 753.0</u>
In this reach, the emergent, scrub-shrub, and forested wetlands and riparian forest support a wide variety of wildlife. Snow geese (*Chen caerulescens*) and wild turkey (*Meleagris gallopavo*) are important game species in this reach. Agricultural conversion of wetlands and riparian forest has eliminated over 60 percent of these habitats within 0.6 mile of the river (from Clapp 1977 as stated in Corps 2004a). Vegetation encroachment limits the use of numerous sandbars and islands by shorebirds and waterfowl. In most years, between 70 and 300 acres of sandbar are exposed during the fall migration at flows of 20 kcfs and 35 kcfs, respectively (from Corps 1994 as stated in Corps 2004a). There were at least two active bald eagle nests in Nebraska in 1998.

There are 19 areas in this reach that provide habitat for wintering bald eagles, especially areas downstream of Gavins Point Dam and near the mouth of the James River. These areas have large stands of riparian forests and are near waterfowl concentration sites along the river. From Gavins Point Dam to Rulo, Nebraska, over 200 bald eagles were observed wintering in 1997, many of which were in this segment (from USFWS 1998 as stated in Corps 2004a).

The Missouri River below Gavins Point Dam contains the highest number of piping plovers and least terns found during the 13 years (1988 to 2000) that adult censuses have been conducted on the river. This part of the river accounted for 24 percent (1,414 of 5,899) of all plovers and 28 percent (2,240 of 7,867) of all terns found on the river from 1988 to 2000. During this time period, an annual average of 109 adult piping plovers have been observed. The adult numbers ranged from a high of 212 plovers in 1988 to a low of 22 plovers seen in 1996 and 1997. Least tern numbers on this part of the river have averaged 172 adult birds annually. The adult numbers ranged from a high of 272 terns in 1993 to a low of 82 terns in 1996. Flat releases (equivalent to anticipated mid-August discharges) are made from Gavins Point Dam during the nesting season to ensure that terns and plovers do not nest at low elevations on sandbars that would likely be flooded between nesting initiation and late August, when young birds have fledged. High flows from rainstorms and erosion also destroy a small percentage of the nests each year. Predation, however, is the largest cause of nest losses in this reach. Rain storms and recreational use of the river during the summer also limit tern and plover productivity.

In 2008 and 2009 the ESH program created 76 acres of ESH habitat at RM 795 and 49 acres of ESH habitat at RM 774. During the 2009 monitoring, 17 least terns and 29 piping plovers were recorded using the sites at RM 795. A total of 35 least terns and 19 piping plovers were recorded using the sites at RM 774. Approximately 96 percent of the least tern nests and 81 percent of the piping plover nests in the Gavins Point Segment were located on the constructed sandbars (MMRP 2009). The ESH team plans to create an additional 30 acres of nesting habitat at RM 781 and 20 acres of nesting habitat at RM 781.4. The project at RM 781 would include constructing a backwater and using the material from the backwater and adjacent submerged sandbars to increase the elevation of three sandbars. The project at RM 781.4 would include removing vegetation and increasing the height of the sandbars.

Record runoff from 1995 to 1997 greatly increased the amount of suitable sandbar habitat in this reach. The American burying beetle may occur on the older, wooded islands in the reach, but none have been confirmed. The beetles appear to require forested islands with an accumulation of humus sufficient to bury carrion.

In accordance with its 2003 Amended BiOp, the USFWS recommends flow modification by 2003 at Gavins Point Dam to provide an ecologically improved hydrograph for the Lower Missouri River. According to the USFWS, flow modifications at Gavins Point Dam will restore and serve to maintain sandbars and shallow water areas that serve as nesting and foraging habitat for least terns and piping plover. The USFWS recommended the spring rise to be run at 17.5 kcfs every third year between May 1 and June 15 as runoff conditions permit. Summer flows are to be decreased every year from June 21 until September 1. A period of 3 weeks before and after the summer flow will be needed to adjust the river to implement the new summer-flow regime.

<u>Segment 13 (Platte River to Kansas City, Missouri) – RM 595.5 - RM 367.5</u>
Bald eagles nest and overwinter along the Lower River. No nesting bald eagles had been reported in Kansas or Missouri in areas adjacent to the Missouri River until recent years. In 1973, eagles constructed a nest along the Nebraska/Iowa border but later abandoned it. More than 200 bald eagles have wintered along the Nebraska/Iowa reach of the Missouri River (from USFWS 1998 as stated in Corps 2004a). Cold winters and lack of ice-free open water upstream often force the eagles to overwinter along the Lower River. No least tern or piping plover nesting has been recorded along the portion of the river from Ponca to the mouth of the Missouri River in recent times.

3.5.4 Aquatic Resources

Over 156 fish species have been documented in the Missouri River. These species include a wide variety of native species and numerous species that have been introduced into the mainstem lakes and riverine stretches of the river. The habitat classes available and, correspondingly, the species composition of the Missouri River differ considerably between the riverine and lake segments. The large mainstem reservoirs formed by the six dams on the river greatly changed the character of the river water and thus fish habitat. Even the river reaches below the dams have changed, particularly in terms of water temperature, clarity, chemical composition, and bottom configuration and substrate. The diversity of habitat has led to a greater diversity in the fish community.

Priority River Segments

Segment 4 (Garrison Dam to Lake Oahe Headwaters near Bismarck, North Dakota) – RM 1389.9 to 1304.0

The Missouri River channel downstream of Garrison Dam has remained in a near-natural state, except for some bank stabilization. Backwater and side channel habitat is common, and numerous sand bars and deep pools are present. The reach is dominated by releases of cold, clear water releases from Garrison Dam. In the tailwaters, water temperatures are cold enough to support populations of trout and salmon. Walleye (*Sander vitreus*), sauger (*Sander canadensis*), white bass (*Morone chrysops*), and channel catfish (*Ictalurus punctatus*) are also common in the tailrace. Temperature and turbidity increase downstream as a result of local runoff and bank erosion. In the downstream sections of the reach, carp (*Cyprinus carpio*), white bass, yellow perch (*Perca flavescens*), and river carpsucker (*Carpiodes carpio*) dominate the species composition. The lower portion of the reach also supports substantial populations of shovelnose sturgeon (*Scaphirhynchus platorynchus*), blue sucker (*Cycleptus elongates*), sauger, walleye, shorthead redhorse (*Moxostoma macrolepidotum*), and channel catfish. Pallid sturgeon may occur in this reach.

Segment 6 (Oahe Dam to Big Bend Dam, including Lake Sharpe) - RM 1072.3 - RM 987.4

The 5-mile-long reach between Oahe Dam and Lake Sharpe is dominated by coldwater releases from the dam. These releases vary hourly and cause wide fluctuations in water surface elevations. The reach supports a strong and very popular sport fishery. Rainbow trout (*Oncorhynchus mykiss*) have been stocked annually in the Oahe Dam tailwaters since 1981, providing a popular fishery (from Johnson et al. 1998 as stated in Corps 2004a). Throughout the reservoir, primary species include sauger, walleye, smallmouth bass, white bass, and channel catfish. Paddlefish (*Polyodon spathula*) were once a popular target species; however, that fishery has been closed to protect the remnant population. Management objectives are largely oriented toward enhancing the coolwater sport fisheries. A population of pallid sturgeon also exists in this reach. They are in poor condition, and the potential for reproduction appears limited.

Segment 8 (Fort Randall Dam to Niobrara River) – RM 880.0 to RM 845.0

Fish habitat in the 39-mile-long reach between Fort Randall Dam and Lewis and Clark Lake is more similar to natural river conditions than reaches downstream. This reach is designated as a Recreational River under the Wild and Scenic River System. The channel, including banks of the Yankton Reservation, is wide and meandering and contains numerous shifting sandbars and side channels. Because neither Lake Sharpe nor Lake Francis Case stratify strongly, release water temperatures do not support coldwater species and the reach is dominated by coolwater and warmwater species. The reach is subject to considerable bank erosion because of variable flows released from the dams and the natural meandering of the river. Native fish populations in the area are relatively productive. A naturally reproducing population of paddlefish occurs in the reach. This reach is one of the recovery-priority areas for the pallid sturgeon. Little is known about the specific habitat requirements of fish in the reach or how their populations respond to changes in the flow regime of the river. The principal tributary in this river reach is the Niobrara River.

Segment 9 (Niobrara River to Lewis and Clark Lake, including Lewis and Clark Lake) - RM 845.0 - RM 811.1

Sauger are the most sought after sport species in Lewis and Clark Lake. Walleye, freshwater drum (*Aplodinotus grunniens*), and channel catfish are also common in catches, and smallmouth bass (*Micropterus dolomieu*) are becoming more common. Smallmouth bass were stocked below Fort Randall Dam and have since become established in Lewis and Clark Lake. A small population of adult paddlefish is also present in the lake and is believed to be spawning naturally upstream of the lake near the Santee Reservation banks. High water levels during the spring spawning period increase the reproductive potential of most fish species in the lake. Fish production appears negatively related to the rate of water flow through the lake.

Segment 10 (Gavins Point Dam to Ponca, Nebraska) – RM 811.1 - RM 753.0

Studies of the benthic fishes within the Missouri River were conducted between 1995 and 1999 (Berry and Young 2001). Results from the 1996 and 1997 field seasons indicate that the overall diversity of species in the unchannelized reaches is increasing, which reflects the greater number of microhabitats and available niches. The largest number of species (40) was collected in the segment downstream from Gavins Point Dam. According to the USFWS, flow modifications at the Gavins Point Dam provide nursery habitat for pallid sturgeon and other native fishes, trigger spawning activity in fishes, and reconnect potential riverine and floodplain habitat by inundating side channels needed as spawning areas for fish.

Segment 13 (Platte River to Kansas City, Missouri) – RM 595.5 - RM 367.5

In the channelized reaches downstream of Sioux City, fish are associated with revetments and dikes. Side channels yield the greatest species richness and greatest numbers of fish; however, very few side channels remain. Little is known about what controls fish production under current conditions in this reach of the river. It also should be noted that more natural flows occur in this stretch of the river as one moves toward the mouth because the river has more unregulated tributary inflow. Principal fish species are similar in the unchannelized and channelized portions of the river and include emerald shiner (*Notropis atherinoides*), river carpsucker, channel catfish, gizzard shad (*Dorosoma cepedianum*), red shiner (*Notropis lutrensis*), shorthead redhorse, carp, and goldeye (*Hiodon alosoides*). Pallid and shovelnose sturgeon and paddlefish are also found in the Lower River and its major tributaries.

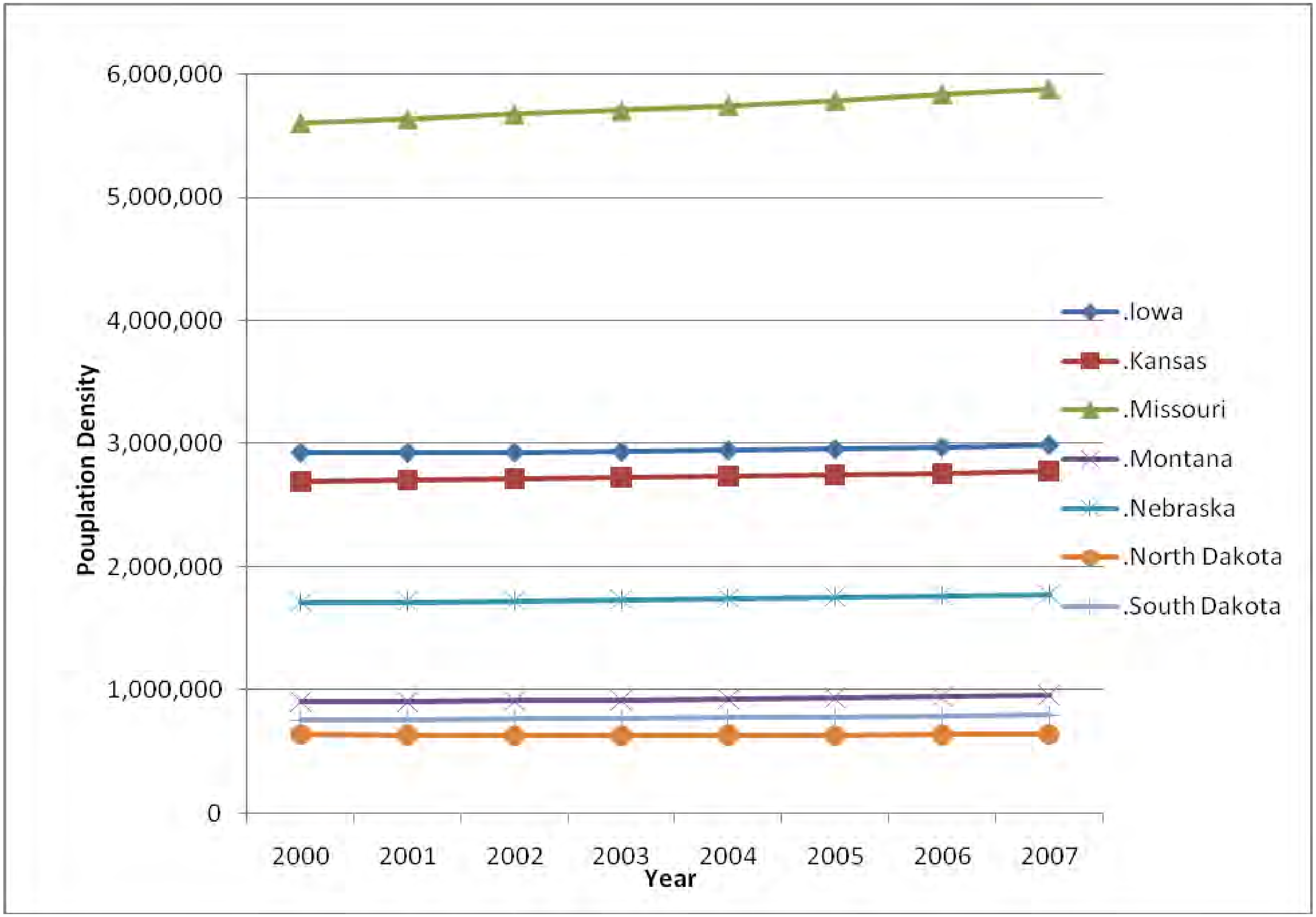
3.6 Socioeconomic Resources

The Missouri River basin is home to about 10 million people from 28 American Indian Tribes, 10 states (Colorado, Iowa, Kansas, Minnesota, Missouri, Montana, Nebraska, North Dakota, South Dakota, Wyoming), and a small part of Canada (MRNRC undated circa 1999). Seven states border the mainstem Missouri River from Fort Peck Lake to its confluence with the Mississippi River and benefit directly from the presence of the river. Thirteen (13) American Indian Reservations encompass or border the mainstem Missouri River. The Reservations along the mainstem include Fort Peck Reservation, Fort Berthold Reservation, Standing Rock Reservation, Cheyenne River Reservation, Lower Brule Sioux Reservation, Crow Creek Sioux Reservation, Yankton Reservation, Ponca Tribal Land, Santee Reservation, Omaha Reservation, Winnebago Reservation, Iowa Reservation, and Sac and Fox Reservation. The Missouri River system is a valuable source of jobs, recreation, hydropower, transportation of goods, and water supply for powerplants and domestic, agricultural, and industrial uses. In addition, operation of the mainstem reservoirs affects flows in the Mississippi River and, therefore, could affect transportation and the economies of Illinois, Kentucky, Tennessee, Mississippi, Arkansas, and Louisiana.

The states along the Missouri River have had low levels of population growth rates ranging from 2 percent to 6 percent over the past decade (Figure 3-8) (USCB 2007). North Dakota was the only state that had a decline in population from 2000 through 2003; however the population began to grow starting in 2004. For comparison, the United States had an overall population growth of approximately 7 percent from 2000 to 2007 (USCB 2007).

Farming and agriculture continue to grow in the United States. From 2000 through 2004, farm business equity grew at a compound annual rate of 6.7 percent, while net cash income rose by 7.5 percent. From 2005 through 2008, the farming industry continued to grow, with a compound annual rate of 6.7 percent and a growth of net cash income of 3.4 percent (USDA 2008). Farm wealth has steadily recovered and is forecasted to continue to increase from the farm crisis in the 1980s. Feed crops and oil crops had the highest level of crop production in 2008. Meat products and poultry and eggs had the highest level of livestock production in 2008 (USDA 2008). In 2008 the Northern Great Plains, which includes Montana, North Dakota, the majority of South Dakota, and northern Nebraska, contributed 6.4 percent of the net value of farm resources in the United States. The Heartland, which includes Iowa, Missouri, eastern South Dakota, and eastern Nebraska contributed 24.4 percent of the net value of farm resources (USDA 2008).

Figure 3-8. Population Density of States Bordering the Missouri River (2000-2007)



The following sections below describe the demographic characteristics and land use statistics of the counties bordering the reservoirs and river segments, when applicable. These counties are hereafter referred to as the first-tier counties and are identified for each reservoir and river segment.

Priority River Segments

Segment 4 (Garrison Dam to Lake Oahe Headwaters near Bismarck, North Dakota) – RM 1389.9 to 1304.0

Burleigh, Morton, Oliver, one-fourth of McLean, and one-half of Mercer Counties border the Garrison Dam to Lake Oahe reach of the Missouri River. Some of the largest cities included in this area are Underwood, Washburn, Stanton, Hazen, Beulah, Wilton, Bismarck, Mandan, and New Salem, North Dakota. Interstate 94 provides major access to the southern portion of the reach, as does U.S. Highway 83.

In 2007, a total of 4,095,019 acres of farmland exist in the first-tier counties. The average size farm within these counties is 1,183 acres. Approximately 2,325,103 acres (57 percent) of the farmland is considered cropland and 27,159 acres (less than 1 percent) are irrigated. The average market value for the land and buildings of the farms is $795,728 per farm or $677 per acre (USDA 2007).

There are 123 water supply intakes in the reach, providing water for irrigation (77), municipal (3 intakes serving 69,960 people), domestic (28), industrial (6), and public (3) uses. Land use in this reach consists of 34,600 acres of farmland, 6,123 residential buildings worth $332.7 million, and 333 nonresidential buildings worth $158.3 million. This reach also has six thermal powerplants with a combined capacity of 3,147 megawatts (MW). River flows from Garrison Dam releases affect recreation, water supply intakes, and flood potential. The municipal water supply facilities serve a population of approximately 70,000 persons. Low flows affect water intakes, boating access, and other recreational opportunities.

There are no American Indian Reservations that border the Missouri River in this reach.

Segment 6 (Oahe Dam to Big Bend Dam, including Lake Sharpe) - RM 1072.3 - RM 987.4

Socioeconomic data for the area surrounding Lake Sharpe only are described in this section. One-half of Stanley, Buffalo, and Lyman Counties and all of Hughes and Hyde Counties surround Lake Sharpe in central South Dakota. Pierre, Fort Pierre, Highmore, Fort Thompson, and Lower Brule are the larger cities in these first-tier counties. U.S. Highway 14 and Interstate 90 are major east-west routes through the area.

In 2007, Lake Sharpe had a total of 3,101,823 acres of farmland in the first-tier counties surrounding the lake. A total of 1,217,441 acres (39 percent) of the farmland was considered cropland and 20,515 (less than 1 percent) were irrigated farmland. The average size of the farms was 3,084 acres. The average market value for the land and buildings of the farms is $1,680,129 per farm or $609 per acre (USDA 2007).

The lakeshore includes 5,795 acres of managed recreational use areas. There are 115 water supply intakes on the lake, providing water for irrigation (91), municipal (3 intakes serving 2,390 people), domestic (19), and public (2) uses. The municipal water supply facilities serve a population of approximately 2,390 persons. Releases from Lake Oahe affect fishing and boating in the upper end of Lake Sharpe.

The Lower Brule Sioux Reservation and the Crow Creek Sioux Reservation are bisected by the Missouri River reservoir, Lake Sharpe and Lake Francis Case. The Lower Brule Sioux Reservation encompasses the western portions of Lake Sharpe and Francais Case from river miles 976 and 1048 in central South Dakota. The Reservation lies primarily within Lyman County, and a small portion lies in Stanley County. The Reservation covers an area of about 226,660 acres, of which 22,400 acres are covered by reservoirs. Approximately 165,657 acres are owned by the Tribe and Tribal members. There are an additional 29,314 acres owned by the Tribe adjacent to the Reservation. The Reservation population has approximately 1,582 tribal members. There are 444 residences on the Reservation. The U.S. Department of Housing and Urban Development helped fund the construction of 300 residences. The Tribe's major economic occupation is cattle ranching and farming. Approximately 11,686 acres of the Reservation land is devoted to crops and 118,232 acres are used for grazing for cattle and small herds of horse, bison, and elk (LBST 2009). The Tribe operates three large irrigated farms totaling 8,000 acres, a tribal construction enterprise, and a guided hunting camp operation. In addition the Tribe also operates the Golden Buffalo Casino and Motel, an RV Park, and a gas station. The Lower Brule Sioux Tribe is one of the nation's top popcorn producers (LBST 2009, Alan Lien, BIA personal comm..).

The Crow Creek Sioux Reservation is located across the lake from the Lower Brule Sioux Reservation on the eastern shore of Lake Sharpe, with a small part of the Reservation on the eastern shore of the upper reaches of Lake Francis Case. It lies within Buffalo, Hughes, and Hyde Counties in South Dakota. The reservation is approximately 125,591 acres with approximately 1230 enrolled members living on the reservation. The major industry for the Tribe is agriculture. The large majority of the farms on the reservation are for raising cattle. Hay, soybeans, and corn are also produced on the reservation (SDTGR 2004).

Segment 8 (Fort Randall Dam to Niobrara River) – RM 880.0 to RM 845.0

Below Fort Randall Dam, the Missouri River extends from RM 880 to RM 836 at Lewis and Clark Lake delta. One-half of Charles Mix County, South Dakota, and all of Boyd County, Nebraska, border this reach. Wagner, South Dakota, is the largest town in the reach.

In 2007, a total of 912,266 acres of farmland in the first-tier counties within this segment. A total of 493,645 acres (54 percent) of the farmland was considered cropland and 14,309 (1.5 percent) were irrigated farmland. The average size of the farms was 962 acres. The average market value for the land and buildings of the farms is $978,213 per farm or $1,018 per acre (USDA 2007).

Eight irrigation intakes exist on the reach. Flood control on this reach benefits 2,200 acres of farmland, 62 residential buildings worth $6.4 million, and 4 nonresidential buildings worth $0.6 million. Water releases from Fort Randall Dam affect fishing and boating opportunities in the river and, to some extent, visitor use patterns. A new Missouri River bridge below Niobrara opened in summer 1998. It furnishes a much needed tie between Nebraska and South Dakota.

The Yankton Reservation is located on the northeastern shore of the Missouri River in Charles Mix County in southeastern South Dakota. The reservation, which is approximately 40,000 acres is mostly farmland with some small areas of timber. The Missouri River is the southern border of the reservation. Today, the major employers of the Yankton Sioux Tribe are the Fort Randall Casino, Marty Indian School, Yankton Sioux Housing Authority, and Indian Health Services. The reservation population is approximately 3,800 individuals (SD 2009).

Segment 9 (Niobrara River to Lewis and Clark Lake, including Lewis and Clark Lake) - RM 845.0 - RM 811.1

Socioeconomic data for the areas surrounding the Lewis and Clark Lake only are described in this section. Bon Homme County and one-half of Yankton County, South Dakota, and all of Knox County, Nebraska make up the first-tier counties for Lewis and Clark Lake. The lake includes RM 836 through RM 811. Major cities in the area include Tyndall, Springfield, and Yankton, South Dakota. U.S. Highway 81 and Interstate 29 provide major access to the lake.

In 2007, Lewis and Clark Lake had a total of 1,167,282 acres of farmland in the first-tier counties within this segment. A total of 742,615 acres (64 percent) of the farmland was considered cropland and 70,654 (6 percent) were irrigated farmland. The average size of the farms was 553 acres. The average market value for the land and buildings of the farms is $891,875 per farm or $1,266 per acre (USDA 2007).

The lakeshore includes 2,860 acres of managed recreational use areas. There are 37 intakes on the lake, providing water for irrigation (27), municipal (2 intakes serving 4,380 people), domestic (6), and public (2) uses. The municipal water supply facilities serve a population of approximately 4,380 persons. Since the water level of the lake is generally unaffected by Mainstem Reservoir System operation, local tourism and visitation remain stable.

The Santee Reservation and the Ponca Tribe of Nebraska (Ponca Tribal Lands) are both located along the shorelines of Lewis and Clark Lake. The Santee Reservation is located in northeastern Nebraska in Knox County, along the southern shoreline of Lewis and Clark Lake. The reservation population is approximately 600 individuals. The reservation is approximately 9,449 acres, with the majority of the land used for farming. The major economic occupations on the reservation are cattle ranching and farming. Commercial businesses by private operators include a convenience store, laundromat, fast food shop, hunting and fishing guide service, and a small motel (NAIT 2009).

The Ponca Tribal Lands are located in portions of three counties located in the eastern third of the State of Nebraska. The counties are Knox and Madison, situated in the northeastern section of the State, Douglas and Lancaster, located in southeastern Nebraska, and Charles Mix in south central South Dakota. The Tribal headquarters is located in Niobrara with satellite offices in Lincoln, Omaha, and Norfolk Nebraska. The Ponca Tribe has approximately 1,300 enrolled members with a Reservation population of 30. Tribal owned land consists of 159 acres.

Segment 10 (Gavins Point Dam to Ponca, Nebraska) – RM 811.1 - RM 753.0

The first-tier counties in this segment from Gavins Point Dam to Sioux City (RM 811 to RM 717) include Clay and Union Counties in southeastern South Dakota and Cedar, Dixon, and one-half of Dakota Counties in northeastern Nebraska. Primary access into the area is via U.S. Highway 20 and Interstate 29. Vermillion, South Dakota; Hartington and South Sioux City, Nebraska; and Sioux City, Iowa, are the largest cities in the area.

In 2007, a total of 1,435,418 acres of farmland existed in the first-tier counties within this segment. A total of 1,191,176 acres (83 percent) of the farmland was considered cropland and 206,449 (14 percent) were irrigated farmland. The average size of the farms was 527 acres. The average market value for the land and buildings of the farms is $1,109,656 per farm or $2,100 per acre (USDA 2007).

Eight irrigation intakes exist in the reach. In addition, there are 91 water supply intakes providing water for irrigation (75), municipal (3 intakes serving 103,800 people), industrial (1), domestic (7), and public (3) uses. Flood control on this reach benefits 1,900 acres of farmland, 39 residential buildings worth $2.9 million, and seven nonresidential buildings worth $5.2 million. There are two thermal powerplants with a total capacity of 1,535 MW (Corps 2004a). The social well being of the county residents along this reach, which has been designated as the MNRR, is moderately tied to the river, because of the high visitor use.

Segment 13 (Platte River to Kansas City, Missouri) – RM 595.5 - RM 367.5

The first-tier counties in this segment from the Platte River to Kansas City, Missouri include the following: Cass, Otoe, Nemaha, Richardson, and Douglas, Nebraska; Mills, Fremont, Pottawattamie, Iowa; Atchinson, Holt, Andrew, Buchanan, and Platte, Missouri; and Doniphan, Atchinson, Leavenworth, and Wyandotte, Kansas.

In 2007, a total of 3,802,548 acres of farmland existed in the first-tier counties within this segment. A total of 3,154,320 acres (83 percent) of the farmland was considered cropland and 498,575 (13 percent) were irrigated farmland. The average size of the farms was 358 acres. The average market value for the land and buildings of the farms is $893,222 per farm or $2,505 per acre (USDA 2007).

This segment is important for transporting goods and materials via barge. An estimated 130 barge and terminal companies located on this segment moved 8,859,492 tons in 1999. In addition, 51 water supply intakes exist on the reach, providing water for irrigation (22), municipal (14 intakes serving 2,250,200 people), domestic (1), and public (4) uses. An estimated 1,158,000 recreation days occurred in 1992. Flood control on this reach benefits 834,700 acres of farmland, 8,973 residential buildings worth $477.8 million, and 856 nonresidential buildings worth $1,103.1 million. There are 13 thermal powerplants with a total capacity of 7,936 MW, making this the most energy-productive segment of the Mainstem Reservoir System. Two of these are nuclear powerplants with a total capacity of 2,040 MW. Associated with this energy production is the need for reliable, high-quality cooling water. The social value of the river includes its transportation, water supply, and recreational uses. Each use has a high inherent value, and, when combined, make the river an important factor in the local and regional economies. The mainstem dams contribute to this value with water releases in support of navigation and flood control capacity.

The Iowa Reservation and the Sac and Fox Reservation are both located within this reach of the Missouri River. The Iowa Reservation is located on the western shore of the Missouri River and is split evenly between southeastern Nebraska and northeastern Kansas. It lies in Richardson County, Nebraska, and Brown and Doniphan Counties, Kansas. The reservation is approximately 2,100 acres. The tribe's economy is primarily based on agriculture. The tribe raises cattle and operates the Flaky Mills and a grain elevator. The tribe also operates a casino, social services, gas station, and fire station (ICI 2008). The current population on the reservation is unknown.

The Sac and Fox Reservation lies within Tama County, Iowa; Richardson County, Nebraska; and Brown County, Kansas. The Sac and Fox Nation of Missouri, Nebraska, and Kansas has approximately 400 members. The exact number of people living on the reservation is unknown. The tribe currently operates a casino in Powhattan, Kansas (LK 2009).

3.7 Cultural Resources

Cultural resources include historic and prehistoric archaeological sites, historic architectural and engineering features and structures, and resources having traditional cultural or heritage significance to American Indians and other social or cultural groups. Paleontological resources are fossils of prehistoric plants and animals. Historic and archaeological resources are the physical remains of human occupation and activity that extend back in time for approximately 11,500 years in North America.

The NHPA and its implementing regulations (36 CFR 800) define responsibilities for managing cultural resources when a federal agency considers an undertaking. Any undertaking that would affect sites, structures, or objects eligible for nomination to the National Register of Historic Places (NRHP) according to the criteria set forth in 36 CFR 800 merits an analysis of the significance of the effect and potential avoidance or mitigation measures under the NHPA. The Antiquities Act of 1906 mandates that the federal government protect significant fossil discoveries.

There are two federal laws that apply to American Indian resources. The American Indian Religious Freedom Act (AIRFA) provides American Indians the right to practice their religion and is sometimes applied to federal installations where American Indians have religious sites that they require permission to visit and use a sacred site. Additionally, the NHPA recognizes a historic property class known as Traditional Cultural Properties (TCPs). These are often American Indian sacred sites, and can be determined eligible for nomination to the NRHP. When TCPs are identified, they have to be treated as eligible resources where project effects are taken into consideration.

In September 2001, the Corps made the decision to replace the existing Programmatic Agreement (PA) for implementation of Section 106 of the NHPA, which was signed in 1993. The existing PA was an agreement between the Corps, the Nebraska, South Dakota, North Dakota, and Montana State Historic Preservation Offices (SHPOs), and the Advisory Council on

Historic Preservation (ACHP). Since the signing of the agreement, a federal requirement came into effect that required the Corps to involve the American Indian Tribes within the Missouri River Basin on the implementation of the Cultural Resources Program in the Omaha District, which is the upper Missouri River Basin. The District and the consulting parties signed this agreement on April 13, 2004. The final PA included twenty-nine signatories, including representatives from three federal agencies, sixteen Tribal governments, one state agency, and one private organization, as well as two Tribal Historic Preservation Officers (THPO) and four SHPOs.

There are significant paleontological resources along the Missouri River in the Fort Peck region. Additionally, the lakes, shoreline zones, and adjacent uplands of the System contain a variety of archaeological site classes, including prehistoric sites of all periods and historic-era forts and homesteads. Under the auspices of the Smithsonian Institution's River Basin Surveys program, over 800 archaeological sites have been discovered and recorded and more than 200 sites have been excavated (Lehmer 1971 as stated in Corps 2004a). The Corps Cultural Resources Program has always been active in the preservation and protection of cultural sites within the Missouri River basin. Section 106 of NHPA responsibilities for inventory, testing and evaluation, impact assessment, and mitigation have been, and continue to be, the focus of the program. With the enactment of the Native American Graves Protection and Repatriation Act (NAGPRA) and the Archaeological Resources Protection Act (ARPA), the Cultural Resources Program now is responsible for the implementation of more than 20 federal laws, regulations, and Executive Orders, to include EO 13007, Indian Sacred Sites

Through operations and maintenance appropriations, the Corps has made progress in bank stabilization efforts for the protection of archaeological sites. The Corps will continue to consult with American Indian Tribes, THPOs, and SHPOs to determine priority sites where bank stabilization efforts should be focused. Site-stabilization work is contingent upon available funds. Additional sites will be protected as funding becomes available.

On November 16, 1990, the NAGPRA was signed into law. NAGPRA addresses the recovery, treatment, and repatriation of American Indians and Native Hawaiians cultural items by federal agencies and museums. NAGPRA also addresses the inadvertent discovery of American Indians or Native Hawaiian cultural items. As defined by the Act, cultural items are human remains, associated funerary objects, unassociated funerary objects, sacred objects, and objects of cultural patrimony. It is the policy of the Corps, to repatriate the remains of American Indians that are inadvertently uncovered by erosion or any other means in accordance with NAGPRA. Disposition of human remains, artifacts, and funerary objects is made to the Tribe whose cultural affiliation to the remains has been established. Within North Dakota, transfer of custody of human remains, artifacts, and funerary objects of American Indians is made to the North Dakota Intertribal Reinternment Committee (NDIRC). A NAGPRA-based Memorandum of Agreement was signed in 1993 among the Devil's Lake Sioux Tribe, Standing Rock Sioux Tribe, Three Affiliated Tribes, and Turtle Mountain Band of Chippewa, as represented by the NDIRC, and the Corps, concerning the protection, preservation, and disposition of unmarked human burials, burial mounds, and cemeteries.

CHAPTER 4. ENVIRONMENTAL CONSEQUENCES

NEPA requires the evaluation of environmental impacts associated with the alternatives including the No Action Alternative. This section presents the environmental impacts of the No Action Alternative (Alternative 1) and the Action Alternatives 2 and 3 on physical resources, water resources, biological resources, socioeconomic resources, and cultural resources. These analyses provide a basis for comparing the effects of the alternatives. NEPA requires consideration of context, intensity, and duration of impacts; indirect impacts; cumulative impacts; and measures to mitigate for impacts.

The physical, chemical, and biological characteristics of the Missouri River today vary significantly throughout the 2,300 miles of river length. Consequently, the status of listed threatened and endangered species, candidate species, and their respective habitats within the ecosystem upon which they depend, impacts to these species and habitats, and opportunities to implement actions necessary to conserve, restore, or recover these species and their habitats may differ by river reach or reservoir for the Missouri River (USFWS 2000a). Chapter 4 describes and analyzes the potential environmental effects on the physical, natural, and human environment associated with the No Action Alternative and the Action Alternatives 2 and 3, and the No Action Alternative. In addition, cumulative impacts are discussed throughout this chapter for each resource.

As a note, the range of measures includes several strategies that are included for completeness, but recognized as requiring substantial review, beyond the scope of this environmental assessment. While these measures are included in the toolbox for future consideration, this environmental assessment does not evaluate the potential impacts of these measures as that is beyond the scope of the document and not a reasonable alternative at this time.

4.1 Introduction

The following is a list of NEPA impact descriptors created to evaluate the impacts of the No Action Alternative and the Action Alternatives.

Significant Impact is a measure of the intensity and the context of effects of a major federal action on, or the importance of the action to, the human environment (40 CFR 1508.27). "Significant" is a function of the short-term, long-term, and cumulative impacts, both positive and negative, of the action on the environment.

Short-term Impacts are impacts with no lasting effects (temporary) which would subside and return to normal after the initial implementation of the CMP.

Long-term Impacts are defined as impacts with lasting effects that remain and do not diminish after the implementation of the CMP.

Direct Impacts are defined as impacts caused by the action and occur at the same time and place (40 CFR 1508.8).

Indirect Impacts are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable.

Cumulative Impacts are those combined effects on quality of the human environment that result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what federal or non-federal agency or person undertakes such other actions (40 CFR 1508.7). Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time or taking place within a defined area or region. It is the combination of these effects, and any resulting environmental degradation, that should be the focus of cumulative impact analysis.

Beneficial Impacts are those impacts that result in a net gain of resources associated with the proposed project or a favorable change in existing conditions.

Adverse Impacts are those impacts that result in a net loss of resources associated with the proposed project or an unfavorable change in existing conditions.

4.2 Physical Resources and Current Operations

Alternative 1 No Action Alternative: Under the No Action Alternative, the CMP would not be implemented. Current operation of the Missouri River would continue as it exists today, therefore no impacts are anticipated.

The No Action Alternative would continue to have long-term, adverse impacts to the physical resources of the system. The Missouri River would continue to have little overbank flooding and the natural cottonwood recruitment would continue to decline. The river south of Sioux City would continue to be a stabilized navigational channel with very few islands, backwaters, or oxbow lakes. .

Common to Action Alternatives 2 and 3: The Missouri River Basin drains four physiographic provinces, including the Rocky Mountain System, Great Plains, Central Lowlands, and Interior Highlands Provinces (Berry and Young 2001). The implementation of the CMP would have no impact to the four physiographic provinces associated with the Missouri River. The CMP would have no influence to the characteristics of each physiographic province, including precipitation and climate.

Alternative 2 Implementation of the CMP with Limited Strategies: Under Alternative 2, the CMP would be implemented using strategies that would protect and preserve existing cottonwood trees and plant and protect new cottonwood trees. Discouraging development near the river or clearing of cottonwoods and purchasing new lands or easements would have no impact to the physical resources or operation of the river (Appendix E, Box 1-5). Additionally the harvesting and planting of cottonwood seeds would have no impact (Appendix E, Box 18-22). The operation of the river would remain unchanged.

Alternative 3 Implementation of the CMP: The implementation of the CMP would create direct, long-term, beneficial impacts to the Missouri River. The CMP would continue to restore and preserve many of the existing characteristics of the pre-dam geomorphology of the river including, islands, sandbars, backwaters, oxbow lakes, and side channels. Large segments of the river below Sioux City have been modified over the years to include an intricate system of dikes and revetments designed to provide a continuous navigational channel without the use of locks and dams. This area has few islands, backwaters, or side channels. The implementation of the CMP would create long-term, beneficial impacts to these areas of the river by creating fluvial features, such as side channels, oxbow lakes, and backwaters, which would create suitable areas for cottonwood establishment (Appendix E, Box 14). The creation of these fluvial features would restore the historical geomorphology within the currently channelized portions of the river. Connecting the river to these habitats is critical to many fish and wildlife species, including many native fish species. Creation of these habitats and flow manipulation would reduce the rate of bed degradation and improve areas with low water tables. These techniques would require further NEPA analysis.

Cumulative Impacts: When combined with other programs or actions ongoing along the Missouri River, the implementation of the CMP under Alternatives 2 and 3 would create long-term, beneficial impacts to physical resources. Combined actions of the CMP, MRRP, and other projects would improve the geomorphology of the river.

4.3 Sedimentation and Erosion

Alternative 1 No Action Alternative: Under the No Action Alternative, the CMP would not be implemented and the current conditions of the river would persist. Long-term, adverse impacts are anticipated. The riverine segments of the river would continue to degrade and erode away. There would be no establishment of a cottonwood community along the unprotected riverbanks.

Common to Action Alternatives 2 and 3: Soils along the Missouri River are typically a mixture of clay, silt, sands, and gravel; and the bedrock is generally composed of shales and sandstones. Due to these soil characteristics, shorelines and river bottoms are highly erodible. The implementation of Alternatives 2 and 3 would create long-term, beneficial impacts by minimizing erosion and improving sedimentation processes along the riverine reaches. Bank erosion would be minimized through discouraging the clearing of cottonwoods along the river and through the establishment of new cottonwood communities along the highly eroded riverbanks (Appendix E, Box 2, 18-22). The establishment of these new communities would help protect the riverbanks from further erosion.

Cumulative Impacts: When combined with other Missouri River projects, the implementation of the CMP would create long-term, beneficial cumulative impacts. Impacts would include an increase in bank stabilization through the establishment of new cottonwood forests.

4.4 Water Resources

Alternative 1 No Action Alternative: Long-term, adverse impacts to river hydrology and water quality are anticipated as a result of the No Action Alternative. Development along the Missouri River is anticipated over the next 100 years, which would increase the amount of runoff entering the system. Livestock in the area would continue to graze along the riverbanks creating adverse impacts to water quality.

Common to Action Alternatives 2 and 3: Runoff varies from year to year within the Missouri River Basin. The implementation of the CMP under Alternatives 2 or 3 would create long-term, beneficial impacts to the overall water quality of the Missouri River. The Action Alternatives may include discouraging development along the riverbanks and purchasing lands or pursuing an easement to prevent the development of the land along the riverbank (Appendix E, Box 1, 3-5). The careful management and minimization of riverbank development would reduce the amount of runoff in the future. Livestock waste, which contains nitrogen, phosphorus, and organic matter is a significant source of nutrient pollution of the Missouri River. High levels of nitrogen and phosphorus entering into the system can promote algal growth and organic matter is decomposed by bacteria which typically decreases the amount of dissolved oxygen in the water. An additional long-term, beneficial impact to water quality would result from the management of livestock grazing on the existing cottonwoods along the riverbanks (Appendix E, Box 11). The control of the number of livestock along the riverbank would reduce the amount of ammonia, nitrogen, phosphorus, organic matter, and fecal matter entering the Missouri River.

Potential adverse impacts to water resources would also result from the implementation of the CMP under Alternative 2 or 3. Adverse impacts to water quality would result if pesticides were used to clear land of exotic species or if fertilizers were used to promote the growth of cottonwood communities along the river (Appendix E, Box 23). These adverse impacts would be short-term in nature, as multiple treatments are not expected. To reduce impacts to water quality from the use of pesticides and herbicides, nonpersistent pesticides and herbicides would be used and would be applied only in accordance with label and application permit directions.

Alternative 3 Implementation of the CMP: Potential adverse impacts resulting from the implementation of the CMP under Alternative 3 would include a decrease in the groundwater availability if there were irrigation of the agricultural fields to benefit the growth of cottonwood stands (Appendix E, Box 27). To minimize impacts to groundwater, the use of Irrigation Water Management Plans would be promoted and encouraged for more efficient uses of water in irrigation.

Cumulative Impacts: Cumulative impacts to water resources are expected to be long-term and beneficial. The control of livestock along the river and the discouragement of development would improve water quality. When combined with other projects within the area, the impacts associated with the implementation of the CMP under Alternative 2 or 3 would be negligible.

4.5 Biological Resources

4.5.1 Wetland and Riparian Vegetation

Alternative 1 No Action Alternative: Under the No Action Alternative, there would be long-term, adverse impacts to wetland and riparian vegetation. The operation of the Missouri River by the Corps would continue to restrict overbank flooding, which would continue to cause a reduction in the number of cottonwood stands along the river.

Common to Action Alternatives 2 and 3: Wetlands associated with the Missouri River provide wildlife habitat, fish breeding and foraging habitat, nutrient/sediment trapping, flood control, and recreation. Wetland vegetation includes herbaceous plants, woody vegetation, and shrubs. Riparian forests serve as important wildlife habitat, timber sources, wind shelters for residences, and locations for recreational activities. The implementation of the CMP under Alternatives 2 or 3 would create long-term, beneficial impacts to wetland and riparian vegetation. In order to reduce the mortality of the existing cottonwood trees, the Corps would conserve surface water and alluvial groundwater (Appendix E, Box 13). The conservation of surface waters and groundwater would allow wetland and riparian vegetation to thrive. Although most of the larger trees probably obtain supplemental subsurface moisture, the present surface soil conditions are more xeric (dries) in the absence of flooding and may contribute to higher cottonwood seedling-sapling mortality.

Implementation of the CMP under Alternatives 2 or 3 could include planting new cottonwood stands through methods including harvesting seeds and seeding or planting saplings, or cuttings (Appendix E, Box 18-22). The establishment of new cottonwoods would benefit the riparian buffer along the river. Additional benefits of wetland and riparian vegetation would be created through discouraging the public and property owners from clearing existing vegetation, purchasing and conserving land, and purchasing an easement on properties located adjacent to the Missouri River (Appendix E, Box 2-5). Additional benefits to the wetland vegetation and riparian vegetation would result from the control and removal of exotic species (Appendix E, Box 23). Removal of invasive species within established forests would increase the diversity and cover of native understory herbaceous vegetation and shrubs, and to encourage recruitment of native later successional species, such as green ash and elm species. This practice would also minimize competition of native species.

Alternative 3 Implementation of the CMP: Additional beneficial impacts to wetland and riparian vegetation would occur under Alternative 3. By creating side channels, reconnecting former oxbow lakes, and establishing backwaters, new habitat for wetland and riparian vegetation, including cottonwoods would be created (Appendix E, Box 14). Additional NEPA analysis would be required for these techniques.

Cumulative Impacts: Long-term, beneficial cumulative impacts to wetland and riparian vegetation would result from the implementation of the CMP when combined with other Missouri River Projects. Many projects along the Missouri River include the acquisition of new land and habitat for restoration and preservation.

4.5.2 Wildlife Resources

***Alternative 1 No Action Alternative*:** Under the No Action Alternative, the CMP would not be implemented. The requirements of the 2003 Amended BiOp concerning the bald eagle would not be achieved. The existing cottonwood stands along the Missouri River would continue to decline, decreasing habitat availability for the bald eagle and other wildlife species. The No Action Alternative would create long-term, adverse impacts to wildlife.

Common to Action Alternatives 2 and 3: Long-term, beneficial impacts to wildlife is expected under Alternatives 2 and 3. Existing cottonwood forest that is used by many wildlife species, including the bald eagle would be preserved by discouraging development along the river, discouraging clearing of existing cottonwood forests, and pursuing appropriate easements (Appendix E, Box 1-5). Bald eagles use cottonwood forests for nesting, roosting, and wintering habitat. The planting of cottonwood seedling, saplings, and cuttings would provide additional habitat over the years to many wildlife species (Appendix E, Box 18-22).

Long-term, adverse impacts are expected to those wildlife species, such as rodents, ungulates, and white-tailed deer that typically feed on cottonwood trees. Impacts would be long-term, since the plan is a 100-year process. The implementation of the CMP may include the control and prevention of deer and rodent/ungulate herbivory on existing cottonwood stands (Appendix E, Box 12). To minimize the impacts to rodent and deer populations that typically feed on cottonwood trees, the Corps would provide access to alternative grazing and shelter. If deer exclosures are installed, a Deer Management Plan based on habitat targets for the designated site would be prepared and implemented.

Federally threatened and endangered species that occur or potentially occur along the Missouri River include the whooping crane, Eskimo curlew, interior least tern, piping plover, Indiana bat, gray bat, and American burying beetle. Impacts to the federally threatened and endangered species would be evaluated during the NEPA process on a segment/site level. Additional agency consultation and field studies would be completed in the future prior to implementation of any of the suggested strategies associated with the CMP.

The bald eagle was delisted from the ESA in 2007, although it continues to be protected under other federal laws, including the BGEPA, the MBTA, and the Lacey Act (USFWS 2008a). The implementation of the CMP would create long-term, beneficial impacts to the bald eagle by creating additional nesting, foraging, and wintering habitat. The implementation of the CMP would also meet the requirements of the 2003 Amended BiOp.

Alternative 3 Implementation of the CMP: Many wildlife species along the Missouri River depend on the wetland and forest habitats. The implementation of the CMP under Alternative 3 would create long-term, beneficial impacts to wildlife in the area. The creation of side channels, oxbow lakes, and backwater channels would provide additional habitat to the 21 species of waterfowl that use this habitat year round or during migration (Appendix E, Box 14). In addition, to waterfowl, mammals, amphibians, reptiles, and other bird species would also use this newly created habitat.

Cumulative Impacts: Long-term, beneficial cumulative impacts to wildlife would result from the implementation of the CMP under Alternatives 2 or 3 when combined with other Missouri River Projects. The acquisition of new land along the Missouri River associated with the CMP along with other mitigation projects and programs would create additional habitat or improve current habitat for many species. Cumulative impacts to protected species including the interior least tern, piping plover, and the bald eagle would be beneficial. The CMP would restore and preserve existing cottonwood stands necessary for bald eagles and other migratory birds as well as avoid impacts to created emergent sandbar habitat for the terns and plovers. Coordination between the Cottonwood Management Team and the Emergent Sandbar Habitat and Shallow Water Habitat Programs would be initiated and maintained throughout the planning and implementation stages to ensure that no adverse impacts are created.

4.5.3 Aquatic Resources

Alternative 1 No Action Alternative: Under the No Action Alternative, the CMP would not be implemented. Impacts are expected to be long-term and adverse. The areas surrounding the Missouri River would potentially become developed and the health of the system could degrade. The historic features of the river would not be restored.

Common to Action Alternatives 2 and 3: The diversity of habitat along the Missouri River reflects the diversity of the aquatic community. As discussed above, the implementation of the CMP under Alternatives 2 and 3 has the potential to improve the water quality of the Missouri River, which would ultimately create a long-term, beneficial impact to aquatic resources. The management and minimization of riverbank development would reduce the amount of runoff into the river which would benefit the fish, invertebrates, and other species that rely on the Missouri River (Appendix E, Box 1, 3-5). In addition the management of live stock grazing would reduce the amount of ammonia, nitrogen, phosphorus, and fecal matter entering the Missouri River which could be toxic to some aquatic species (Appendix E, Box 11). Reducing the amount of pollutants entering the system would benefit the aquatic communities' habitat and feeding regimes.

Alternative 3 Implementation of the CMP: Additional beneficial impacts to aquatic resources would result under Alternative 3. The creation and reconnection of chutes, backwaters, and oxbow lakes would increase the habitat availability for aquatic species in the area (Appendix E, Box 14).

Cumulative Impacts: When combined with other Missouri River projects or programs, cumulative impacts to aquatic resources would be beneficial. Impacts would include the improvement of water quality and aquatic habitat. Impacts associated with the implementation of the CMP would be negligible when compared to other projects.

4.6 Socioeconomic Resources

Alternative 1 No Action Alternative: Under the No Action Alternative, the CMP would not be implemented. There would be no impact to the socioeconomics in the area. There would be no conversion of agriculture land to conservation land or no tax incentive or small business benefits. The land along the Missouri River would continue to be used by the current property owners.

Common to Action Alternatives 2 and 3: The implementation of the CMP under Alternatives 2 or 3 would create long-term, negligible impacts to socioeconomic resources. The majority of the land bordering the Missouri River is used for agriculture and cropland. The implementation of the CMP could include the Corps and other entities purchasing lands, creating voluntary property buyout programs, and pursuing applicable easements (Appendix E, Box 3-4). Some agricultural land would be planted with cottonwood seedlings, saplings, and cuttings (Appendix E, Box 18-22). Land owners would be compensated for converting agricultural lands to conservation land.

The implementation of the CMP has the potential to benefit some land owners and small businesses. The Corps could utilize short-term conservation loans, which may benefit small local businesses and also use tax programs and state incentives for land owners donating land for conservation (Appendix E, Box 6-7). Management measures would be implemented in compliance with the Corps Operating Principles and laws regarding property rights. Implementation of these techniques would require additional NEPA analysis.

Cumulative Impacts: The implementation of the CMP when combined with other Missouri River projects would create negligible cumulative impacts. Like the CMP, other projects may purchase agricultural land and convert it to conservation land, which could impact the income of land owners; however they may receive economic benefits from tax incentives.

4.7 Cultural Resources

Alternative 1 No Action Alternative: Under the No Action Alternative, the CMP would not be implemented. There would be no impact to cultural resources. The Corps would continue to progress in bank stabilization efforts for the protection of archaeological resources.

Common to Action Alternatives 2 and 3: Historic properties include historic and prehistoric archaeological sites, historic architectural and engineering features and structures, and resources having traditional cultural or heritage significance to American Indians or other social or cultural groups. There are numerous cultural resources along the Missouri River. Impacts to cultural resources would be determined during the NEPA process on a segment/site basis. The Corps would continue to consult with American Indian tribes, THPOs, and SHPOs.

Cumulative Impacts: Impacts to cultural resources would be analyzed during the NEPA process on a segment/site level. At this time there would be no foreseeable cumulative impacts to cultural resources.

4.8 Compliance with Corps Environmental Operating Principles

The Corps has reaffirmed its commitment to the environment by formalizing a set of Environmental Operating Principles applicable to all its decision making and programs. The intent of the Environmental Operating Principles is to ensure that the effects of the Corps activities upon the environment are included in the decision process at the earliest possible juncture. The principles help the Corps, within the context of their activities, to define their role in creating and maintaining conditions under which humans and nature can exist in harmony. They also ensure that conservation, environmental preservation and restoration are considered in all Corps activities at the same level as economic issues. The principles are consistent with NEPA, other environmental statutes and environmental provisions of Water Resources Development Acts that govern Corps activities, and the Army's Environmental Strategy for prevention, compliance, restoration, and conservation. The following Corps Environmental Operating Principles would be incorporated into the implementation of the CMP:

- Strive to achieve environmental sustainability. An environment maintained in a healthy, diverse and sustainable condition is necessary to support life.
- Recognize the interdependence of life and the physical environment. Proactively consider environmental consequences of Corps programs and act accordingly in all appropriate consequences.
- Seek balance and synergy among human development activities and natural systems by designing economic and environmental solutions that support and reinforce one another.
- Continue to accept corporate responsibility and accountability under the law for activities and decisions under the Corps control that impact human health and welfare and the continued viability of natural systems.
- Seek ways and means to assess and mitigate cumulative impacts to the environment; bring systems approaches to the full life cycle of the Corps processes and work.
- Build and share an integrated scientific, economic, and social knowledge base that supports a greater understanding of the environment and impacts of the Corps work.
- Respect the views of individuals and groups interested in Corps activities, listen to them actively, and learn from their perspective in the search to find innovative win-win solutions to the nation's problems that also protect and enhance the environment.

Environmental sustainability is a synergistic process whereby environmental and economic considerations are effectively balanced through the life cycle of project planning, design, construction, operation and maintenance to improve the quality of life for present and future generations. Throughout the development of the CMP, the Cottonwood Management Team has strived to achieve environmental sustainability in the planning process. This concept would be incorporated into the alternative designs for each site and throughout the construction, operation, and monitoring phases of this project.

In the further development and implementation of the CMP, the Corps would consider all environmental consequences of the CMP program and activities. Although this programmatic EA evaluates the potential impacts of cottonwood management along the Missouri River, site-specific environmental review, in the form of supplemental EAs, would be required in the future prior to construction or implementation of the management strategies presented in the CMP. During the NEPA process, the Corps would consider the full range of consequences of their actions on the environment, in conjunction with the actions of others (cumulative impacts). The Corps would seek ways and means to assess and mitigate any cumulative impacts to the environment. The Cottonwood Management Team has used innovative technologies, materials, and designs to lessen the stress of the activities on the environment and the economy. Prior to the implementation of the CMP, a cost-benefit analysis would be performed to ensure that relevant environmental and economic factors were taken into consideration.

Over the 100 year life span of this project, the Corps would continue to accept responsibility and accountability for all activities performed under the CMP. All aspects of the work would include administrative, technical, scientific, and managerial tasks associated with the CMP. The Corps would continue to make certain that all activities associated with the CMP comply with federal, state, and local environmental laws, regulations, and mandates. In addition, the Corps would continue to effectively use the specialized environmental expertise that is available throughout the federal government, state and local agencies, and the private sector. During the development of the CMP, the Corps has interacted with the public to take into account their opinions and views. The Corps has contacted numerous agencies, stakeholders, non-profit societies, land owners, and tribal governments, in which many have participated in various meetings and workshops. The Corps would continue this relationship with the public during future development of the CMP. In addition, this environmental assessment and future supplemental environmental assessments would be open for review and comment by the public.

CHAPTER 5. ADAPTIVE MANAGEMENT

As stated in the USFWS 2003 Amended BiOp, adaptive management is a process that allows regular modification of management actions in response to new information and to changing environmental conditions. Adaptive management is based on the premise that managed ecosystems are complex and inherently unpredictable. The complexity of the Missouri River ecosystem and management for fish and wildlife underscores the need for such an approach to ensure the variability and flexibility necessary to manage multiple species and be consistent with project purposes. Specifically, adaptive management is an important and effective way to insert variability and flexibility in river operations, taking maximum advantage of the inherent variability of precipitation and runoff within the river system (USFWS 2000a).

5.1 Introduction

Adaptive management is briefly defined as a type of natural resource management in which decisions are made as part of an ongoing science-based process. Adaptive management involves testing, monitoring, and evaluating applied strategies and incorporating new knowledge and learning into management approaches that are based on scientific findings and the needs of society. This iterative approach uses results to modify management policy, strategies, and practices (if necessary) due to the uncertainty of ecological responses to management actions as stated in NRC (2002). The purpose of adaptive management is not only to facilitate meeting the goals set forth in this CMP, but also to balance the greater environmental, social, and economic goals of the Missouri River ecosystem, increase scientific knowledge of river functions and restoration efforts, and reduce any tensions that exist among stakeholders (Williams et al. 2007).

An adaptive management process (AMP) should be employed for Missouri River ecosystem management that focuses on larger spatial and longer temporal scales to complement multiple river values using a collaborative, decision-making process which embraces the uncertainty of ecological responses to management actions. The management of large river ecosystems such as the Missouri River System is complex and contentious, likely due to the fact that stakeholders and scientists disagree about the social, economic, and ecological consequences of alternative management actions. Adaptive management is also important due to changing management actions in light of new information or changes in legislation. It has been suggested by Jacobson (2006) that the management of natural resources for large-scale ecosystem restoration efforts in the context of uncertainty requires an adaptive management process in which management actions are treated as experiments, and results are incorporated back into management strategies. Adaptive management has been recommended for the future management of cottonwood populations along the Missouri River. Adaptive management for the Missouri River System has been recommended by the National Research Council in NRC (2002), embraced by the Corps, and given serious consideration by the Missouri River Basin Association and USFWS (Prato 2003).

Prato (2003) and Jacobson (2006) describe adaptive management as including the selection, implementation, monitoring, and evaluation of a chosen implementation and restoration strategy (as applicable), with that action being retained provided cottonwood riparian stands improve and socioeconomic indicators do not fall below established acceptability limits. The value of using multidisciplinary approaches such as biological and socioeconomic indicators for adaptive management of the Missouri River floodplain restoration have been suggested and demonstrated by many documents and authors, including NRC (2002), Jacobson (2006), Prato (2003), and others.

Adaptive management can be generally described as a formal, multi-step process (Williams et al. 2007):

1. Identification of management problems.
2. Setting of management objectives through the lens of the ecosystem/basin stakeholder vision and goals.
3. Integration of existing information on how the system operates into dynamic models to predict how alternative management decisions will alter the system.
4. Testing and selection of management experiments through modeling.
5. Design of actual field experiments.
6. Implementation of management experiments.
7. Monitoring and evaluation of experiments and their effects on system performance.
8. Feedback to update models, reassessment, update of management actions.
9. Repeat as necessary to achieve objectives, goals and vision.

These nine AMP steps are a good foundation, but the AMP proposed in this CMP needs to be tailored to meet the goals and objectives of this CMP. In the 2002 paper, the NRC recommended immediate development and implementation of "an adaptive management approach to reverse the ecological decline of the Missouri River." The NRC favored this approach because treating management actions as experiments is likely to improve understanding and management of river ecology, and establishing a stakeholder group would result in more flexible river management policies and organizations. NRC (2002) stated that adaptive management of the Missouri River System would: 1) be challenging because it has never been done at that large a scale, 2) not solve all water resource conflicts in the river ecosystem, 3) entail significant resources, and 4) be challenged by traditional interests and users.

NRC (2002) offered several guidelines for using adaptive management to achieve ecological restoration in each of the 19 reaches of the Missouri River System. The first guideline is to coordinate adaptive management actions for separate river reaches. This is desirable because actions taken in one reach could affect ecological and socioeconomic conditions in downstream reaches (impacts of actions are spatially correlated). The second guideline is to implement management actions in a logical sequence. For example, impediments to channel widening should be removed before altering the flow regime. The third guideline is to subject management actions – such as prescribing flows to achieve desired rates of channel movement – to experimentation and refinement at the reach level before scaling them up to the whole river. This approach accounts for spatial variability in socioeconomic and ecological uncertainties. The fourth guideline is to prioritize management actions with the highest priority given to river reaches having the most compromised ecological processes. Since ecological processes and degradation are unique to each river reach, the fifth guideline is to customize restoration actions to each river reach.

Adaptive management should also be employed to allow the flexible implementation of flow regimes and river management along the Missouri River, schedule reach-specific appropriate measures, expand the cottonwood management activities beyond original segment boundaries, coordinate with other concurrent and future projects and policy, and to incorporate lessons learned from past projects. Each of these ideas is described in more detail in the following paragraphs. The AMP also embodies a monitoring program to determine the success (or failure) of measures suggested in this CMP. The design of a baseline hydrographic, biological, vegetation, and geomorphic data collection program to establish post-restoration conditions as well as the development of a long-term monitoring program is suggested as part of this CMP. Implementing the AMP represents a long-term commitment to monitoring the restoration of the Missouri River ecosystem.

5.2 Adaptive Management for the CMP

The CMP was written as a programmatic document for the Missouri River. The next phase will involve the development of segment plans to evaluate sites and alternatives within specific segments. Sites will be ranked and prioritized within a segment and then site specific plans will be developed for implementation. Similarly, adaptive management must occur at all three levels, with goals and objectives for each level.

The program goal is rooted in the goals for this programmatic CMP. Specifically, the goal is to maintain the Missouri River cottonwood community with no more than 10 percent mortality over the life of the project.

To determine if the program goal is being achieved, a monitoring program will be required. The purpose of monitoring will be to assess the status of the Missouri River cottonwood community, especially within the six priority segments. Data to be collected will be similar to that collected for the development of the Cottonwood Community HEP Model. It is anticipated that the data will need to be collected every 10 years to provide timely data and adequate response time, should the data indicate the need for adjustments to the program.

Adaptive management goals for the segment and site levels will be developed as those plans are developed. These goals will reflect the overall goals of the CMP, but will include more specific goals tied to condition within the segment or site. For example, Segment 10 has some recruitment but not enough to maintain the cottonwood communities, so goals in Segment 10 will need to include recruitment of new cottonwoods, either naturally or through plantings, and also protection of existing communities to maintain a diversity of age classes. Segment 13 has substantial natural recruitment, so the goals in this segment will likely be to protect a variety of age classes, to provide diversity of habitat.

5.3 Integration, Evaluation, and Maintenance

5.3.1 Integration of Data and Evaluation of Goals and Objectives

A description of the existing conditions and the integration of future conditions through monitoring to determine the long-term response of the restoration and/or preservation projects and subsequent management actions are critical to the AMP. As described below, the data collection process will involve establishing baseline conditions prior to restoring or preserving sites and will set in motion a monitoring plan for comparison purposes of future activities. Baseline data will be incorporated into the habitat modeling, and post-implementation monitoring will assess the geomorphological and ecological trends and to determine if the goals and objectives of this CMP are being met, thus creating a feedback loop.

Two key processes in this AMP include feedback (learning) and adjustment (adapting). Feedback requires the transfer of information about the effects of an action to decision-makers. Adjustment requires the use of this information to redirect subsequent action. The feedback loops accelerate the rate at which environmental decision-makers and stakeholders learn from experience and the implementation of measures.

5.3.2 Maintenance Program and Effectiveness

The CMP should become a permanent feature of the Missouri River and adaptive management policies should recognize the permanency of this plan. Due to the combination of the relatively short life expectancy of cottonwoods (substantial mortality normally occurs by 100 years) and the altered hydrology of the Missouri River regime, a perpetual maintenance program involving cyclic or periodic plantings would likely be required for success. Some replanting would be required in the years following initial plantings. If cottonwoods are not replanted during the first or second year, the continuous barrier, or newly established stand, could be jeopardized.

5.4 Continuation of the Cottonwood Management Team Role

Development of this CMP involved the cooperation of multiple agencies and individuals at various levels of participation, referred to as the Cottonwood Management Team. As segment specific plans are developed, new teams will be developed for each segment. The teams for this project include cooperating agencies and institutions that have agreed to provide expertise and data on pertinent topics of the CMP throughout the planning process. Numerous agency workshops have been conducted to gather information and request input from federal agencies, American Indian tribal governments, state agencies, academic institutions, and nonprofit agencies. Cottonwood Management Team Meetings have been conducted since 2002. The Cottonwood Management Team has been described in detail in Chapter 2. The role of the Cottonwood Management Team would continue, serving an active role in the AMP. The goal of public involvement through the MRRP is to create a MRRIC to work collaboratively with basin stakeholders. The MRRIC consists of the full range of basin interests and provides recommendations to the entities that are implementing the recovery program. The Cottonwood Management Team would exchange information with the MRRIC and the larger MRRP about restoration and preservation strategies to accomplish the larger Missouri River ecosystem recovery goals in coordination and collaboration with agency partners and stakeholders.

5.5 Incorporation of Lessons Learned

As described previously, adaptive management is a challenging blend of scientific research, monitoring, and practical management that allows for experimentation and provides the opportunity to *learn by doing*. Therefore, it is imperative to incorporate *lessons learned* from previous projects into the measures suggested in this CMP to ensure a high probability of success. If pilot programs are scheduled as part of the CMP, a feedback loop for experimental processes in the form of successes and failures would be implemented. Not only should lessons learned through this CMP be communicated and incorporated into the AMP, but lessons learned through past and other present projects should also be communicated and incorporated.

Based on the experience gained from other projects, several key *lessons learned* have been incorporated into the CMP and associated AMP. An important consideration throughout the planning process for the CMP has been building in the flexibility and procedures to quickly respond to unanticipated occurrences during and throughout the life of the project. The AMP provides a structure for submitting and gaining approval from the project stakeholders for any proposed changes. For example, the lessons learned from the following projects should be communicated and incorporated into this AMP and CMP:

- The *Fort Peck Dam Flow Modifications Project* (NRC 2002)
- *Missouri River Water Control Manual* and associated flow modifications
- The *Lower Colorado River Multi-Species Conservation Program* and pilot programs for cottonwood plantings (LCR MSCP 2007b).

In order to recognize "lessons learned" from other projects, the After-Action-Reports could be obtained or someone could be appointed to absorb the "lessons learned" via a larger Project Delivery Team and inform all other teams working on similar projects.

5.6 Coordination of Future Activities in the Missouri River Basin

Because numerous agencies, groups, and academia have been and are currently conducting research and programs in the upper and lower Missouri River, comprehensive coordination between these activities should be described and should continue to occur, including discussions of reach specific approaches and project expansion beyond original segment boundaries, as described in the sections that follow.

5.6.1 Coordination with Other Projects, Programs, Plans, and Policies

Comprehensive coordination between the activities that are currently implemented or are scheduled for implementation along the Missouri River should continue to occur. It is recommended that the Corps Integrated Science Program continue to work with other Corps and outside research programs to further implement this plan. This program would allow for projects such as the CMP to coordinate with other, smaller projects along the Missouri River. The MRRP includes implementation of the BiOp as well as the BSNP Mitigation Project on the Missouri River below Sioux City. Elements of the MRRP that could occur within the same geographic area as the CMP include the ESH Program, the SWH Program, and the Missouri River Mitigation Project. These programs and projects all stem from the 2000 BiOp and are described in more detail in the paragraphs that follow. As with the monitoring program, coordination would minimize interagency overlap and maximize information return and could be achieved through a central, management-related database of Missouri River restoration activities. The database could be a reference for those interested in coordinating a restoration program and could include a work-in-progress to which updates and additions could be made regularly; a list of significant monitoring programs in the U.S., and a starting point for users that provides appropriate contact information, websites, and references if further detail is needed. In addition, the program should interact with other national and international programs that study the ecology of large river systems such as the Missouri River.

Coordination with the following applicable projects, program, plans, and policies that are occurring (or are scheduled to occur) in the Missouri River Basin is described below:

- ***Coordinate the flexible implementation of flow regimes*** and river management, such as the optimization of natural flood events and coordination with lake operation activities. Coordination with the MRRP and the *Missouri River Master Manual* could benefit the CMP and well as other aspects of the MRRP. The Manual is the guide used by the Corps to operate the dams on the Missouri River. The Final (and revised) Manual (2006) included mimicking a spring pulse, known as the Spring Rise Alternative. The participating federal and state agencies as well as other stakeholders should continue to take part in the implementation of the Master Manual with the Corps and coordinate the operation of the dams and any future spring rises or pulses to determine if cottonwood restoration could be implemented at locations the pulse are scheduled to occur.

- ***Coordination with other non-Corps programs***, such as the LCRMSCP, which is designed to promote the recovery of six federally protected species while ensuring the certainty of existing river water and power operations. It also provides incidental take authorization for many specific future flow- and nonflow-related activities by federal and non-federal entities covered under the plan. The goal of the LCRMSCP is to increase the amount of four types of habitat along the river, including lower terrace cottonwood riparian woodlands. In addition to planting cottonwoods and other native plants, possible actions to restore and enhance habitat include construction of infrastructure for water delivery to habitat areas and dredging to create marsh and backwater habitats. Implementing the LCRMSCP (2007b) will create 8,132 acres of new habitat, which includes 5,940 acres of cottonwood-willow habitat. Work began in 2003 by restoring 154 acres with native riparian plant species including cottonwood, willow, and mesquite. This involved site preparation (clearing, root-ripping, leveling), soil testing, installation of irrigation infrastructure, and planting. Monitoring of irrigation and maintenance of planted areas has been on-going throughout the process. Although this project is located on the Colorado River, coordination with this program could be initiated to determine if integration of restoration methods would be useful along the Missouri River.

- ***Education and coordination with programs*** that are negatively impacting existing cottonwoods or preventing establishment, including cottonwood elimination in grassland and prairie restoration areas. Specifically, there are state parks and/or state forests between

Garrison Dam in North Dakota and the Kansas where cottonwoods are considered a weed; due to management activities to establish grasslands for prairie restoration, cottonwoods that grow naturally in these grasslands have been eliminated and have also been removed from Corps-owned lands in Kansas. These removal activities should, at the least, be coordinated between the entities that are completing them, including the different sections and districts of the Corps.

- ***Coordination with other Corps Programs under the BiOp*** that may affect existing cottonwoods, such as the ESH Program, the SWH Program, and the Missouri River Mitigation Project are recommended. These projects and programs, as well as the CMP, are part of the larger MRRP. In November 2000, the USFWS issued a BiOp for the federally endangered interior least tern and the federally threatened piping plover, which stated that their habitat (newly created or scoured sandbars with sparse vegetation) has been adversely affected by the operation of the Missouri River mainstem system. Responding to BiOp recommendations that approximately 12,000 acres be available for use by terns and plovers by 2015, the Corps began creating tern and plover habitat (or ESH) through mechanical habitat creation and by removing vegetation from existing sandbars in and along the Missouri River. Over the past two years, the Corps has created more than 800 acres of emergent sandbar habitat. Most of this was created by vegetation removal and close to 150 acres was created by dredging and other mechanical equipment. Killing the vegetation (including cottonwoods) with herbicides, then clearing the dead vegetation away is thought to be effective in creating barren sandbars. Similarly, the 2003 Amended BiOp by the USFWS stipulates the creation of SWH as a component of the reasonable and prudent alternative. Nearly 20,000 acres of SWH must be created by 2020 and existing SWH must be preserved. Therefore, the direct competition for resources among threatened and endangered species and created habitats under the BiOp should be avoided. Coordination between the Cottonwood Management Team and the ESH and SWH Programs as well as the Missouri River Mitigation Project should be initiated and maintained throughout the planning and implementation stages of the activities to reduce any negative effects, since the CMP and the ESH and SWH Programs and mitigation project are part of the larger MRRP.

5.6.2 Potential Expansion Beyond Segment Boundaries

Because this CMP is viewed as a living document that has built-in flexibility through the AMP, the implementation strategies may have applicability outside the six priority segments. Therefore, the measures could potentially be expanded beyond the defined segment boundaries and/or project boundaries into headwaters, tributaries, and deltas of the Missouri River. It is believed that these areas could play a role in the recovery of the Missouri River in addition to the priority segments. It was recommended by Johnson (2002) to assess the potential value and composition of the so-called “novel” habitats along the Missouri River, including reservoir mainstem deltas and those at the junction between tributaries and mainstem reservoirs. These habitats were identified as areas where conditions could potentially be suitable for short- or long-term establishment of native riparian vegetation, including cottonwood forest, but little work has been done to document their vegetation patterns (Johnson 2002). It has also been noted that tributary junctions should also be included as potential preservation sites because they are the most highly dynamic sites on the river where diversity can be maintained.

5.7 Monitoring

A key component of adaptive management is monitoring. Developing and implementing an appropriate and reasonable long-term monitoring program to evaluate the implemented restoration and/or preservation projects, as well as any subsequent or concurrent management or corrective actions is critical to the success of this CMP. Initiating the first post-implementation monitoring and assessment effort following completion of a project sets in motion the long-term monitoring plan. Subsequent monitoring efforts will be compared to this initial monitoring effort and to any baseline condition or reference site data that may have been collected prior to implementation of a project, as described earlier in Chapter 2. The post-implementation monitoring data and future monitoring data is incorporated into the habitat model to assess geomorphologic and ecological trends. In addition, the actual site conditions are compared to the predicted conditions based on the design of the project or to established performance criteria for a particular period of time following project implementation to determine the need for action under adaptive management. Monitoring post-implementation conditions provides a roadmap to allow for evaluation of future trends and the probability of success for other similar restoration and preservation projects proposed along the Missouri River.

Depending on the action implemented at a site, it will be important to select key variables to monitor and to determine how often (seasonally or year-round) to measure the identified influential parameters. As planned, monitoring will be conducted at individual sites as well as monitoring the progress of the overall program to achieve RPM #3 or "…ensure that no more than 10 percent of the cottonwood forest habitat that is suitable for bald eagles, is lost as eagle habitat during the project life."

As stated previously in Chapter 2, for site-specific monitoring, a baseline condition for the restored and preserved project areas must be established and incorporated into the habitat modeling, to be compared with future monitoring to assess any trends or changes in conditions. The baseline conditions for most restoration and preservation projects would be two-fold; 1) baseline conditions immediately prior to restoration or preservation (Chapter 2), and 2) post-restoration and post-preservation baseline conditions; monitoring landscape changes versus field-based changes; description of vegetation mapping and monitoring and establishment of permanent monitoring sites that would occur to determine if goals/objectives have been met. Baseline conditions would include channel geometry surveys at high flows of the proposed restoration reaches, aquatic and terrestrial habitat surveys for diversity, vegetation composition and density surveys, and all biotic and abiotic factors that can be used as metrics for success on individual projects. It is anticipated that some of the long-term monitoring parameters will vary from the initial baseline data variables as restoration projects evolve and various habitat trends are identified.

Monitoring protocols would be developed for each segment and for each restoration and/or preservation site to ensure accurate, valid data. Monitoring would be initiated following implementation. In addition to site-specific monitoring, the overall program will also require monitoring, which may include determining if the sites achieve the project HSIs in a set number of years and if RPM #3 is being met. Details of program monitoring will require input and agreement from the Cottonwood Model Development Team in the future.

Monitoring data will be incorporated into the ERDC Habitat Model to assess the effectiveness of the project. Assessment is the evaluation of data and allows the comparison of desired and actual outcomes as part of performance evaluation, the comparison and prioritizing of potential management actions, the comparison of predicted and actual outcomes in the process of learning, and the parameter estimation and model development. For example, post-restoration and post-preservation monitoring could be used to determine if the requirements of the RPMs have been met. If monitoring revealed that the objective for a management measure was not met, a responsive management action would be initiated.

Monitoring variables could be defined by the Cottonwood Model Development Team to assess geomorphic trends and to determine biological quality (and changes) at the restoration and/or preservation sites. Biological quality could include species diversity, distribution and abundance in conjunction with the processes and environments that sustain them as well as other fundamental variables. These variables could be separated into variables analyzed on an annual basis, such as hydrology and geomorphology data variables and biological data variables. Not all of the variables need to be monitored at each restoration project. Selecting variables to monitor for a given project depends on the established monitoring program already in place at other sites. Additionally, forecasting using detailed satellite imagery could be used or infrared aerial photography could be taken every three years at the restoration and/or preservation sites. Realistically, the satellite imagery could be used during monitoring to look at the landscape to determine a gross estimate of success, but would be integrated with some level of ground-truthing. If aerial photography is acquired, it could be used to conduct a geomorphic assessment on a cycle of defined years and could also be applied to various biological assessments, such as updating vegetation maps. Possible data variables that could be collected annually at restoration and/or preservation sites are based on those used in the Cottonwood Community Habitat Model.

5.7.1 Integration with Other Monitoring Activities

Due to the magnitude of this project, it is critical that the monitoring program proposed in this CMP be integrated with other, concurrent monitoring programs that are being conducted along the Missouri River. Specifically, this CMP will take into consideration applicable facets of the Missouri River Monitoring and Assessment Program (MoREAP) and similar programs that have either been previously implemented or are scheduled for implementation.

Obtaining information from monitoring helps ensure that MRRP decisions are utilizing the most current science available when determining what actions will promote recovery of the river ecosystem. Towards this end, MRRP habitat restoration programs will coordinate monitoring efforts to ensure sharing of critical data and to avoid unnecessary duplication of effort. In addition to the monitoring proposed in this CMP for cottonwood and bald eagle recovery efforts, the following monitoring programs are planned for the MRRP (Corps 2008):

- **Pallid Sturgeon Population Assessment –** has been developed by a team comprised of representatives of state and federal agencies and academia.

- **Shallow Water Habitat Assessment and Monitoring –** was developed to assess the physical and biological responses to shallow water habitat creation actions and assimilate information collected from monitoring efforts to inform habitat creation managers as to the effectiveness of habitat creation efforts.

- **Least Tern and Piping Plover Population Monitoring –** includes monitoring the production of young birds and conducts an annual adult census of least terns and piping plovers on the Missouri River.

- **Emergent Sandbar Habitat Assessment –** was developed to monitor and evaluate the effectiveness of constructed sandbar habitat. The goal of this project is to determine if sandbar habitat created by the Corps is providing suitable habitat features for nesting and foraging least terns and piping plovers, while avoiding negative impacts to other ecosystem functions or social values.

- **Water Quality Monitoring –** was developed to monitor the status and trends of ambient water quality parameters (i.e., temperature, nutrients, turbidity) throughout the basin. The data will be used to assess pallid sturgeon recovery, shallow water habitat development, and ultimately ecosystem recovery.

- **Missouri River Mitigation Wetland Restoration Functional Assessment** - was developed to evaluate the success of restored wetlands in the Missouri River floodplain in Iowa, Nebraska, Kansas, and Missouri. During 2009-2012 the occurrence and recruitment of amphibians and reptiles at Corps mitigation sites will be recorded. This data will be used to create models of quality wetland restorations, which will then be used by managers when designing future restorations and for adaptive management of existing restorations.

It has been suggested in Palmer et al. (2005) that the funders and/or regulators of restoration projects should ensure that an appropriate number of projects include broad ecological monitoring and evaluation. A critical first step is for regulatory and funding entities that promote, permit and fund river restoration to create and maintain databases that use a standardized protocol to record where and how restoration is performed. These databases should also maintain and analyze the monitoring information associated with restoration projects (Palmer et al. 2005). Integration with other Missouri River monitoring activities could be achieved through a database that indexes Missouri River monitoring programs in the United States. This database could be made available to practitioners to locate regional monitoring programs that may serve as models for the establishment or improvement of their own efforts. The database could be a reference for those interested in coordinating a monitoring program and would include a work in progress to which updates and additions will be made regularly; a list of significant monitoring programs in the United States (i.e., those programs that are well known among the scientific and non-scientific restoration and monitoring community in the US); and a starting point for users that provides appropriate contact information, websites, and references if further detail is needed. The National Oceanic and Atmospheric Administration (NOAA), National Centers for Coastal Ocean Science has created such a database for coastal habitat restoration practitioners (NOAA 2007). A database similar to the one described above for NOAA could be created for the MRRP and the monitoring portions of this CMP could be integrated with the known restoration programs described in the sections below.

5.7.2 The Missouri River Monitoring and Assessment Program (MoREAP)

The goal of the MoREAP is to provide the scientific basis for balanced management of the Missouri River's mainstem and floodplain fish and wildlife resources while avoiding or minimizing conflicts with other river uses (MRNRC Undated, circa 1999). The MOREAP proposes to expand existing monitoring programs and initiate new monitoring efforts to assess the biological, physical, and chemical responses to changes in Missouri River system operation and management. The intentions are to generate a system-wide database on Missouri River water quality, habitat, and biota and define the baseline environmental conditions. The Program includes two primary components: 1) long-term resource monitoring to define the baseline condition of river resources and identify trends along with 2) focused investigations, to predict cause-and-effect relationships between Corps operations and fish and wildlife resources. New data generated from the Program will provide benefits for not only fish and wildlife managers, but a wide range of other user's river interests including the Corps, the tribes, commercial navigators, floodplain managers, farmers, power generators, recreationists, agriculture, hydropower, recreation, and municipal and industrial water users (MRNRC Undated, circa 1999).

The MoREAP proposes 5 state-run field stations located in Montana, North Dakota, and South Dakota with shared stations for Iowa/Nebraska and Missouri/Kansas and would have a central scientific support facility administered by the USGS-Biological Resource Discipline in Columbia, Missouri. The MoREAP will integrate, but not duplicate, the data generated by existing state fish and wildlife and water quality monitoring and assessment programs on the river and is proposed for 15 years with the option to extend the entire program, or individual components, if necessary (MRNRC Undated, circa 1999).

5.7.3 Region 8 Surface Waters Plan for Ecology Monitoring and Assessment Program (EMAP).

The EMAP was developed in the USEPA's Office of Research and Development (ORD) to monitor status and trends in the condition of the nation's aquatic ecological resources at regional and national scales. The EMAP Western Pilot (Western EMAP) is a five-year effort (1999-2003) by USEPA Regions 8, 9 and 10 in partnership with states (CO, UT, MT, North Dakota, South Dakota, and WY), tribes and other parties to advance the science of aquatic ecosystem health monitoring and to demonstrate the applicability and usefulness of EMAP indicators in environmental assessments. Western EMAP is intended to demonstrate the value of monitoring based on a randomized design in the western United States by applying these techniques to assessment questions of regional and state interest (USGS 2007).

Comprehensive assessments resulting from the Western EMAP will serve as a baseline against which future assessments can be compared in order to reveal improvements in biological conditions resulting from regulation and restoration efforts. The focus area is based on the desire of Region 8 to better characterize the ecological conditions of aquatic resources in the Upper Missouri River Basin. This focus area will be sampled over the same four-year period as the base sample sites. Resources to be examined within the Upper Missouri River Basin focus area include streams, large rivers, mainstem Missouri River Reservoirs and riverine wetlands. For streams and rivers (excluding the mainstem Missouri River), about 275 sites will be sampled within the Upper Missouri River Basin (USGS 2007).

CHAPTER 6 IMPLEMENTATION OF THE CMP

6.1. Revisions/Updates to the CMP

Because adaptive management is an important and effective way to insert variability and flexibility in river operations and because this plan is viewed as a living document which has built-in flexibility through adaptive management, revisions and updates to the plan will be necessary as measures are implemented along the River. Individual sites will be monitored on a site-by-site basis, dependent upon the implementation measure(s) identified for the site. All sites will be evaluated on a ten-year overview along with review of the actual plan every ten years. Therefore, at a minimum, revisions and updates to the plan will occur every five years.

6.2. Implementation Timeline

The timeline for implementation of the CMP will be structured to meet the overall goal of the program: to restore cottonwood communities within the priority segments and to prevent further loss of cottonwoods from exceeding 10 percent of the baseline population.

Implementation will occur by segment, as each segment plan is complete. The proposed plan for completion of segment plans, subject to funding availability and other MRRP priorities, is as follows: Segment 10 Plan complete in FY 2011; Segment 6 Plan complete by end of FY 2012; Segments 8 & 9 Plan complete by FY 2013; Segment 4 Plan complete by FY 2014; and Segment 13 Plan complete by FY 2015. As each segment plan is completed, specific projects will be funded and implemented as partners are identified and funding is available. The intent is to have at least one or more implementations per segment for each fiscal year in the early stages.

Modeling for Segment 10 indicates that the cottonwood community will reach 10 percent population loss by 2020 due primarily to the lack of new recruitment. Information for other segments will become available as those plans are completed. Monitoring will provide updated information on cottonwood population levels and guide decisions regarding the timeline for implementation.

6.3. Funding Sources and Project Lands

The larger MRRP project is designed to restore Missouri River habitat not only along the upper reaches of the river but also along the lower portions, starting roughly at Sioux City, Iowa, and ending approximately 750 miles downstream at St. Louis, Missouri. The project, which ranks in size with the effort to restore the Florida Everglades, is only in the initial stages. The sections below describe in more detail funding sources and potential programs with funding for measures in this plan as well as project lands where implementation measures could restore and/or preserve cottonwoods.

6.3.1. Other Federal, State, and Local Programs

Federal Programs to Fund the CMP

Water Resources Development Act –WRDA is the principal legislative act authorizing all Corps projects and programs, including locks and dams for inland waterway navigation, dredging of harbors, flood control and ecosystem restoration. This legislation also authorizes billions of dollars for projects and programs to restore wetlands, streams, floodplains and coasts.

U.S. Congress passed the WRDA of 2007, which provided funding for the Missouri River Recovery and Mitigation Program under Section 5018. This Program authorizes the use of Missouri River mitigation funds for projects across the entire river basin. WRDA also established the MRRIC which consists of federal agencies, states, Indian tribes and stakeholders to provide guidance on restoration plans and activities throughout the Missouri River Basin. Specifically, implementation guidance for Section 5018 of the WRDA of 2007 authorized the Corps to:

- Prepare a study to determine the actions required to mitigate losses of aquatic and terrestrial habitat; recover federally listed species under the ESA; and to restore the ecosystem to prevent further declines among other native species. The study is referred to as the MRERP, and

- Establish a MRRIC. The MRRIC will include representatives from federal agencies, tribes, states, local governments and non-governmental stakeholders in the Missouri River basin.

Section 404/10 Activities – Activities requiring Section 10 permits include structures and work such as dredging or disposal of dredged material, or excavation, filling or other modifications to the navigable waters of the United States. Section 404 of the 1972 Act establishes the major federal program regulating activities in wetlands, and the 1977 Amendments significantly expand on the design of the Section 404 program, including exemption categories, the option of delegation of the 404 program to states, and enforcement powers. Section 404, jointly administered by the Corps and the USEPA, regulates the discharge of dredged or fill material into "waters of the United States," which includes wetlands. Discharge of dredged or fill material requires a permit from the Corps based on regulatory guidelines developed in conjunction with USEPA pursuant to Section 404(b)(1). This plan may be generalized for the entire river so that it may be stepped down for Corps project lands and other public and private lands where the Corps may be involved with Section 404/10 activities or other authorizations and funding. A management implementation measure entitled *Federal Use of Mitigation Projects to Require Cottonwood Plantings* is suggested in Box 30 as part of this plan with details using cottonwoods as mitigation for Section 404/10 Activities.

Federal Programs to Fund Individual Components of the CMP

U.S. Department of Agriculture Natural Resources Conservation Service Programs – Conservation Reserve Program (general and continuous), WRP, Wildlife Habitat Incentive Program, Environmental Quality Incentive Program, Grassland Reserve Program, Farm and Ranch Lands Protection Program.

U.S. Department of the Interior National Park Service Programs – Conservation Easement Programs (Scenic / Sloughing), Fee Title Acquisition, Fish and Wildlife Habitat Improvement Program, Rivers, Trails, and Conservation Assistance Program.

Funding through Easements – When a private land owner voluntarily gives up "developmental" rights and donates or sells this right to a government agency, it's called an easement. The landowner, still owns and manages the land. If the land interest is being purchased by the agency, an appraiser estimates the value of the easement based on a portion of the fair market value. Landowners who donate their land may be eligible for a federal income tax deduction equal to the value of their property minus the developmental rights. The following types of easements may be applicable as measures in this plan: Sloughing Easements, Conservation Easements, Wetland Easements, Flowage Easements, Recreational River Easements, Recreational River Feature Easement, and MNRR Sloughing Easement.

MNRR Program Funding – If a restoration/preservation site is identified within the MNRR boundary, landowner cooperation could be encouraged through the availability of MNRR program funding through the Corps. The Missouri River Futures Stakeholder Group has developed a description of potential MNRR program funding, which includes pursuing applicable easements and obtaining funding for the WRP. Other federal programs funded by the Corps include: MNRR Cottonwood Regeneration, Protection and Enhancement for Fish and Wildlife (Section 514), Aquatic Ecosystem Restoration (Section 206), Project Modifications for Improvement of Environment (Section 1135), Planning Assistance to States and Tribes (Section 22).

Other Federal Programs

Implementation strategy goal, Use Funding Programs to Protect Cottonwoods, describes in detail funds that may be applied for by private home owners, including the following (Appendix E, Box 6-10):

- Short-Term Conservation Loan Funds
- Tax Incentives and State Programs
- Existing Programs
- Forest Legacy Program Funds
- Conservation Cost-Sharing Programs

State and Local Programs to Fund Individual Components of the CMP

- WILD Nebraska - Nebraska Game & Parks Commission (in partnership with Lewis and Clark Natural Resource District and Lower Niobrara Natural Resource District)

- Landowner Incentive Payment - Nebraska Game & Parks Commission (in partnership with US Fish and Wildlife Service)

- Land Acquisition - Nebraska Game & Parks Commission, South Dakota Game, Fish & Parks, North Dakota Game and Fish Department

- Nebraska Soil & Water Conservation Program - Nebraska Natural Resource Districts (Lewis & Clark and Lower Niobrara)

- Conservation Easements - The Nebraska Land Trust

6.3.2. Project Lands

The restoration and preservation implementation measures identified in this plan could occur on federal, state, county, and private lands as well as on tribal lands. The Corps will work with local agencies and organizations to identify potential opportunities for projects. Private landowners, including non-governmental organizations, could be involved in developing and participating in the monitoring program. As part of the plan, the Corps may pursue real estate interests on lands where restoration and/or preservation is identified. All actions would be pursued on a willing seller basis and could include fee title purchase and easements, such as conservation easements. As these actions may involve the fee-title purchase of land and easement purchases along the river, some land may be transferred from private to federal holding and development may be limited.

CHAPTER 7. REFERENCES

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APPENDIX A

USFWS 2000 BiOp and 2003 Amendment

The USFWS 2000 BiOp and 2003 Amendment are available on the Missouri River Recovery Program website:

http://www.moriverrecovery.org/

The files are located under the **MRRP Documents** link.

APPENDIX B

Cottonwood Management Team Workshop Documentation

**MISSOURI RIVER COTTONWOOD MANAGEMENT PLAN
PROGRAMMATIC ENVIRONMENTAL ASSESSMENT SCOPING
WORKSHOP &
HABITAT MODELING WORKSHOP
Yankton, South Dakota
August 21 – 23, 2007**

Meeting Summary

Opening comments – Lisa Rabbe, Corps

Cottonwood Management Plan & Environmental Assessment – Suzie Boltz, EAEST

Brief overview of plan to develop CMP and EA, with project schedule.

Discussion of CMP Part I – potential management strategies – Rich Pfingsten, EAEST

The discussion of various strategies was prompted by the presentation materials, which identified four primary categories of strategies:

- Protection and Conservation
- Engineering Considerations
- Planting Methodologies
- Management Policies

Rich led participants through potential strategies for each category. Information on existing programs, including easements by the Corps and NPS, protection programs by various state agencies, and others were discussed. Some new ideas for strategies were offered. Suggestions for easements – conservation, sloughing, recreational river and flowage easements may provide opportunities for cottonwood protection and restoration. Joel Bich of the Lower Brule Sioux Tribe provided information on their cottonwood restoration efforts. Given the limited cottonwood management information in the literature, this information was helpful for assessing potential strategies.

Overview of Vegetation Mapping – Carter Johnson and Mark Dixon, USD

The discussion focused on the history of cottonwood studies on the Missouri River and the context of the current efforts to map cottonwoods. A pilot study was completed in 2006. Full-scale mapping studies for priority reaches are being completed in 2007 and the remainder will be completed in 2008. Field methods, data analysis and results of the pilot study were presented.

Review of Draft Community Model – Antisa Webb, Corps

An overview of the cottonwood community model being developed by ERDC was presented. Each priority reach will have a list of potential strategies that will be analyzed by the model to develop appropriate strategies by reach.

General Scoping – Suzie Boltz, EAEST

A general scoping session was help to solicit input for the development of the environmental assessment. An overview of the NEPA process was presented, and information applicable to development of the EA was requested, especially regarding appropriate alternatives, concerns with the proposed project, and other projects that should be addressed in the cumulative impacts analysis. A list of other projects was developed. Much of the information on alternatives and data was discussed in the earlier discussion on management strategies. It was noted that all information obtained during the 3-day workshop would be considered as part of the scoping process.

Cottonwood Community Model – Antisa Webb, Corps

Tisa led a discussion of model parameters were discussed, soliciting input on parameters and codes. Changes were made to the model as a result of the discussion and are summarized below:

1. CBIOTA and CTWFORESTRIPFOREST Cover type: replaced the NATIVES and INVASIVES with FQI and WIS
   Reasoning: the WIS - wetland indicator status will help further describe groundwater and terrestrialization index (to determine where the plant species will occupy). The FQI, because it help capture the herbaceous layer and will indicate invasives and natives.
2. Distinguished the Habitat Code of SANDBAR into sidebars and mid-channel islands, calling them ESH – emergent sandbar habitat (islands) and non-ESH sandbars, which are attached to the shoreline.
   Reasoning: to be consistent with the Emergent Sandbar EIS model, to ensure we do not choose planting sites on mid-channel bars with vegetation spraying will occur, and to capture the difference between these two sandbar habitat types.
3. CLANDSCAPE and CTWFORESTRIPFOREST Cover type: added [PATCHSIZE] and divided all three parameters by 3 (at the subreach level or higher).
   Reasoning: because all three parameters are equally important and we want to design large patches versus smaller patches
4. OVERALL HSI: changed to the percentages from CBIOTA (0.3333) and CLANDSCAPE (0.1667) to (0.25[CBIOTA]) + (0.5[CWATER]) + (0.25[CLANDSCAPE]).
   Reasoning: There was no justification for why the CBIOTA percentage was greater than the CLANDSCAPE percentage. This can change, and if we have reason to change this later, then the numbers will be re-adjusted.
5. Distance to nearest forest patch was changed from distance to next cottonwood stand to distance to next forest patch.
   Reasoning: because we couldn't distinguish in GIS or through the aerials the difference between a cottonwood tree and other riparian tree species

Summary of other important discussions on the Cottonwood Community Model:

- Tisa is currently using Chuck's model specifications (USACE Mitigation Project – used NLCD codes – Missouri River Cover Classes) and the USACE-Omaha Emergent Sandbar model specifications as a starting point and determine where the CMP project falls under and which cover types are applicable to our project. However, we may end up using Mark Dixon's cover classes because that is how the data were collected.
- The Study Area Boundary issue has still not been resolved: suggestions were made to look at soil data, historic flood events (25-yr), Carter Johnson suggested that

cottonwoods tend to die out in areas where they are 15 ft or higher above mean river stage.

- We still need to determine minimum mapping units for cover type classification – Mark Dixon used one hectare and that size seems a bit large for this project.
- Depth to Groundwater – Carter Johnson suggest we look at the elevation of the stand and the mean river level and can determine depth to groundwater through the difference of these two measurements.
- Tisa is relying on Mark Dixon to provide for adjacent land use data, age class data, age distribution, and there is still the outstanding issue of distance to patch and patch size.
- Water hydrology data – to be provided by Mike Gilbert and John Remus at the USACE.
- Adjacent land use – better explanations of category will be written by Tisa for the Team to review (if no age classes are present, how do we capture?).

FINAL LIST OF TASKS/NEEDS, DUE BY DECEMBER 2007 (and Responsible Party)

- Finalize Study Boundary (Lisa Rabbe/Chuck/Jeff Cowman/Tisa Webb)
- Finalize Cover Types from compiling ESH and Mark Dixon's cover classes (Tisa Webb/Lisa Rabbe/Kristine Nemec/Mark Dixon)
- Depth to Groundwater (Dan Pridal/Tim Cowman/Mike Gilbert)
- Add Floristic Quality Index (FQI) to Model (Tisa Webb/Mark Dixon)
- Add Wetland Indicator Status (WIS) to Model (Tisa Webb/Mark Dixon)
- Get GIS data for DIPATCH, PATCHSIZE, ADJLANDUSE (District GIS)
- Get AGECLASS data (Mark Dixon)
- Flood Data (frequency, stage, and rate of groundwater recedence) (Mike Gilbert/Dan Pridal)
- Complete year 2007 field data (Mark) – November 2007
- Acres per cover type for each site, subreach, and segment (Mark Dixon)
- Better define ADJLANDUSE categories for team to review (Tisa Webb)
- Census data for WOP (Suzie Boltz)
- Define Target Years (TY 0 = Baseline)

Habitat Evaluation Procedures (HEP) Analysis for Cottonwood Riparian Community Workshop, February 2008
Summary of Meeting Minutes

<u>20 FEBRUARY 2008 SUMMARY:</u>

Lisa Rabbe announced the introductions and the purpose of the project, which primarily includes trying to map habitat and take to different applications and integrate measures into the CMP and the EA. Described that ERDC is developing the actual model and the variables and Lisa and Kristine are conducting the planning process, which eventually will incorporate implementation.

Tisa Webb and Kelly Burks-Copes provided a review of the ERDC Habitat Evaluation Procedure (HEP) model process. An updated handout entitled "FIELD KIT" which describes the Habitat Suitability Index (HSI) Model Concept is a working model, still in draft. Noted that the model has changed a bit since August of 2007. Kelly mentioned that ERDC is required to have all models certified to ensure they are doing the best science.

Mark Dixon provided an update of the data collection process and reviewed the basic rationale of what they completed in Summer of 2007 that will be used to develop, calibrate, and incorporate into the ERDC model. Reviewed the GIS mapping portion of the project which includes using historic maps and aerial photos to quantify pre- (1890s to 1956) and post-dam (1956-2006) landscape changes. Also reviewed the vegetation sampling that is being conducted to quantify vegetation characteristics by stand age class – trees, shrubs, and herbs (structure, composition, metrics such as floristic quality and wetland affinity, native vs. exotic dominance) along with sampling design.

Tisa Webb and Kelly Burks-Copes continued the discussion of the ERDC (HEP) model and discussed the recently published Land Capability Potential Index (LCPI) paper written by Rob Jacobson at the USGS. One of the things ERDC will need for the model is a shapefile that shows flood stages and exceedences. It is not clear in the USGS Jacobson paper what was used in their formula for the LCPI paper – we need to know what layers they used for all of their data, is there any way to simplify their process because if this is adopted into our model, we need our model for all segments, and need to know their cell size, the 7 drainage classes, what field it was done for, and was Soil Survey Geographic (SSURGO) data used, and can it be automated. Kelly stated that we need Jacobson and his team for input. Kelly also stated that ERDC made a voting file for select team members to rank desired states for mature, saplings, young, and pole cottonwoods. ERDC needs to develop a non-cottonwood curve. More polling is needed on both the non-cottonwood and cottonwood curves.

Kelly stated that Tim Cowman, Theresa Smydra, Caleb Caton, and Mark Dixon created a list of criteria used for cottonwood site selection to generate some sites and that they should provide justification (describe why) for these criteria as well as note if there is different criteria for restoration vs. preservation sites. The criteria paper is entitled

Criteria for Assessing Priority Project Sites, Assigning Priorities for Cottonwood Restoration – Reach 10. Tim Cowman also mentioned that contouring the water table should be completed to generate a water table grid for the model.

It was noted by Mike Scott that tributary junctions should also be included in preservation because they are the most highly dynamic sites on the river where diversity can be maintained. One change that occurred was to consider the tributaries and the second change that occurred was to develop a separate set of criteria for preservation versus restoration. It was also determined that we need a flood frequency shapefile generated for our project; Dan Pridal stated that the Rec River Reach could be generated by September of 2008. To define the project boundary, Mike Gilbert asked if the 100-yr or 500-yr floodplain map that could be used to define the project boundary to use a project boundary that is consistent across the board. Lisa Rabbe agreed that the 500-year flood map could be used as the project boundary.

Finally, a discussion of the model input variables occurred and team members provided input for Suitability Index (SI) values for the model variables.

<u>21 FEBRUARY 2008 SUMMARY:</u>

Tisa Webb and Kelly Burks-Copes continued the discussion of the ERDC (HEP) model and the model input variables. Kelly made a model change for age distribution, by adding a variable called recruit – the sum of saplings and poles. Also, for the pre-settlement contribution of different age classes, we could map it for the segment and determine how far off we would be from the numbers presented in the 1992 Carter paper entitled *Dams and Riparian Forests: Case Study from the Upper Missouri River* in *Rivers*. Some segments would meet this structure or goals and some wouldn't – we will do this outside of the HEP, by making a matrix or do something similar to the LCPI and see how close the sites are to the pre-settlement numbers. Kelly stated that typically for adaptive management, during the monitoring cycles, the HEP model variables are re-run and compared to future projects and that there should be a section for monitoring and response in the CMP. The age distribution variable was dropped from the model. The correlation between native species richness, the C-value, the FQI, and the WIS was discussed.

Mike Scott stated that mortality effects are different now than the data Carter has published. For forecasting, there is detailed satellite imagery available that is a good resource that could be incorporated into a monitoring program – a segment-wide monitoring program would benefit from this. Lisa Rabbe added that for realistic monitoring, we would like to use the satellite imagery in monitoring to look at the landscape to get a gross estimate of success, but that some ground-truthing would still be required.

Tisa Webb brought up the point that the RPM states that the actions must be implemented with no less than 10% of cottonwood loss for project life for bald eagle use [regeneration must maintain pace with or exceeding mortality (of existing)]. How do we maintain or exceed mortality rate if we don't know what the current mortality rate is for base year 2006? Mark Dixon noted that Carter has run a model along the Platte River, that may have the answer to this question and that Mark and Carter could give you approximate answers.

It was noted that for the Emergent Sandbar Habitat Project, we need the plans (GIS layers) for the sturgeon and the terns to mark as out-of-bound areas (mid-channel islands) for our project as well as the ESH Site Selection Criteria.

Kelly Burks-Copes stated that at the next meeting, the without project conditions variables would be factored in, and should be able to predict shift in acres across habitat types and that there should then be a suite of management measures that will change the no-action.

Rich Pfingsten presented an updated outline of the Management Measures for the CMP as changed from the last meeting and from additional references that were reviewed. Finally, for each one of the 10 criteria on the list developed by Mark Dixon, Theresa Smydra, Caleb Caton, and Tim Cowman, the team went through each bullet and added the reasoning why the criteria were important (Tim Cowman was not available and did not provide input on 21 February 2008). Rich Pfingsten recorded the reasoning directly in the word document.

<u>22 FEBRUARY 2008 SUMMARY:</u>

Finally, for each one of the 10 criteria on the list developed by Mark Dixon, Theresa Smydra, Caleb Caton, and Tim Cowman, the team went through each bullet and added the reasoning why the criteria were important, while Tim Cowman was available. Rich Pfingsten recorded the reasoning directly in the word document. The team then looked at each of the 10 Site Selection Criteria and determined if restoration and/or preservation was applicable to each criterion. The team then added a new criterion: "Sites that would potentially provide connectivity and add to the size of existing cottonwood/riparian forest patches "connectivity to landscape" and reduction of fragmentation (not necessarily mature or just cottonwoods) – Preservation and Restoration." The team also discussed the potential to piggyback with backwater restoration projects. Tim Cowman will look at the 59-mile segment and will draw in polygons of high-risk erosion.

Habitat Evaluation Procedures (HEP) Analysis for Cottonwood Riparian Community Workshop Meeting Minutes November 18-21, 2008

The Cottonwood Management Team met in Vermillion, South Dakota from November 18 through November 21, 2008. The goals of the meeting were to review the status of the Cottonwood Management Plan (CMP), review the Segment 10 field data collection, discuss the Land Capability Potential Index (LCPI), explain the conceptual model, look at the Habitat Suitability Index (HSI) Model, review the site selection criteria for DSS, review the baseline results, determine the future conditions for Without Project conditions (WOP), and solicit input from team members for GIS-based forecasting protocols.

The twelve steps of the Habitat Evaluation Procedures (HEP) were explained. The first six steps of this process have been completed. During the meetings, November 18-21, 2008, the project team worked on completing Steps 7 (Calculate Baseline Conditions) and Step 9 (Determine Without Project Condition and Calculate Results). The future plan includes HEAT training, model refinement, completion of site selection criteria, developing with project alternatives, and WOP calculations in the winter; calculating with project results, developing cost plans, and comparing alternatives in the spring; and model documentation/certification and writing the draft assessment report in the summer.

The Preliminary Draft CMP has been completed and is currently in internal review at EA Engineering, Science, and Technology. The Preliminary Draft CMP will be submitted to the United States Army Corps of Engineers (USACE) in January. The CMP includes an introduction (project history and goals), the development of the CMP (data collection, site selection criteria, and habitat modeling), potential implementation strategies, monitoring processes and assessment, the adaptive management plan, and the implementation of the CMP, followed by the conclusions, references, and appendices.

A site visit to Segment 10 was conducted October 27 through 31, 2008. The purpose of the site visit was to observe current site conditions to facilitate development of alternatives for the HEP analysis. The alternatives developed would include minimal effort (single strategies), moderate effort (more than one strategy), and maximum effort (best approach without regard to cost, multiple strategies).

Field studies have been conducted by Mark Dixon, Mike Scott, and Dan Bowen. The overall goal of the field studies is to quantify the age distribution, structure, and composition of the cottonwood forests. GIS mapping shows the age distribution of the stands and the historic land cover change. Overall a total of 295 tree stands have been sampled across the entire Missouri River. A total of 224 of these stands were in priority segments, while the remaining stands were located adjacent to the segments. Progress thus far includes completion of vegetation sampling, drafts of GIS Mapping, and the pilot work on Segment 10. The field studies have found that there has been historic changes in understory species, historic land use changes (decline in forest, shrub, and sandbar habitat), and declines in cottonwood recruitment.

The Land Capability Potential Index (LCPI) is a tool used to understand the potential “wetness” of an area, to better estimate the potential for cottonwood regeneration. The LCPI objective is to develop a regional scale to classify the Missouri River valley bottom lands and related habitat and management potential, including topography, soil/sediment, morphology, and water. Vegetation is not included in the LCPI; it only looks at physical processes. For Segment 10 we have the topography, relative wetness (how often flooded), soil drainage classes, terrain classes, and elevation. When this data is brought together, the former floodplain of this area was very dry. The LCPI can be used to understand project alternatives by manipulating the topographic dataset and see how the LCPI values change.

Conceptual models are descriptions of the general functional relationships among essential components of an ecosystem (Fischenich 2008). They tell the story of how the system works and in the case of ecosystem restoration, how restoration actions aim to alter those processes or attributes for the betterment of the system. The CMP conceptual model has natural and anthropogenic drivers; hydrologic, geomorphic, climatic, human environment, and exotic invasion stressors. The significant ecosystem components of the model include water and soils, habitat, and landscapes, which create effects (reduced ground water, water quality, increase in invasive species, etc). The effects tie into the model components of hydrology, soils, structure, biotic integrity, spatial integrity, and disturbance which yield many attributes.

Mark Dixon mapped the 1892, 1954, and 2006 cover types. The 1892 mapping is the reference conditions used to scale the model (GIS Variable). Areas that were less than half an acre were aggregated up. A total of 63 different types of land cover were described, however these were lumped into 10 cover types. There are a total of 14 proposed action sites, however not all sites will be implemented. The sites are named by sub segment or property holders. The National Park Service site has been renamed to the Bow Creek Restoration Area. All sites will be renamed by river mile, so that they will no longer include the landowner's name.

Variables of the Model

The team discussed each of the ten variables which include Adjacent Land Use, Shrub Canopy Cover, C Value, Depth to Groundwater, Distance to Patch, LCPI, Patch Size, Recruit, Native Richness, and Wetland Indicator Score. Changes were made to the variables and additional variable were added. The changes/conclusions are discussed below.

- **Adjacent Land Use (ADJLANDUSE):** The team decided that the 2km buffer should be changed to the floodplain soils. This will be completed by interpreting the SERGO maps.
- **Shrub Canopy Cover (CANSHRUB):** The team decided that the canopy cover should include herbaceous cover and shrub cover. Herbaceous Canopy (CANHERB) was added as a new variable. The CANSHRUB and CANHERB will be averaged together within the formula for BIOTA. One curve will be used for CANHERB and one curve will be used for CANSHRUB. These curves will be developed by combining the CTWSHRUB and CTWFOREST to get the median. By using only the cottonwood shrub and forest, the suitability index (SI) for the riparian area will be lower.
- **C Value (CVALUE):** One curve will be used for the overall study area. This curve will be developed by combining the CTWSHRUB and CTWFOREST to get the median. By using only the cottonwood shrub and forest, the SI for the riparian area will be lower.
- **Depth to Groundwater (DEPTHGW):** The definition of groundwater changed from levels over the past 10 years to just summer levels. The SI for groundwater at 0m was changed to 0.0 and the SI for groundwater at 1m was changed to 1.0.
- **Distance to Patch (DISPATCH):** The team decided to use the distance between nearest forest patch for this variable.
- **Land Capability Potential Index (LCPI):** No changes were made. The team was asked to rank the categories in the LCPI. These votes will be pulled.
- **Patch Size (PATCHSIZE):** No changes. The 1892 data will be used as a reference to calibrate the curve.

- **Recruit (RECRUIT):** This variable was moved to the Landscape Component because of the scale capturing and protocols for curve calibration. This variable will only use the cottonwood dominant polygons (poles and saplings) in the numerator and the denominator will include all acres of woody cover type.
- **Native Richness (RICHNATIVE):** The definition of RICHNATIVE was changed from the percent of native species to the true native richness (count). One curve will be used for the overall study area. This curve will be developed by combining the CTWSHRUB and CTWFOREST to get the median. By using only the cottonwood shrub and forest, the SI for the riparian area will be lower.
- **Wetland Indicator Score (WIS):** For the shrub cover type, the obligate category was changed to 0.75 instead of 0.5 because typically optimum sites are wetter.
- **Cottonwood Proportion (PROPCTW):** This is a new variable that was added to the landscape component to capture the proportion of the total forest that is cottonwood and to show that the cottonwood forest is dying out with very little recruitment to replace the loss. Carter Johnson's paper (Table 5) will be used to calibrate the curve. We will start with 90 percent cottonwood is optimum.
- **Mosaic/Interspersion (MOSAIC):** This is a new variable added to the landscape component. This variable will capture interspersion of other cover types like wetland, open water, and other topographic features. The curve will be calibrated based upon the 1892 data. If the site has multiple habitats you will get a score of 1, if the site is only one habitat, it will receive a lower score of 0.75.

The team discussed each of the eleven site selection criteria. The team was asked to rank the site selection criteria. The criteria used for restoration will now be the same for preservation. The site selection criteria *Find Sites inside the High Bank* was determined to be unimportant in the selection process, therefore this criteria was dropped. The site selection criteria *Sites that Overlap with Existing or Potential Backwater Restoration* was expanded to include the side channels. A new criterion, *Nearness to Seed Source* was added to the site selection.

Without Project Trends

The team began the voting process for each variable for forest and shrubs for the WOP trends. A forest is located along the fringes of the river; by the time the forests have reached the bluffs they are considered uplands and include both riparian and cottonwood stands. Young forests are those that are 25 to 50 years of age, mature forests include trees that are 50 to 75 years of age, and old forests include those that are greater than 75 years of age. Shrubs include riparian shrubs and cottonwood shrubs. Poles are defined as those trees less than 10 m and saplings are trees 10 to 25 years of age. Herbaceous is not part of the model. Voting was used to avoid group thinking and to also quantify uncertainty. The polling was documented using Turning Point Software. Demographic questions including knowledge of the river and expertise were also polled.

The team began voting on the Sister Island site. There were six target years used during the voting, these included TY0 (2006 baseline), TY4 (2010), TY6 (2015), TY31 (2040), TY76 (2085), and TY100 (2110). The voting variables included RICHNATIVE, CALUE, WIS, CANSHRUB, and CANHERB. After voting on all variables for the forest, the team decided to use the real data to predict the succession changes, therefore voting ended.

To predict succession the team set assumptions which included, (1) To use actual data and apply trends to all 14 sites, (2) To capture young shrubs and old trees dying assume five, 25-year flood events over the life of the project, and (3) Existing sandbars will convert to young shrubs. At the end of a succession cycle tree composition of those greater than 114 years will be non-cottonwood riparian by the 2040. The acreage of cottonwoods will be placed in the model as riparian and will receive riparian scores. Those trees within the 25 to 50 year age class would be 150 year old in 2110; these trees would remain as cottonwoods. Shrubs that are less than 10 years of age at baseline will become young forest in 2040. They will become the baseline on the forest scale and then will move to 2040 then 2085. Shrubs within the 10 to 25 year age class will become young forest in 2015. These young forests will be the baseline and then move to 2040, 2085, and then 2110.

To predict recruitment, the PROPCTW variable was added to capture the proportion of the total forest that is cottonwood to show that the cottonwood forest is dying out with very little recruitment to replace the loss. Carter Johnson's paper will be used to calibrate the curve using 90 percent as the optimum. For recruitment the team has decided to look at the poles and saplings and assume that they were recruited during the 1997 flood event accretion. The team has assumed that every 25 years this will happen. The site boundaries currently do not match the vegetation boundaries; therefore they will be redrawn by selecting Mark Dixon's polygons and absorbing then to create the new site boundary. The site boundary at each site will be expanded to the opposite side of the river so that this will leave room for accretion. To determine the accretion and erosion, the team will calculate the per bank length rate of erosion and accretion for the entire geomorphic subreach for each segment and apply the rate to each of the sites. For accretion, the team will assume that 50 percent of the accretion area will become more successful cottonwoods and 50 percent will remain sandbars. For erosion, the erosion rate will be the same as calculated, a 1:1 ratio. A total of six sites have high erosion rates, these will be the focus. The team will assume that if there is a revetment, the accretion and erosion rates would not apply.

Review of Segment 10 Sites and Potential Alternatives

The project team reviewed aerial images for each of the fourteen sites in Segment 10 and discussed the features at each site. As they discussed each site, the team began brainstorming ideas for the alternatives at each of the sites. A new rule for land use conversion was determined: Any old or mature forest (class 1 or 2) adjacent to agriculture/cropland will be converted within the next 100 years except for a 50 meter buffer along the river. Category 3 age class will be converted to cabins depending on the site over the next 100 years. The team decided to expand and or change some of the property boundaries at the sites to now include features such as backwaters and forest areas. Property boundary changes included the following:

- **RM 793** – Expand the property boundary to include the chute.
- **RM 766** – Expand the property boundary to include the adjacent agriculture and forest area to five the site more restoration potential.
- **RM 757.1** – Extend the property boundary to include the backwater.

During the discussion, the team determined the enhanced value of backwaters and wetland areas to the cottonwood community were not being captured by the model. To capture this concept a new variable was added to the model, MOSAIC. This variable will capture the interspersion of other cover types like wetland, open water, and other topographic features. The curve will be calibrated based on the 1892 data. A total of four new cover types were added to the model and included the following:

- **ISLANDS –** these include the vegetated islands in the river, but not the ESH sandbars.

- **NEWWATER** – captures the newly developed backwater area without an outlet and newly developed flow-thru channels.
- **OTHERWATER** – backwaters and chutes that were originally named RIVER.
- **NEWCTWSEED** – capture the with-project designs for planting cottonwood seeds.

On Friday, November 21, 2008, a slideshow summarizing the status of the cottonwood management project was presented. It described future needs of the project: LIDAR, MEANDER/erosion model and channel migration, monitoring/pilot program, global climate change modeling, risk and uncertainty modeling, and multi-criteria decision analysis for the DSS. Casey Kruse requested that a general session proposal be submitted to the NCER conference by December 12, 2008, and a proposal for monitoring and LIDAR processing be submitted to the USACE.

Upcoming meetings will include the following:

- December 4, 2008: Conference Call – Lisa Rabbe, Suzie Boltz, and Kelly Burks-Copes to discuss abstracts
- December 11, 2008: Team Conference Call – set up journal article summit
- December 12, 2008 – Deadline for NCER abstracts and MNR abstracts
- Early January 2009 – Baseline Results via Live Meeting
- March 25-27, 2009 – MNR Conference, Billing, MT
- March 30 – April 3, 2009 – Segment 10 With-Project Trends Meeting, Vermillion, SD

Recorder: Jeannette Dawson

Cottonwood Management Plan
Alternative Designs Workshop
Vermillion, SD

March 30 – April 3, 2009
Summary Minutes

The Cottonwood Management Team met in Vermillion, South Dakota from March 30 through April 3, 2009. The goals of the meeting were to discuss the progress of the project to date, to review the implementation strategies, to present the five alternatives designed for each of the fifteen sites on Segment 10, to discuss the thresholds for Adaptive Management, and to review the draft Cottonwood Management Plan (CMP).

The United States Army Corps of Engineers (the Corps) certification process for the model was explained to the project team. The review process can take up to eighteen months. The certification process includes a list of 23 questions that need to be addressed and submitted to the Corps. The Corps would then contract out the review to a group of experts which would include a planner, hydrologist, Habitat Evaluation Procedure (HEP) expert, and cottonwood expert. The biographies of all experts that worked on this project were requested from the project team and would be included in the model submittal to the Corps.

The Without Project (WOP) analysis has begun. The WOP GIS was based on land use projections, acreage of fifteen sites, and baseline cover types. A visual flyover of cover types using Google is currently being created, which would allow users to turn on the 1892, 1950's, and present land cover types to show how the river has changed. The five rules of the land conversion model were presented to the project team. The five factors used to predict what the land use will be in the future include urban sprawl, erodible areas, agricultural land use conversion, federal and state lands, and cottonwood succession. Through the Baseline and WOP analysis we will see what the lift will be in each reach, site, and segment.

The CMP identified implementation strategies for the project. As a result of the comments received on the first draft of the CMP, some implementation strategies were lumped or deleted. The four implementation strategies that were carried forward through the alternatives development process include the following: Protection and Conservation Options, Engineering Opportunities, Planting Methodologies, and Management Policies. Each implementation strategy has general goals with associated techniques. Goals for the protection and conservation options include establishing land conversion measures, purchasing lands, utilizing funding programs, and preventing competition. General goals for the engineering opportunities would include channel restoration activities, creating fluvial processes, and floodplain activities, such as lowering the bench. Planting methodologies would include planting or propagating cottonwood seeds, seedlings, and saplings, in addition to disking the land and removing invasive vegetation. Management strategies would include encouraging irrigation water management plans to benefit cottonwood stands. The implementation strategies would be used in conjunction with one another for the alternatives.

As the team discussed the implementation strategies and techniques some further changes were made. For the Protection and Conservation Options, the control and prevention of domestic livestock grazing within existing cottonwood stands was changed to establishing best management practices for livestock grazing, which would include the seasonality and intensity of the grazing. For the engineering opportunities, in order to increase sediment supply and transport, bank stabilization in the area would need to be removed; therefore these two strategies were determined to be associated with one another. For planting methodologies, the team determined that the technique for planting cottonwood seeds should be through natural regeneration rather than the harvesting or planting of cottonwood seeds. An additional technique was added to the disking the land strategy, which included killing and removing existing vegetation to create bare mineral soil for seed contact.

Alternative maps were distributed to the project team. Each map included one of the five alternatives for each of the fifteen sites. The sites were classified as preservation, restoration, or complex (preservation + restoration). The preservation sites include Hagg, Blickle, and Bruening/Heine. Restoration sites include Rush Island, Ponca State Park, Wynot Farms, and Pinckleman. The complex sites include Anderson, Sippel, Geo-Schmidt, Schmidt, Bow Creek, Elk Point, Sister Island, and Burbank. The team discussed the conceptual design for each alternative at each site. Changes to the alternatives, site boundaries, and cover types were determined.

For the preservation sites, the initial designs included both preservation techniques and restoration techniques, which would ultimately create a complex site. The team decided that a total of two alternatives would be applicable for the preservation sites. Alternative One would be the preservation alternative, which was defined as preserving existing and future cottonwood forest areas using one or more of the following strategies:

- Utilize funding programs
- Discourage clearing of cottonwoods through Stream Buffer Protection and Management Plans; establish local stream buffer programs and determine who will administer those programs.
- Discourage development through local and regional land planning efforts; zoning; conservation districts; river setbacks; watershed protection plans and local master plans.
- Obtain easements, including sloughing easements, conservation easements, recreational river easements, etc.
- Purchase of the land through the Corps and other cooperating agencies, establishment and use of a voluntary buyout program, or bequest for conservation and donations.

Alternative Two would be the segment-wide alternative. This alternative would recommend and work with other programs on proposed modifications to flow and sediment supply transport to encourage positive changes to site conditions that would encourage natural recruitment of cottonwoods; preserve the remaining cottonwood forest, future cottonwood forest, and future cottonwood recruitment areas using one or more of the strategies listed above. The original alternatives for the Hagg, Blickle, and Bruening/Heine sites would be changed to reflect the two new alternatives.

Each of the restoration and complex site alternatives were presented to the team. In most alternatives where there were small agricultural or open areas between existing cottonwood shrub or forest, the areas were proposed to be planted with seeds, seedlings, or saplings. It was determined that planting in these areas may not be successful due to shading and competition from the existing cottonwood stands. Spending the money to seed or plant cottonwoods in larger open areas would be more beneficial to the project, because success is more likely and there would be a greater lift. This change was made to alternatives at the following sites: Elk Point, Sister Island, Burbank, Schmidt, and Bow Creek.

Another conclusion which resulted in changes in the alternatives at many sites included allowing the existing cottonwood shrubs and forest to persist. Many of the alternatives included removing the existing cottonwood stands and replanting with new seedlings or saplings. Although, the existing stands would convert to riparian faster, the team decided that these stands should be allowed to age because there would be a chance of less success of the new plantings. This change was made at the following sites: Elk Point, Rush Island, Anderson, Pinckleman, Sister Island, Burbank, Sipple, and Bow Creek. Additional changes to the alternatives at some sites included modifications to the base cover types, backwaters, and planting techniques.

While discussing the alternatives, the team decided to adjust some of the site boundaries. The changes to the site boundaries would be implemented in the Segment 10 Environmental Assessment, not the Programmatic Environmental Assessment due to schedule constraints The following changes to the site boundaries were determined:

- Sister Island – Add Beaver Creek into the site boundary.
- Geo-Schmidt – this site was combined with the Schmidt site by extending the boundary to meet the Schmidt site and also extending the boundary to include the opposite bank of the river.
- Schmidt – combined with Geo-Schmidt site.
- Anderson – Add the land adjacent to the downstream portion of the site.
- Burbank – Add the oxbow to the north.

Throughout the discussion of the alternatives, the team agreed on a few changes within the model. The first change included adding a 150 foot buffer for new development along the river shoreline except in the wetland areas. The team agreed that any river front property could be subject to development. The second change to the model would include a 10-15 percent reduction of the WIS and C-Value for having low quality habitat. The team decided that artificially restored habitat (planting just cottonwoods) would have a lower quality or biodiversity than naturally regenerating cottonwood habitat. This quality of the habitat needs to be accounted for in the model. No final decision was made for when planting seed, seedlings, or saplings, should cottonwoods or a cottonwood community be planted. It was suggested that we could create test plots at Wynot Farms to see which option would be more successful. A new criterion, Distance to the Dam, was identified. An ideal site for cottonwoods would be further from the upstream dam and closer to the downstream dam, since there is typically degradation below the dam and the area is typically wetter before a dam.

A presentation was given by Paul Boyd on the Lewis and Clark Lake Sediment Management Study. The goal of the project is to evaluate the engineering viability using various discharges and stages through the Lewis and Clark Lake to transport currently deposited sediments in the lake and develop modeling tools that will allow for analysis of upstream and downstream flow and sediment transport scenarios. The sediment model would be for an 80 mile reach from Gavins Point to Sioux City. The model is proposed to be complete in May 2010.

Suzie Boltz led a discussion on using adaptive management to address uncertainty in the management of the Missouri River cottonwoods. Adaptive management is needed after the implementation of the cottonwood management techniques. The age class and quality of the cottonwood forest will be used to create response thresholds. Initially, monitoring of the entire segment will be every five years.

The Draft Cottonwood Management Plan was distributed to the team and reviewed. On the final day of the meetings in Vermillion, the team went through the CMP and made recommendations for changes. The CMP will be ready for internal Corps review at the beginning of May 2009.

Participants:

Participant	Affiliation
Lisa Rabbe	U.S. Army Corps of Engineers
Suzie Boltz	EA Engineering
Kristine Nemec	U.S. Army Corps of Engineers
Carter Johnson	South Dakota State University
Mark Dixon	The University of South Dakota
Theresa Smydra	Missouri River Futures/NRCS
Robb Jacobson	U.S. Geological Survey
Steve Wilson	National Park Service
Tim Cowman	The University of South Dakota
Chris Svensen	U.S. Army Corps of Engineers
Tisa Webb	U.S. Army Engineer Research and Development Center
Kelly Burks-Copes	U.S. Army Engineer Research and Development Center
Rich Pfingsten	EA Engineering
Jeannette Dawson	EA Engineering
Trent Bristol	North Dakota Forest Service
Paul Boyd	U.S. Army Corps of Engineers
Steve Rasmussen	Nebraska Forest Service
John Hinners	S.D. Division Resource Conservation

Recorder: Jeannette Dawson, EA Engineering

APPENDIX C

Public Involvement

APPENDIX C-1

Notice of Availability

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, OMAHA DISTRICT
1616 CAPITOL AVENUE
OMAHA NE 68102-4901

February 8, 2010

Dear Interested Party:

The plains cottonwood (*Populus deltoides*) was once the dominant floodplain vegetation in the Missouri River ecosystem. Natural cottonwood regeneration has largely ceased along the Missouri River following the construction of the Missouri River Mainstem Reservoir System and Bank Stabilization and Navigation Project. The reduction in the number of young cottonwoods to replace older cottonwoods concerns biologists because a variety of plant and wildlife species, including some protected species, are associated with cottonwoods. Bald eagles (*Haliaeetus leucocephalus*) and other native wildlife species depend on the adjacent cottonwood forest for nesting, roosting, and wintering habitat along the Missouri River. The degradation of the cottonwood forests will likely continue in the future and result in additional impacts to these native species.

The Proposed Action for this project includes the implementation of a Cottonwood Management Plan (CMP). The purpose of the CMP is to guide management actions along the Missouri River to protect and restore cottonwood forests in the six priority river segments identified by the U.S. Fish and Wildlife Service in the Biological Opinion, to the extent possible, the natural range of cottonwoods. The CMP suggests ways the Corps can protect cottonwood stands as well as establish new cottonwood stands to keep the riparian habitat along the river a viable forest community.

The Draft CMP/Programmatic Environmental Assessment (EA) discusses the proposed management techniques for the CMP. It also discusses the environmental consequences to the physical, natural, cultural, and human resources along the Missouri River as a result of the implementation of the CMP. The CMP/EA is now available for a 30-day public review period. An electronic copy of the CMP/EA can be found on the Missouri River Recovery Program website at:

www.moriverrecovery.org

Written comments are being accepted until March 12, 2010. Please send all comments to:

Suzanne Boltz
EA Engineering
15 Loveton Circle
Sparks, MD 21152

Sincerely,

Suzanne E Boltz

for
Lisa Rabbe, Program Manager

Draft Cottonwood Management Plan/Programmatic Environmental Assessment Distribution List

First Name	Last Name	Affiliation
Daniel	Bowen	Benedictine College
Jessica	Cozart	Benedictine College
John	Davis	Benedictine College
Terry	Malloy	Benedictine College
Michelle	Parks	Benedictine College
David	Seefeldt	Benedictine College
Martin	Simon	Benedictine College
Paul	Clark	Benedictine College
Jay	St. Goddard	Blackfeet Tribe
Michael	Ellis	Boyer Chute National Wildlife Refuge
Michael	Black	Bureau of Indian Affairs
Julie	Thorstenson	Cheyenne River Sioux Tribe
Joseph	Bringsplenty	Cheyenne River Sioux Tribe
Raymond	Jake Parker Jr	Chippewa Tribe of the Rocky Boy's Reservation
Brandon	Sazue, Sr	Crow Creek Sioux Tribe
Carl	Venne	Crow Nation
Ivan	Posey	Eastern Shoshane Tribe
Jim	Berkley	Environmental Protection Agency
Dana	Allen	Environmental Protection Agency
Joseph	Cothern	Environmental Protection Agency
Joshua	Wetson	Flandreau Santee Sioux Tribe
Tracy	Ching King	Gros Ventre and Assiniboine Tribe
Jeremy	Cochran	Iowa Department of Natural Resources
Paul	Tauke	Iowa Department of Natural Resources
Paul	Lepisto	Izzak Walton League of America
Julie	Thompson	Kansas Dept of Wildlife and Parks
Tom	Moser	Lewis and Clark Natural Resource District
Jim	Biche	Lower Brule
Michael	Jandreau	Lower Brule Sioux Tribe
Lonnie	Messbarger	Missouri Department of Conservation
Brian	Graff	Missouri Department of Conservation
Theresa	Smydra	Missouri River Futures
Stan	Wilmoth	Montana State Historic Preservation Office
Jim	Riis	MRNRC Missouri River Fisheries Center

Draft Cottonwood Management Plan/Programmatic Environmental Assessment Distribution List

First Name	Last Name	Affiliation
Ernest	Quintana	National Park Service
Sandra	Washington	National Park Service
Nick	Chevance	National Park Service
Sue	Jennings	National Park Service
Gia	Wagner	National Park Service
Stephen	Wison	National Park Service Missouri National Recreational River
Mike	Madell	National Park Service Missouri National Recreational River
Gary	Wilson	National Park Service Research
Barbara	Pahl	National Trust for Historic Preservation
Valerie	Hauser	Native American Program coordinator
Steve	Grube	Natural Resources Conservation Service
Contsance	Miller	Natural Resources Conservation Service
Janet	Oertly	Natural Resources Conservation Service
Steve	Chick	Natural Resources Conservation Service
Jack	Russell	Natural Resources Conservation Service
Jason	Skold	Nature Conservancy
Steve	Rasmussen	Nebraska Forest Service
Scott	Luedtke	Nebraska Games and Park Commission
Michael	Smith	Nebraska State Historic Preservation Office
Trent	Bristol	North Dakota Forest Service
Fern	Swenson	North Dakota State Historic Preservation Office
Harvey	Spoonhunter	Northern Arapaho Tribe
Linwood	Tall Bull	Northern Cheyenne Tribe
John	Davidson	Northern Prairie Land Trust
Theresa	Two Bulls	Oglala Sioux Tribe
Mike	Tyndall	Omaha Tribe
Tony	Wounded Head, Sr.	Pine Ridge Agency
Jeff	Fields	Ponca State Park
Lary	Wight Jr	Ponca Tribe of Nebraska
Victor	Douville	Rosebud Sioux Tribe
Rodney	Bordeaux	Rosebud Sioux Tribe
Edmore	Green	Sac and Fox Nation
Felix	Kitto	Santee Sioux Nation
Mick	Selvage	Siisteon-Wahpeton Oyate

Draft Cottonwood Management Plan/Programmatic Environmental Assessment Distribution List

First Name	Last Name	Affiliation
Dave	Ode	South Dakota Department of Game, Fish, and Parks
John	Hinners	South Dakota Division Resource Conservation
Jay	Vogt	South Dakota State Historic Preservation Office
Carter	Johnson	South Dakota State University
Gary	Larson	South Dakota State University
Craig	Novotny	South Dakota State University
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Lisa	Rabbe	U.S. Army Corps of Engineers
Chris	Svendsen	U.S. Army Corps of Engineers
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Casey	Kruse	U.S. Army Corps of Engineers
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Karla	Sparks	U.S. Army Corps of Engineers
Teresa	Reinig	U.S. Army Corps of Engineers
Brad	Thomspon	U.S. Army Corps of Engineers

Draft Cottonwood Management Plan/Programmatic Environmental Assessment Distribution List

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Craig	Fleming	U.S. Army Corps of Engineers
Rosemary	Hargrave	U.S. Army Corps of Engineers
Tisa	Webb	U.S. Army Corps of Engineers, Engineer Research and Development Center
Kelly	Burkes-Copes	U.S. Army Corps of Engineers, Engineer Research and Development Center
Richard	Straight	U.S. Department of Agriculture Forest Service
Bruce	Wight	U.S. Department of Agriculture Forest Service
Wayne	Nelson-Stastny	U.S. Fish and Wildlife Service
Carol	Aron	U.S. Fish and Wildlife Service
Robert	Harms	U.S. Fish and Wildlife Service
Heather	McSharry	U.S. Fish and Wildlife Service
Mike	Olson	U.S. Fish and Wildlife Service
John	Cochnar	U.S. Fish and Wildlife Service
Pete	Gober	U.S. Fish and Wildlife Service
Jeffrey	Towner	U.S. Fish and Wildlife Service
Carol	Aron	U.S. Fish and Wildlife Service
Bill	Bicknell	U.S. Fish and Wildlife Service
Mark	Wilson	U.S. Fish and Wildlife Service
Mindy	Sheets	U.S. Fish and Wildlife Service, DeSoto National Wildlife Refuge
Michael	Bryant	U.S. Fish and Wildlife Service, Karl Mundt National Wildlife Refuge
Michael	Scott	U.S. Geological Survey
Robert	Jacobson	U.S. Geological Survey
Carrie	Elliott	U.S. Geological Survey
Mark	Sherfy	U.S. Geological Survey
Tom	Btagg	University of Nebraska at Omaha
Mark	Dixon	University of South Dakota
Tim	Cowman	University of South Dakota
Caleb	Canton	University of South Dakota
Drew	Price	University of South Dakota
Rebekah	Jessen	University of South Dakota
Adrienne	Ricehill	Winnebago Tribe of Nebraska
John	Black Hawk	Winnebago Tribe of Nebraska
Robert	Cournyer	Yankton Sioux Tribe
C.G.	Spies	

**Notice of Availability of the Cottonwood Management Plan /
Draft Programmatic Environmental Assessment**

Proposed Implementation of a Cottonwood Management Plan
Along Six Priority Segments of the Missouri River

The plains cottonwood (*Populus deltoides*) was once the dominant floodplain vegetation in the Missouri River ecosystem. Natural cottonwood regeneration has largely ceased along the Missouri River following the construction of the Missouri River Mainstem Reservoir System and Bank Stabilization and Navigation Project. The reduction in the number of young cottonwoods to replace older cottonwoods concerns biologists because a variety of plant and wildlife species, including some protected species, are associated with cottonwoods. Bald eagles (*Haliaeetus leucocephalus*) and other native wildlife species depend on the adjacent cottonwood forest for nesting, roosting, and wintering habitat along the Missouri River. The degradation of the cottonwood forests will likely continue in the future and result in additional impacts to these native species.

The Proposed Action for this project includes the implementation of a Cottonwood Management Plan (CMP). The purpose of the CMP is to guide management actions along the Missouri River to protect and restore cottonwood forests in the six priority river segments identified by the U.S. Fish and Wildlife Service, to the extent possible, the natural range of cottonwoods. The CMP suggests ways the Corps can protect cottonwood stands as well as establish new cottonwood stands to keep the riparian habitat along the river a viable forest community.

The Draft CMP/Programmatic Environmental Assessment (EA) discusses the proposed management techniques for the CMP. It also discusses the environmental consequences to the physical, natural, cultural, and human resources along the Missouri River as a result of the implementation of the CMP. The CMP/EA is now available for a 30-day public review period. An electronic version of the document can be found under MRRP documents or under the Cottonwood Forest sections on this website. Written comments on the CMP/EA may be submitted to: Suzie Boltz, EA Engineering, 15 Loveton Circle, Sparks, MD 21152. Please send comments by March 12, 2010.

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, OMAHA DISTRICT
1616 CAPITOL AVENUE
OMAHA NE 68102-4901

REPLY TO
ATTENTION OF

District Commander

Mr. Rober Cournoyer, Chairman
Yankton Sioux Tribe
P.O. Box 248
Marty, South Dakota 57361

Dear Mr. Cournoyer:

The U.S. Army Corps of Engineers (Corps) has prepared the Cottonwood Management Plan/Draft Programmatic Environmental Assessment (CMP/EA). The purpose of the CMP is to guide management actions along the Missouri River to protect and restore cottonwood forests in the six priority river segments identified by the U.S. Fish and Wildlife Service in the Biological Opinion, to the best extent possible, as being the natural range of cottonwoods. The CMP suggests ways the Corps can protect cottonwood stands as well as establish new cottonwood stands to keep the riparian habitat along the river a viable forest community. The CMP/EA discusses a suite of proposed management techniques for the CMP. It also discusses the environmental consequences to the physical, natural, cultural, and human resources along the Missouri River as a result of the implementation of the CMP.

As required by Stipulation 6 of the Programmatic Agreement, the Corps is providing the CMP/ EA for review and comment for 30 days. The CMP/Draft EA is provided on the compact disc accompanying this letter. Accordingly, I request written comments regarding the report be provided no later than 30 days of receiving this mailing. Please send all comments to:

Suzanne Boltz
EA Engineering
15 Loveton Circle
Sparks, MD 21152

Sincerely,

Robert J. Ruch
Colonel, Corps of Engineers
District Commander

Enclosure

Copy Furnished: (Electronic Distribution)

CENWD-PDR (Farhat)
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CENWO-OD-T (Janis)
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CENWO-OD-GP (Becker)
CENWO-OD-GP (Ledbetter)
CENWO-OD-FR (Wilson)
CENWO-OD-FR (Curran)
CENWO-OD-BB (Fink)
CENWO-OD-BB (Key)
CENWO-OD-BB (Winter)
CENWO-OD-OA (Harnois)
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APPENDIX C-2

Comments Received

United States Department of Agriculture

NRCS

Natural Resources Conservation Service
P.O. Box 1458
Bismarck, ND 58502-1458

EA Engineering Science and Technology
MAR 08 2010
RECEIVED SPARKS, MD

March 2, 2010

Suzanne Boltz
EA Engineering
15 Loveton Circle
Sparks, MD 21152

Ms Boltz:

Below are my comments referenced to specific sections of the Missouri River Cottonwood Management Plan (CMP). All comments regard the conditions found in Segment 4, the river reach between the head waters of Lake Oahe and the tail race of Garrison Dam in North Dakota.

1. Page 2-15

   The first paragraph refers to the impact of climate change on the ability of the area to regenerate a riparian cottonwood forest. Such an event will likely have <u>minimal</u> impact on the success of cottonwood regeneration compared to other <u>existing</u> conditions. The existing conditions having the most effect on reforestation are: The down cut stream channel. When combined with present flow manipulation, the previous riparian (flood plain) area is no longer subject to flooding which created the necessary bare soil for cottonwood establishment. AND the entire area of the previous floodplain is choked with smooth brome grass *Bromus inermus.* Brome creates such a dense sod and is such a high water user that only the seeds from a few large seeded tree species are able to penetrate the duff layer, withstand the water competition, and become established. Onsite evidence shows that the two species most adapted to these conditions are Russian olive and Eastern redcedar. Even with the "climate change" experienced to date, newly created mud flats and sandbars, easily become established to cottonwoods and willows. Since the only areas of wet mineral soil lie within the banks of the downcut channel, newly established cottonwoods and willows are often wiped out due to the management applied to favor piping plover. As long as there are mud flats, access to a water table, and adequate seed trees, cottonwood recruitment is a regular event.

   For much of this reach, the downcut Missouri river channel is working as a drainage ditch, lowering the water table within the previous riparian zone. The change in hydrology has converted the previous flood plain to an upland site. In areas where sands were deposited, it has become a droughty upland site. Such soil and water conditions favor the establishment of grasses rather than native woody vegetation.

   As noted, cottonwood recruitment requires bare wet soil at seed dispersal. It also requires continuous access to soil moisture once the seed has germinated. To achieve those conditions will require extensive chemical and tillage manipulation of the brome sod and extensive irrigation until young cottonwood roots have accessed the water table which may be 5-8 feet below the surface. To date we have not found the correct combination of management actions that yield a young riparian forest at an affordable cost.

Besides the brome and the dewatered soils, currently and for the past decade, deer numbers have been so high that all but a few species planted in riparian areas are repeatedly browsed to the point they die. Any planting will require hundreds of thousands of seedlings through natural regeneration so that a few get past the deer, or expensive deer protection in the form of individual tree shelters or area fencing.

2. Page 2-19
This section addressed the concern about adequate cottonwood seed trees adjacent to sites needing reforested. From personal experiences across the state, this would not be much of a concern. There are usually enough cottonwoods around to provide the seed that can be distributed with our high winds. What is needed is the bare wet soil at the correct time. Witness the extensive cottonwood recruitment observed on the midchannel bars in the river and the mud flats left after receding water levels on the reservoirs. Additionally, irrigations ditches, drainage ditches and mud flats distant from the river often become dense stands of cottonwoods, assuming correct soil moisture at the correct time. We should have plenty of cottonwood seed for quite a few years.

3. Page 2-27
This section creates nurseries to harvest seed and grow seedlings for distribution and planting. Such creation is totally unnecessary. Currently Lincoln-Oakes nursery in Bismarck, ND, owned by the North Dakota Association of Soil Conservation Districts, Big Sioux Nursery in Watertown, SD, privately owned by members, and Bessey Nursery in Halsey, NE owned by the National Forest Service, within the Nebraska National Forest have decades of experience producing conservation grade trees for distribution and planting in the Great Plains. They have the storage and distribution systems in place to allow delivery at the time and place needed by the customer. Currently they are running at 30% or less of their potential capacity. They could quickly produce seedlings in quantities adequate to meet foreseeable planting needs. They also have capacity and experience to produce unrooted and rooted cuttings. With enough lead time they would be able to produce unrooted poles for water jet planting. There are other conservation nurseries across the Great Plains with the capability to provide needed planting stock. Note: The locations of the seed collection sites determine the genetics of the trees, not the location of the nursery that propagated the seedlings.

4. Page 3-20
This section implies the presence of salt cedar and purple loose strife as part of the reason that cottonwood forests are declining. For most of segment 4 these particular species have not impeded cottonwood regeneration. Yes, those species are present but active and vigilant eradication efforts have slowed the rate of spread. Yes, if salt cedar becomes established, it can use lots of water, but on a per plant basis, it does not use much more or less than cottonwood. Purple loosestrife, even if it becomes established, would not compete directly with cottonwoods as loosestrife grows on different sites than do cottonwoods. Our biggest invasive problem restricting tree establishment (all species,

not just cottonwood), is the vast expanses of dense brome sod and the fact that our riparian soils have been dewatered and no longer get flooded in the spring. See comment 1 above.

5. Page 3-2
   This section refers to Slippery Elm, *Umus rubra*. I have not personally identified any of this species in North Dakota, but it is likely that it is here. However, we do know that we still have large areas of American Elm, *Ulmus Americana*.

   Side Note: One of the key succession species that develop after cottonwood and would be adapted to the upland sites is Green Ash, Fraxinus pennsylvanica. As the Emerald Ash Borer marches steadily westward across the country, most forestry experts feel that green ash will soon disappear from many of our native areas. Currently no control options seem feasible in conservation settings. Other species will have to be considered. Most of the issues identified in comment #1 apply to other species establishment as well.

Forestry, conservation, and urban groups have been trying different methods to establish cottonwoods in areas no longer subject to flooding. Brome, deer, and competition from existing mature cottonwoods have limited success. Methods that have potential, but await funding and staff include:

- Scarification and control of brome on selected sites, followed by flooding at cottonwood seed dispersal to encourage natural seeding, followed by irrigation until young roots have reached a growing season water table. Selecting sites that are closer to a water table will reduce the number of years of required irrigation.
- Control brome on selected sites with herbicides before planting and for 5 years or more after planting. Plant conservation grade cottonwoods in 5' tree shelters and irrigate until tree roots reach the growing season water table.
- Control brome on selected sites with herbicides before planting and for 5 years or more after planting. Using a water jet, hydraulically plant cottonwood poles of sufficient length to reach the growing season water table. Install 5' tree shelters to protect from deer, rabbits and beavers. Onsite investigations will be needed to determine depth to growing season water table.

Thank you for the opportunity to review this document. Please remember that there is a diverse group of practitioners who have been trying a variety of methods to maintain and reestablish cottonwood forests. Utilizing their years of on-the-ground experiences could greatly improve the chances that this massive undertaking will result in future cottonwood nest sites for bald eagles. Feel free to contact me regarding my comments or any of the establishment techniques discussed.

Craig M Stange CF

Craig M Stange CF
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Excerpts from COE Missouri River Cottonwood Management Plan about which I sent comments. Yellow highlighted areas where specifically commented upon. Craig Stange Staff Forester, NRCS, North Dakota, 2010

From page 2-15

5) Climate Change – Perhaps the single most pervasive threat to the Missouri River cottonwood community is a change in precipitation and/or temperature patterns stimulated by global climate change that in turn disrupts the extremely sensitive hydrologic regime of the system. Risk and uncertainty surrounding current predicted climate patterns suggests that any planning activity intent on adaptively managing dynamic systems over the long-term must take into account a series of potential future scenarios under a broad range of climate regimes. Currently, the E-Team is using a somewhat static "No Action" scenario that incorporates urban growth as a land use conversion factor, but ignores potential threats to hydrological regime caused by global climate change. The E-Team would like to pursue a series of activities that would capture varying future forecasted conditions using climate envelope models (http://wikiadapt.org /index.php?title=Decision_Climate_Envelopes) tied to biome shift models (http://www.earthscape.org/r1/wwf04/wwf04.doc; http:// www.aibs.org/bioscience-pressreleases/ resources/03-07.pdf. In addition, because 70 percent of the Missouri River flow is generated by snowpack in the Rocky Mountains where the headwaters are found (pers. communication Mark Dixon, Univ. of South Dakota, April 2009), the impacts of water supply and dam operations are also relevant to these activities and would provide another suite of alternative actions to adaptively manage under these changed regimes. The ETeam would like to pursue hydrologic scenario modeling and formulate alternatives (with *Environmental Assessment/Proposed Cottonwood Management Plan February 2010 U.S. Army Corps of Engineers* 2-16
Risk and uncertainty incorporated into the approach) to better plan for these potential future scenarios.

From page 2-19

10. Site are positioned near a seed source (RC) – There is a higher likelihood that there will be heavier seed fall on the area (i.e., less work to restore the sites) if sites are positioned close to seed sources.

From page 2-27

Establishment of an On-Site Cottonwood Plant Nursery for Stock – If vast amounts of native cottonwoods are required for planting, a locally-created on-site nursery may be an option to ensure that a mix of genetically known plant stock is available for future restoration activities, especially if a large plant supply does not currently exist and the purchasing of individual plants would be costly (LCR MSCP 2007a). A nursery would provide a consistent and readily accessible source of plant materials for additional restoration sites and for future conservation areas. Cottonwoods could be planted 20 ft apart (based upon their center), smaller trees could be planted 10 ft on center, and a cover crop could also be planted, as long as the cover plant does not compete with the cottonwood seedlings. A contractor could be hired for propagating, delivering, and mass planting the native trees as well as regular irrigation, which would be required until the seedlings are established. The cottonwoods could then be transplanted on an as-needed basis to restoration sites that have been carefully chosen based on habitat requisites for cottonwoods.

From page 3-20

Exotic and Invasive Plant Species

Undesirable plants include species classified as undesirable, noxious, harmful, exotic, injurious, or poisonous under state or federal law. Some of the noxious/exotic weeds found throughout the Missouri River project area include saltcedar (*Tamarix ramosissima, Tamarix chinensis,* and *Tamarix parviflora*), purple loosestrife (*Lythrum salicaria*), leafy spurge (*Euphorbia esula*), field bindweed (*Convolvulus arvensis*), Canada thistle (*Cirsium arvense*), musk thistle (*Carduus nutans*), Russian knapweed (*Acroptilon repens*), absinth wormwood (*Artemisia absinthium*), spotted and diffuse knapweed (*Centaurea stoebe* ssp. *micranthos*), yellow starthistle (*Centaurea solstitialis*), Russian olive (*Elaeagnus angustifolia*), common buckthorn (*Rhamnus cathartica*) and dalmatian toadflax (*Linaria genistifolia* ssp. *dalmatica*) (USDA 2008). Both saltcedar and purple loosestrife are the most prevalent invasive plant species in the priority river segments and are therefore, described in more detail below.

Environmental Assessment/Proposed Cottonwood Management Plan February 2010
U.S. Army Corps of Engineers

Saltcedar – these species are a persistent pioneer that is able to survive in a wide variety of habitats. An enormous water consumer, a single large plant can absorb 200 gallons of water a day, although evapotranspiration rates vary based on water availability, stand density, and weather conditions (Hoddenbach 1987; Davenport et al. 1982). Saltcedar's high water consumption further stresses native vegetation by lowering ground water levels and can dry up springs and marshy areas. Paradoxically, saltcedar infestations may also lead to flooding, as its extensive root system can choke streambeds (Rush 1994). It frequently forms monotypic stands that replace willows, cottonwoods, and other native riparian vegetation.

Purple loosestrife – this species caused few problems until the 1930s when it became aggressive in the floodplain pastures of the St. Lawrence River (USGS 1999). Since then, it has steadily expanded its local distribution and now poses a serious threat to native emergent vegetation in shallow water marshes throughout the northeastern and north central regions. Recent records indicate that purple loosestrife is also tolerant of soils and climates beyond these regions and threatens to become a serious problem in wetlands and irrigation systems in the Great Plains. Purple loosestrife was added to the North Dakota Noxious Weed List in 1996. North Dakota State law requires all purple loosestrife plants to be removed to prevent this plant from becoming a major weed problem in the wetlands of the state.

From page 3-22

Riparian vegetation constitutes about 47 percent of the floodplain in this segment, water about 28 percent, exposed shoreline about 16 percent, and wetlands about 9 percent. The Garrison reach supports about 25 percent of the riparian vegetation along the Upper River of the Missouri. Emergent wetlands constitute about 68 percent of the wetland acreage in the Garrison reach; most of the remainder is scrub-shrub wetland (22 percent) (Corps 2004a). Emergent wetlands generally support a mix of hydric and mesic species, including quackgrass (*Elymus repens)*, bluegrass (*Poa* sp.), and mints (*Mentha* spp.). Reed canarygrass (*Phalaris arundinacea)* dominates some areas and slough sedge (*Carex obnupta*) forms extensive stands, particularly near Bismarck, North Dakota. Cottonwood, indigo bush (*Psorothamnus*), and peachleaf willow characterize most of the scrub-shrub wetlands. This reach supports a much lower density of wetlands (38 acres/mile) than the other Upper River reaches. The large diurnal and seasonal variations in river flow for the peaking operation of Garrison Dam probably impede wetland establishment and survival, resulting in greater amounts of exposed shore. The large islands and bars, particularly those close to the dam, are periodically scoured and support little, if any, perennial vegetation. Riparian forest constitutes just over half of the riparian vegetation in this reach, commonly lining both shores. Cottonwood, slippery elm (*Ulmus rubra*), green ash, and box elder are the most common tree species on the floodplain (from Johnson et al. 1976 as stated in Corps 2004a). Sandbar willow (*Salix interior*), peachleaf willow, and cottonwood occur along the river sandbars. The acreage of riparian forest in this reach has been greatly reduced since settlement. Canada thistle and leafy spurge are the primary threats on the exposed shorelines of Garrison Reservoir. Saltcedar also poses an immediate threat to the natural resources around the reservoir but is a more constant threat throughout the full range of reservoir levels—high, low, and normal (Corps 2007).

South Dakota Department of Agriculture
Division of Resource Conservation & Forestry
PO Box 940, Huron, SD 57350-0940
Phone: (605) 353-7187/Fax: (605) 353-7192
Web Address – www.state.sd.us/doa

Suzanne Boltz
EA Engineering
15 Loveton Circle
Sparks MD 21152

March 11, 2010

Dear Ms Boltz:

I have served on the cottonwood management team since its inception.

I have reviewed the COTTONWOOD MANAGEMENT PLAN/DRAFT PROGRAMMATIC ENVIRONMENTAL ASSESSMENT. The plan deals with three actions: 1) no action, 2) Implementation of the CMP with Limited Strategies, and 3) The proposed action, Implementation of the CMP. I support the third action. If you want to assure that no more than 10% of existing cottonwood forest is lost over the 100 year life of this plan you will need to protect existing cottonwood stands and create new stands as described in action 3.

The Assessment does a good job of taking recommendations submitted at the various Habitat Modeling Workshops and including them in the Cottonwood Management Plan. I also like the idea that the plan is a living program that will be reviewed/revised every five years to account for changing environmental and economic climates, new science that is available, and on the ground practices that have been proven to work or not work.

Sincerely,

John Hinners

John Hinners
Agroforester

United States Department of the Interior

NATIONAL PARK SERVICE
Missouri National Recreational River
508 E. 2nd Street
Yankton, SD 57078

IN REPLY REFER TO:

L7615(MNRR)

March 12, 2010

Suzanne Boltz
EA Engineering, Science and Technology
Mid and South Atlantic Region
15 Loveton Circle
Sparks, MD 21152

Dear Ms. Boltz:

Thank you for the opportunity to comment on the Cottonwood Management Plan and Environmental Assessment. The following comments represent review by staff from both Lewis and Clark National Historic Trail and Missouri National Recreational River. Both National Park Service units participated in scoping and provided comments at that time.

The alternatives do not consider altering flow regimes from the dams. Restoring a more natural hydrograph (flow regime) to better reflect the streamflow of the pre-dam Missouri River is vital to establishing self-sustaining cottonwood communities, particularly in un-channelized and un-stabilized areas such as Segment 10. Implementing a spring rise and summer drawdown from Gavin's Point Dam would not only benefit native fishes (e.g., pallid sturgeon *Scaphirhyncus albus*) and nesting birds such the endangered least tern (*Sterna antillarum*) and threatened piping plover (*Charadrius melodus*), but also contribute toward improving the overall health of the cottonwood forest community.

The use of Adaptive Management is commendable and the alternatives address all possible actions for cottonwood community management with the exception noted above. However, the long-term sustainability of cottonwood plant communities along the Missouri River is questionable without the ability to manipulate flows. The activities described for restoration are likely more expensive both in dollars and in effort than flow modifications.

The National Park Service looks forward to assisting the Army Corps of Engineers and its other partners with planning, land protection, and adaptive management activities to improve habitat conditions for all Missouri River ecosystems and species. If you have questions regarding this response or need additional information, please contact me at (605)-665-0209.

Sincerely,

Gia Wagner
Chief, Resources Management/ Acting Superintendent
Missouri National Recreational River

Matkowski, Jeannette

From: Rabbe, Lisa A POA [Lisa.A.Rabbe@usace.army.mil]
Sent: Wednesday, March 24, 2010 12:28 PM
To: Horihan, Christopher J NWO; Matkowski, Jeannette
Cc: Boltz, Suzanne
Subject: RE: Extension to Comment Period - Cottonwood Management Plan/EA

Jeanette: Make sure to capture Bob's comments. Thanks!

Lisa A. Rabbe
Environmental Resource Specialist
CEPOA-EN-CW-PF
2204 3rd Street
Elmendorf AFB 99506
(907)753-2634

-----Original Message-----
From: Horihan, Christopher J NWO
Sent: Wednesday, March 24, 2010 7:32 AM
To: Rabbe, Lisa A POA; 'Matkowski, Jeannette'
Subject: FW: Extension to Comment Period - Cottonwood Management Plan/EA

Lisa/Jeanette,

Jeanette it was nice to meet you in NE City (all though to brief).

See below for a comment from Bob Nebel, retired environmental specialist, in Omaha.

Thanks - Chris

-----Original Message-----
From: nebelfam [mailto:nebelfam@cox.net]
Sent: Wednesday, March 24, 2010 9:51 AM
To: Missouri River Recovery Program
Subject: Re: Extension fo Comment Period - Cottonwood Management Plan/EA

Section 2.7.2 does not discuss all the items listed in Table 2-3 (specifically, the floodplain activities). Section 2.7.2 should also recognize the timing of such activites to cottonwood seed dispersal.

You're doing a fine job.

----- Original Message -----
From: <mrrp@usace.army.mil>
Sent: Monday, March 15, 2010 10:42 AM
Subject: Extension fo Comment Period - Cottonwood Management Plan/EA

> Hello,
>
>
> We have received several requests for an extension of the comment
> period for the Missouri River Cottonwood Management Plan/EA. We

> appreciate the interest in the document and welcome your comments. To
> accommodate the requests, we have decided to extend the comment period
> until April 15, 2010.
>
>
> For more information, please visit:
> http://www.moriverrecovery.org/mrrp/f?p=136:134
>
>
> Thank you again for your interest in this project, we look forward to
> your comments. Written comments on the CMP/EA may be submitted to:
> Suzie Boltz, EA Engineering, 15 Loveton Circle, Sparks, MD 21152.
>

State of North Dakota

Office of the State Engineer

900 EAST BOULEVARD AVE. • BISMARCK, ND 58505-0850
701-328-2750 • FAX 701-328-3696 • http://swc.nd.gov

April 13, 2020

Suzie Boltz
EA Engineering
15 Loveton Circle
Sparks, MD 21152

Dear Ms. Boltz:

Thank you for the opportunity to provide comment on the *Cottonwood Management Plan/Draft Programmatic Environmental Assessment, Proposed Implementation of a Cottonwood Management Plan Along Six Priority Segments of the Missouri River.* Restoration and preservation of plains cottonwood habitat associated with the Missouri River is quite obviously a daunting task. Close coordination with the seven State governments, Tribal governments, the many county and municipal governments, riparian landowners, and local interests along the Missouri River is imperative to the success of your efforts.

I understand that this Environmental Assessment is programmatic in scope covering a wide range of activities along the entire length of the Missouri River and that the Corp of Engineers will prepare an Environmental Assessment for each of the six priority river segments indentified by the U.S. Fish and Wildlife Service in the 2003 Amended BiOp, as well as site specific National Environmental Policy Act compliance for specific projects.

Of particular interest to the State of North Dakota is Priority River Segment 4, Garrison Dam to Lake Oahe Headwaters near Bismarck, North Dakota, River Mile 1389.9 to 1304.0. The Missouri River is a navigable river and therefore sovereign to the State of North Dakota. The State of North Dakota holds title to the bed, sandbars, and islands below the ordinary high watermark of the Missouri River in North Dakota. These areas, as well as similar lands along other navigable waterways, are administered by the State Engineer. Projects to be constructed on the State's sovereign lands require an authorization from the State Engineer prior to construction.

As a primary stakeholder of the Missouri River in North Dakota, I am requesting that the State Engineer be represented on the "Team" that coordinates the preparation of the Cottonwood Management Plan and Environmental Assessment for Priority River Segment 4, as well as any specific projects proposed for this river segment.

The political, social, economic, and logistical issues associated with development and implementation of the Cottonwood Management Plan will be many. However, involving all interested and potentially affected parties in every stage of the planning process presents the greatest opportunity for success.

Thank you again for the opportunity to provide comment on the Plan/Draft Environmental Assessment, and I look forward to our continued involvement in this process.

Sincerely,

Dale Frink
State engineer

DLF:GRH:mmb/1625

Jeremiah W. (Jay) Nixon, Governor • Mark N. Templeton, Director
STATE OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES
www.dnr.mo.gov

April 14, 2010

Suzie Boltz
EA Engineering
15 Loveton Circle
Sparks, MD 21152

Dear Ms. Boltz:

Thank you for the opportunity to provide comments on the Draft Cottonwood Management Plan/ Programmatic Environmental Assessment (Draft EA). I currently have no comments regarding the substance of the Draft EA. However, with the breadth and implications contained in a management plan with a projected life-span of 100 years it should receive careful deliberation.

The Draft EA is being developed as a part of the Missouri River Recovery Program (MRRP) and could play a significant role in the development of the Missouri River Ecosystem Restoration Plan (MRERP). The piecemeal approach to Missouri River restoration causes a great deal of confusion for the public. Releasing the Cottonwood Management Plan Draft EA while the Corps is developing an Environmental Impact Statement for MRERP unnecessarily adds to the confusion.

Additionally, given the scope of the Draft EA, it has the potential to affect many stakeholders throughout the Missouri River basin. With that in mind, it seems wholly reasonable for the comment period for the Draft EA to be extended until such time as it can be vetted through the Missouri River Recovery Implementation Committee (MRRIC).

MRRIC was authorized by the Water Resources Development Act of 2007. MRRIC is a Missouri River basin-wide organization whose membership includes local, state, tribal and federal interests. As the State of Missouri's representative to MRRIC, I encourage you to include MRRIC in the public participation process. The principle charges of MRRIC are to consult with the Corps of Engineers in developing the MRERP and to provide guidance on Missouri River mitigation and recovery activities across various programs to ensure consistency.

Given that no funding is currently allocated for Cottonwood Habitat creation in the Missouri River Restoration Program FY2011 work plan, including MRRIC in the public comment process should not delay the implementation of the plan. The Draft EA should be delayed until MRRIC can be integrated into the Cottonwood Management Plan review process.

If you have any questions, please call me at (573) 751-4732.

Sincerely,

DEPARTMENT OF NATURAL RESOURCES

Michael D. Wells

Michael D. Wells
Chief of Water Resources

c: Witt Anderson, USACE, Northwest Division
John Thorson, MRRIC Chairman
Mike George, USACE MRRP Coordinator

Matkowski, Jeannette

From: Boltz, Suzanne
Sent: Wednesday, April 14, 2010 4:06 PM
To: Matkowski, Jeannette; Rabbe, Lisa A POA
Subject: FW: Cottonwood Management Plan (CMP)/Programmatic Environmental Assessment (EA) Comments

EA Engineering, Science, & Technology, Inc.
Suzanne Boltz ~ Project Manager
15 Loveton Circle
Sparks, MD 21152
410.329.5143 (Office)
410.771.4204 (Fax)
410.458.8272 (Cell)
sboltz@eaest.com

-----Original Message-----
From: Randy Asbury [mailto:moriver@howardelectricwb.com]
Sent: Wednesday, April 14, 2010 4:05 PM
To: Boltz, Suzanne
Cc: 'John E. Thorson'; Witt Anderson; Lynn M. Muench
Subject: Cottonwood Management Plan (CMP)/Programmatic Environmental Assessment (EA) Comments

April 14, 2010
Ms. Suzie Boltz
EA Engineering
15 Loveton Circle
Sparks, MD 21152

Dear Ms. Boltz:

I am writing in regard to the Missouri River Draft Cottonwood Management Plan (CMP)/Programmatic Environmental Assessment (EA). Unfortunately, I became aware of the CMP/EA today; therefore, I am unable to offer any substantive comments at this time.

Notwithstanding that, I am concerned with the process under which the CMP/EA has been administered. The CMP/EA Purpose and Need introduction states the CMP is a component of the Missouri River Recovery Program (MRRP) and "ultimately...may also inform the long-term" Missouri River Ecosystem Recovery Plan (MRERP).

Pursuant to Section 5018 of the 2007 Water Resource Development Act, "the Secretary of the Army, in consultation with the Missouri River Recovery Implementation Committee [MRRIC].shall conduct" the MRERP and also "provide guidance to the Secretary with respect to the Missouri River recovery and mitigation plan [i.e. MRRP] in existence on the date of enactment".

The CMP/EA raises two process concerns: 1) The CMP/EA never came before the MRRIC for consultation or guidance purposes; and, 2) Administering an EA separate from the MRERP EIS seems disjointed and confusing. Stakeholders are struggling to engage the plethora of studies simultaneously occurring throughout the Missouri River Basin without EAs taking place that should seemingly fit under the MRERP EIS.

Consequently, I urge the Corps to: 1) Pause the CMP/EA process until such time as the MRRIC has an opportunity to consult/guide the Secretary of the Army; 2) Determine with MRRIC consultation whether the CMP should be a part of the MRERP EIS or a standalone EA; and, 3) Extend the public comment period to accommodate input resulting from the MRRIC discussions.

Thank you for the opportunity to provide comments on this matter.

Sincerely,

Randy Asbury
Executive Director
Coalition to Protect the Missouri River (CPR)
4849 Hwy B
Higbee, MO 65257
660-273-9903 Phone
660-273-2124 Fax
573-823-7906 Cell
moriver@howardelectricwb.com
www.ProtectTheMissouri.com

Cc: John Thorson, Chair, MRRIC
Witt Anderson, Chief of the Programs Directorate, U.S. Army Corps of Engineers, NW Division
Lynn Muench, Chair, Coalition to Protect the Missouri River

"VARIETY IN HUNTING AND FISHING"

NORTH DAKOTA GAME AND FISH DEPARTMENT

100 NORTH BISMARCK EXPRESSWAY BISMARCK, NORTH DAKOTA 58501-5095 PHONE 701-328-6300 FAX 701-328-6352

April 15, 2010

Suzie Boltz
EA Engineering
15 Loveton Circle
Sparks, MD 21152

Dear Ms. Boltz,

RE: U.S. Army Corps of Engineers Draft Cottonwood Management Plan/Draft Programmatic Environmental Assessment (CMP)

The North Dakota Game and Fish Department (NDGFD) has reviewed the above referenced document. The NDGFD's comments pertain primarily to Segment 4 of the Missouri River.

There are inconsistencies with the delineation of Segment 4. For example, in section 1.4.1 Project Area, Segment 4 is listed as Garrison Dam to Lake Oahe Headwaters near Bismarck, North Dakota (RM 1389.9 – RM 1304.0). The title of Figure 3-2 indicates Segment 4 is RM 1390 – RM 1306 but the text box indicates Segment 4 is RM 1389.8 to 1286.3. We recommend Segment 4 be RM 1390 – RM 1284. Lake Oahe Wildlife Management Area (WMA), managed by the NDGFD, spans RM 1303 – RM 1284. We believe the potential for cottonwood restoration and re-establishment in this nearly 17,000 acre WMA is substantial.

This CMP appears to be a comprehensive yet intensive approach to restore and sustain the cottonwood forest of the Missouri River. The specific techniques outlined in Table 2-3 and described in Appendix D will be costly. Chapter 6, Implementation of the CMP, provides some sources of funding to implement the CMP. The NDGFD believes the Water Resources Development Act (WRDA) could be a primary funding avenue for implementation. The NDGFD may provide limited funding on some aspects of the CMP. However, the NDGFD is not listed under "State and Local Programs to Fund Individual Components of the CMP." The NDGFD currently is not even listed in the CMP, whereas the Nebraska Game & Parks Commission and the South Dakota Game, Fish and Parks are mentioned.

In 2008 the NDGFD purchased over 200 acres of Missouri River forest adjacent to Smith Grove WMA. Additionally, the NDGFD is currently trying to acquire 800 acres of land at the

Yellowstone-Missouri River confluence. This is adjacent to the 1,700 acres of Missouri River forest that the NDGFD and partners purchased several years ago. The NDGFD's budget to manage these lands is limited primarily to general maintenance. As a result, the removal of invasive vegetation such as Russian olive and re-establishment of cottonwoods is needed on these WMA's.

The CMP proposes increased hunting pressure as a specific technique to meet the goal of controlling and preventing deer grazing on existing cottonwoods (Appendix D, Box 12). As the agency responsible for setting deer management goals and issuing deer hunting licenses in North Dakota, we believe that altering the deer harvest for the expressed purpose of reducing cottonwood depredation would take considerable discourse and effort, and may not be possible.

The NDGFD provided comment on the Environmental Assessment in September 2007 (see attached). The NDGFD has a vested interest in the restoration and preservation of cottonwoods along the Missouri River and looks forwards to coordinating on the development of the site specific Environmental Assessment for Segment 4.

Sincerely,

Michael G. McKenna
Chief
Conservation and Communications Division

enclosure

SKJ

"VARIETY IN HUNTING AND FISHING"

NORTH DAKOTA GAME AND FISH DEPARTMENT

100 NORTH BISMARCK EXPRESSWAY BISMARCK, NORTH DAKOTA 58501-5095 PHONE 701-328-6300 FAX 701-328-6352

September 12, 2007

Suzanne Boltz
EA Engineering, Science, and Technology
15 Loveton Circle
Sparks, MD 21152

Re: Environmental Assessment for a Cottonwood Management Plan

Dear Ms. Boltz:

Thank you for the letter informing us of the U.S. Army Corps of Engineers (Corps) proposal to develop a Cottonwood Management Plan (CMP). The cottonwood forest along the Missouri River in North Dakota is a rare and declining habitat. Much of it is not protected and is in need of regeneration, reestablishment and protection. The Missouri River cottonwoods provide habitat for over half of the bald eagles nesting in North Dakota. Many other species of wildlife utilize this unique habitat and would greatly benefit from improved cottonwood health.

As per your request, we are providing information on bald eagle nests/territories and winter roosts sites, proposed or listed species within the project area, and recommend specific sites for cottonwood reestablishment or regeneration.

Bald Eagle Nesting and Roost Areas

The U.S. Fish and Wildlife Service (Service) in Bismarck have surveyed the Missouri River for bald eagle nests in the past. Due to funding constraints the Service was unable to continue the surveys. The ND Game and Fish Department (Department) conducted the last flight survey in 2004. Currently, the Department in cooperation with the Service maintains an active database of bald eagle nests across the state. Approximately 23 nesting areas have been documented along the Missouri River. (See Table 1 and Figure 1 for a list and map of the bald eagle nesting areas along the Missouri River). Only legal descriptions of nest sites are being provided at this time.

Bald eagles commonly use the Missouri River during spring and fall migration and eagles frequently winter along the river. Since the early-1980's, the Department has participated the Midwinter Bald Eagle Survey. An average of 32 bald eagles has been counted each year along 75 miles of river from Bismarck to Garrison Dam. The cottonwood habitat just south of Garrison Dam (i.e. the tailrace) is a particularly important winter roost area for bald eagles.

Table 1. Bald eagle nesting areas on the Missouri River system.

NEST ID	TOWNSHIP	RANGE	SECTION	LAND OWNERSHIP
BE122	134	79	16	U.S. Army Corps of Engineers
BE002	136	79	13	U.S. Army Corps of Engineers
BE020	137	79	22	U.S. Army Corps of Engineers, NDGF Managed
BE001	137	79	33	U.S. Army Corps of Engineers, NDGF Managed
BE003	138	80	30	Private
BE004	140	81	21	Private
BE021	140	81	33	Private
BE022	141	81	26	Private
BE005	143	81	32	Private
BE023	144	84	15	Private
BE032	144	83	13	Private
BE017	144	82	17	Private
BE012	144	84	25	Private
BE011	144	83	27	Private
BE010	144	83	33	Private
BE007	144	81	31	Private
BE006	144	82	36	Private
BE015	145	84	9	Private
BE014	145	84	22	Private
BE013	145	84	27	Private
BE031	146	84	7	U.S. Army Corps of Engineers, NDGF Managed
BE018	146	84	19	U.S. Army Corps of Engineers, NDGF Managed
BE000	152	103	14	U.S. Army Corps of Engineers, NDGF Managed

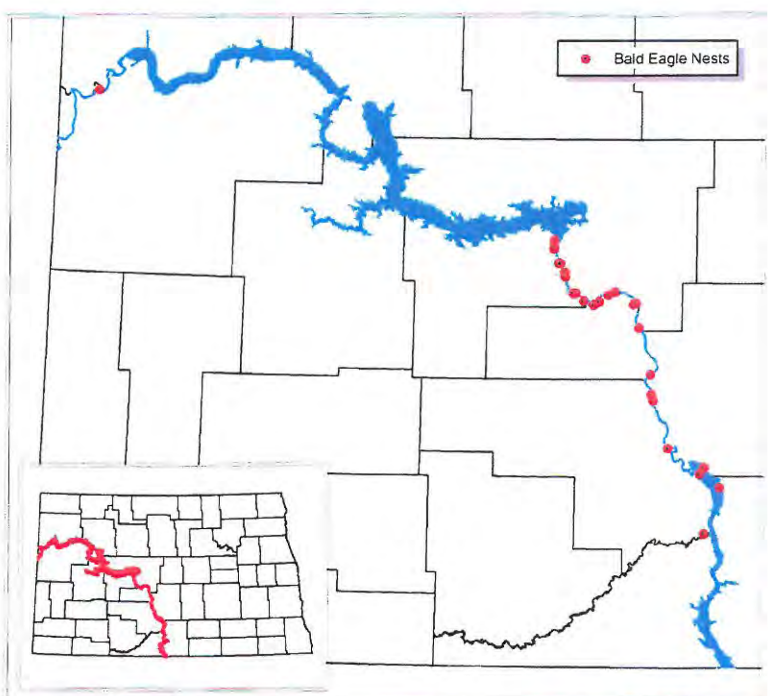

Figure 1. Location of bald eagle nests along the Missouri River system in North Dakota.

Proposed or Listed Species
Three federally listed threatened or endangered species are known to occur within the project area. They are: Interior Least Tern (*Sterna antillarum*), Piping Plover (*Charadrius melodus*), and Pallid Sturgeon (*Scaphirhynchus albus*). These species are not likely to be adversely affected by protecting or regenerating cottonwood. If cottonwood regeneration were to occur within inner channel sandbars or islands, this would reduce breeding areas for the least tern and piping plover. A fourth federally listed species which could potentially use cottonwood habitat is the Gray Wolf (*Canis lupus*). The Western Great Lakes Distinct Population Segment has been delisted under the Endangered Species Act, however the Northern Rocky Mountain Population Segment remains on the list. Highway 83 serves as the boundary between these two segments in North Dakota. Therefore, any wolves that may exist in the project area would still be considered federally listed species.

Proposed Sites
Developing a habitat model to prioritize river segments for cottonwood preservation and reestablishment will provide a useful planning tool. Advances in spatial analysis technologies should provide for a scientifically based model which can be used to implement this project.

While habitat modeling is an important tool, we believe there is enough information for some locations to proceed with implementation. For example, the Department has entered into long term agreements on several Corps owned areas along Lakes Sakakawea and Oahe. We manage these areas as Wildlife Management Areas (WMA's). The Department believes several WMA's along the Missouri River System provide prospective sites and that cottonwood reestablishment and regeneration should be directed towards these areas.

Trenton Wildlife Management Area:
Trenton WMA contains over 6,600 acres of grasslands, wetlands, riparian woodlands (i.e. cottonwood) and agricultural fields. As indicated in Figure 2, there is an active bald eagle nest in Trenton WMA. The Corps also owns land in this area that is licensed and being used by an irrigation district to raise crops. The entire area is zoned "wildlife" in the Corps general plans, with cropping designated as an interim use. Periodically, the WMA and the irrigation district floods from mountain runoff. Under optimal conditions, the cropped land is flooded for a brief time, followed by cottonwood seeds being blown onto the land, which allows for natural cottonwood regeneration. However, the young cottonwood seedlings are then destroyed due to the cropping practices.

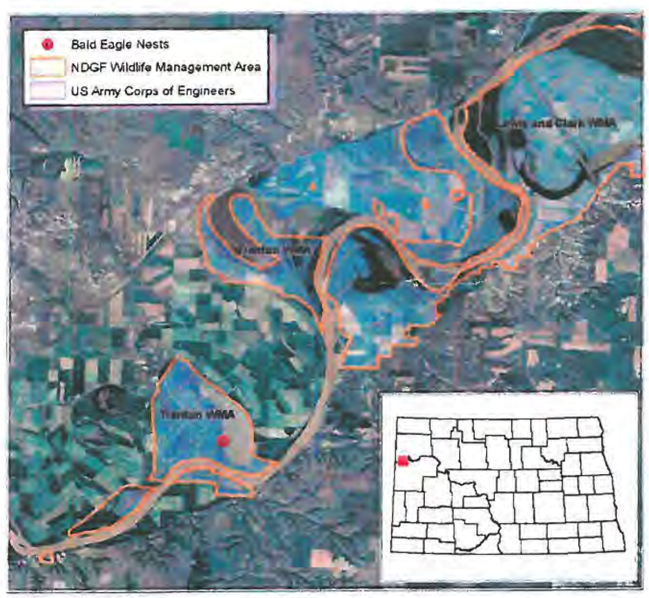

Figure 2. Trenton Wildlife Management Area and other Corps owned land.

If cottonwood regeneration were allowed to occur in this area, additional bald eagle habitat could be produced. We believe the area outlined in Figure 2 is potentially a model area for where cottonwood regeneration would naturally occur, if allowed. Recognize that timing would be critical. We recommend Trenton WMA crop fields and irrigation district fields, or portions of fields, be removed from cropping status when the aforementioned optimal conditions occur.

Riverdale Wildlife Management Area:
Riverdale WMA contains nearly 3,000 acres of grasslands, wetlands, riparian woodland (i.e. cottonwood). Some cropped areas are present. An active bald eagle nest is in this area (see Figure 3). The primary concern with the area is that the existing cottonwood stands are decadent and very little cottonwood regeneration is occurring. The woodlands in this area serve as the primary winter roosting site for bald eagles during the winter in North Dakota. Cottonwood regeneration or establishment efforts should be directed here to sustain this important habitat.

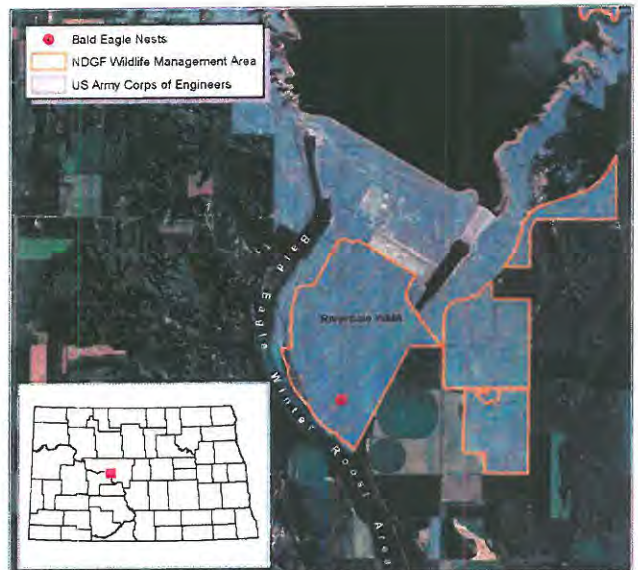

Figure 3. Riverdale Wildlife Management Area and other Corps owned land.

Oahe Wildlife Management Area:
The entire Oahe WMA is nearly 17,000 acres of grasslands, wetlands, riparian woodland (i.e. cottonwood) and agricultural fields. Figure 4 depicts Oahe WMA and the location of bald eagle nests. Several hundred acres of cottonwoods have been cut down and are currently being cropped. This is particularly evident in the Little Heart bottom and Graner bottom portion of the WMA and to a lesser degree in the MacLean bottoms. This cropping has highly fragmented the cottonwood forests. The eagle nests are found both on the WMA and on privately owned stands of cottonwood. Yet the high degree of edge and fragmentation created by the cropped areas in Little Heart and Graner bottoms may be deterring eagles from utilizing these areas. We recommend the Corps, in cooperation with the Department, reestablish cottonwoods in

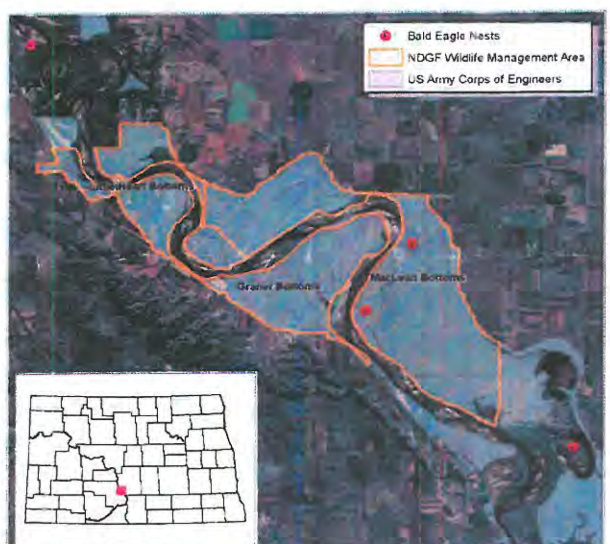

Figure 4. Oahe Wildlife Management Area and other Corps owned land.

selected locations. There are numerous other sites on the WMA that may have potential for cottonwood regeneration.

Thank you for the opportunity to comment on the proposed action. We are pleased to see the Corps taking a proactive approach to preserving and reestablishing cottonwoods. We hope the information we have provided is incorporated in the Cottonwood Management Plan and look forward to assisting the Corps in developing this plan.

Sincerely,

Michael G. McKenna
Chief
Conservation and Communications Division

Matkowski, Jeannette

From: Boltz, Suzanne
Sent: Thursday, May 13, 2010 4:28 PM
To: Jason Skold
Cc: Rabbe, Lisa A POA; Tyler P. Janke; Matkowski, Jeannette
Subject: RE: Cottonwood EA Comment

Jason,

Thanks for your comment. I reviewed the relevant page and understand your concern, we will delete the TNC logo to make the example more generic.

Suzie

From: Jason Skold [mailto:jskold@TNC.ORG]
Sent: Thursday, May 13, 2010 4:11 PM
To: Boltz, Suzanne
Cc: Rabbe, Lisa A POA; Tyler P. Janke
Subject: Cottonwood EA Comment

Suzanne-

Hello and hope things are going well.

Not sure if I will be able to submit more detailed comments, but there is one item I wanted to make sure you were aware of from The Nature Conservancy. In Appendix D, page 13 The Nature Conservancy is mentioned in the text which given the context I do not view as a problem, but the section also contains a graphic containing the Conservancy's logo or entire graphic may have been created by the Conservancy.

I think it is important in this document that text, tables, graphics, etc., do not depict or name specific organizations in such a manner that it could be easily viewed by the public that the specific organization named or depicted is planning to conduct or endorses any action(s) associated with the plan. Again, the text seems fine, but I believe the graphic could be easily misunderstood or misrepresented either as TNC planning to take this action and/or endorsing the action associated with the plan .

Please use a different or more generic example (removal of TNC logo) if this graphic remains in the final Environmental Assessment.

Thank you and please contact me if I could clarify the concern or request,

-Jason

Jason Skold
Missouri River Program Manager
The Nature Conservancy
1007 Leavenworth Street
Omaha, NE 68102
Office: 402-342-0282 X 1006
Cell: 402-432-3599
jskold@tnc.org

FORT PECK TRIBES

Office of Environmental Protection

Suzie Boltz
EA Engineering
15 Loveton Circle
Sparks, MD 21152

May 19, 2010

RE: Comments on the Draft CMP/Programmatic Environmental Assessment

Dear Ms. Boltz;

I am submitting these comments on the Draft Cottonwood Management Plan/Programmatic Environmental Assessment (CMP/PEA) on behalf of the Fort Peck Assiniboine and Sioux Tribes, Poplar, Montana.

Although the Tribes are encouraged by the approach outlined in the Draft CMP, we were disappointed to note that no cottonwood management activities were targeted for segment 3 of the Missouri River. Segment3 includes the southern border of the Fort Peck Indian Reservation. Even though several segments have been identified as the principle focus of the CMP, no approach is given regarding the priority for the remaining segments on the Missouri, such as Segment 3. The Tribes feel that the CMP needs to address all segments of the Missouri River, in terms of priority, approach, and timelines and not simply be done to comply with only the Biological Opinion.

Segment 3 has some of the highest acres/river mile of cottonwood forest, although regeneration of the this cottonwood forest is limited by the current hydrology of the river. Yet, the CMP addresses this issue for the targeted segments specifically on page 2-25 Sec. 2.7.2 **Restoration of Hydrologic and Geomorphic Processes for Cottonwood Regeneration**. These same techniques could be applied to segment 3 for cottonwood regeneration with some alteration in the hydrograph and still meet the authorized purposes under the Master Manual. These approaches need to be evaluated for all segments of the river especially those with the landscape level resource such as segment 3.

Cottonwoods are a significant cultural resource to the Tribes. Their importance to the spiritual practices and beliefs of the Fort Peck Assiniboine and Sioux Tribes cannot be overstated. The Corps has consulted several times with the Tribes on the Master Manual, Missouri River Ecological Restoration Project, and the Missouri River Authorized Purposes Study where the Tribes have always voiced their concerns regarding cottonwood regeneration on the Missouri River. Yet, the Tribes were not consulted during the planning stages of the Programmatic EA and were not invited to the Cottonwood Management Team Meetings. Consultation and especially coordination needs be done with the Tribes on the Missouri River especially the Tribes with significant land holdings on the mainstem reaches of the river.

In summary, the Tribes support an expansion of the plan to other segments in addition to those identified in the Biological Opinion. The Environmental Assessment should include a prioritization methodology for adding segments. The addition of segments to the plan should include a timeline, specific techniques for regeneration, and demonstration projects.

Thank you for this opportunity to comment on the CMP/PEA.

Sincerely,

Roxann Bighorn, Vice-Chairman

A.T. "Rusty" Stafne
Chairman
Fort Peck Assiniboine and Sioux Tribes

Jeremiah W. (Jay) Nixon, Governor • Mark N. Templeton, Director
STATE OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES
www.dnr.mo.gov

May 20, 2010

Suzie Boltz
EA Engineering
15 Loveton Circle
Sparks, MD 21152

Dear Ms. Boltz:

This letter provides the Missouri Department of Natural Resources comments on the Draft Cottonwood Management Plan, Programmatic Environmental Assessment (CMP). While detailed comments are attached, we are providing several important general comments that are more procedural in nature and should be carefully considered by the U.S. Army Corps of Engineers (the "Corps") before finalizing the CMP.

1. The CMP is an integral part of the Missouri River Recovery Program (MRRP) and should not be finalized without further coordination with the Missouri River Recovery Implementation Committee (MRRIC). Congress has authorized MRRIC for specific purposes, which include providing guidance and recommendations to the Corps on the MRRP. Numerous members of MRRIC, primarily tribal members, have expressed great concern regarding cottonwood management. Coordination with MRRIC on the CMP has been practically nonexistent. Since the development and implementation of the CMP is not currently scheduled to be funded in FY2011, there is adequate time to conduct the required coordination with MRRIC on the CMP, and the Corps should not skip this important step in the process.

2. The Environmental Assessment for the CMP is premature, given its relationship to the Missouri River Ecosystem Restoration Plan (MRERP) Environmental Impact Statement. The CMP states that the Cottonwood Management Plan is part of the Missouri River Recovery Program (MRRP), which is developing an environmental impact statement (EIS) for the MRERP. Given that cottonwood management is a subset of ecosystem restoration addressed in MRERP, it is premature and practically impossible for the Corps to develop reasonable alternatives in the CMP that fully analyze the trade-offs between managing for cottonwoods and other resources (e.g. emergent sand habitat) that are still being analyzed under MRERP. Moreover, until the MRERP EIS process more fully develops the long term restoration plan, it is impossible for the Corps to adequately assess cumulative impacts from the CMP.

3. The Corps' plan to conduct a "programmatic environmental assessment" followed by site specific environmental assessments for the various project areas is an improper tiering under the National Environmental Policy Act (NEPA) regulations. NEPA regulations issued by the Council on Environmental Quality do not allow environmental assessments to be tiered (or incorporated by reference) into later environmental assessments. See 40 CFR 1508.28. Tiering is only appropriate when the first document is an environmental impact statement, which is intended to fully evaluate impacts and alternatives of a major federal action such as the CMP. We are very concerned that the Corps is only conducting a programmatic EA because it does not currently have sufficient information to conduct the required EIS. Few of the issues involving the CMP are ripe for decision. In which case, we would again encourage you to delay finalizing the CMP until more information can be obtained and MRRIC can be properly consulted.

Slowing down the CMP process will not keep the Corps from implementing measures to address pressing problems with cottonwood management where they exist. From the CMP this appears to be in Segments 4, 6, and 8. We are aware that in other recovery efforts, the Corps has demonstrated that projects can be implemented without a programmatic EA. While we oppose piece-meal development of projects and the implications it creates for compliance with NEPA, the fact is that the Corps is currently using this approach on the creation of Emergent Sandbar Habitat with an environmental assessment that is currently out for public comment.

4. The plan for implementation outlined in the CMP should be revised to begin in a segment where the need is most pressing, and actions in Alternative 2 are more appropriate for Segments 10 and 13, than those in Alternative 3 (Proposed Action). The CMP, and the *Status and Trend of Cottonwood Forests Along the Missouri River*, indicate that cottonwoods are doing much better below Gavins Point (Segments 10 and 13). Segment 10 has a large population of trees younger than 50 years, and Segment 13 shows natural recruitment and has trees across all age groups. Segments 4, 6, and 8, located above Gavins Point are dominated by mature and old growth cottonwood trees (91%, 85%, and 68% respectively), and show a lack of regeneration. Given this information it is difficult to understand the Corps' priority in implementing cottonwood restoration activities below Gavins Point first, instead of above Gavins Point where the documents indicate that problems are the most pressing.

Given that cottonwood trees have a more diverse population in Segments 10 and 13, Alternative 2, which includes education and cottonwood planting, appears to be a better approach than Alternative 3 which includes more extreme measures. This approach would likely save money and allow the Corps to concentrate more intensive efforts upstream where problems exist.

5. The CMP is completely inadequate in terms of the level of analysis provided and supporting materials referenced. The attached comments specify many of the areas where little or no analysis was provided or supporting material referenced to support a broad statement or conclusion. This fact supports my earlier statement that this CMP is premature and lacks sufficient information, which is apparently why the Corps is attempting to tie it to future EAs, instead of doing the necessary homework upfront. A substantial amount of work needs to be conducted before this document is NEPA-compliant. We request the Corps to address these areas and avoid making unsubstantiated conclusions.

In conclusion, we strongly encourage the Corps to delay finalizing the programmatic EA and complete coordination with MRRIC, incorporate the CMP into the MRERP process, and conduct appropriate analyses to adequately support the NEPA process. Should the Corps decide to move forward with the CMP, we recommend revising the plan for implementation to begin in segments upstream of Gavins Point that would provide a more direct benefit. Further comments are attached. If you should have any questions or need additional information, please feel free to contact me at (573) 751-4732.

Sincerely,

DEPARTMENT OF NATURAL RESOURCES

Michael D. Wells

Michael D. Wells
Deputy Director for Water Resources

MDW:mvv

Attachment

Cottonwood Management Plan
Additional Comments
Missouri Department of Natural Resources

1. **Flow changes and eliminating structural impediments, not supported by analysis and are not reasonable or prudent in Segments 10 and 13**

   i. Page 2-30: *"Flexible flow manipulations within those limits could be important and cost-effective in optimizing cottonwood regeneration in segment 10. The potential may exist for flow modification that will promote cottonwood regeneration without conflicting with flows designed to promote sturgeon, piping plover, and interior least tern reproduction."'*

   ii. Page 5-6: *"...coordinate the operation of the dams and any future spring rises or pulses to determine if cottonwood restoration could be implemented at locations the pulse are scheduled to occur."'*

   iii. Appendix D Box 17: *"If sufficient channel meandering is allowed through elimination of structural limitations (and flow pulses are allowed which emulate the natural hydrograph)"*

   Analysis was not provided to evaluate the impacts of flow or structural changes. Given the relative good health of cottonwoods downstream of Gavins Point, these measures appear to be extreme. We recommend Alternative 2 for Segments 10 and 13.

2. **Statements lacking supporting analysis**

   i. Section 4.2 Physical Resources and Current Operations - Page 4-3: *"The implementation of the CMP would create long-term, beneficial impacts to these areas of the river by creating fluvial processes, such as side channels, oxbow lakes, and backwaters, which would create suitable areas for cottonwood establishment."*

   The conclusion that implementation of the CMP would create long term beneficial impacts is not supported with analysis. Although this statement is followed by the recognition that further NEPA analysis would be required, the conclusion should not be included until such analysis has been completed.

   ii. Section 4.4 Water Resources – Page 4-4: *"The implementation of the CMP under Alternatives 2 or 3 would create long-term beneficial impacts to the hydrology of the system."*

      - Page 4-4: *"The control of livestock along the river and the discouragement of development would improve water quality."'*

   These conclusions need to be supported with analysis.

iii. Section 4.5.1 Wetland and Riparian Vegetation – Page 4-5: *"The implementation of the CMP under Alternatives 2 or 3 would create long-term, beneficial impacts to wetland and riparian vegetation."*

This conclusion needs to be supported with analysis.

iv. Section 4.5.1 Wetland and Riparian Vegetation – Page 4-5: *"In order to reduce the mortality of the existing cottonwood trees the Corps would conserve surface water and alluvial groundwater"*

There needs to be supporting explanations and analysis of how this would be achieved.

v. Section 4.5.2 Wildlife Resources – Page 4-6: *"Impacts to protected species including the interior least tern, piping plover, and the bald eagle would be beneficial."*

Further explanation and analysis of how the CMP would benefit the interior least tern and piping plover are needed in order to include this conclusion in the document. It seems more reasonable that there would be negative impacts to interior least terns and piping plovers through the direct conflict with maintaining un-vegetated sand bars (emergent sand habitat) and a potential increase in predation.

vi. Section 4.5.3 Aquatic Resources – Page 4-7: *"...the implementation of the CMP under Alternatives 2 and 3 has the potential to improve water quality of the Missouri River, which would ultimately create a long-term, beneficial impact to aquatic resources."*

This conclusion needs to be supported with analysis.

vii. Section 4.6 Socioeconomic Resources – Page 4-7: *"The implementation of the CMP under Alternatives 2 or 3 would create long-term negligible impacts to socioeconomic resources."*

- Page 4-7: *"The implementation of the CMP has the potential to benefit some land owners and small businesses. The Corps could utilize short-term conservation loans, which may benefit small local businesses and also use tax programs and state incentives for land owners donating land for conservation."*

Further analysis and explanation are needed to describe the impact on small local businesses and local landowners. Upon review of Appendix D, Box 6, it is unclear how small local businesses will benefit or that the overall impact to local land owners would be beneficial. Changing the land use from agricultural production to cottonwood forest would more than likely have a significant adverse economic impact to local businesses and government, rather than a benefit.

3. Discrepancies that need to be resolved

i. Descriptions of Segment 13

- Page 2-22 *"...cottonwood growth and recruitment may not currently be an issue in Segment 13"*
- Page 5-3 *"Segment 13 has substantial natural recruitment."*
- Page 4-2 *"The river south of Sioux City...would continue to lack habitat needed for the regeneration and recruitment of the cottonwood communities."*

The description of the river south of Sioux City, which includes Segment 13, is contradictory of statements made throughout the paper and in the March 2010 Status and Trend of Cottonwood Forests Along the Missouri River. The statement on page 4-2 should be corrected to reflect the data.

ii. Monitoring and Update Periods

- Page 5-3: *"To determine if the program goal is being achieved, a monitoring program will be required. ...It is anticipated that the data will need to be collected every 10 years to provide timely data and adequate response time, should the data indicate the need for adjustments to the program."*
- Page 6-1: *"All sites will be evaluated on a five-year overview along with review of the actual plan every five years. Therefore at a minimum, revisions and updates to the plan will occur every five years."*

The discrepancies in the monitoring period should be resolved. It would be difficult to revise and update the plan without sufficient data to incorporate into those revisions.

iii. Conflicting Segment labels need to be corrected

Figure 1-1 and Figure 1-2 have segments labeled differently. Figure 1-2 corresponds with the segments outlined in the BiOp. Upon review of other restoration activities, the Pallid Sturgeon Population Assessment also has segments labeled differently. This needs to be corrected to avoid confusion.

4. Misleading Statements that need to be clarified

i. Section 4.3 Sedimentation and Erosion

- Page 4-3: *"In addition, long-term, adverse impacts are anticipated as a result of the No Action Alternative. There would be no release of sediment from the dams within the Upper River,* *therefore the accumulation of sediment within the catchment basins would continue. The storage capacity of the reservoir would continue to decrease over the years."*

- Page 4-3: *"Impacts would include an increase in bank stabilization and an increase in the total storage capacity in the six reservoirs."*

These statements are misleading. There would be no release of sediment from the dams under any of the alternatives. Although the establishment of cottonwood communities along the erodible riverbanks would help to prevent bank erosion, erosion would still be occurring throughout the watershed and the accumulation of sediment in the catchment basins would continue regardless of the implementation of the CMP. Further analysis is needed to quantify the source of sediment within the basin/sub-basin. This would provide a more detailed understanding of the amount of sediment that actually originates from areas that the CMP is being implemented and the impact of the CMP on sediment rates in the reservoirs. Due to the large amount of sediment from the watershed, it is questionable whether the CMP would measurably decrease sedimentation of the mainstem reservoirs.

5. Missing information

i. Page 1-23: *"NEPA requires that the EA include...a list of agencies, interested groups, and the public consulted."*

This list needs to be incorporated into the document.

6. Effects of climate change need to be incorporated

i. Page 2-15: *"Perhaps the single most pervasive threat to the Missouri River cottonwood community is a change in precipitation and/or temperature patterns stimulated by global climate change that in turn disrupts the extremely sensitive hydrologic regime of the system."*

As climate change is a significant threat to the goals of this plan, it would be beneficial to have analysis of the projected range of effects completed and included in the document prior to implementation.

Matkowski, Jeannette

From: Boltz, Suzanne
Sent: Friday, May 21, 2010 11:47 AM
To: Matkowski, Jeannette; Rabbe, Lisa A POA
Subject: FW: Cottonwood Management Plan (CMP)/Programmatic Environmental Assessment (EA) Comments
Attachments: CMP-EA MDNR Comments 5-20-10.pdf

-----Original Message-----
From: Randy Asbury [mailto:moriver@howardelectricwb.com]
Sent: Friday, May 21, 2010 11:45 AM
To: Boltz, Suzanne
Subject: RE: Cottonwood Management Plan (CMP)/Programmatic Environmental Assessment (EA) Comments

May 21, 2010

Ms. Suzie Boltz
EA Engineering
15 Loveton Circle
Sparks, MD 21152

Dear Ms. Boltz:

I appreciate the opportunity to comment on the Missouri River Draft Cottonwood Management Plan (CMP)/Programmatic Environmental Assessment (EA).
I place these comments on record on behalf of the Coalition to Protect the Missouri River (CPR) which represents the diverse interests of agricultural, navigational, industrial, utility and business-related entities.

Attached you will find a letter in regard to the CMP/EA from Michael D. Wells, Missouri Department of Natural Resources. This email is to inform you of our organization's absolute concurrence with the comments provided by Mr. Wells.

In addition, I strongly reiterate the concerns expressed in the following April 14 email in regard to the Missouri River Recovery Implementation Committee's (MRRIC) lack of input into the CMP/EA. Moreover, I maintain the CMP/EA creates a disjointed and confusing relationship with the Missouri River Ecosystem Restoration Plan (MRERP). MRRIC's guidance should be sought per Section 5018 of the 2007 Water Resource Development Act and to determine whether the CMP should be a part of the MRERP EIS or a standalone EA.

Thank you for the 30-day extension in accepting these public comments.

Sincerely,

Randy Asbury
Executive Director
Coalition to Protect the Missouri River (CPR)
4849 Hwy B
Higbee, MO 65257
660-273-9903 Phone
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-----Original Message-----
From: Randy Asbury [mailto:moriver@howardelectricwb.com]
Sent: Wednesday, April 14, 2010 3:05 PM
To: 'sboltz@eaest.com'
Cc: 'John E. Thorson (johnethorson@mac.com)'; Witt Anderson (G.Witt.Anderson@usace.army.mil); Lynn M. Muench
(lmuench@vesselalliance.com)
Subject: Cottonwood Management Plan (CMP)/Programmatic Environmental Assessment (EA) Comments

April 14, 2010
Ms. Suzie Boltz
EA Engineering
15 Loveton Circle
Sparks, MD 21152

Dear Ms. Boltz:

I am writing in regard to the Missouri River Draft Cottonwood Management Plan (CMP)/Programmatic Environmental Assessment (EA). Unfortunately, I became aware of the CMP/EA today; therefore, I am unable to offer any substantive comments at this time.

Notwithstanding that, I am concerned with the process under which the CMP/EA has been administered. The CMP/EA Purpose and Need introduction states the CMP is a component of the Missouri River Recovery Program (MRRP) and "ultimately...may also inform the long-term" Missouri River Ecosystem Recovery Plan (MRERP).

Pursuant to Section 5018 of the 2007 Water Resource Development Act, "the Secretary of the Army, in consultation with the Missouri River Recovery Implementation Committee [MRRIC].shall conduct" the MRERP and also "provide guidance to the Secretary with respect to the Missouri River recovery and mitigation plan [i.e. MRRP] in existence on the date of enactment".

The CMP/EA raises two process concerns: 1) The CMP/EA never came before the MRRIC for consultation or guidance purposes; and, 2) Administering an EA separate from the MRERP EIS seems disjointed and confusing. Stakeholders are struggling to engage the plethora of studies simultaneously occurring throughout the Missouri River Basin without EAs taking place that should seemingly fit under the MRERP EIS.

Consequently, I urge the Corps to: 1) Pause the CMP/EA process until such time as the MRRIC has an opportunity to consult/guide the Secretary of the Army; 2) Determine with MRRIC consultation whether the CMP should be a part of the MRERP EIS or a standalone EA; and, 3) Extend the public comment period to accommodate input resulting from the MRRIC discussions.

Thank you for the opportunity to provide comments on this matter.

Sincerely,

Randy Asbury
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Cc: John Thorson, Chair, MRRIC
Witt Anderson, Chief of the Programs Directorate, U.S. Army Corps of Engineers, NW Division
Lynn Muench, Chair, Coalition to Protect the Missouri River

LOWER BRULE SIOUX TRIBE

COMMENTS TO THE COTTONWOOD MANAGEMENT PLAN
DRAFT PROGRAMMATIC ENVIRONMENTAL ASSESSMENT

General Comments

I. Tribes have not been consulted properly or specifically for this proposed PEA. This document is intended to be a 100 year plan which may have enormous impact on tribal communities in future years.

American Indian Tribal Consultation (p. 1-22) This section currently only identifies existing laws and statutes that apply. A protocol that addresses how the ACE will undertake and complete consultations on each program/project that results from this study, who will be contacted and how, and a piece that addresses the tribal input for this needs to be added. There are specific protocols for tribal involvement and partnering, which should provide Tribes – through consultation – with the opportunity to assist in writing this document. This proposed PEA impacts cultural resource office/THPO offices/tribal elders, as well as tribal wildlife/natural resource offices.

Under Affected Environment there needs to be more about cultural / natural resources from the tribal perspective and discussion of the tribal / Corps PA needs to be clearer. The tribal perspective is important because at the time of the dams, tribes were not consulted in the damming of the river and creation of the lake system, and had no input into agreements, loss etc. These impacts were devastating and continue today, particularly for those tribes situated directly on the River who experienced the greatest loss.

Tribes are not the public. Tribes are sovereign governments whose communities were impacted the most by the dam system. They need to have their own standing and priority in evaluating and executing projects under this proposed programmatic agreement.

II. It is understandable that a document like this would specifically choose to address only one priority segment – in this case a segment on a free flowing stretch of the River downstream; however, not exploring the upper basin and the lakes (which are so very different) with more thoughtfulness leaves an enormous void in a long term document.

The conditions, needs and planning for the lakes and their accompanying stretches of rivers are very different for the priority segments located upstream – and different from lake to lake. For a long term document, these stretches of the Missouri River Basin and its lakes need to be addressed. They are only mentioned in the current document in a manner which describes the physical segment only. The upper Missouri River Basin also impacts federally recognized tribes and their communities in many critical ways.

Specific Comments

p. 1-3, sec. 1.3 needs paragraph on importance of cottonwoods to Native Americans – "The cottonwood provides material, cultural and spiritual benefits to Native Americans. For the inhabitants of the Missouri River Valley, these great sheltering trees emerged from Mni Sose and covered its floodplains and low terraces, providing fuel, and wood, and a lush habitat for plants and animals. Its leaves and heartwood form symbols that reach deeply into Lakota spiritual traditions, and its trunk forms the sacred center of the Sundance ceremony."

p. 1-5, figure 1-1 segment numbers don't match segment numbers of figure 1-2
p. 1-8, section 1.4, first paragraph, last sentence states "...to keep the riparian habitat along the river a viable forest community." This statement presupposes that the riparian community as it currently exists is a viable forest community when it is in reality an extremely degraded system in need to restoration. This sentence should include verbiage such as "... and restore degraded or inundated riparian habitat..."
p. 1-13, sec. 1.5.1 Objectives the terms "priority" segments seem to be interchanged with "critical" segments – suggest using just "priority" since this has been defined in the CMP.
p. 1-13, sec 1.5.2 Objectives 2-3 need to include along with "extend" and "enhance" the segments native cottonwood communities, "restore destroyed native cottonwood communities".
p. 1-13, sec 1.5.2 Objective 5 deals only with free-flowing stretches of the river. There needs to be another objective that deals with the segments that consist of reservoirs. This objective could say "implement measures to reestablish riparian communities in the segment, including river bank stabilization and modifications to enable natural regeneration as well as planting of cottonwoods."
Also, for objective #6, should expand "listed" species to "rare or imperiled species identified by federal, state or tribal governments."
p. 1-22 American Indian Tribal Coordination – addressed in general comments above
p. 2-24 Table 2-3 for Restoration Strategy include "creation of shoreline or in-reservoir bench to naturally revegetate with cottonwoods" and for Artificial Propagation add "irrigate for cottonwood planting establishment" and in addition to rodent herbivory add "ungulate"
p. 2-25, sec 2.7.2 this section deals only with riverine systems, a second paragraph needs to be developed to deal with the reservoir parts of the system, such as segments 6 and 9. The restoration of these areas will be quite different than riverine stretches and needs to be explained here.
p. 2-26 sec 2.7.3 same comment as for section 2.7.2 above. Also the opening sentence of this section is not consistent with the rest of the section, actually is inaccurate when it says "the preferred method of planting cottonwoods is encouraging natural establishment", i.e. encouraging natural establishment is not planting. Should read that the preferred method of establishment is enabling natural regeneration but where that is not possible, planting is a valid alternative.
p. 3-4 "DeGray" is spelled "DeGrey"

p. 3-11, sec 3.3 need paragraph with information on shoreline erosion, this is one of the most significant processes that has occurred since the dams were completed and is continuing to this day. Shoreline erosion is perhaps the most important factor limiting cottonwood reestablishment.

p. 3-12 Segment 6 needs to have a paragraph describing shoreline erosion.

"Wind-driven waves and ice along the mainstem reservoirs have created a pattern of systemic bank erosion and shoreline recession that dumps acres of silt into the water annually. At Lower Brule, for example, the average loss ranges between 8 and 12 feet of shoreline a year. This pattern has created a dead zone of eroding cliffs and wave-washed beaches that prevents the redevelopment of a riparian habitat suitable for the growth of cottonwoods and other river species."

p. 3-33 Segment 6 second paragraph, 5th sentence should read "Additionally, the Lower Brule Sioux Tribe and Crow Creek Sioux Tribe have departments that restore and manage habitats on tribal lands."

p. 3-37 Segment 6, 5th sentence should read "Throughout the reservoir, primary species include walleye, sauger, smallmouth bass, white bass and channel catfish." Also, cannot state that management objectives are largely oriented toward protecting endangered species because of lack of any management activities for the nearly extirpated pallid sturgeon.

p. 3-38, sec 3.6, 3rd sentence "border" should be changed to "encompass or border"
next sentence, there is no such thing as a "mainstem Reservation", this should be changed to Reservations along the mainstem"
next sentence, reservations are properly referred to as "Lower Brule Sioux Reservation", etc. here and throughout document
next sentence, the "System" is not defined, presumably the river system

p. 3-42 paragraph has several errors, should read as follows: The Lower Brule Sioux Reservation and the Crow Creek Sioux Reservation are bisected by the Missouri River reservoirs Lake Sharpe and Lake Francis Case. The Lower Brule Sioux Reservation encompasses the western portions of Lakes Sharpe and Francis Case from river miles 976 to 1048 in central South Dakota. The Reservation lies primarily within Lyman County, and a small portion lies in Stanley County. The Reservation covers an area of about 226,660 acres, of which 22,400 acres are covered by reservoirs. Approximately 165,657 acres are owned by the Tribe and Tribal members. There are an additional 29,314 acres owned by the Tribe adjacent to the Reservation. The Reservation population has approximately 1,582 tribal members. There are 444 residences on the Reservation. The U.S. Department of Housing and Urban Development helped fund the construction of 300 residences. The Tribe's major economic occupation is cattle ranching and farming. Approximately 11,686 acres of the Reservation land is devoted to crops and 118,232 acres are used for grazing for cattle and small herds of horse, bison, and elk. The Tribe operates three large irrigated farms totaling 8,000 acres, a tribal construction enterprise, and a guided hunting camp operation. In addition the Tribe also operates the Golden Buffalo Casino and Motel, an RV Park, and a gas station. The Lower Brule is one of the nation's top popcorn producers (LBST 2009, Alan Lien, BIA personal comm.).

p. 6-4, sec 6.3.2, 5th sentence, last word probably intended to be “conservation easements”

APPENDIX C-3

Response to Comments

Response to Comments

Name/Affiliation/Date	Summary of Comment	Response
Craig Stange, Natural Resources Conservation Service, March 2, 2010	Page 2-15: The first impact refers to the climate change on the ability of the area to regenerate a riparian cottonwood forest.	Comment addressed in *Section 2.2.6 Incorporation of Future Data, Models, and Recommendations*. Removed text referring to climate change being the single most pervasive threat to the cottonwood community.
	Page 2-19: This section addressed the concern about adequate cottonwood seed trees adjacent to sites needing reforested. From personal experience, there are usually enough cottonwoods (in segment 4) around t provide the seed that can distributed to high winds. What is needed is the bare wet soil at the correct time.	The site selection criteria listed in *Section 2.3.2 Pilot Study – Segment 10 Site Selection Criteria* was intended to be used for Segment 10. As the other priority segments are studied and data is collected, the site selection criteria would be developed based upon the conditions of the particular segment. This comment would be noted during the development of site selection criteria for Priority Segment 4.
	Page 2-27: This section creates nurseries to harvest seed and grow seedlings for distribution and planting. Such creation is totally unnecessary as there are local nurseries in North and South Dakota that have experience producing conservation grade trees.	Comment addressed in *Section 2.7.3 Artificial Propagation of Cottonwoods*.
	Page 3-20: This section implies the presence of salt cedar and purple loosestrife as part of the reason that cottonwood forests are declining. For most of segment 4 these particular species have not impeded cottonwood regeneration. Our biggest invasive problem restricting tree establishment is the vast expanses of dense bome sod and the fact that our riparian soils have been dewatered and no longer get flooded in the spring. This section also refers to Slippery Elm. I have not personally identified any of this species in North Dakota, but it is likely that it is here. However, we do know that we still have large areas of American elm.	Comment addressed in *Section 3.5.2 Wetland and Riparian Vegetation* Segment 4.
John Hinners, South Dakota Department of Agriculture, March 11,2010	The plan deals with three actions. I support the third action, Implementation of the CMP.	Comment noted.
Gia Wagner, National Park Service, March 12, 2010	The alternatives do not consider altering flow regimes from the dams. Restoring a more natural flow regime to	The CMP team recognizes the value of the manipulation of the Missouri River flow regime to

Name/Affiliation/Date	Summary of Comment	Response
	better reflect the streamflow of the pre-dam Missouri River is vital to establish self-sustaining cottonwood communities. Implementing a spring rise and summer drawdown from Gavin's Point Dam would benefit native fish, nesting birds, and the cottonwood forest community. The long-term sustainability of the cottonwood community is questionable without the ability to manipulate flows.	establish the cottonwood community; however this action does not comply with the current Master Manual. In order to implement this hydrologic technique, a revision to the Master Manual would be needed.
Bob Nebel, March 24, 2010	Section 2.7.2 does not discuss all items listed in Table 2-3. This section should also recognize the timing of such activities to cottonwood seed dispersal.	Comment addressed in *Section 2.7.2 Restoration of Hydrologic and Geomorphic Processes for Cottonwood Regeneration*.
Dale Frink, State of North Dakota, Office of the State Engineer	The State of North Dakota holds title to the bed, sandbars, and islands below the ordinary watermark of the Missouri River in North Dakota. Projects to be constructed on the State's sovereign lands require an authorization from the State Engineer prior to construction. The State Engineer should be represented in the CMP team for Segment 4.	The North Dakota State Engineer would be invited to join the CMP team for Segment 4 and would be notified of any construction within the Missouri River.
Randy Asbury, Coalition to Protect the Missouri River, April 14, 2010	The CMP/EA raises two process concerns: 1) The CMP/EA never came before the MRRIC for consultation or guidance purposes, and 2) Administrating the EA separate from the MRERP EIS seems disjointed and confusing. Consequently I urge the Corps to pause the CMP/EA process until such time as the MRRIC has the opportunity to consult/guide the Secretary of the Army, determine with MRRIC consultation whether the CMP should be part of the MRERP EIS, and extend the public comment period to accommodate input resulting from the MRRIC discussions.	In response to requests from multiple parties, the Corps extended the comment period for 30 days in two instances for a total extension of 60 days. MRRIC members and support staff were notified of the extensions of the comment period. Should the MRRIC come to a consensus agreement on a recommendation regarding the CMP/EA, the recommendation would be fully considered, even after the close of the comment period. The CMP is required as a Reasonable and Prudent Measure in the U.S. Fish and Wildlife Service 2003 Amended Biological Opinion on the Corps operation of the Missouri and Kansas River projects, while the Missouri River Ecosystem Restoration Plan (MRERP) study is authorized by Water Resources Development Act (WRDA) of 2007. The two efforts are separate; however, the CMP will inform the MRERP study. The CMP recognizes that this is a

Name/Affiliation/Date	**Summary of Comment**	**Response**
		dynamic time for Missouri River recovery, mitigation, and restoration efforts and is the subject of an overall adaptive management strategy to address changes in ecological conditions and changes in management efforts as other programs come online.
Michael Wells, Missouri Department of Natural Resources, April 14, 2010	It seems wholly reasonable for the comment period of the Draft EA to be extended until such time can be vetted through MRRIC. The Draft EA is being developed as part of the MRRP and could play a significant role in the development of the MRERP. The piecemeal approach to the Missouri River restoration could cause a great deal of confusion for the public. I encourage you to add MRRIC in the public participation process. The Draft EA should be delayed until MRRIC can be integrated into the Cottonwood Community Management review process.	Should the MRRIC come to a consensus agreement on a recommendation(s) regarding the CMP/EA, the recommendation(s) would be fully considered. The CMP is required as a Reasonable and Prudent Measure in the 2003 BiOp, while the MRERP is authorized by WRDA 2007. The two efforts are separate; however, the CMP may inform the MRERP process. The CMP recognizes that this is a dynamic time for Missouri River restoration efforts and includes adaptive management to address changes in ecological conditions and changes in management efforts as other programs come online. In response to requests from multiple parties, the Corps extended the comment period for 30 days in two instances for a total extension of 60 days. MRRIC members and support staff were notified of the extensions of the comment period.
Michael McKenna, North Dakota Game and Fish Department, April 15, 2010	There are inconsistencies with the delineation of Segment 4. We recommend Segment 4 be RM 1390-1284.	Segments are based on the USFWS 2000 BiOp (page 131). Segment 4 includes RM 1389.9 to 1304.0.
	The NDGFD may provide limited funding on some aspects of the CMP. However the NDGFD is not listed under State and local Programs to Fund Individual Components of the CMP.	Comment addressed in *Section 6.3.1 Other Federal, State, and Local Programs*
Michael McKenna, continued	NDGFD is acquiring approximately 1,000 acres of land along the Missouri River (200 acres adjacent to Smith Grove WMA and 800 acres at Yellowstone/Missouri River confluence). NDGFD already owns 1,700 acres along the Missouri River. The NDGFD's budget to manage these lands is limited primarily to general	The Cottonwood Management team will take this into consideration when planning implementation in Segment 4.

Name/Affiliation/Date	Summary of Comment	Response
	maintenance. As a result, the removal of invasive vegetation such as Russian olive and re-establishment of cottonwoods is needed on these WMA's.	
	The CMP proposes increased hunting pressure to prevent deer grazing on existing cottonwoods. As the agency responsible for setting deer management goals and issuing deer hunting licenses in North Dakota, we believe altering the deer harvest for the expressed purpose of reducing cottonwood depredation would take considerable discourse and effort, and may not be possible.	Alternative 2 and 3 present a suite of management techniques that may be used during implementation of the CMP. It is not anticipated that every technique would be implemented. During the planning of Segment 4, the effort needed to control deer grazing would be taken into account.
Jason Skold, The Nature Conservancy, May 13, 2010	In Appendix D, Page 13, the Nature Conservancy is mentioned in the text which given the context I do not view as a problem, but the section also contains a graphic containing the Conservancy's logo or entire graphic may have been created by the Conservancy. I believe the graphic could be easily misunderstood or misrepresented either as TNC taking or endorsing this action.	Comment addressed in Appendix D. Graphic removed.
A.T. Rusty Stafne, Fort Peck Tribe, May 19, 2010	We are disappointed to note that cottonwood management activities were not targeted for Segment 3. The Tribe feels that the CMP needs to address all segments of the Missouri River, in terms of priority, approach and timelines and not simply done to comply with the Biological Opinion.	The CMP only addresses the six priority segments defined in the USFWS 2000 BiOp. The Missouri River Ecosystem Restoration Plan (MRERP) may look into cottonwood management along Segment 3 in the future.
	The Tribes were not consulted during the planning stages of the Programmatic EA and were not invited to the Cottonwood Management Team Meetings. Consultation and especially coordination needs to be done with the Tribes on the Missouri River especially the Tribes with significant land holdings on the mainstem reaches of the river.	The tribes listed within the Programmatic Agreement with the Corps Omaha District will be contacted and will have an additional 30-day review period for the CMP/EA. In addition, 5 tribes within the Corps Kansas City District will also be contacted.
Michael Wells, Missouri Department of Natural Resources, May 20, 2010	The CMP is an integral part of the Missouri River Recovery Program and should not be finalized without further coordination with MRRIC. The EA for the CMP is premature, given its relationship to the Missouri River	Should the MRRIC come to a consensus agreement on a recommendation(s) regarding the CMP/EA, the recommendation(s) would be fully considered. The CMP is required as a Reasonable and Prudent Measure

Name/Affiliation/Date	Summary of Comment	Response
	Ecosystem Restoration Plan (MRERP) EIS. It seems wholly reasonable for the comment period of the Draft EA to be extended until such time can be vetted through MRRIC.	in the 2003 BiOp, while the MRERP is authorized by WRDA 2007. The two efforts are separate; however, the CMP may inform the MRERP process. The CMP recognizes that this is a dynamic time for Missouri River restoration efforts and includes adaptive management to address changes in ecological conditions and changes in management efforts as other programs come online. In response to requests from multiple parties, the Corps extended the comment period for 30 days in two instances for a total extension of 60 days. MRRIC members and support staff were notified of the extensions of the comment period.
	The Corps' plan to conduct a "programmatic environmental assessment" followed by site specific environmental assessments for the various project areas is an improper tiering under NEPA regulations.	The Corps, as well as many other federal agencies, frequently use Programmatic EAs for broad programs such as the CMP. The Corps considered the need for an EIS and determined potential impacts were not likely to be significant. Comments on the Draft CMP/EA have not identified significant impacts and have mostly been supportive of the proposed action. The Corps' decision to prepare a programmatic EA is appropriate.
	The CMP is completely inadequate in terms of the level of analysis provided and supporting materials referenced.	The CMP/EA is a programmatic document and does not authorize construction. It evaluates, and if a FONSI is signed will authorize, the plan, which recommends development of site-specific plans with associated environmental assessments. Each site-specific EA will be available for public review and will provide more detailed information on potential impacts.
Michael Wells, continued	The plan for implementation outlined in the CMP should be revised to begin in a segment where the need is most pressing, and actions in Alternative 2 are more appropriate for Segments 10 and 13, than those in Alternative 3.	Alternative 3 presents a wider range of techniques that may be implemented. Not every technique would be implemented. For all segments, only appropriate techniques would be implemented. Techniques that would not benefit the cottonwood community would

Name/Affiliation/Date	Summary of Comment	Response
		not be implemented.
	Flow changes and eliminating structural impediments, not supported by analysis and are not reasonable or prudent in Segments 10 and 13. Analysis was not provided to evaluate the impacts of flow or structural changes. Given the relative good health of cottonwoods downstream of Gavins Point, these measures appear to be extreme. We recommend Alternative 2 for Segments 10 and 13.	Comment addressed in *Section 2.6.2 Alternative 3 Implementation of the CMP*. The toolbox of techniques presented are options that can be used if Alternative 2 or 3 are implemented. Not all techniques would be used. If manipulating flows or eliminating structural impediments in Segment 10 and 13 are not needed, these techniques would not be implemented under Alternative 3. Alternative 3 gives the Corps a more diverse set of options to choose from during the site planning.
	Section 4.2 Physical Resources and Current Operations (Page 4-3): The conclusion that implementation of the CMP would create long-term, beneficial impacts is not supported with analysis. Although this statement is followed by recognition that further NEPA analysis would be required, the conclusion should not be included until such analysis has been completed.	Comment addressed in *Section 4.2 Physical Resources and Current Operations*. The CMP/EA is a programmatic document and does not authorize construction. Each site-specific EA will be available for public review and will provide more detailed information and analysis of potential impacts.
	Section 4.4 Water Resources. The implementation of the CMP under Alternatives 2 and 3 would create long-term beneficial impacts to the hydrology of the system. The control of livestock along the river and the discouragement of development would improve water quality. These conclusions need to be supported with analysis.	Comment addressed in *Section 4.4 Water Resources*. The CMP/EA is a programmatic document and does not authorize construction. Each site-specific EA will be available for public review and will provide more detailed information and analysis of potential impacts.
Michael Wells, continued	Section 4.5.1 Wetland and Riparian Vegetation: The implementation of the CMP under Alternatives 2 and 3 would create long-term, beneficial impacts to wetland and riparian vegetation. This conclusion needs to be supported with analysis.	Comment addressed in *Section 4.5.1 Wetland and Riparian Vegetation*. The CMP/EA is a programmatic document and does not authorize construction. Each site-specific EA will be available for public review and will provide more detailed information and analysis of potential impacts.
	Section 4.5.2 Wildlife Resources: Impacts to protected species including the interior least tern, piping plover, and the bald eagle would be beneficial. Further explanation and analysis of how the CMP would benefit	Comment addressed in *Section 4.5.2 Wildlife Resources* The CMP/EA is a programmatic document and does not authorize construction. Each site-specific EA will be available for public review and

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	the interior least tern and piping plover are needed in order to include this conclusion in the document. It seems more reasonable that there would be negative impacts to interior least terns and piping plovers through the direct conflict with maintaining un-vegetated sand bars and a potential increase in predation.	will provide more detailed information and analysis of potential impacts.
	Section 4.5.3 Aquatic Resources: The implementation of the CMP under Alternatives 2 and 3 has the potential to improve water quality of the Missouri River, which would ultimately create a long-term, beneficial impact to aquatic resources.	Comment addressed in *Section 4.5.3 Aquatic Resources* The CMP/EA is a programmatic document and does not authorize construction. Each site-specific EA will be available for public review and will provide more detailed information and analysis of potential impacts.
	Section 4.6 Socioeconomic Resources. Further analysis and explanation are needed to describe the impact on small local businesses and local landowners.	Further analysis would be described in site specific EA's. The CMP/EA is a programmatic document and does not authorize construction. Each site-specific EA will be available for public review and will provide more detailed information and analysis of potential impacts.
Michael Wells, continued	Descriptions of cottonwood growth along Segment 13 are contradictory throughout the document.	Comment addressed by deleting statement in *Section 4.2 Physical Resources and Current Operation*
	There are discrepancies between a 5-year and 10-year monitoring period in Chapters 5 and 6.	Comment addressed in *Section 6.1* Revisions/Updates to the CMP. Monitoring would be every 10 years.
	Figure 1-1 and Figure 1-2 have conflicting Segment labels	Figures revised.
	Section 4.3 Sedimentation and Erosion: Statements concerning release of sediments misleading.	Comment addressed in *Section 4.3 Sedimentation and Erosion*. Statements concerning sediment release were removed.
	NEPA requires that the EA include a list of agencies, interested groups, and the public consulted.	Comment addressed in *Section 1.7Relevant Government and Public Involvement*. An additional Appendix (C) was added that contains public comments and distribution list.
	Effects of climate change need to be incorporated.	Comment addressed in *Section 2.2.6 Incorporation of Future Data, Models, and Recommendations*. Climate change will be incorporated in the site specific EA's.

Name/Affiliation/Date	Summary of Comment	Response
Randy Asbury, Coalition to Protect the Missouri River, May 21, 2010	This email is to inform you of our organization's absolute concurrence with the comments provided by Mr. Wells.	Comments provided by Mr. Wells were addressed in this document.
	I strongly reiterate the April 14th email in regard to MRRIC lack of input into the CMP/EA. I maintain the CMP/EA creates a disjointed and confusing relationship with MRERP.	MRRIC members and support staff were notified of the extensions of the comment period. Should the MRRIC come to a consensus agreement on a recommendation regarding the CMP/EA, the recommendation would be fully considered, even after the close of the comment period. The CMP is required as a Reasonable and Prudent Measure in the U.S. Fish and Wildlife Service 2003 Amended Biological Opinion on the Corps operation of the Missouri and Kansas River projects, while the Missouri River Ecosystem Restoration Plan (MRERP) study is authorized by Water Resources Development Act (WRDA) of 2007. The two efforts are separate; however, the CMP will inform the MRERP study. The CMP recognizes that this is a dynamic time for Missouri River recovery, mitigation, and restoration efforts and is the subject of an overall adaptive management strategy to address changes in ecological conditions and changes in management efforts as other programs come online.
Lower Brule Sioux Tribe, undated	Tribes have not been consulted properly or specifically for this proposed PEA. A piece needs to be added to American Indian Tribal Consultation (page 1-22) to explain the protocol of who will undertake consultation, who will be contacted, and tribal input.	The tribes listed within the Programmatic Agreement with the Corps Omaha District will be contacted and will have an additional 30-day review period for the CMP/EA. In addition, 5 tribes within the Corps Kansas City District will also be contacted.
	It is understandable that a document like this would specifically choose to address only one priority segment, in this case on a free flowing stretch of river downstream; however, not exploring the upper basin and lakes (which are very different) with more thoughtfulness leaves an enormous void in the long-term document.	The project team realizes that each of the priority segments have different river characteristics. The site selection criteria selected for Segment 10 would be adapted to meet the needs of each specific segment. New data would be collected and the HEP Model would be re-calibrated for each individual segment.
	Section 1.3, Page 1-3: Needs a paragraph on the	Comment addressed in *Section 1.3 Background*.

Name/Affiliation/Date	**Summary of Comment**	**Response**
	importance of cottonwoods to Native Americans.	
	Segments numbers in Figure 1-1 and 1-2 do no match.	Figures revised
	Section 1.4, Page 1-8: This paragraph presupposes that the riparian community as it currently exists is a viable forest community when in its reality an extremely degraded system in need of restoration.	Comment addressed in *Section1.4 Purpose and Need of the Proposed Action*.
	Section 1.5.1, Page 1-13. Use only "priority" segments	Comment addressed in *Section 1.5.1 Program Level*.
	Section 1.5.2, Page 1-13. Add new objective to deal with segments that consist of reservoirs. Expand definition of "listed" species.	Comment addressed in *Section 1.5.2 Segment Level*.
	Table 2-3. Add Creation of Shoreline or In-Reservoir Bench to Naturally Re-vegetate with Cottonwoods. Add Irrigate for Cottonwood Planting Establishment. In addition to Rodent Herbivory and Ungulate.	Comments addressed in *Table 2-3. Brief Description of Implementation Strategies Presented in Alternative 3*. Irrigation is covered under Management Policies to Protect/Restore Cottonwoods. Techniques would be used in conjunction with one another. Lowering the bench would allow for cottonwoods to naturally re-establish.
	Section 2.7.2, Page 2-25: This section deals only with the riverine reaches of the river. A separate paragraph needs to be developed to deal with the reservoir parts of the system, such as Segments 6 and 9.	Comments addressed in Section 2.7.2 *Restoration of Hydrologic and Geomorphic Processes for Cottonwood Regeneration*. Reservoirs incorporated.
Lower Brule Sioux Tribe, continued	Section 2.7.3, Page 1-16. A separate paragraph for reservoir parts of the river is needed. Also, encouraging natural regeneration is not planting.	Comments addressed in *Section 2.7.3 Artificial Propagation of Cottonwoods*.
	Page 3.4. DeGrey is misspelled.	Comment addressed in *Section 3.2 Physical Resources and Current operations.*
	Section 3.3, Page 3-11: Need paragraph on shoreline erosion.	Comment addressed in *Section 3.3 Sedimentation and Erosion*.
	Segment 6, Page 3-12: Needs to have a paragraph describing shoreline erosion.	Comment addressed in *Section 3.3 Sedimentation and Erosion*, Segment 6.
	Segment 6, Page 3-33: Sentence should read "Additionally, the Lower Brule Sioux Tribe and Cow Creek Sioux Tribe have departments that restore and manage habitats on tribal lands."	Comment addressed in *Section 3.5.3 Wildlife Resources*, Segment 6.
	Segment 6, Page 3-6: Sentence should read "Throughout	Comment addressed in *Section 3.5.4 Aquatic*

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	the reservoir, primary species include walleye, sauger, smallmouth bass, white bass, and channel catfish." Remove management efforts are oriented to protect endangered species.	*Resources*, Segment 6.
	Section 3.6, Page 3-38: Border should be encompass or border. Change mainstem Reservation to Reservations along the mainstem. Correct to read Lower Brule Sioux Tribe throughout document. Define "System".	Comment addressed in *Section 3.6 Socioeconomic Resources*.
	Section 3.6, Page 3-42: Paragraph has several errors. Update.	Comment addressed in *Section 3.6 Socioeconomic Resources* Segment 6.
	Section 6.3.2, Page 6-4. Change last word to conservation easements	Comment addressed in *Section 6.3.2 Project Lands.*

APPENDIX D

Field Sampling Protocols and Annual Reports

Field Sampling Protocols

Sampling Methods:

Three methods will be used in concert to sample the vegetation of cottonwood stands in the Missouri River floodplain. Sampling will include characterization of (1) overstory composition and structure using the point quarter method; (2) shrub/sapling composition, density, and cover using belt sampling and line intercept methods; and (3) herbaceous species composition and cover using 1 x 1 m quadrats.

Stand Selection:

Within each study reach, 30 stands should be sampled, with 6 stands each within the following 5 age classes:

- >100 years (old growth)
- 50-100 years (mature, pre-dam)
- 25-50 years (young-mature, post-dam)
- 10-25 years (young, pole)
- <10 years (seedling, sapling)

Sampling should also be stratified longitudinally by dividing the reach into thirds, relative to river miles, with 2 stands per age class sampled in each third (if possible).

We will analyze historical maps and imagery using GIS to screen stands by approximate age and will provide maps depicting forest patches, by age class. Because errors in stand age classification are bound to occur, workers on the ground should determine whether the age classification provided makes sense, given the size of the trees. Any obvious errors in classification should be reported to Mark Dixon at USD.

Stands to be sampled should meet the following criteria:

- At least 10-15% overstory cover by cottonwood
- An unmanaged or “natural” overstory, shrub, and herbaceous layer
  - no selective clearing of overstory trees
  - no selective clearing of red cedar, Russian olive, or other species
  - no campgrounds or sites with otherwise managed understories
- Patch size of at least 4-6 hectares (10-15 acres) for pole through old growth stands. Seedling/sapling sites can be smaller, down to 1 ha. (2.5 acres) or less.
- A stand, or the area of the stand included in a given sample, should be relatively homogeneous in terms of age and management
  - No mixture of our age classes
  - Preferably, no mixture of samples across obviously different cohorts of cottonwoods, even if the stand as a whole falls within a single crude age class (as defined above)

- Avoid mixing portions of a stand with different past management regimes or obviously different vegetation structure (e.g., big differences in tree density, abundance of red cedar, etc.)

Sampling locations within each stand will be established using a stratified random design. Sampling sites will be randomly located within equal-sized segments on each transect. Transects themselves (4 per stand) will be positioned perpendicular to the river channel and also located randomly within equal-sized segments (strata) within each stand. Forty sample points will be located for trees (160 trees per stand), 10 per transect. Twenty-four sample points will be located for the herbaceous layer (6 per transect), while 12 points will be located for the shrub layer (3 per transect).

Lay out sampling within a stand using the following guidelines:

- Using an aerial photograph or map, determine the compass direction that would be approximately perpendicular to the river and try to envision how a large, rectangular plot could be laid out within the area to be sampled.
    - For very large stands, restrict sampling to only an approximately 30 ha area or less (transect points ≤ 50 m apart, transects ≤ 150 m apart)
- Partition this rectangle laterally into 4 equal sections
- Draw a random number between 1 and the width of each section. Use this random number to determine the position of the transect within each of the 4 sections. As noted above, these 4 transects will run approximately perpendicular to the river and parallel to each other
- Divide each transect into equal segments longitudinally (running toward the river): 10 for overstory sampling, 6 for shrub and herb sampling. Note that the actual transect and sampling point locations should be separate between the overstory and the understory/shrub sampling.
- Within each transect segment, draw a random number between 1 and the length of the segment. Place the actual sampling point at this distance within that segment. Repeat this for all the segments on a given transect.
- We find that it is helpful to write down (and sketch the layout) all of these distances before going out to the field to sample a given site. T The actual distances should be paced out on the ground when locating the next sampling point. It may be helpful to measure out your pace (e.g., see how many paces it takes for you to walk 50 m) ahead of time, to aid in determining distances more accurately
- Avoid placing the sampling point within 25 m of a “hard” edge (river, farmland, clearing, etc.),
- The above layout can be modified based on site conditions (e.g., could do 5 transects of 8 points each). Also, based on your discretion, if a random number selection places two transects or individual points too close together (so that there is risk of double sampling, or of inadequately covering the plot in a spatial sense), feel free to draw a new random number.

In the field, obtain and record GPS coordinates (UTM NAD83) for at least the beginning (farthest from the river) of transect 1 and the end (closer to the river) of transect 4. GPS coordinates of other transect locations are also welcome, but not required.

Overstory Sampling

We will use the point quarter method (Cottam and Curtis 1956) for sampling and characterizing stand-level species composition, density, and basal area. This method provides an efficient technique for rapidly surveying stand characteristics. In pilot sampling of cottonwood stands last year, we found that a stand could be easily sampled by a crew of three in a single day. These methods are consistent with those used by Carter Johnson (Johnson et al. 1976) on the Garrison to Oahe reach of the Missouri River in North Dakota in the late 1960s, and should enable comparisons with the results of that study. I believe that Tom Bragg has also used similar methods to sample floodplain forest composition in portions of river segment 13 (mouth of Platte River to Kansas City) (T. Bragg, personal communication).

As indicated above, 40 points should be sampled per stand, with 4 trees per point (160 total per stand). From each point, divide the area into four 90 degree quadrants based on the transect bearing and a line perpendicular to it. Within each of these quadrants, locate the nearest live tree (dbh ≥ 10 cm), identify it to species, measure its diameter at breast height (dbh) to the nearest cm, and measure the distance from the point to the closest part of the trunk of the tree to the nearest 0.1 meters. If the nearest tree in a quadrant is dead, record its species (if known), dbh, and distance from point, and then look for the nearest live tree within the quadrant.

Other specifications:
- If tree is multi-trunked, record all stems ≥10 cm dbh
- If no live trees can be located within a reasonable distance in the quadrant (e.g., the distance to the next sampling point), then leave that quadrant blank
- If closest tree in a quadrant is dead, record the species (if known), diameter, and distance from the point. Then, locate and sample the nearest live tree within the quadrant
- Note and record whether that tree has a liana (woody vine) growing on the trunk

Suggested crew/equipment:
- Crew of 2-3 people
- 2-3 dbh tapes, metric
- Compass
- Rangefinder or other distance measuring device (resolution must be to 0.1 m)
- 30-50 meter tape for measuring distance under conditions unsuitable for rangefinder (or if rangefinder not available)
- At least one clipboard with datasheets, including some on 'rite-in-the-rain' paper
- GPS for recording outer transect locations within stand

Understory Sampling

Understory sampling will characterize both the shrub and herbaceous layers. In contrast to the overstory sampling, only 12 (for shrubs) and 24 (for herbaceous layer plants) points will be sampled per stand. These points should be on separate transects from those used in the overstory sampling, with 4 transects per stand and 3 (for shrubs) or 6 (for herbaceous) points per transect.

Shrub layer (≥ 1 m)
Plants occupying the shrub layer (shrubs and tree saplings > l m tall < 10 cm dbh) will be sampled using the line-strip method (Lindsey 1955), using a sampling strip 2 m x 10 m with a tape defining the centerline. This sampling strip should begin at the point and run along the bearing of the transect. Plant density (#/ha) will be estimated by counting all individual shrubs, saplings, and woody vines found within the sampling strip (1 meter to either side of the 10 m transect). Numbers should be tallied for each species.

Percent cover will be estimated by inventorying cover by shrubs (or saplings and woody vines) that intercept the centerline vertical plane of the plot above 1 m off the ground. Segments of the transect with overhead shrub cover should be recorded by noting the starting and ending distances of cover, by species, on the tape from 0 to 10 meters. It is important to list the actual distances covered by each species, so that overlaps in coverage by multiple species can be subtracted when estimating total cover.

Herb layer (< 1 m)
Plants in the herbaceous layer (herbs and woody seedlings < 1 m tall) will be sampled using a 1 m x 1 m sampling frame (quadrat) beginning at or centered on the sampling point. Care should be taken to avoid trampling on the area prior to sampling. For this reason, it may be advisable to sample the herbaceous quadrat prior to the shrub sampling. All species of non-woody vascular plants and woody seedlings should be noted and their percent cover within the 1 m^2 quadrat estimated to the nearest 5%. Species with trace occurrence should be recorded as 1% cover.

Unknown species should be noted and numbered (e.g., unk # 1) and collections made from individuals outside of the quadrat, if possible. These unknowns may be submitted (or scanned) to Dr. Gary Larson of South Dakota State University for assistance with identification.

Voucher specimens of all species of native plants encountered during sampling should be obtained and submitted to Dr. Gary Larson of South Dakota State University. Specimens should be obtained in full flowering condition if possible. Specimens should be pressed and dried using a standard plant press and mounted and labeled using standard herbarium protocols or sent for preparation to Dr. Gary Larson, the curator of the herbarium at South Dakota State University. If desired, additional specimens may also be prepared and housed in the home institution (e.g., University of South Dakota, Benedictine College, USGS).

Suggested crew/equipment:

- Crew of 2-3 people
- 1 x 1 meter sampling frame
    - Material of your choice (e.g., rebar or pvc)
    - A three-sided frame often works well for trying to place the frame around tree trunks and shrub stems
- Dbh tape, metric
- Compass
- 10 meter tape
- Meter stick
- Chaining pins for holding down transect end (optional)
- Standard plant press with blotters (blotter paper or newspaper)and ventilators (corrugated cardboard)
- One or more standard references and keys for flora of the region
    - E.g., *Flora of Nebraska* by Kaul, Sutherland, and Rolfsmeier, *Flora of the Great Plains* by Barker et al., *Steyermark's Flora of Missouri* by G. Yatskievych (http://www.efloras.org/flora_page.aspx?flora_id=11)
    - USDA plants website is a helpful resource (http://plants.usda.gov/)

Plant Species Data Summaries and Metadata

These sampling protocols will produce the following basic information: stand-level and complete plant species lists, including the presence of any indicator species; frequency and percent cover of each species in the herbaceous layer; frequency, percent cover, and density of each species in the shrub layer; and the frequency, density, dominance (basal area/ha) and importance value (sum of percent relative frequency, density, and dominance, with a maximum value of 300) of each tree species.

Each investigator is responsible for submitting a master spreadsheet listing the Latin names of each species encountered during sampling, any code names used to identify that species in the data, whether the species is native or introduced, its wetland indicator status, and its Coefficient of Conservatism. Wetland Indicator status codes (Reed 1988 and later updates) have been standardized by region and may be obtained from the following website: http://www.fws.gov/nwi/plants.htm. These codes are also available on the USDA plants website (http://plants.usda.gov/). Coefficients of Conservatism (i.e., how indicative is a given species of the "naturalness" or conservation value of a study site) have been developed for the flora of a number of regions (e.g., The Northern Great Plains Floristic Quality Assessment Panel 2001 for North and South Dakota, http://www.npwrc.usgs.gov/resource/plants/fqa/index.htm) and is most often used for calculating the Floristic Quality Index (Swink and Wilhelm 1994). These codes can enable calculation of cover-weighted estimates of wetland affinity and overall vegetation quality or "naturalness" in each stand.

Other Sampling and Data Formats

All investigators will be responsible for ground-truthing GIS maps of stand age for their study reaches. Methods for ground-truthing (and the maps themselves!) have not been finalized yet.

We may also request that investigators verify stand age by coring 3-5 cottonwood trees in each stand and counting the growth rings and/or developing diameter-age regression relationships that can be used as a rough screening technique for verifying stand age.

Investigators are also responsible for entering and submitting their data in Excel spreadsheets according to a standard format to Mark Dixon at the University of South Dakota. Formats for data entry and submission have not been finalized yet.

References

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2007 ANNUAL REPORT – MISSOURI RIVER COTTONWOOD STUDY

by

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EXECUTIVE SUMMARY

Cottonwood (*Populus* spp.) forests were historically a major component of the floodplain of the Missouri and other Great Plains rivers. On many western rivers, major changes in flow regime occurred following the advent of flow regulation in the mid-20th century, leading to chronic recruitment failure by cottonwood on meandering rivers, with long-term implications for landscape configuration and biodiversity (Johnson et al. 1976, Rood and Mahoney 1990, Johnson 1992, Miller et al. 1995). On the Missouri, the elimination of normal flow and sediment patterns are blamed for a host of natural resource problems, including the lack of sandbar nesting habitat for endangered bird species, poor spawning conditions for native river fishes, reductions in bald eagle nesting habitat, and declines in establishment of new cottonwood stands (NRC 2002).

The aim of our project is to assess the current status of cottonwood forests along the Missouri River, including their composition, structure, health, areal extent, and age distribution. Data and conclusions derived from this project will be used by the US Army Corps of Engineers for developing a Cottonwood Community Model using the HEAT methodology for six moderate to high priority Missouri River segments for the Bald Eagle (segments 4, 6, 8, 9, 10, and 13). This model will be used to evaluate the present condition of the cottonwood community and forecast future conditions under a range of alternatives for cottonwood management actions.

Our project involves (1) GIS-mapping of present-day and historic land cover, including cottonwood forest extent and age class distribution, and (2) characterization of vegetation structure, composition, wetland affinity, and floristic "quality" within cottonwood stands across a gradient of successional age classes. Our study areas included the six priority segments, plus two other segments in Montana, one of which has the closest approximation on the Missouri to an unregulated flow regime. The segments under study include all five of the unchannelized, unimpounded segments below Fort Benton (Wild and Scenic, 2, 4, 8, and 10); two impounded or partially impounded segments (6 and 9); and one channelized segment (13). Here we report only the results from segments 8 (plant data only) and 10 (both GIS and plant data) on the Missouri National Recreational River in South Dakota and Nebraska. Other work is ongoing or forthcoming on the other priority segments (4, 6, 9, 13), plus segment 2 and an unregulated Wild and Scenic reach of the Missouri in Montana.

Major findings of our work to date are as follows:

1. Land cover within the historic floodplain in segment 10 is dominated by agricultural cropland (80%), with riparian forest dominated by cottonwood occupying approximately 5.9% of the total area and early successional woody vegetation occupying 1.4%. Total area of cottonwood-dominated patch types (including both established forest and early successional, sapling sites) was approximately 14,900 acres along the 59-mile river segment.

2. Dramatic changes in land cover occurred along a 20-mile stretch of segment 10 in the vicinity of Vermillion, South Dakota from 1892 to 2006. Grassland (40%) dominated the 1892 land cover, while agriculture (80%) dominated in 2006. Riparian forest declined by about ½ from 1892 to 2006, with an increasing proportion of the remaining forest occurring in patches <100 hectares (<250 acres) in size or smaller.

3. The total area of cottonwood patch types in segment 10 in 2006 was almost evenly split between stands originating pre- and post-dam (before and after 1956). About ¾ of the cottonwood area was composed of mature pre-dam (50-114 years) and intermediate-aged post-dam (25-50 years) stands, at 41% and 33%, respectively. Both older (>114 years) and younger (<10 years, 10-25 years) age classes occupied smaller proportions of the total cottonwood area, at 10%, 12%, and 4%, respectively.

4. We sampled 17 species of trees (trees > 10 cm dbh) in 47 stands on segments 8 (17 stands) and 10 (30 stands) in 2007. Cottonwood dominated most stands, but declined in importance with stand age. Later successional tree species, including green ash, American elm, white mulberry, and European buckthorn, increased in importance with stand age and were absent or scarce on stands <50 years old. Eastern redcedar and Russian olive, two species that were probably scarce or absent from the floodplain prior to flow regulation, were relatively widespread, with Russian olive primarily on post-dam (<50 year old) sites and redcedar on intermediate-aged (25-50) to older sites.

5. We sampled 29 species of vascular plants in the shrub layer across the 47 stands. Species richness increased with stand age, as did the richness, absolute cover, and relative cover of exotic shrub species (primarily European buckthorn). Shrub cover and stem density had a bi-modal distribution, with the lowest values in pole (10-25 years) and intermediate-aged (25-50 years) stands, and the highest values in mature and old growth stands.

6. We sampled 173 species of vascular plants in the herbaceous layer across the 47 stands. Species richness increased with stand age, but was approximately equal among all age classes >25 years old. Stands established >50 years ago (pre-dam) had a higher component of exotics than did younger stands.

7. Across the herbaceous, shrub, and tree strata, we sampled 179 species of vascular plants across the 47 stands. As with the herbaceous flora, species richness increased with stand age, but leveled off and was approximately equal for stands >25 years old. Most (>80%) of species were native in each stand age class, although the proportion of exotic species was slightly higher for stands > 25 years old (and approximately equal for intermediate, mature, and old growth stands) than those <25 years.

8. Mean Coefficient of Conservatism (0-10 possible range) values ranged from 2.7 in sapling stands to 3.3 in old growth stands, suggesting a flora composed primarily of widely distributed species without a strong affinity for undisturbed natural areas. These low values might be expected for early successional, disturbance-driven communities like cottonwood forests. Mean Wetland Indicator Scores (1-5, with 1 for upland and 5 for wetland obligate) decreased with stand age, but were approximately equal for all age classes >25 years old. Mean scores were 2.3-2.7, suggesting that the bulk of species were between facultative upland and facultative, across all age classes.

Recommendations are given of key areas for future work, including landscape modeling of floodplain forest trajectories, using the GLO notes and sampling of cottonwood stands on unregulated tributaries to derive reference conditions for the vegetation of the pre-regulation Missouri, and assessing the value of “novel” habitats at reservoir and tributary deltas for biodiversity and cottonwood recruitment.

INTRODUCTION

Cottonwood (*Populus* spp.) forests were historically a major component of the floodplain of the Missouri and other Great Plains rivers. Floods maintained the ecological health of these forests by providing moisture to sustain the growth of trees and wetland plants, depositing fine sediments and nutrients that enhance the fertility of floodplain soils, stimulating decomposition of leaves and woody debris, dispersing seeds of floodplain trees, and forming sediment bars that provide seedbeds for establishing new cottonwood and willow (*Salix* spp.) stands. In the absence of flooding and river channel migration, establishment of new cottonwood stands along meandering rivers declines, with existing cottonwood stands aging and eventually being replaced by later-successional species such as ash (*Fraxinus pennsylvanica*), elm (*Ulmus americana*), and box elder (*Acer negundo*) (Johnson et al. 1976, Johnson 1992). Maximal biodiversity in the riparian landscape occurs with a dynamic mix of young, mature, and old cottonwood stands, driven by river flooding and channel migration (Johnson 1992). The Bald Eagle may be dependent on large, mature cottonwood trees that occur in older stands for nesting and roosting habitat along the Missouri. On many western rivers, major changes in flow regime have occurred following the advent of flow regulation in the mid-20th century, leading to chronic recruitment failure by cottonwood on meandering rivers, with long-term implications for landscape configuration and biodiversity (Johnson et al. 1976, Rood and Mahoney 1990, Johnson 1992, Miller et al. 1995).

In the 1950s and 1960s, the Pick-Sloan Plan resulted in the construction of a series of dams on the upper basin of the Missouri River, drowning forests upstream of the dams and greatly altering flow patterns and sediment transport downstream (NRC 2002). On the lower Missouri, bank stabilization, building of levees, and channelization has greatly altered the river channel itself, as well as landscape patterns in the former floodplain and its forests. The elimination of normal flow and sediment patterns are blamed for a host of natural resource problems along the Missouri, including the lack of sandbar nesting habitat for endangered bird species, poor spawning conditions for native river fishes, reductions in Bald Eagle nesting habitat, and declines in establishment of new cottonwood stands (NRC 2002). In South Dakota, most of the remaining floodplain forests on the Missouri River are concentrated in two remaining flowing and unchannelized river segments (8 and 10), designated as the Missouri National Recreational River (MNRR), below the Fort Randall and Gavins Point dams. These forests continue to serve as important habitat for the Bald Eagle, migratory songbirds (Gentry et al. 2006), and many other woodland species. However, present forests are aging, rates of new forest establishment appear to be declining, and other factors, such as clearing and bank erosion, are reducing the area of existing forests (Hesse et al. 1988). Furthermore, changes in flow patterns and the absence of overbank flooding over the last 50 years may be fundamentally changing the species composition, structure, and trajectories of change within these remnant forests.

Our project was motivated by the need to assess the current status of cottonwood forests along the Missouri River, including their composition, structure, health, areal extent, and age distribution and is a continuation of an earlier pilot project (Johnson et al. 2006). This work is being conducted in support of the U.S. Fish and Wildlife Service's Biological Opinion on the Missouri River in regard to reasonable and prudent measures for the Bald Eagle. Data and conclusions derived from this project will be used by the US Army Corps of Engineers to develop a Cottonwood Community Model using the HEAT methodology for 6 moderate to high priority Missouri River segments for the Bald Eagle (segments 4, 6, 8, 9, 10, and 13). This model will be used to evaluate the present condition of the cottonwood community and forecast future conditions under a range of alternatives for cottonwood management actions.

We are conducting field vegetation sampling and GIS-based mapping of forest extent and age on all six of these priority reaches, plus two other segments in Montana (segment 2 and Wild and Scenic), one of which (the Wild and Scenic reach below Fort Benton) has the closest approximation on the Missouri to an unregulated flow regime. The segments under study include all five of the unchannelized, unimpounded segments below Fort Benton (Wild and Scenic, 2, 4, 8, and 10); two impounded or partially impounded segments (6 and 9); and one channelized segment (13).

The results reported here apply only to segments 8 (plant data only) and 10 (both GIS and plant data) on the Missouri National Recreational River in South Dakota and Nebraska. Other work is ongoing or forthcoming on the other priority segments (4, 6, 9, 13), plus segment 2 and the Wild and Scenic reach of the Missouri in Montana.

Our aims were to determine the following:

1. Present-day land cover within the historic Missouri River floodplain, including the distribution of cottonwood forest and early successional cottonwood sites;
2. Historic land cover patterns and forest distribution along the Missouri, particularly baseline pre-dam conditions, and changes from these historic pre-dam patterns to present-day patterns;
3. The present-day successional stage and age distribution of riparian woody vegetation patches, particularly those containing cottonwood;
4. The plant species composition and structure within existing cottonwood stands, across the successional gradient from sapling stands to old growth stands;
5. Included in #4, the characteristics of the plant species occurring in these cottonwood stands, in terms of their affinity for wetland habitats and their affinity or dependence on undisturbed natural habitats (i.e., the floristic “quality” of the vegetation).

METHODS

GIS Mapping

Current Land Cover and Cottonwood Age Class Mapping

We mapped current (2006) land cover in segment 10 by interpreting and digitizing 2006 county mosaic orthophotography from the National Agricultural Imagery Project (NAIP), obtained from the USDA NRCS Geospatial Data Gateway (http://datagateway.nrcs.usda.gov/). This NAIP imagery is in natural color, and has a pixel size of 2 m and horizontal positional accuracy of approximately 10 m (Table 1). The projection for the imagery and for all subsequent shapefiles and geodatabases in ArcGIS 9.1 was NAD 1983 UTM Zone 14N. Digitizing was done on the screen (“heads-up” digitizing) with the image at a scale of 1:10,000. For particularly large and simple polygons (e.g., agricultural cropland), we sometimes zoomed out to a resolution of 1:24,000 for interpretation and digitizing, and sometimes zoomed in to scales finer than 1:10,000 for particularly complex polygons or for vegetation types that were difficult to discern. A minimum mapping unit of 1 hectare (2.47 acres) was used, although all polygons were retained in a vector format. Hence, for the most part, patches < 1 hectare were not mapped, but were effectively merged with the surrounding dominant land cover (e.g., agricultural cropland). We developed our own land cover classification system specifically for the vegetation types encountered along the Missouri River and based upon the resolution of our imagery and level of training of our technicians. A list of the land cover categories and a short description is given in Table 2.

Although we have produced draft maps of all eight of our study segments, only the GIS datasets for segment 10 have been ground-truthed and revised. Ground-truthing consisted of boating the river or driving roads in the floodplain and comparing classified land cover with observations on the ground. Field ground-truthing was the primary means of splitting out patch types with cottonwood from non-cottonwood sites, rather than trying to determine species composition in woodlands and forest from the aerial imagery. Because identifying cottonwood and non-cottonwood sites was the main aim of the ground-truthing, we did not calculate estimates of classification error.

We also digitizing and interpreting historic land cover from 1892 and 1956 for our study segments (Table 1). The 1892 land cover is based on digitizing the vegetation type designations on the Missouri River Commission (MRC) maps, published in 1895. We obtained digital, georeferenced images of the MRC maps from the U.S. Army Corps of Engineers, Omaha District (personal communication, Jon Kragt). These maps were originally at a scale of 1:63,360 with a scanned pixel resolution in ArcGIS of 4.6 m. Because of the coarser nature of these images, we interpreted and screen-digitized at a scale of 1:24,000 for most polygons. Original maps were in latitude-longitude, and scanned georeferenced images were in the Albers projection. Land cover classes in the 1892 map differed somewhat from what we used for the 2006 land cover. Because of this, comparisons between the 2006 and 1892 landscape composition required determination of comparable patch types and lumping of others. For some patch types (e.g., willows, bushes, sandbar), it was difficult to discern unambiguously what criteria were used in classification in the MRC maps, and whether our classes were completely comparable (e.g., are some young recruitment sites for cottonwood coded as ‘sandbar’ in the 1890s imagery). These limitations should be taken into account when interpreting historic changes in vegetation between the 1892 maps and the 2006 orthophotographs.

For our forest age class mapping, and for future mapping of 1956 land cover, we obtained and geo-rectified aerial photography from 1955/56 and the 1980s (mostly 1983/84 for segment 10) (Table 1). For segment 10, we also had access to fine-resolution (1 foot) natural color digital orthophotography from 1997, supplied by the US Army Corps of Engineers. 1950s imagery was black-and-white aerial photography flown for the USDA Commodity Stabilization Service of the FSA (Farm Service

Administration), originally at 1:20,000 scale, and was obtained principally through the USDA Aerial Photography Field Office. These images were obtained as 25 micron digital scans, with a pixel resolution of approximately 0.5-0.6 m. In addition, we scanned hard copies of some of the 1950s imagery at had some scans of hard copies of the 1950s photography, scanned to a pixel resolution of 2.8 meters. A few coarser scans of 1953 imagery from the USDA Soil Conservation Service (also FSA), originally shot at 1:63,360 scale and scanned at 200 dpi, were used to fill in gaps in coverage of the finer resolution 1955/56 imagery. Aerial photography from the 1980s was obtained from the USGS NHAP1 project. The imagery was color-infrared, shot at an original scale of 1:60,000 and scanned at 21 microns, for a resulting pixel resolution of approximately 1.3 m. Imagery was obtained from the USDA APFO and the USGS EROS Data Center.

For geo-rectification, we used the 2006 NAIP orthophotography as our base map and referenced historical imagery to it. We used the geo-rectification tool in ArcGIS and selected approximately 5-20 points common to both images (e.g., road intersections, corners of buildings, trees, bridges, etc.) as control points for geo-referencing the historic image to the base map. We applied 1st order or 2nd order transformations in the geo-rectification process, depending on the degree of distortion in the image and the RMS (root mean square) error of the rectification process, aiming for an error less than 5 m, and preferably closer to 2-3 m. All interpretation and digitizing were done on the rectified images.

We constructed ArcGIS geodatabases and maps depicting the approximate age class for cottonwood and other riparian woodland, forest, and shrubland in the study area. Draft age maps have been completed for several segments, but only the age map for segment 10 has been intensively checked and revised. Hence, only those results are reported here. We delineated approximate stand age using the following steps: (1) selected polygons on the 2006 land cover that corresponded to woodland, forest, shrubland, or vegetated sandbar categories; (2) visually overlaid these polygons in ArcGIS with historic georeferenced maps or photographs from 1997, 1983/94, 1955/56, and 1892; (3) determined the approximate photograph/map interval during which the present woody vegetation colonized the polygon of interest (e.g., converted from unvegetated sandbar to woody vegetation); (4) assigned the polygon, or portions of it, the age class (1 = >114 years, 2 = 50-114 years, 3 = 25-50 years, 4 = 10-25 years, 5 = <10 years) consistent with that establishment interval. In some cases, different parts of a given polygon differed in age class, and we split the polygon into multiple polygons of woody vegetation with different ages. We assigned two age variables in the ArcGIS geodatabase. One ("age" applied to all woody vegetation types within the historic floodplain (upland forest was excluded), while the other ("cw_age") applied only to patch types containing significant cottonwood cover. We used the cw_age variable to tabulate areas and proportions of the different cottonwood age classes in the study area.

Vegetation Sampling

Three methods were used in concert to sample the vegetation of cottonwood stands in the Missouri River floodplain. Sampling included characterization of (1) overstory composition and structure using the point-centered quarter method or (on pole and sapling sites with few tree-sized individuals) fixed radius circular plots; (2) shrub/sapling composition, density, and cover using belt sampling and line intercept methods; and (3) herbaceous species composition and cover using 1 x 1 m quadrats.

Stand and Sampling Point Selection

We stratified each river segment into longitudinally into three subreaches, based on river miles. When possible, we sampled 10 cottonwood stands within each sub-reach, for a total of 30 stands in each river segment. Within each subreach, we sampled 2 stands from each of the following age classes: >114 years (old growth), 50-114 years (mature), 25-50 years (intermediate), 10-25 years (pole), and <10 years (sapling). Approximate stand ages were determined by overlaying historical maps and aerial photographs by the methods outlined above (in the section detailing the GIS mapping methods).

Sampled stands met the following criteria:

- At least 10-15% overstory cover by cottonwood
- An unmanaged or “natural” overstory, shrub, and herbaceous layer
  - No or minimal selective clearing of overstory trees
  - No selective clearing of redcedar, Russian olive, or other species
  - No campgrounds or sites with otherwise managed understories
- Patch size of at least 4-6 hectares (10-15 acres) for pole through old growth stands. Seedling/sapling sites could be smaller, down to 1 ha. (2.5 acres) or less.
- A stand, or the area of the stand included in a given sample, should be relatively homogeneous in terms of age and management
  - No mixture of our age classes
  - Preferably, no mixture of samples across obviously different cohorts of cottonwoods, even if the stand as a whole falls within a single crude age class (as defined above)
  - Avoid mixing portions of a stand with different past management regimes or obviously different vegetation structure (e.g., big differences in tree density, abundance of redcedar, etc.)

Sampling locations within each stand were established using a stratified random design. Sampling points were randomly located within equal-sized segments on each transect. Transects themselves (generally 4 per stand) were positioned perpendicular to the river channel and also located randomly within equal-sized segments (strata) within each stand. For the point-centered quarter method, 40 sample points were located for trees (160 trees per stand), with 10 per transect. Twenty-four sample points were located for the herbaceous quadrat sampling (6 per transect), while 12 points were located for shrub sampling (3 per transect).

In general, we sought to sample an area of 30 hectares (74 acres) or less within each stand, even if the total size of the forest patch was greater. Hence, points on each transect were ≤ 50 m apart and transects usually ≤ 150 m apart. In the field, we located the beginning and ending points of each transect with GPS coordinates (UTM NAD83).

Thus far, 30 stands have been sampled in segment 10, 17 in segment 8, 4 in the Wild and Scenic reach in Montana, and 11 in segment 13. We plan to sample approximately 30 stands per segment and will initiate sampling in segments 2, 4, 6, and 9 in summer 2008, as well as completing the segments mentioned above. In addition, similar protocols will be employed to sample up to 18 additional stands (6 disturbed cottonwood and 12 non-cottonwood riparian forests) per segment for the 6 priority segments (segments 4, 6, 8, 9, 10, and 13).

Overstory Sampling

We used the point-centered quarter method (Cottam and Curtis 1956) for sampling and characterizing stand-level species composition, density, and basal area. This method provides an efficient technique for rapidly surveying stand characteristics, enabling a crew of three to easily sample a stand in 4-8 hours. These methods are consistent with those used by Carter Johnson (Johnson et al. 1976) on the Garrison to Oahe reach (segment 4) of the Missouri River in North Dakota in the late 1960s, and should enable comparisons with the results of that study. Similar methods may have been used to sample stands along segment 13 (mouth of Platte River to Kansas City) in the early 1970s as well (T. Bragg, personal communication).

As indicated above, 40 points were sampled per stand, with 4 trees per point (160 total per stand). At each point, we divided the area into four 90 degree quadrants, relative to the transect bearing and a line perpendicular to it. Within each of these quadrants, we located the nearest live tree with a trunk diameter at breast height (dbh) ≥ 10 cm, identified it to species, measured the dbh to the nearest centimeter, and measured the distance from the point to the center of the tree trunk to the nearest 0.1 meters or finer. For trees with multiple trunks, we measured and recorded all stems that equaled or exceeded 10 cm dbh. If the nearest tree in a quadrant is dead, we recorded the species (if known), dbh, and distance from point, and then looked for the nearest live tree within the quadrant. In cases where no live tree could be located within a reasonable distance in the quadrant (e.g., > 35 m), then the quadrant was recorded as "open." Distances were measured using an electronic measuring device (Sonin multi-measure), optical rangefinder, or measuring tapes. For sites with open quadrants, we applied a correction factor to estimates of stem density, using the correction suggested by Dahdouh-Guebas and Koedam (2006). In addition to measuring trees, we also noted and recorded whether each tree measured had a liana (woody vine) growing on its trunk.

Because many or most of the cottonwoods in sapling and pole stands had stem diameters <10 cm at breast height, these sites often had a large number of points (or all points) with open quadrants where a tree with dbh ≥ 10 cm could not be measured within a reasonable distance and/or the same individual tree was measured more than once at multiple points. For such sites, a large correction factor would have to have been applied to generate density estimates, and we considered the estimates of density unreliable. Hence, for all sapling sites and most pole sites, we sampled tree density using fixed radius (15 m) circular plots instead of or in addition to the point-centered quarter sampling. Circular plots were located at the same points used for the point-centered quarter method, except that only 12 points were sampled per stand. Within each circular plot, we tallied the number of stems and identified and measured the stem diameter for all trees (≥ 10 cm dbh). This enabled us to obtain real density estimates for points with no trees (i.e., 0 stems per unit area), whereas the point-centered quarter method requires that trees be present and cannot yield density estimates of zero.

On some sites in the Wild and Scenic segment in Montana, where cottonwoods often occur in smaller, linear patches paralleling the river, neither point-centered quarter nor fixed radius circular plots were effective, given the geometry of the stands. Hence, strip transects or narrow, rectangular plots were used to sample tree density (Michael Scott, USGS Fort Collins, personal communication).

In the data summaries that follow, we combine data from both the point-centered quarter and fixed radius plot techniques, retaining the point-centered quarter estimates for stands >25 years old and pole stands with few or no open quadrants.

Both the literature (Mark and Esler 1970, Johnson et al. 1976) and our initial assessment of our data suggest that estimates of stand basal area and stem density derived from the point-centered quarter method may be biased. In particular, the values for both density and basal area appear to be inflated in our data, apparently due to underestimates of the average distance from the sampling point to each tree. We are currently evaluating our data and sampling methodologies, and will make adjustments as necessary to sampling protocols and density and basal area estimates. Hence, current estimates of these values in our results should be considered provisional.

Understory Sampling

Understory sampling characterized both the shrub and herbaceous layers. In contrast to the overstory sampling, only 12 (for shrubs) and 24 (for herbaceous layer plants) points were sampled per stand. These points were either on completely separate transects from those used in the overstory sampling, or were offset to avoid trampling the herbaceous vegetation. Four transects were used, as with the trees, with 6 herb points and 3 shrub points per transect.

Shrub layer (≥ 1 m)

Plants occupying the shrub layer (shrubs and tree saplings > l m tall < 10 cm dbh) were sampled using the line-strip method (Lindsey 1955), using a sampling strip 2 m x 10 m with a tape defining the centerline. This sampling strip began at the point and ran along the bearing of the transect. Woody stem density (#/ha) in the shrub layer was estimated by counting all individual shrubs, saplings, and woody vines found within the sampling strip (1 meter to either side of the 10 m transect). Numbers were tallied for each species.

Percent cover was estimated by recording cover by shrubs (or saplings and woody vines) that intercepted the centerline vertical plane of the plot above 1 m off the ground. We noted the total distance along the 10-meter tape length with overhead shrub cover by each species and summed the contributions of individual species to get total cover. Note that this can exceed 100 percent, as different species can have overlapping coverage over the same length of tape.

Herb layer (< 1 m)

Plants in the herbaceous layer (herbs and woody seedlings < 1 m tall) were sampled using a 1 m x 1 m sampling frame (quadrat) beginning at or centered on the sampling point. Care was taken to avoid trampling on the area prior to sampling. For this reason, we sampled the herbaceous quadrat prior to the shrub sampling. All species of non-woody vascular plants and woody seedlings were noted and recorded and their percent cover within the 1-m2 quadrat estimated to the nearest 5%. Species with trace occurrence were recorded as 1% cover.

Unknown species were noted and numbered (e.g., unk # 1) and collections made from individuals outside of the quadrat, if possible. These unknowns were identified in the laboratory using herbarium specimens and keys or other guides to the vascular flora of the region, or were submitted to Dr. Gary Larson of South Dakota State University for assistance with identification.

Voucher specimens of all species of native plants encountered during sampling are being obtained and will be submitted to Dr. Gary Larson of South Dakota State University. Specimens will be obtained in full flowering condition if possible. Specimens will be pressed and dried using a standard plant press and mounted and labeled using standard herbarium protocols. We plan to obtain voucher specimens in triplicate, so that at least one specimen will be kept in the herbarium of South Dakota State University, another in the home institution (e.g., University of South Dakota, Benedictine College, USGS), and additional specimens may be donated to US Fish and Wildlife Service or National Park Service collections.

Data Reduction and Analysis

These sampling protocols produced the following basic information: stand-level and complete plant (vascular plant) species lists; frequency and percent cover of each species in the herbaceous layer; frequency, percent cover, and density of each species in the shrub layer; and the frequency, density, basal area (m^2/ha) and importance value (sum of percent relative frequency, density, and basal area, with a maximum value of 300) of each tree species. By assigning published wetland indicator values (Reed 1988) and Coefficients of Conservatism (C-values) (Swink and Wilhelm 1994, Taft et al. 1997, Northern Great Plains Floristic Quality Assessment Panel 2001) to species of plants, estimation was made of the wetland affinity and overall quality of the vegetation in each stand.

Plant Species Data Summaries and Metadata

Each investigator was responsible for submitting a master spreadsheet listing the Latin names of each species encountered during sampling, any code names used to identify that species in the data, whether the species is native or introduced, its wetland indicator status for the relevant region, and its Coefficient of Conservatism. Wetland Indicator status codes (Reed 1988 and later updates) have been standardized by region and may be obtained from the following website: http://www.fws.gov/nwi/plants.htm or from the USDA NRCS Plants Database (http://plants.usda.gov/) (USDA, NRCS 2008). Coefficients of Conservatism (i.e., how indicative is a given species of the "naturalness" or conservation value of a study site) have been developed for the flora of a number of regions (e.g., The Northern Great Plains Floristic Quality Assessment Panel 2001 for North and South Dakota, http://www.npwrc.usgs.gov/resource/plants/fqa/index.htm) and is most often used in Floristic Quality Assessment for calculating the Floristic Quality Index (Swink and Wilhelm 1994, Taft et al. 1997) or FQI. These codes can enable calculation of species- or cover-weighted average estimates of wetland affinity and overall vegetation quality or "naturalness" in each stand.

For segments 8 and 10, we obtained Coefficient of Conservatism (C) values from a software package called Floristic Quality Assessment Computer Program, Version 1.0 (October 2000) by Gerould S. Wilhelm and Linda A. Masters, with the Dakotas database (North and South Dakota). These data were originally derived from the publication by the Northern Great Plains Floristic Quality Assessment Panel(2001), mentioned above. For species that were not found in the Dakotas database, we used the Cvalues from a 2006 draft update of the Nebraska Natural Heritage Program state list (Rolfsmeier andSteinauer 2003). In a limited number of cases (for species not listed in either the Dakotas or Nebraska lists), we used a draft list compiled for Iowa (http://www.public.iastate.edu/%7Eherbarium/coeffici.html). Similar information is being compiled for segments 13, using Ladd (1997) and the previously mentioned Nebraska and Iowa lists, and for the Wild and Scenic reach and segment 2 in Montana.

We calculated FQI and mean C as in Swink and Wilhelm (1994) and Taft et al. (1997), except that we included all species for which we had C values, and used a value of 0 for non-native species. So, overall mean C and FQI values were computed based on the complete list of species sampled at each stand (across the herb, shrub, and tree strata). We also computed weighted mean C values that were weighted by relative cover or importance values of the individual species in the herb and shrub strata. We obtained information on native vs. exotic status from the program and from the USDA NRCS Plants Database (USDA, NRCS 2008).

For analyses of Wetland Indicator Status in segments 8 and 10, we used lists for Regions 4 (South Dakota), 5 (Nebraska), and 3 (Iowa), in that order of preference, based on Reed (1988). Scores for segments 13 and the Wild and Scenic reach of Montana (not reported here), were obtained from the appropriate regional list. We used the USDA NRCS Plants Database to confirm the most up-to-date classification of WIS and native vs. exotic status (USDA, NRCS 2008). As with C values and FQI, we computed both unweighted average WIS scores (average of all of the species encountered at a site) and scores weighted by percent cover or importance value of herbs or shrubs. Overall scores that included both herbaceous and woody species were based only on the unweighted species lists, for mean C, FQI, and WIS.

Our numeric scale for scoring Wetland Indicator Status (W) differed from other investigators (e.g., Stromberg et al. 1996), is that we assigned a value of 5 to wetland obligate plants and a 1 to upland species (this is the opposite of the normal approach). In essence then, higher scores (closer to 5) represent higher wetland affinity in our system. We ignored + or - modifiers in our scoring (e.g., FACU, FACU- and FACU+ are scored as a 2, FAC and FAC- as 3, etc.). As with C values and FQI, we computed overall (across plant strata) average W scores based both on unweighted species lists, but also computed separate estimates weighted by relative cover or importance value for herbs and shrubs.

Data entry, error checking, and production of graphics was done in MS-Excel. Most data manipulation and analysis was done in the Statistical Analysis System software (SAS®, version 9.1).

RESULTS AND DISCUSSION

GIS Data (segment 10 only)

2006 Land Cover

The total land area measured for segment 10 in our GIS was approximately 217,000 acres (88,000 hectares), or 211,000 acres if upland forest is excluded. For estimates of percent coverage of different land cover types, we use the former estimate (total land area minus upland forest), as upland areas and upland forest were not of interest. Hence, the land area of interest corresponded to the historic Missouri River floodplain (and river) extending to the bluffs, or to the edge of the 1890s Missouri River Commission maps, whichever was closer to the river. Agricultural cropland dominated land use / land cover in 2006, occupying approximately 80% of the total area or about 168,000 acres along the 59 miles of river. (Figure 1) Pasture or grassland, which was the dominant land cover prior to extensive development (see below), only occupied 1% (2200 acres) of the area in 2006.

About 7% of the landscape (about 14,900 acres) was composed of land cover types dominated by trees (Figure 1). Natural woodlands or forest with cottonwood as a major component comprised the bulk (about 85%) of this total at 12,500 acres, or 5.9% of the total area of the historic floodplain. The remainder was composed of non-cottonwood riparian woodland or forest (718 acres, 0.3% of landscape) and farm woodlots (1600 acres, 0.8% of landscape). Farm woodlots were generally small forest fragments associated with farmsteads and/or woodlots that appeared to have been planted. It is possible, however, that some farm woodlots may represent small patches of remnant cottonwood or other riparian forest. The area of farm woodlots and other woodland fragments may be underestimated, as we employed a minimum mapping unit of 1 hectare (2.47 acres). Woodlots smaller than this threshold were simply lumped with the dominant habitat type (e.g., agricultural cropland).

About 6200 acres or 3% of the landscape was considered ‘urban’, which included residential areas, towns (e.g., Vermillion, Yankton, Elk Point, Burbank, Gayville, Meckling), developed rights-of-way, boat landings, and parking lots (Figure 1, Table 2). Some of these urban areas (e.g., most of Vermillion) are on the bluffs, and hence would be technically in the upland.

The total area of river channel (excluding sandbars) was comparable to that of forested or wooded land cover, at 14,500 acres, or about 6.9% of the landscape (Figure 1). Unvegetated sandbars comprised only about 500 acres or 0.24% of the entire landscape. Like grassland, the area of unvegetated sandbars may have greatly decreased from pre-development to present. Early successional vegetation occurred on many sandbars, including cottonwood and other riparian seedlings, saplings, and shrubs. Overall, riparian/cottonwood shrubland and woody early successional habitats make up about make up about 2960 acres or 1.4% of the landscape, with most (94%) mapped as containing at least some cottonwood recruitment.

Some differences existed in land cover among subreaches (Figure 2). Dominance by agricultural cropland increases downstream, while miscellaneous developed areas classified as ‘urban’ decreased. Area of cottonwood forest, riparian forest, and sandbar were lowest in the most downstream subreach, subreach 3.

Age Distribution of Cottonwood Stands

Cottonwood stands occurred in (and dominated) both the wooded/forest and shrubland land cover categories (Figures 1 and 2). Overall, a total of approximately 14,900 acres (about 6000 ha.) of cottonwood patch types was mapped along 59 miles of river, or about 253 acres per mile. Total cottonwood area was dominated by two age classes, mature (50-114 years old) and intermediate (25-50 years old) forest, together comprising 74% of the cottonwood area (approx. 41% for mature, 33% for intermediate) (Figure 3). About 10% of the cottonwood patch area was mapped as old growth (>114 years old), having presumably established prior to the 1892 MRC maps and still present today. This number is likely an overestimate, as some of these areas had likely been reworked by the river channel after 1892 and then re-established cottonwood before 1956.

About 16% of the cottonwood area was mapped as <25 years old, with most of this in sapling (<10 years old) cover (12.4% of total cottonwood area) (Figure 3). Stands 10 years old or older, but less than 25 years old (pole stands), were relatively scarce and small in area, covering about 3.5% of the total cottonwood area. The preponderance of stands <10 years old in this group may be linked to recruitment opportunities afforded by the 1997 high flow event, although there is some question as to whether these young sapling stands will persist and develop into forest over the long-term. The relatively smaller proportion in the 10-25 year range suggests either that recruitment opportunities between circa 1980 and 1997 were very limited, or that recruitment sites during that period failed to survive to the pole stage.

All in all, the present-day area of cottonwood established in the pre- and post-dam periods is nearly equal, at approximately 50% each (Figure 3). The rather large extent (33% of total) of intermediate-aged forest (25-50 years) is somewhat surprising, given that the changes in the post-dam flow regime are thought to have negatively affected opportunities for cottonwood establishment. The much smaller proportion of young forest less than 25 years old (16% of total), and particularly the low proportion of pole-aged stands, suggest more recent opportunities for recruitment have not been strong, although significant recent recruitment may be linked to flows and sandbar formation related to the 1997 high flow event. We hypothesize that the relatively high representation of 25-50 year old stands may be linked to two factors: (1) clearing of older stands on the high terrace (formerly historic floodplain) and (2) recruitment opportunities afforded by the occurrence of the flood of record (480,000 cfs instantaneous peak at Yankton) in April of 1952, which was closely followed by completion of Fort Randall Dam in 1953 and Gavins Point Dam in 1957. The very large flood event of 1952 could have created open, bare sediment bars that provided recruitment surfaces for cottonwood establishment over the next several years following the flood. The subsequent completion of the two nearest upstream dams resulted in more stabilized flows that could have favored survival of the young seedlings. In addition, the subsequent advent of channel incision would have effectively raised the elevation and decreased the inundation frequency of what were formerly low sandbars near mean river level, making areas of former channel available for seedling recruitment. Recruitment of this kind would be roughly analogous to the vegetation expansion and channel narrowing observed on braided, sand-bed rivers in the Great Plains following flow regulation (Johnson 1994, 1997; Friedman et al. 1998). It is notable that many of the areas along the river with significant post-dam recruitment are actually on the outside of former meander bends, areas that would not normally be considered as prime recruitment sites in terms of geomorphic context. In some cases, sites with post-dam recruitment occur adjacent to locations on the bank where bank stabilization (rip-rap) had been put in to stop erosion.

The area and age distribution of cottonwood stands changed from upstream (subreach 1) to downstream (subreach 3) in the study area (Figure 4). As mentioned above, the total area of cottonwood patches declined downstream, with about 5906 acres (300 acres/river mile) in subreach 1, 5070 acres in subreach 2 (258 acres/river mile), and only 3961 acres (201 acres/river mile) in subreach 3. The abundance of pre-dam forest (mature and old growth) declined downstream, and was especially low in subreach 3, with 30.5% of the cottonwood area in the mature class and only 4% in old growth. In this subreach, post-dam forests, particularly 25-50 year old, comprised a high proportion of the total cottonwood area, with these intermediate-aged forests occupying 51% of the cottonwood patch area in subreach 3. The highest total and relative area (18.7%) of old growth (>114 year) forest occured in subreach 2, perhaps related to large scale channel cutoff event that dramatically altered course of Missouri in 1881 and moved the South Dakota - Nebraska border by several miles. Several old growth stands occur along this old Missouri River channel bed or banks.

Historic Land Cover Change (1892-2006)

We have not yet clipped the 1890s land cover to comparable boundaries to the full 2006 land cover for segment 10. However, an earlier comparison of 1892 and 2006 land cover (prepared for and presented at the annual meeting of the US Chapter of the International Association for Landscape Ecology, Tucson, Arizona, April 2007) for an approximately 20-mile portion of the segment 10 (area in vicinity of Vermillion, including portions of subreach 2 and 3) likely provides a representative comparison of the changes across the entire segment. These numbers should be considered provisional and approximate, as some modifications to the 2006 land cover datasets have been done since the original comparison.

Changes in land cover between 1892 and 2006 for this portion of segment 10 have been dramatic (Figures 5 and 6), . The landscape has been converted from one dominated by grassland in 1892 to one dominated by agricultural cropland in 2006. Grassland area decreased from about 40% of the landscape to about 1%, while agriculture increased from about 20% to 80% (Figure 6). Area of forest (including woodlots) (-51%), early successional shrubland (-70%), and unvegetated sandbar (-96%) all had substantial declines as well. Interestingly, the mapped area of the river channel increased 88%, although this number could be highly influenced by river stage at the time of mapping or photography, as could the area of sandbar.

Forested area (including woodlands and farm woodlots) declined from 16.5% of the landscape to about 8% (Figure 6). The total number of patches of forest or woodlots increased by over 3-fold from 1892 to 2006, with the vast majority of forest patches in 2006 being less than 10 hectares (~25 acres) in size (Figure 7). Most striking are the changes in the patch size and contiguity of the forests. In 1892, much of the forest along the riparian corridor was connected, with 83% of the total forest area occurring in patches >100 hectares (>250 acres) and 68% in patches larger than 250 hectares. In contrast, in 2006, there were no mapped, contiguous forest polygons that exceeded 250 hectares (~620 acres) in size, with only 22% (24% if woodlots excluded) of the forested area contained in patches >100 hectares. Approximately 60% (54% if woodlots excluded) of the forest occurred in patches of less than 50 hectares, and about 24% (17% if woodlots excluded) occurred in patches less than 10 hectares.

One caveat for the above analysis of patch sizes is that individual polygons were assumed to represent patches. In some cases, an individual patch may have contained more than one polygon in our GIS coverage (e.g., if a patch contained both closed canopy forest and more open woodland). So, actual forest patch areas, especially for the finer resolution 2006 imagery, may average somewhat higher than indicated above. In addition, as indicated above, some recent revisions of the GIS data were not incorporated into the analyses above. Hence, these estimates should be considered provisional and may change when we reanalyze the revised land cover data and examine patterns over the entire segment 10. Nevertheless, these results suggest that the present-day forest occupies a substantially smaller area and is considerably more fragmented than historically.

Vegetation Data (segments 8 and 10)

Trees

According to site selection criteria, we sampled only stands with significant (>10-15%) overstory cover by cottonwood (*Populus deltoides*), with a few exceptions. For the analyses presented here, only stands meeting the site-selection criteria for cottonwood overstory dominance are included. For segments 8 and 10, we sampled a total of 47 stands (17 in segment 8 and 30 in segment 10) that met these and other site selection criteria (e.g., no signs of severe anthropogenic alteration, no mixed age classes). In addition, 11 stands have been sampled so far in segment 13 and 4 in the Wild and Scenic reach in Montana (results not included here). In most of our comparisons below, we report changes in relative dominance by different species, expressed by the importance value (IV), which is equal to the sum of relative basal area, relative density, and relative frequency of each species. The total of the importance values for all species at a site equals 300 (100% relative density + 100% relative basal area + 100% relative frequency); a species would achieve an importance value of 300 only on a site with no other species of trees.

Relative dominance (importance value) by cottonwood decreased with stand age and mean and maximum cottonwood stem diameter increased, with the largest cottonwood trees in mature and old growth stands averaging over 100 cm diameter at breast height, and average cottonwood stem diameter averaging 54 cm in mature stands and 79 cm in old growth stands (Table 3). Average stem density of tree-sized cottonwoods peaked in intermediate aged stands (25-50 years), but density of all cottonwood stems over 1 m in height (including sapling cottonwoods) declined exponentially with stand age. The presence of woody vines or lianas on trees increased strongly with stand age. No vines were measured within stands <25 years old, and abundance of vines increased 3-fold between 25-50 year old stands and mature or old growth stands.

Tree species richness, overall stem density (for stems >10 cm), and basal area for species other than cottonwood increased strongly with stand age (Table 3, Figure 8). We sampled 17 species of trees, of which 4 are non-native (Russian olive, *Elaeagnus angustifolia*; white mulberry, *Morus alba*; European buckthorn, *Rhamnus cathartica*; Siberian elm, *Ulmus pumila*), 1 was introduced from another region of the country (Catalpa, *Catalpa speciosa*), and 1 (eastern redcedar, *Juniperus virginiana*) which has likely only become common in the historic floodplain in recent decades. Later successional species like green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*), and others, and two non-native species, white mulberry and European buckthorn, were scarce or absent on post-dam sites (<50 years old) and (except for elm) achieved their greatest dominance on the old growth sites (Figure 8). Eastern redcedar occurred as a tree on some sites within all age classes except sapling (<10 years), with greatest dominance on intermediate-aged sites (IV approximately 50), but relatively high importance (IV >35) on mature and old growth sites as well. Russian olive had its highest relative dominance on the youngest stands (<10 years old), although it was generally a minor component compared to cottonwood. Russian olive was also a minor stand component within pole, young, and mature cottonwood stands. Interestingly, tree-sized Russian olive and American elm were never measured together within the same stand. This is likely more a result of the affinity of Russian olive for post-dam established stands (<50 years) and the affinity of elm for pre-dam stands, with no tree-sized elms measured on stands established after 1956.

Non-native tree species as a group had highest dominance (average importance value) within the youngest (<10 years) and the oldest (>114 years) cottonwood stands, with lower importance values in the age classes between these (Figure 8). At the young end of the age gradient, this was because of colonization by Russian olive of early successional sites along with cottonwood (but at much lower densities). At the old end of the gradient, this was because of the increased abundance of the late successional exotic species, European buckthorn and white mulberry. All three of these exotics (as well as eastern redcedar) colonize primarily via animal (bird) dispersal, in contrast to the dominant native trees (e.g., American elm, green ash, cottonwood), which are dispersed primarily by wind and water. These patterns are consistent with the expectation that an increasingly fragmented and human-dominated landscape and the elimination of overbank flooding should reduce recruitment of wind and particularly water dispersed species and favor increases in bird dispersed trees and shrubs.

We hypothesize that eastern redcedar has increased in dominance within cottonwood understories as a result of the elimination of overbank flooding in the post-dam regulated flow regime, and are currently investigating the colonization history of redcedar on selected sites. It is unclear whether the scarcity of elm and ash on younger, post-dam stands are merely a natural result of successional stage, or whether their rates of establishment and survival are lower than would have been expected historically. Johnson et al. (1976) and Reily and Johnson (1982) provided evidence that some later successional species have suffered declines in growth rate and perhaps in survival of young trees and saplings under the cessation of overbank flooding that accompanied flow regulation on segment 4 in North Dakota.

Shrubs

We sampled a total of 29 species of shrubs, saplings, or vines within the 47 cottonwood stands in segments 8 and 10, with 25 native and 4 non-native (exotic) species (counting *Catalpa* as exotic). Species richness of shrubs at individual sites ranged from 1 to 15 species (0-2 exotic species and 1-13 native species). Mean species richness of woody plants in the shrub stratum increased with stand age, from a mean of 4.1 in sapling (<10 year) stands to 6.5-6.6 at mature and old growth stands (Table 4). Mean native species richness was highest in mature stands and lowest in sapling stands, while average exotic species richness was highest in the old growth sites. Exotic shrub cover increased strongly with stand age and was responsible for much of the increase in shrub cover with stand age. The proportion of total shrub cover composed of exotics increased continuously with stand age, with exotic shrubs making up about 20% of the shrub cover in mature stands and over 40% in old growth stands, whereas native species composed more than 95% of the shrub cover in stands less than 50 years old. Accordingly, the importance value (here expressed as average of relative cover, relative frequency, and relative density, with a maximum of 100%) of exotic shrubs was the highest (about 40%) at the old growth stands, vs. <3% at stands less than 50 years old.

Changes in shrub cover with stand age were a composite of individual responses by different species, some with affinities for younger sites, and some for older (Figure 9). Cottonwood and willow (*Salix amygdaloides, S. exigua, and S. lutea*) were found as shrubs essentially only in sites < 50 years old and primarily those <25 years old (sapling and pole). Dogwood (*Cornus drummondii*) was nearly absent on stands <25 years old, and was most abundant on mature (50-114 year old) stands. European buckthorn is an exotic species that only occurred (as a tree or shrub) on stands over 50 years old, with highest abundance (average of >20% shrub cover) within old growth stands.

Together, dogwood and buckthorn comprise the bulk of shrub cover on pre-dam (>50 year old) sites, with higher average cover by dogwood on mature sites and higher cover by buckthorn on the old growth sites. Eastern redcedar was found at low average abundance levels as a shrub in all age classes (but not all stands) except for the sapling class, and peaked in average shrub cover in intermediate aged (25-50 years) stands. Russian olive was found as a shrub on some sites within all age classes except for old growth (>114 years), with highest average cover in the 25-50 year sites.

Shrub cover and density had a bimodal distribution, with lowest values of each in the intermediate (25-50 years) or pole (10-25 years) stands (Table 4, Figure 9). Shrub cover was highest in the mature and old growth stands (average of 52%), with cover in some sites approaching 100% (based on adding cover values of individual species, which sometimes overlapped). Shrub stem density averaged highest in the sapling stands, least in the 25-50 year stands, and increased again in the mature and old growth stands. Average shrub density and percent cover were approximately 2x higher in the mature and old growth stands than the 25-50 year old stands.

Herbaceous Quadrats

Across the 47cottonwood stands in segments 8 and 10, we sampled 173 species of plants within our 1 x 1 m quadrats, with 144 native and 29 exotic species. Mean stand-level species richness in the herb stratum increased from the youngest to intermediate aged stands, but was essentially equal for stands >25 years old (the intermediate, mature, and old growth stands) (Table 5). The proportion of species and of total cover that were exotic tended to increase with stand age, and was higher for sites established pre-dam than those established post-dam. In terms of cover, approximately 9-12% of herbaceous cover was by exotic species in the sapling, pole, and intermediate stands (all post-dam stands), with nearly ¼ of herb cover composed of exotics in the mature and old growth stands. There was a great range of values in proportional cover by exotics among stands within age classes. Some individual mature and old stands had exotic species comprising 70% of the total herbaceous cover, while others had 95% of the herb cover composed of natives. Mean herbaceous cover did not have a strong relationship with stand age, averaging 25-31% among the different age classes.

Mean values of coefficient of conservatism, weighted by relative cover were similar to unweighted values across all species (Tables 5 and 6). Overall, values did not vary strongly with stand age, but averaged slightly higher in the old growth stands. Floristic quality index values did increase with stand age.

Average Wetland Indicator scores (here 5 = obligate wetland, 1 = upland) weighted by relative cover of the component species were between 2.3 and 2.7 for all age classes, suggesting an average scores somewhere between facultative upland and facultative (Table 5). Lowest average wetland affinity occurred in the mature and old growth sites, and highest in the younger (earlier successional) sites.

Patterns of Diversity, Floristic Quality, and Wetland Status with Stand Age

We encountered a total of 179 species, of which 31 (or approximately 17%) were non-native across our herbaceous quadrat, shrub transect, and tree plot or point-centered quarter samples from the 47 stands sampled in segments 8 and 10. Overall plant species richness averaged lowest in the sapling stands (28.4), increased in the pole stands (32.5), and was highest in stands greater than 25 years old (37.4-38.5) (Table 6). Richness did not differ substantially among intermediate, mature, and old growth stands. About 88% of the species in the youngest stands (sapling and pole) were native, while a slightly lower percentage (but still >80%) were native in stands >25 years old, with this percentage approximately equal among intermediate, mature, and old growth stands. Conversely, the proportion of species that were exotic ranged from 11% in the sapling and pole, to 17.7% in the mature. The richness of exotic species averaged from 3.1 to 6.5 species, in sapling and mature stands, respectively.

Average coefficient of conservatism values and wetland indicator scores across all species followed the same patterns as herbs alone (Tables 5 and 6). Average coefficient of conservatism values increased slightly with stand age, from 2.7 in sapling to 3.3 in old growth. Floristic quality index increased with stand age, paralleling increases in overall richness and mean Coefficient of Conservatism scores (Table 6). Average Wetland Indicator Scores (1 = upland, 5 = obligate wetland) were highest in the youngest stands, and decreased slightly with stand age (approximately equal in all stands >25 years old), suggesting that the wetland affinity of the flora decreases with stand age. Mean scores in all age classes were in the range of 2.3-2.7 (between facultative upland and facultative).

The observed trends of mean Coefficient of Conservatism (mean C) and Wetland Indicator Status (mean W) with stand age suggest that these indices should be used with caution in evaluating cottonwood stand quality. Because of the systematic trend with stand age, values are most appropriately used for comparison of different stands within an age class, whereas differences across stands that differ in age may simply be a function of stand age itself, and not in biotic integrity. Ideally, scores would be used to compare sampled stands to regional reference sites on an unregulated or lightly regulated (e.g., tributary replenished reach, Johnson 2002) of the Missouri or to sites sampled prior to substantial flow regulation. Unfortunately, few or no appropriate reference sites or pre-dam data on flora exist. A possible exception would be the data of Keammerer et al. (1975) for segment 4 in North Dakota, sampled within 15 years after Garrison Dam closure. Although sampled following the onset of flow regulation, such data would at least be from sites that had not been exposed to as long of a flow regulation period (15 instead of >50 years) and probably lower levels of channel incision, than the sites that we sampled. We plan to compare the species composition found by Keammerer et al. (1975) to our results on segments 4 and the South Dakota segments (6, 8-10).

Even beyond the difficulties with comparing stands to reference conditions, the value of using mean C values as evaluate stand quality is open to question. Overall values were relatively low in our data (average around 3), suggesting a flora composed primarily of widely distributed species without a strong affinity for undisturbed natural areas. Low scores might be expected, perhaps under even natural conditions, for young, early successional sites (most <100 years old) and for plant communities, like cottonwood forests, that were historically initiated by and maintained by natural disturbance. Comparison of mean C and FQI values of cottonwood forest stands across a gradient of anthropogenic disturbance levels (as is planned for summer 2008 sampling) may be useful to determine the degree of sensitivity and usefulness of Floristic Quality Assessment in evaluating biotic integrity in remnant cottonwood stands.

RECOMMENDATIONS FOR FUTURE WORK

A valuable next step in this project would be to develop a landscape transition / forest succession model to forecast the implications of current successional trajectories and land conversion rates on long-term dynamics of cottonwood forests in the landscape. Johnson (1992) developed a similar model to project the long-term effects of flow regulation on cottonwood forest extent and age distribution on segment 4 of the Missouri below Garrison Dam. Rates of cottonwood recruitment (i.e., river channel or sandbar to woody vegetation), rates of cottonwood loss from clearing for agricultural and residential land use and river channel migration, and senescence of aging stands will all influence the future area and age distribution of the forest. Altered species composition and successional trajectories related to flow regulation will influence the future species composition of these forests. Cottonwood forest area, age distribution, and species composition will influence landscape-level patterns of biodiversity for shrubland- and forest-dwelling organisms, including neotropical migrant birds, and will likely influence habitat suitability for nesting and roosting by the Bald Eagle. Hence, going from a static view of current conditions to a dynamic one that takes into account successional and land use trajectories would enable the Corps to evaluate the long-term effects of restoration actions for the cottonwood community and its residents. Such a model could be parameterized separately for each of the study segments, based on estimates of forest age distribution, recruitment rates, and rates of forest loss occurring on each segment. Model development and parameterization would build naturally off of much of our current GIS mapping work and would also dovetail well with the understanding that we are gaining of cottonwood forest successional patterns on each of the priority segments.

We also recommend that an effort be made to better define the pre-dam reference conditions of the

Missouri and its floodplain vegetation. One problem with defining restoration targets, as well as determining the degree to which remnant forests have degraded as a result of chronic flow regulation and its effects, is that few data exist that can provide reference conditions for healthy cottonwood forests on the Missouri. The work of our colleague, Michael Scott of the USGS, on the Wild and Scenic reach, which experiences conditions closer to the historic flow regime than other river segments, will provide some idea of the species composition and successional dynamics of a free-flowing Missouri River. However, differences in geomorphology, elevation, and species composition from the upper reaches of the Missouri in Montana to the middle and lower reaches in the Dakotas and farther downstream will make direct comparisons difficult. One good source of pre-dam (and pre-settlement) forest age distribution and overstory species composition are the witness tree records from General Land Office Survey Notes of the mid-1800s (Bragg and Tatschl 1977, Johnson 1992). We recommend making use of these notes to better understand the composition and dynamics of the pre-settlement and pre-dam floodplain and, in fact, have initiated pilot work with these notes for segments 8, 9, and 10. It may also be a worthwhile exercise to reconstruct pre-settlement vegetation with the GLO notes on the other priority segments. In addition, present-day floodplain forests along unregulated tributaries of the Missouri should be examined as possible reference sites as well. Within the Dakotas, the lower reaches of the unregulated White River might provide the closest approximation of what the pre-regulation forests of the Missouri looked like and how they functioned. Examining these present-day reference sites would have an advantage over the use of GLO notes alone, in that information on the understory flora and shrubs could be derived.

Finally, we recommend that efforts be made to assess the potential value and composition of “novel” habitats along the Missouri, including reservoir mainstem deltas and those at the junction between tributaries and mainstem reservoirs. These habitats were identified by Johnson (2002) as areas where conditions could potentially be suitable for short- or long-term establishment of native riparian vegetation, including cottonwood forest, but little work has been done to document their vegetation patterns.

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Table 1. Date, type, source, and scale of imagery used in GIS mapping of land cover and forest age distribution for segment 10.

Year(s)	Image type	Agency & Project	Original scale	Pixel resolution (m)	Original Projection	Notes
1892	Map	Missouri River Commission (1895)	1:63,360	4.6 m	lat-long (in 1895)	Maps depict river channel and vegetation / land use
1953	BW aerial photographs	USDA/FSA (SCS)	1:63,360	scanned at 200 dpi	None	Much coarser imagery used when 1955/56 images not available
1955/56	BW aerial photographs	USDA/FSA (CSS)	1:20,000	0.5-0.6 m, 2.8 m	None	Higher resolution (0.5-0.6 m) from 25 micron digital scans by USDA; Lower resolution (2.8 m) scanned from hard copies
1983/84	CIRP aerial photos	USGS, NHAP1 project	1:60,000	1.3 m	None	Obtained as digital scans at 21 microns from USDA and USGS
1997	Natural Color digital orthophotos	USACE	?	0.3 m (1 ft)	?	No metadata available
2006	Natural Color digital orthophotos,	USDA/FSA NAIP project	1:40,000	2 m	NAD 1983 UTM Zone 14N	County mosaic NAIP (Clay, Union, and Yankton Co., SD ; Dixon and Cedar Co., NE)

Table 2. Land cover categories used for GIS mapping of 2006 land cover in segment 10.

1. **Water/bare sandbar**
   11. River main channel (open water, sand, submersed aquatic vegetation)
   12. Oxbow lake/backwater – off channel or connected
   13. Unvegetated sandbar
   14. Farm ponds, other open water habitats
   15. Missouri River reservoir
   16. Tributary river channel
2. **Forest and woodland** (forest has woody plants >6 m tall with >50% cover; woodland has woody plants >6m tall with 25-50% cover)
   20. non-cottonwood (cottonwood <15%) floodplain forest
   21. forest (cottonwood at least 15%)
   22. woodland (cottonwood at least 15%)
   23. planted trees (farm woodlots, shelterbelts, orchards)
   24. upland forest (not in floodplain)
3. **Shrubland** – woody plants <6 m tall account for 25-100% of cover
   30. shrubland (with cottonwood)
   31. non-cottonwood shrubland
4. **Herbaceous/low vegetation**
   41. upland grassland, pasture
   42. riparian low shrub with cottonwood (successional sandbar sites, may include a mixture of low woody and herbaceous vegetation)
   43. emergent wetland (off river)
   44. riparian low herbaceous vegetation
   45. riparian low shrub w/o cottonwood
5. **Planted/cultivated – row crops**
   50. agricultural row crops
6. **Developed/urban**
   61. Town, city (e.g., Vermillion)
   62. Farmstead and building complex (excluding woodlots)
   63. Commercial/Industrial/Transportation (roads, parking lots, boat landings)
   64. Urban/recreational grasses (developed right-of-ways, golf courses)
   65. Cabin or managed cottonwood areas
7. **Barren - bare sand, etc.** (not in river channel, but could include island interior)
   70. barren
8. **Other** – specify in notes
   80. other

Table 3. Summary of overstory (tree) stand characteristics, by age class, across river segments 8 and 10 (Missouri National Recreational River). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Stand age (yrs)	# stands	# species	# trees/ha**	Basal area** (m^2/ha)	CW Importance Value	Mean CW dbh	Max CW dbh	CW trees/ha	Tot CW stems/ha	Prop vines
≤10	9*	1.75* (1-2)	24.6 (0-103.75)	0.35 (0-1.37)	255.5* (215.5-300)	12.5* (11.9-13.3)	19* (15-22)	22.0 (0-100.2)	6281 (542-15833)	0
10-25	7	2 (1-3)	182.2 (10.61-413.9)	4.48 (0.15-11.33)	268.3 (211.7-300)	15.4 (12.1-17.6)	30.9 (19-37)	171.1 (10.6-382.9)	1034 (203-3237)	0
25-50	10	4.5 (1-7)	377.8 (127.2-924.6)	18.38 (12.3-27.3)	220.0 (89.9-300)	26.9 (15.8-33.4)	59.6 (30-81)	279.1 (96.8-744.3)	342 (97-869)	.05 (0-.2)
50-114	12	6.3 (3.0-8.0)	529.4 (273.7-881.3)	55.9 (39.2-88.1)	152.9 (64.0-261.8)	54.4 (42.8-79.2)	102.5 (73-172)	181.8 (66.8-323.6)	182 (67-324)	.15 (0-.57)
>114	9	7.6 (6.0-9.0)	755.9 (352.7-995.4)	94.0 (35.2-150.3)	112.1 (57.6-172.0)	78.5 (48.6-140.3)	137.7 (103-186)	160.3 (24.8-331.1)	160 (25-331)	.15 (0-.35)

*Stands without trees > 10 cm dbh were excluded from calculations.

**Estimates of stand density and basal area derived from point-centered quarter method (mostly stands >25 years old) seem anomalously high. Data and sampling protocols are being evaluated.

Table 4. Summary of shrub data, by age class, across river segments 8 and 10 (Missouri National Recreational River). Numbers are means, with range of stand values (minimum – maximum) in parentheses. Note that for shrub IV, scores have been scaled to 100% (instead of 300 as with the tree data).

Stand age (yrs)	# stands	# species	Shrub Cover	Shrub Density	Exotic Species	Native Species	Exotic Cover.	Natural Cover	Exotic Shrub IV	Native Shrub IV
≤10	9	4.1 (1-7)	.32 (.2-.6)	12287 (3083-36417)	.22 (0-1)	3.8 (1-7)	.002 (0-.02)	.32 (.2-.6)	1.2 (0-7.3)	98.7 (92.7-100.0)
10-25	7	4.42 (2-9)	.2 (.1-.5)	5810 (583-15750)	.42 (0-9)	4.0 (2-7)	.003 (0-.01)	.2 (.1.5)	2.7 (0-12.5)	97.3 (87.4-100.0)
25-50	10	5.1 (2-9)	.26 (.01-.8)	3150 (375-5833)	0.40 (0-1)	4.7 (2-8)	.006 (0-.03)	.26 (.02-.75)	1.76 (0-7.1)	98.2 (92.9-100.0)
50-114	12	6.5 (1-15)	.52 (.15-1.05)	6250 (500-17333)	.66 (0-2)	5.8 (1-13)	.10 (0-.67)	.42 (.10-.85)	12.97 (0-64.6)	87.0 (35.3-100.0)
>114	9	6.6 (2-14)	.52 (.23-.92)	6699 (875-14083)	1.44 (0-2)	5.22 (1-12)	.25 (0-.87)	.30 (.02-.50)	39.8 (0-94.5)	60.2 (5.5-100.0)

Table 5. Summary of herbaceous quadrat data, by stand age class, across river segments 8 and 10 (Missouri National Recreational River). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Stand age (yrs)	# stands	# species	Native species	Exotic species	Mean herb cover (%)	Relative cover native herbs (%)	Relative cover exotic herbs (%)	Mean C weighted by relative cover	Mean W weighted by relative cover	FQI (herbs only)
≤10	9	27.7 (14-45)	24.5 (12-40)	3.0 (2-4)	25.6 (14.2-54.9)	89.7 (84.3-97.6)	10.1 (2.0-15.6)	2.9 1.9-4.0)	2.6 (2.0-3.5)	14.1 (8.2-19.9)
10-25	7	30.2 (16-38)	27.1 (15-36)	3.0 (0-8)	31.0 (22.0-44.0)	90.9 (72.1-100.0)	8.6 (0-27.8)	3.0 (2.1-4.3)	2.7 (1.9-3.0)	15.8 (11.0-19.6)
25-50	10	35.2 (20-57)	30.4 (17-51)	4.4 (0-8)	27.4 (15.7-49.5)	87.5 (76.4-100)	12.1 (0-22.6)	3.14 (2.6-4.2)	2.59 (2.0-3.2)	17.9 (12.4-26.4)
50-114	12	34.1 (20-45)	28 (13-37)	5.9 (3-8)	31.1 (18.2-47.0)	73.0 (26.2-95.3)	26.8 (4.6-72.6)	3.0 (.87-4.6)	2.3 (1.7-2.7)	18.3 (9.4-24.1)
>114	9	34.3 (26-41)	27.4 (22-31)	6.4 (2-11)	30.2 (21.6-43.0)	76.0 (31.1-95.4)	23.4 (4.5-68.8)	3.3 (1.2-4.4)	2.3 (2.0-2.5)	18.9 (16.3-22.1)

Table 6. Summary of stand-level data on species richness, native and exotic abundance, floristic quality, and wetland affinity, by cottonwood forest age class on river segments 8 and 10 (Missouri National Recreational River). Numbers are means within each stand age class , with range (low and high stand values) in parentheses.

Stand age (yrs)	# stands	Total species	Native species	Exotic species	% native	% exotic	Mean C	Mean W	FQI
≤10	9	28.4 (14-48)	25.1 (12-42)	3.1 (2-5)	88.0 (85.2-93.1)	11.3 (6.9-14.2)	2.7 (2.1-3.4)	2.6 (2.4-3.1)	14.6 (8.5-20.9)
10-25	7	32.5 (18-42)	28.5 (16-37)	3.8 (1-10)	88.3 (76.1-97.3)	11.1 (2.6-23.8)	2.8 (2.4-3.3)	2.5 (2.0-2.9)	16.4 (11.0-20.3)
25-50	10	38.5 (24-60)	32.6 (19.0-54.0)	5.5 (0-9.0)	84.7 (79.1-100.0)	14.1 (0-20.8)	3.0 (2.6-3.6)	2.3 (1.9-2.7)	18.7 (12.7-27.8)
50-114	12	37.4 (23-49)	30.6 (16-40)	6.5 (4-9)	81.4 (69.5-88.8)	17.7 (11.1-26.0)	3.2 (2.5-3.8)	2.3 (2.1-2.6)	19.6 (12.3-24.7)
>114	9	38.3 (29-46)	31.4 (25-36)	6.4 (2-11)	82.3 (76.0-94.1)	16.4 (5.8-23.9)	3.3 (2.7-3.8)	2.3 (2.2-2.6)	20.6 (18.4-24.4)

FIGURE CAPTIONS

Figure 1. Percent of historic floodplain in segment 10 composed of different land cover classes. These are aggregated from our original land cover classes in the GIS. 'CTW FOREST' is cottonwood forest, 'CTW SHRUB' is cottonwood sapling/shrub, 'RIP SHRUB' and 'RIP FOREST' are riparian shrubland and forest without significant coverage by cottonwood. 'EMERGENT' refers to herbaceous wetland vegetation, either on-channel (i.e., herbaceous vegetation on sandbars) or off-channel (i.e., emergent wetlands in the floodplain).

Figure 2. Percent of historic floodplain in segment 10 composed of different land cover classes, by subreach. These are aggregated from our original land cover classes in the GIS. 'CTW FOREST' is cottonwood forest, 'CTW SHRUB' is cottonwood sapling/shrub, 'RIP SHRUB' and 'RIP FOREST' are riparian shrubland and forest without significant coverage by cottonwood. 'EMERGENT' refers to herbaceous wetland vegetation, either on-channel (i.e., herbaceous vegetation on sandbars) or off-channel (i.e., emergent wetlands in the floodplain).

Figure 3. Total and relative area of different cottonwood age classes within the historic floodplain in segment 10.

Figure 4. Total area of different cottonwood age classes in each subreach (upstream to downstream) of segment 10. Subreaches are approximately 20 river miles each in length.

Figure 5. Historic land cover in 1892 and 2006 within a portion of segment 10, near Vermillion, South Dakota.

Figure 6. Historic land cover change from 1892 to 2006 within a portion of segment 10, near Vermillion, South Dakota. The top graph depicts the changes in proportional coverage in the study area of different land cover classes. The bottom graph depicts the percentage change in area of each land cover class between dates. "Forest" includes natural riparian woodland and forest and farm woodlots.

Figure 7. Changes in the distribution of forest patch number and total forest area among patches (actually, polygons in the GIS) of different size (in hectares) from 1892 to 2006 within a portion of segment 10 near Vermillion, South Dakota. Forested area includes both natural riparian forests and woodlands (including cottonwood) and farm woodlots.

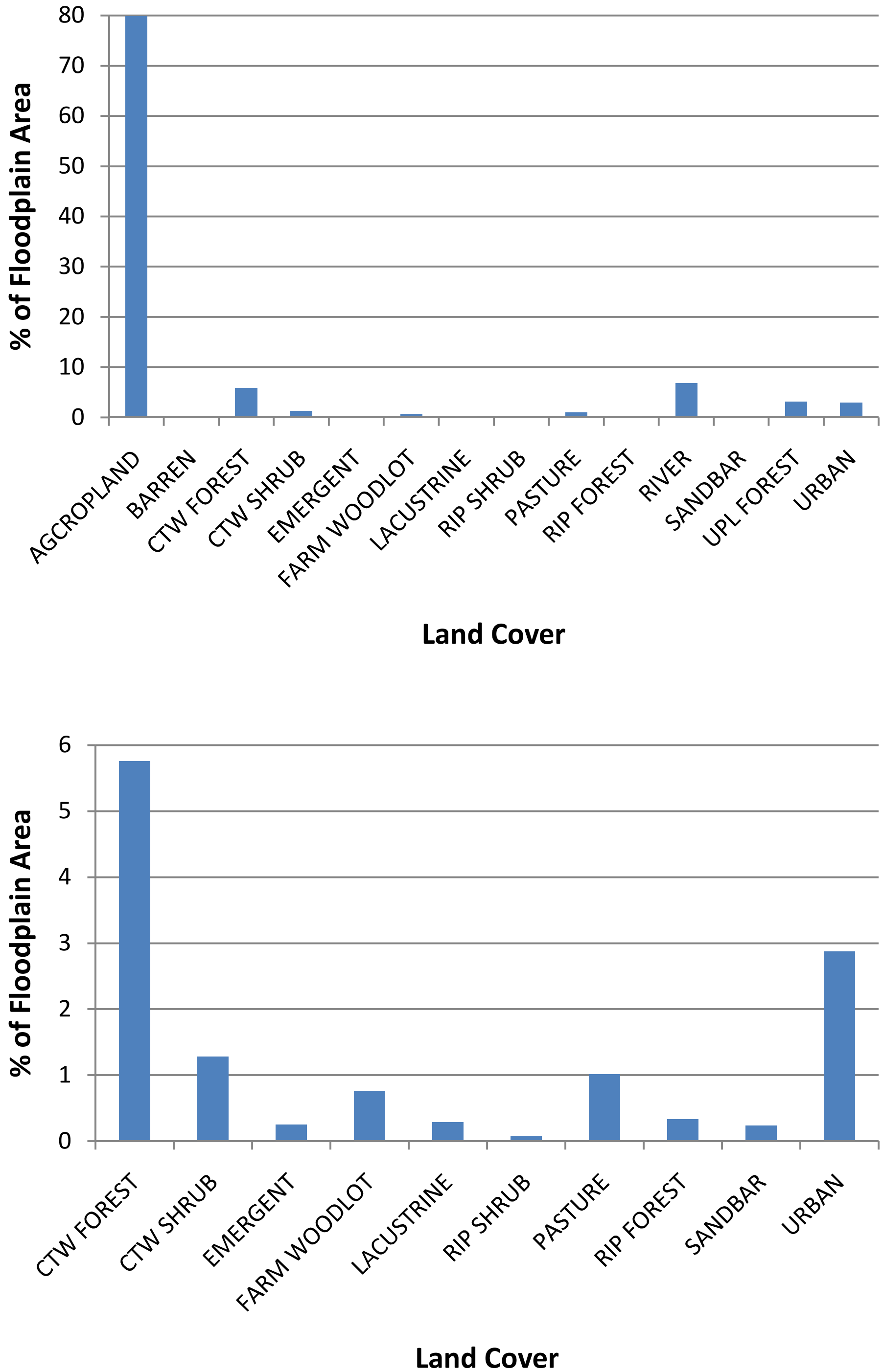
Figure 8. Relative importance value (sum of relative frequency, density, and basal area) of different tree species by cottonwood forest age class in segments 8 and 10.

Figure 9. Mean percent shrub cover by different species and overall mean shrub cover by cottonwood forest age class in segments 8 and 10. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

Figures are in separate, attached document.

Appendix I. List of vascular plants encountered during vegetation sampling on segments 8 and 10 within the Missouri National Recreational River. C refers to Coefficient of Conservatism (0-10), and W to a numeric scale for Wetland Indicator Status (1=upland, 5= obligate wetland). Native species are indicated with an 'N' and exotic species with an 'E'.

Species list is in separate, attached document.



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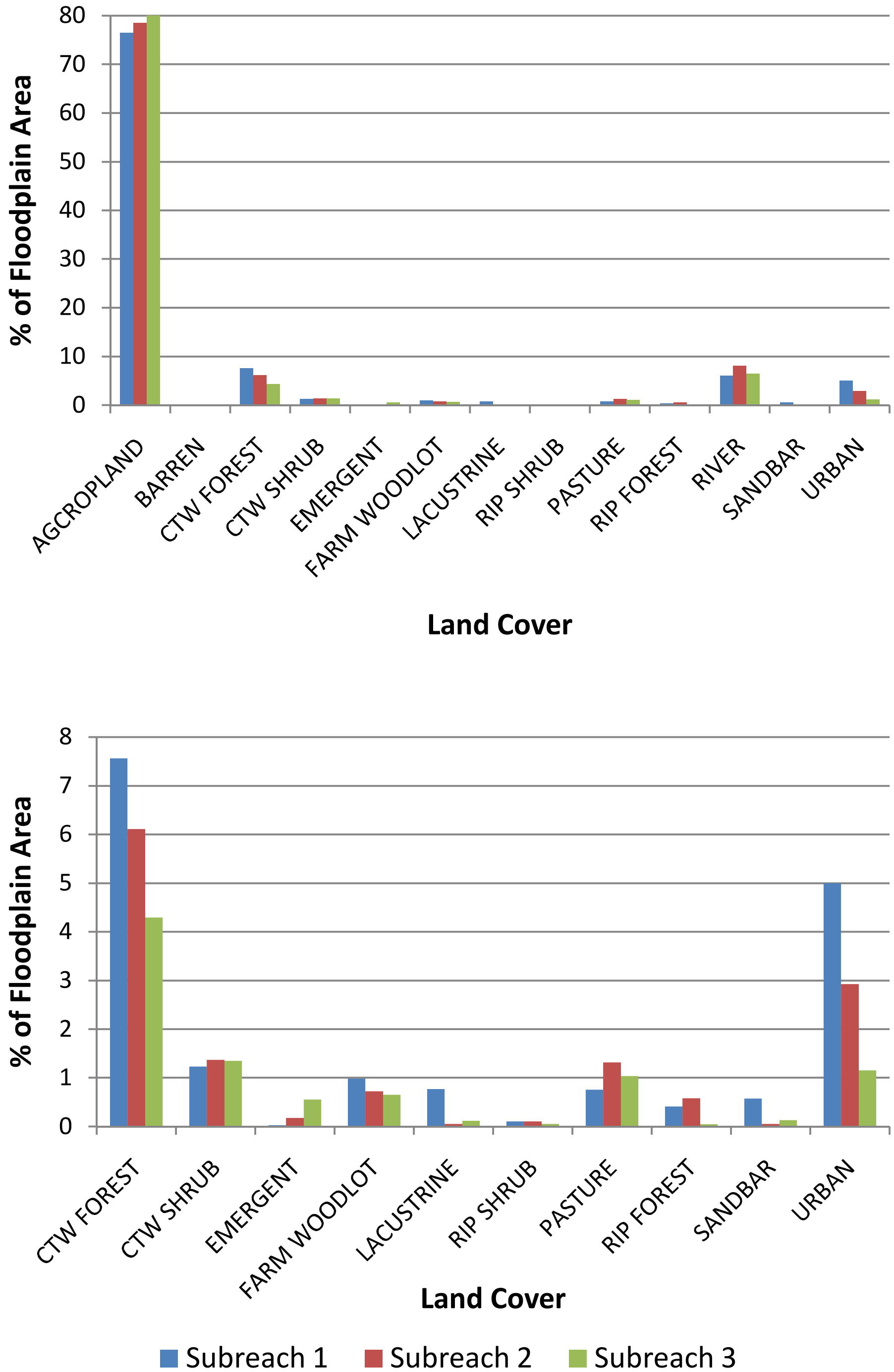

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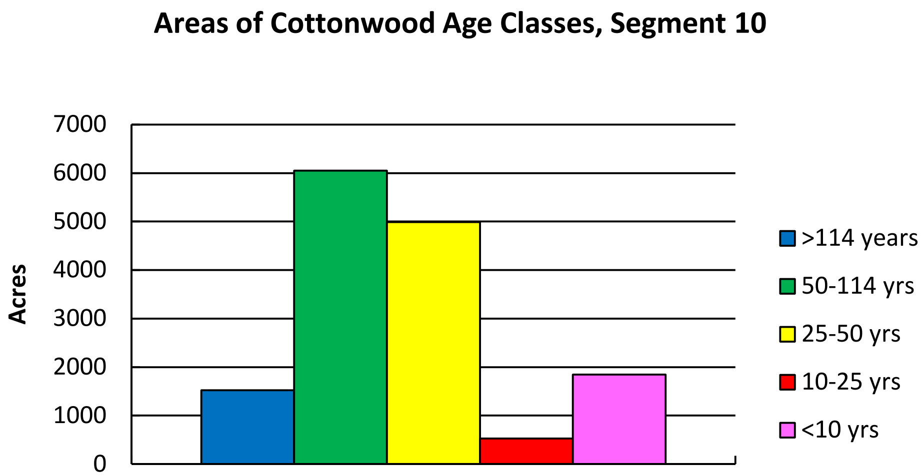

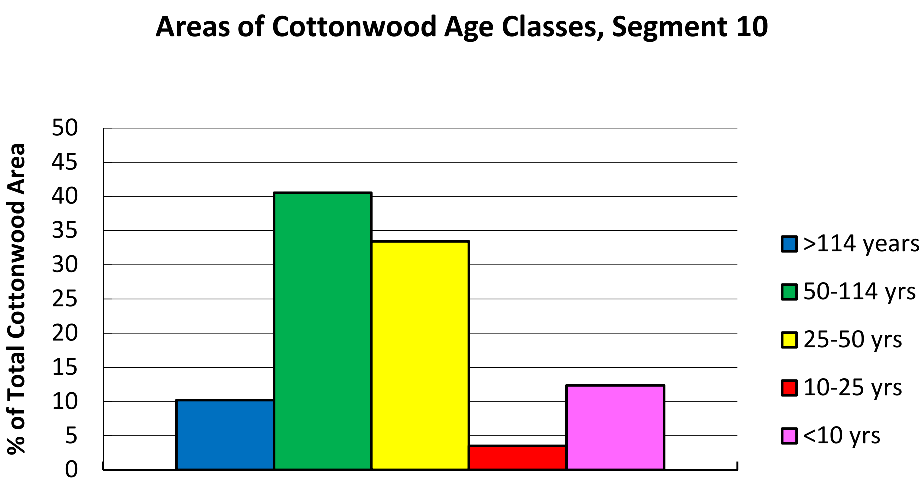

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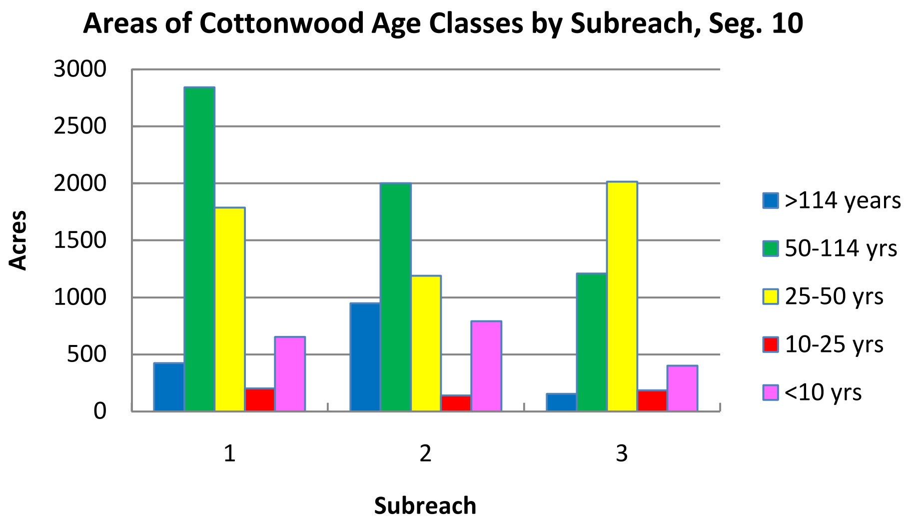

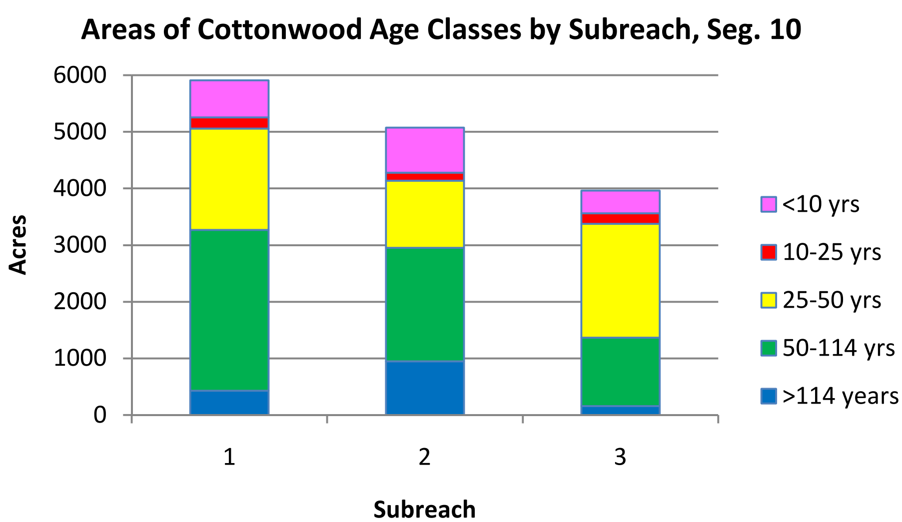

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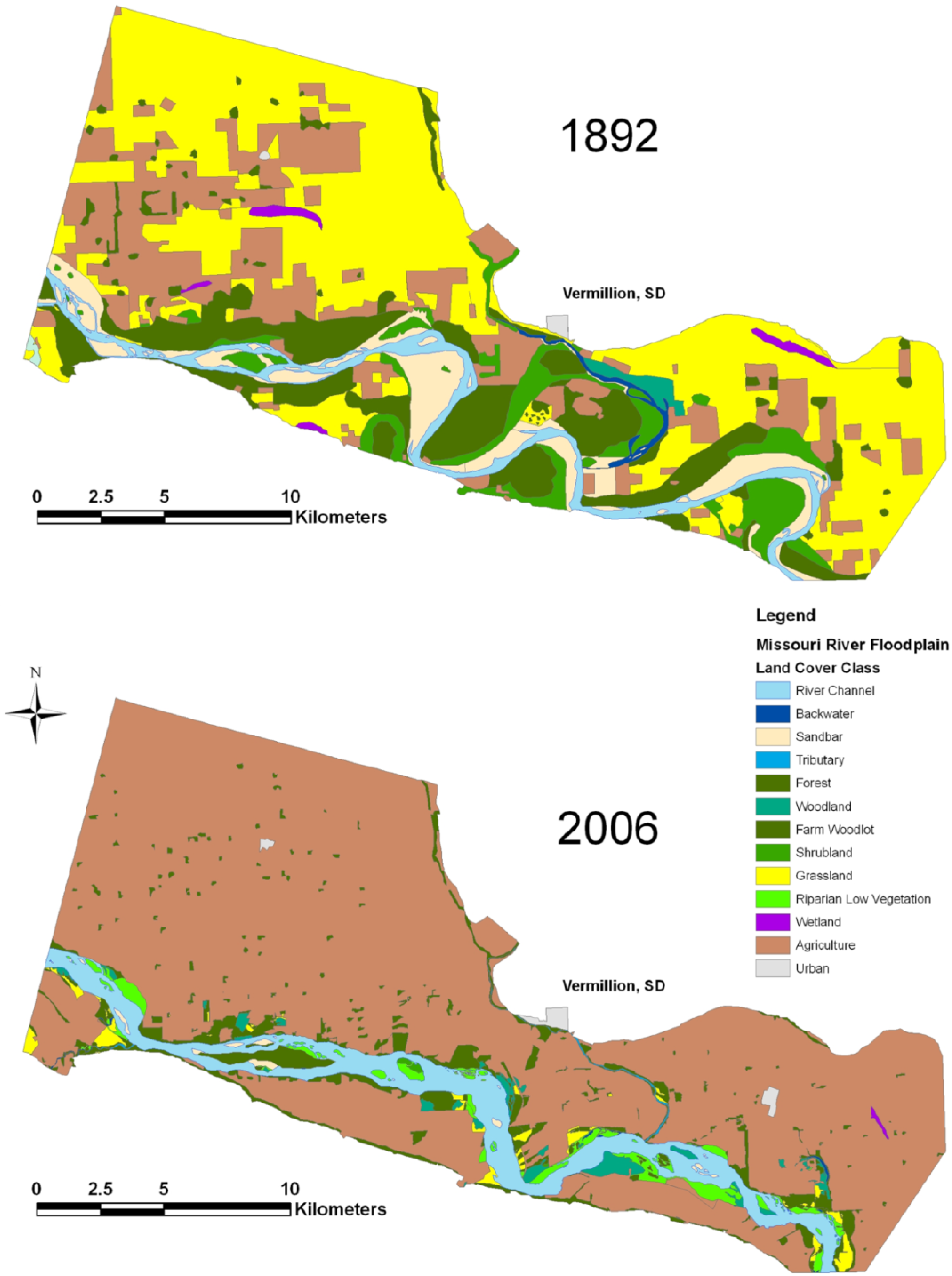

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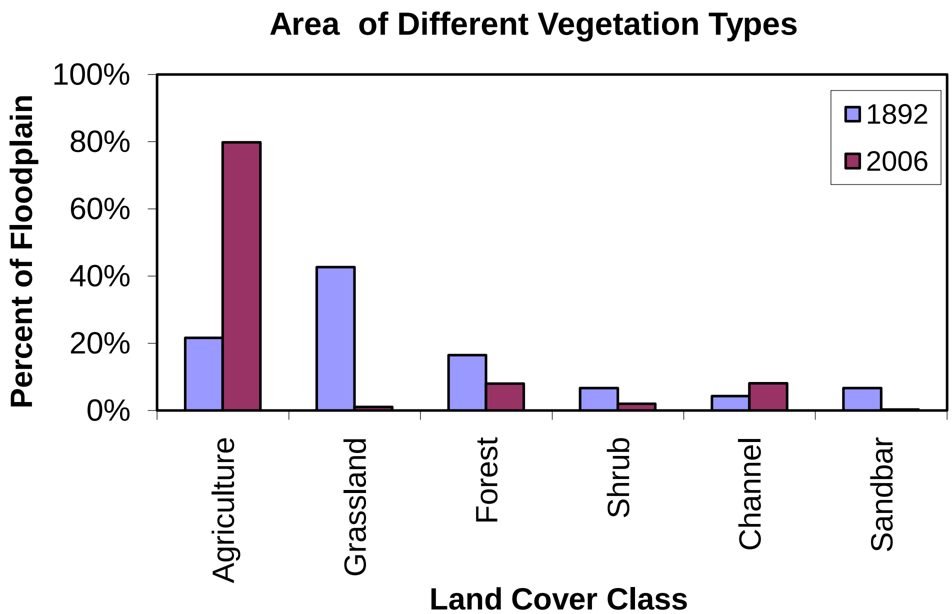

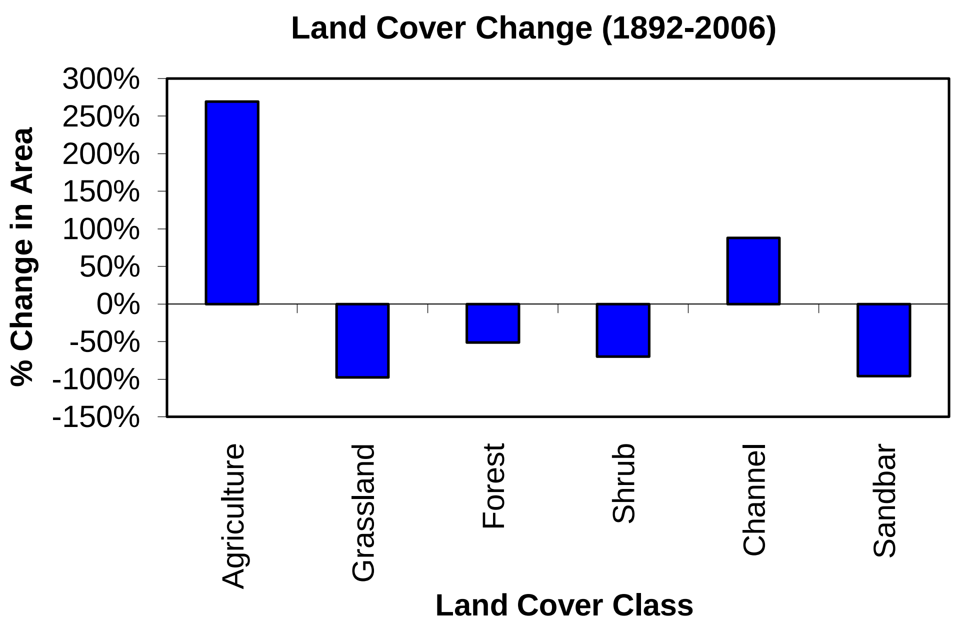

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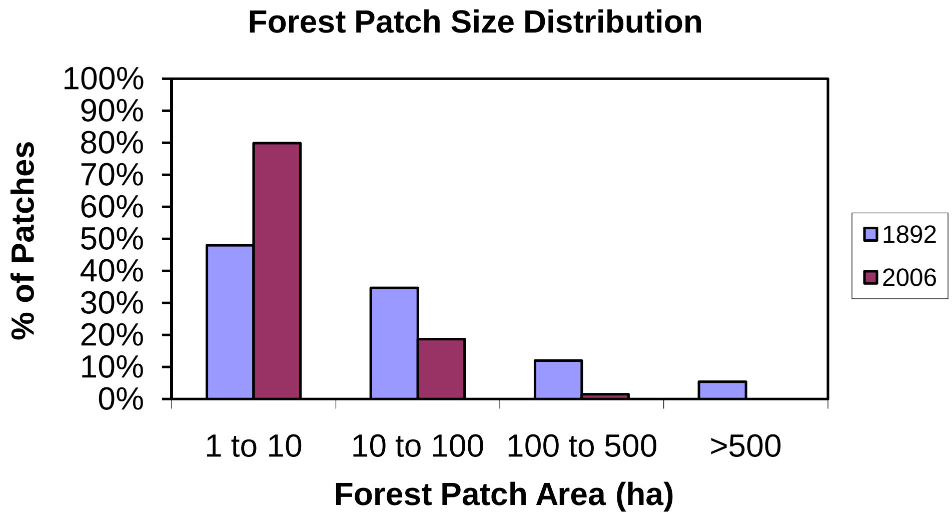

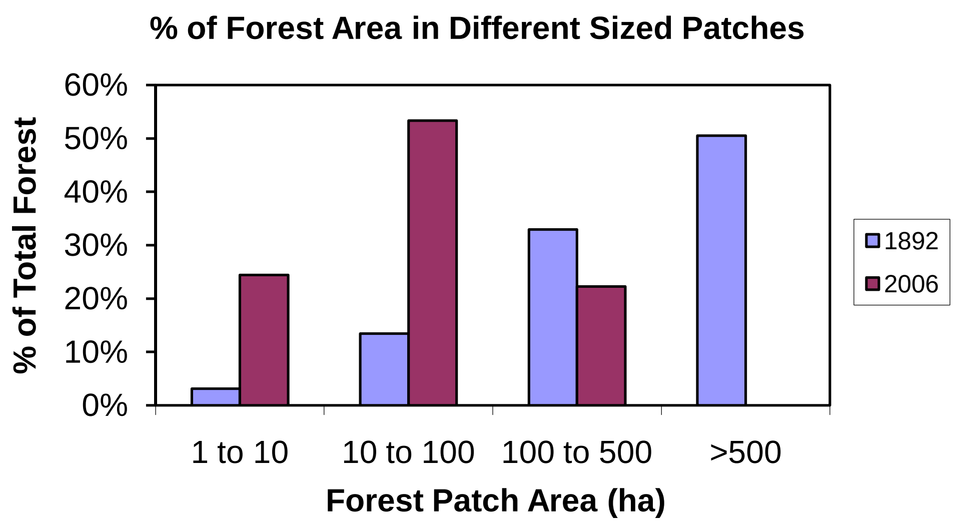

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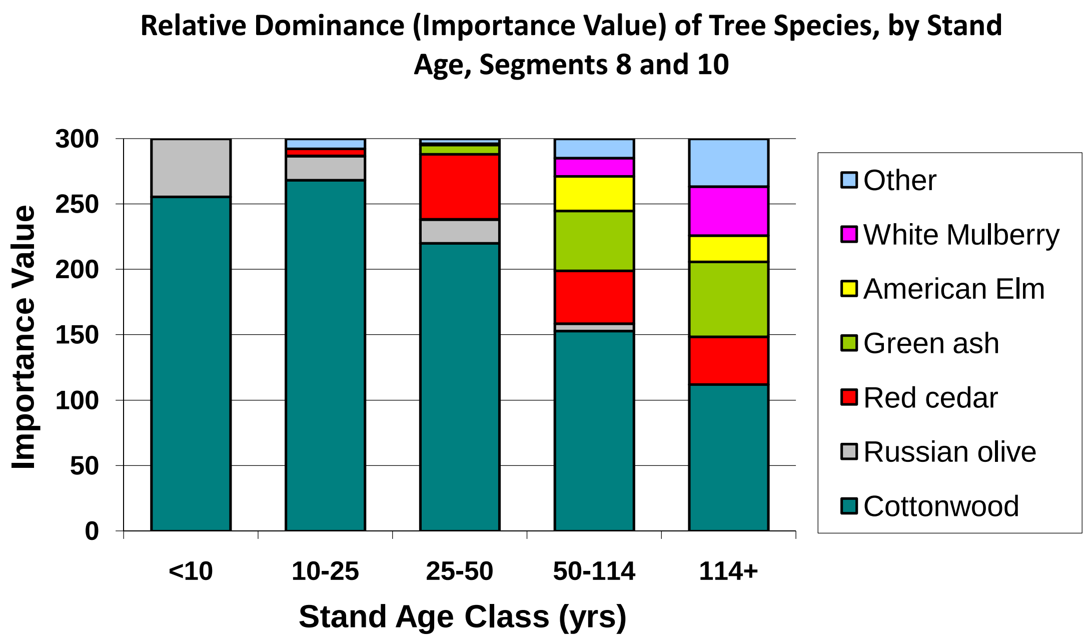

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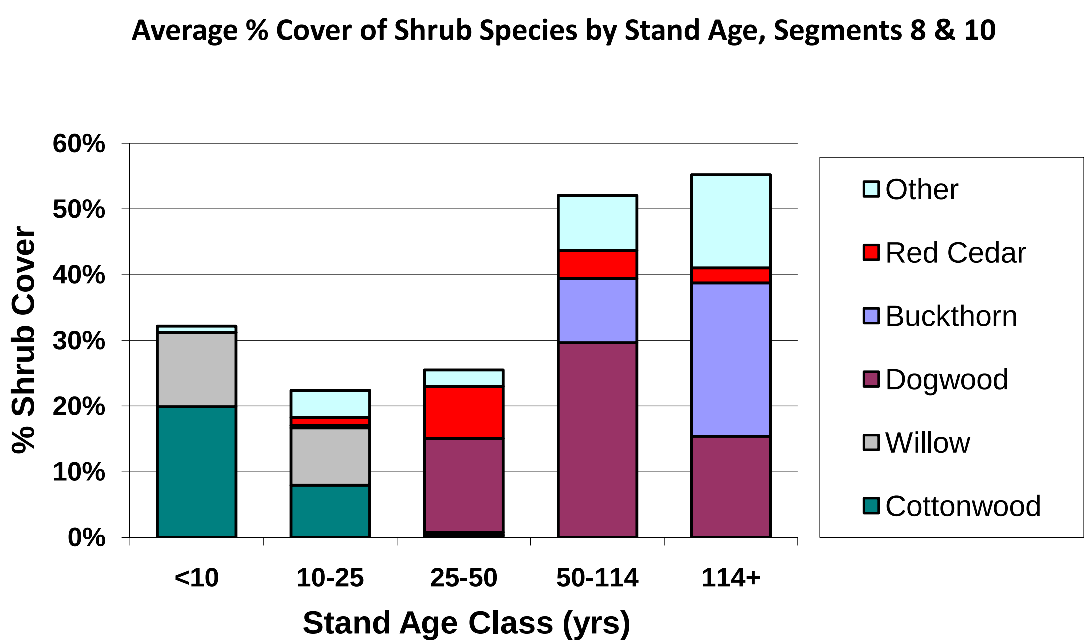

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Appendix I. List of vascular plants encountered during vegetation sampling on segments 8 and 10 within the Missouri National Recreational River. C refers to Coefficient of Conservatism (0-10), and W to a numeric scale for Wetland Indicator Status (1=upland, 5= obligate wetland). Native species are indicated with an 'N' and exotic species with an 'E'.

Acronym	Species Name	Common Name	C	W	Wetland Indicator Status	Native/ Exotic Status
ACENEG	***Acer negundo***	Box elder	1	3	FAC	N
ACESAC	***Acer saccharinum***	Silver maple	4	4	FACW	N
AMBPSI	***Ambrosia psilostachya***	Cumin ragweed/ western ragweed	2	3	FAC	N
AMOFRU	***Amorpha fruticosa***	desert false indigo	4	4	FACW	N
AMPBRA	***Amphicarpaea bracteata***	hog peanut	8	2	FACU	N
ANDGER	***Andropogon gerardii***	big bluestem	5	2	FACU	N
ANECAN	***Anemone canadensis***	Canadian anemone/ meadow anemone	4	4	FACW	N
ANTNEG	***Antennaria neglecta***	field pussytoes	5	1	UPL	N
APOCAN	***Apocynum cannabinum***	Indian hemp dogbane	4	3	FAC	N
ARCMIN	***Arctium minus***	lesser burdock	0	1	UPL	E
ARITRI	***Arisaema triphyllum***	Jack-in-the-pulpit	10	4	FACW	N
ARILON	***Aristida longespica***	slimspike threeawn	4	2	FACU	N
ARTABS	***Artemisia absinthium***	absinthium/wormwood	0	1	UPL	E
ARTCAM	***Artemisia campestris***	western wormwood/ field sagewort	5	5	UPL	N
ARTDRA	***Artemisia dracunculus***	tarragon/silky wormwood	4	1	UPL	N
ASCSP	***Asclepias sp***	milkweed	.	.		N
ASCSPE	***Asclepias speciosa***	showy milkweed	4	3	FAC	N
ASCSYR	***Asclepias syriaca***	common milkweed	0	1	UPL	N
ASCVER	***Asclepias verticillata***	whorled milkweed	3	1	UPL	N
ASTERI	***Aster ericoides***	white heath aster	2	2	FACU	N
ASSP	***Aster sp***	aster	.	.		N
BOLAST	***Boltonia asteroides***	white doll's daisy/white boltonia	3	4	FACW	N
BOTVIR	***Botrychium virginianum***	rattlesnake fern	7	2	FACU	N
BROJAP	***Bromus japonicus***	Japanese brome	0	2	FACU	E
BROINE	***Bromus inermis***	smooth brome	0	1	UPL	E
BROTEC	***Bromus tectorum***	downy brome, cheatgrass	0	1	UPL	E
CANSAT	***Cannabis sativa***	marijuana/hemp	0	3	FAC-	E
CXAURE	***Carex aurea***	golden sedge	8	4	FACW	N
CXBLAN	***Carex blanda***	eastern woodland sedge	5	2	FACU+	N
CXMOLE	***Carex molesta***	troublesome sedge	3	4	FACW	N

CXSP	***Carex sp***	sedge	.	.		N
CXSPRE	***Carex sprengelii***	Sprengel's sedge/ longbeak sedge	7	2	FACU	N
CATSPE	***Catalpa speciosa***	northern catalpa	0	2	FACU	E
CELSCA	***Celastrus scandens***	American bittersweet	5	2	FACU	N
CELOCC	***Celtis occidentalis***	common hackberry	5	2	FACU	N
CENLON	***Cenchrus longispinus***	mat sandbar/field sandbar	0	1	UPL	N
CHAFAS	***Chamaecrista fasciculata***	partridge pea	4	2	FACU	N
CHANUT	***Chamaesyce nutans***	eyebane	4	2	FACU	N
CHEDES	***Chenopodium dessicatum***	goosefoot, sandhill goosefoot	5	1	UPL	N
CHESP	***Chenopodium sp***	goosefoot	.	.		.
CIRALT	***Cirsium altissimum***	tall thistle	3	1	UPL	N
CIRARV	***Cirsium arvense***	Canada thistle	0	2	FACU	E
CLELIG	***Clematis ligusticifolia***	western white clematis	7	2	FACU	N
CONMAJ	***Convallaria majalis***	European lily of the valley	5	1	UPL	E
CONCAN	***Conyza canadensis***	Canadian horseweed	0	2	FACU	N
CORDRU	***Cornus drummondii***	roughleaf dogwood	5	3	FAC	N
CROSAG	***Crotalaria sagittalis***	arrowhead rattlebox	4	1	UPL	N
CYCATR	***Cycloloma atriplicifolium***	winged pigweed	1	3	FAC	N
CYPSCH	***Cyperus schweinitzii***	Schweinitz's flatsedge	5	2	FACU	N
DALLEP	***Dalea leporina***	foxtail prairie clover	2	2	FACU	N
DESPIN	***Descurainia pinnata***	western tansymustard	1	1	UPL	N
DESSOP	***Descurainia sophia***	herb sophia/flixweed	0	1	UPL	E
DESILL	***Desmanthus illinoensis***	Illinois bundleflower	5	2	FACU	N
DESCAN	***Desmodium canadense***	Canada tickclover	6	2	FACU	N
DICOLI	***Dichanthelium oligosanthes***	Scribner's rosette grass	6	1	UPL	N
DICACC	***Dichanthelium acuminatum***	western panicgrass	3	3	FAC	N
ELAANG	***Elaeagnus angustifolia***	Russian olive	0	3	FAC-	E
ELACOM	***Elaeagnus commutata***	silverberry	5	3	FAC	N
ELYCAN	***Elymus canadensis***	Canada wildrye	3	2	FACU	N
ELYVIL	***Elymus villosus***	hairy wildrye	4	2	FACU	N
ELYVIR	***Elymus virginicus***	Virginia wildrye	4	3	FAC	N
EQUARV	***Equisetum arvense***	field horsetail	4	3	FAC	N
EQUHYM	***Equisetum hyemale***	scouringrush horsetail	3	4	FACW	N
ERIANN	***Erigeron annuus***	annual fleabane	3	2	FACU	N
ERIPHI	***Erigeron philadelphicus***	Philadelphia fleabane	2	4	FACW	N
ERISTR	***Erigeron strigosus***	prairie fleabane/daisy fleabane	3	2	FACU	N
EUPPER	***Eupatorium perfoliatum***	common boneset	9	5	OBL	N

EUPRUG	***Eupatorium rugosum***	white snakeroot	6	2	FACU	N
EUPDEN	***Euphorbia dentata***	toothed spurge	2	1	UPL	N
EUPESU	***Euphorbia esula***	leafy spurge	0	1	UPL	E
EUPHEX	***Euphorbia hexagona***	sixangle spurge	2	1	UPL	N
EUPMAR	***Euphorbia marginata***	snow on the mountain	2	2	FACU	N
EUTGRA	***Euthamia graminifolia***	flat-top goldentop	6	4	FACW	N
FRAVES	***Fragaria vesca***	woodland strawberry	6	2	FACU	N
FRAPEN	***Fraxinus pennsylvanica***	green ash	5	3	FAC	N
GALBOR	***Galium boreale***	northern bedstraw	4	2	FACU	N
GALTRI	***Galium triflorum***	fragrant bedstraw	7	2	FACU	N
GEUCAN	***Geum canadense***	white avens	4	2	FACU	N
GLEHED	***Glechoma hederacea***	ground ivy	0	2	FACU	E
GLETRI	***Gleditsia triacanthos***	honeylocust	6	2	FACU	N
GLYLEP	***Glycyrrhiza lepidota***	American licorice/ wild licorice	2	2	FACU	N
GYMDIO	***Gymnocladus dioicus***	Kentucky coffeetree	8	3	FAC	N
HASP	***Hackelia sp***	stickseed	.	2	FACU	N
HACVIR	***Hackelia virginiana***	Virginia stickseed	0	2	FACU	N
HEDHIS	***Hedeoma hispidum***	rough false pennyroyal	2	1	UPL	N
HELPET	***Helianthus petiolaris***	prairie/plains sunflower	0	1	UPL	N
HELTUB	***Helianthus tuberosus***	Jerusalem artichoke	2	2	FACU	N
HORJUB	***Hordeum jubatum***	foxtail barley	0	4	FACW	N
JUGNIG	***Juglans nigra***	black walnut	8	2	FACU	N
JUNBAL	***Juncus balticus***	baltic rush	5	5	OBL	N
JUNVIR	***Juniperus virginiana***	eastern red cedar	0	2	FACU-	N
LACCAN	***Lactuca canadensis***	Canada lettuce	6	2	FACU	N
LACTAT	***Lactuca tatarica***	blue lettuce	1	2	FACU	N
LEOCAR	***Leonurus cardiaca***	common motherwort	0	2	FACU	E
LEPDEN	***Lepidium densiflorum***	common pepperweed/peppergrass	0	2	FACU	N
LESCAP	***Lespedeza capitata***	roundhead lespedeza	9	2	FACU-	N
LONTAT	***Lonicera tatarica***	Tatarian honeysuckle	0	2	FACU	E
LYCAME	***Lycopus americanus***	American bugleweed/water horehound	4	5	OBL	N
LYTSAL	***Lythrum salicaria***	purple loosestrife	0	5	OBL	E
MAISTE	***Maianthemum stellatum***	starry false lily of the valley	5	2	FACU	N
MEDLUP	***Medicago lupulina***	black medick	0	2	FACU	E
MELSP	***Melilotus sp***	sweetclover	0	2	FACU-	E
MENCAN	***Menispermum canadense***	common moonseed	8	3	FAC	N
MORALB	***Morus alba***	white mulberry	0	2	FACU	E
MORRUB	***Morus rubra***	red mulberry	4	2	FACU	N
MUHRAC	***Muhlenbergia***	marsh muhly	4	4	FACW	N

	racemosa					
MUSP	***Muhlenbergia sp***		.	.		N
NEPCAT	***Nepeta cataria***	catnip	0	2	FACU	E
OENBIE	***Oenothera biennis***	common evening primrose	0	2	FACU	N
OXASP	***Oxalis sp***	wood sorrel	.	2	FACU	N
PANCAP	***Panicum capillare***	witchgrass	0	3	FAC	N
PANVIR	***Panicum virgatum***	switchgrass	5	3	FAC	N
PARPEN	***Parietaria pensylvanica***	Pennsylvania pellitory	3	2	FACU	N
PARVIT	***Parthenocissus vitacea***	woodbine/thicket creeper	2	2	FACU	N
PASSET	***Paspalum setaceum***	thin paspalum	4	3	FAC	N
PHAARU	***Phalaris arundinacea***	reed canarygrass	0	4	FACW+	N
PHRAUS	***Phragmites australis***	common reed	0	4	FACW	N
PHYLAN	***Phyla lanceolata***	lanceleaf fogfruit	1	5	OBL	N
PHRLEP	***Phryma leptostachya***	American lopseed	8	3	FAC	N
PHYHET	***Physalis heterophylla***	clammy groundcherry	5	1	UPL	N
PHYLON	***Physalis longifolia***	common groundcherry	0	1	UPL	N
POAPRA	***Poa pratensis***	Kentucky bluegrass	0	2	FACU	E
POLVER	***Polygala verticillata***	whorled milkwort	8	1	UPL	N
POLARE	***Polygonum arenastrum***	oval-leaf knotweed	0	1	UPL	N
POLCON	***Polygonum convolvulus***	black bindweed/ wild buckwheat	0	3	FAC	E
POPDEL	***Populus deltoides***	eastern cottonwood	3	3	FAC	N
POTNOR	***Potentilla norvegica***	Norwegian cinquefoil	0	3	FAC	N
POSP	***Potentilla sp***	cinquefoil	.	.		.
PRUAME	***Prunus americana***	American plum/wild plum	4	1	UPL	N
PSOLAN	***Psoralidium lanceolatum***	lemon scurfpea	6	1	UPL	N
QUEMAC	***Quercus macrocarpa***	bur oak	6	2	FACU	N
RANABO	***Ranunculus abortivus***	early wood/littleleaf buttercup	2	4	FACW	N
RANCYM	***Ranunculus cymbalaria***	alkali buttercup	3	5	OBL	N
RHACAT	***Rhamnus cathartica***	common buckthorn	0	2	FACU	E
RHUGLA	***Rhus glabra***	smooth sumac	4	1	UPL	N
RHUTRI	***Rhus trilobata***	skunkbush sumac	5	1	UPL	N
RIBMIS	***Ribes missouriense***	Missouri gooseberry	4	3	FAC	N
ROSACI	***Rosa acicularis***	prickly rose	8	2	FACU	N
ROSCAR	***Rosa carolina***	Carolina rose	5	2	FACU	N
RUBOCC	***Rubus occidentalis***	black raspberry	5	1	UPL	N
RUDLAC	***Rudbeckia laciniata***	cutleaf coneflower/golden glow	6	2	FACU	N
SALAMY	***Salix amygdaloides***	peachleaf willow	3	4	FACW	N
SALEXI	***Salix exigua***	narrowleaf willow, sandbar willow	3	4	FACW+	N

SALLUT	***Salix lutea***	yellow willow	5	4	FACW	N
SANMAR	***Sanicula marilandica***	Maryland sanicle/ black snakeroot	7	2	FACU	N
SALCOL	***Salsola collina***	slender Russian thistle/ tumbleweed	0	1	UPL	E
SALIBE	***Salsola iberica***	prickly russian thistle	0	1	UPL	E
SCHSCO	***Schizachyrium scoparium***	little bluestem	6	2	FACU	N
SCHACU	***Schoenoplectus acutus***	hardstem bulrush	5	5	OBL	N
SCRLAN	***Scrophularia lanceolata***	lanceleaf figwort	5	3	FAC-	N
SCUPAR	***Scutellaria parvula***	small skullcap/ Leonard's small skullcap	10	1	UPL	N
SETGLA	***Setaria glauca***	yellow foxtail	0	2	FACU	E
SHEARG	***Shepherdia argentea***	silver buffaloberry	5	1	UPL	N
SMILAS	***Smilax lasioneura***	Blue Ridge carrionflower	8	3	FAC	N
SMITAM	***Smilax tamnoides***	bristly greenbrier	8	3	FAC	N
SOLPTY	***Solanum ptycanthum***	West Indian nightshade/ black nightshade	0	2	FACU	N
SOLCAC	***Solidago canadensis***	Canada goldenrod	1	2	FACU	N
SOLGIG	***Solidago gigantea***	giant goldenrod/late goldenrod	4	4	FACW	N
SOLNEM	***Solidago nemoralis***	gray goldenrod	6	1	UPL	N
SOLRIG	***Solidago rigida***	rigid goldenrod, stiff goldenrod	4	2	FACU-	N
SORNUT	***Sorghastrum nutans***	Indiangrass	6	2	FACU	N
SPAPEC	***Spartina pectinata***	prairie cordgrass	5	4	FACW	N
SPHOBO	***Sphenopholis obtusata***	prairie wedgescale	7	3	FAC	N
SPOCOM	***Sporobolus compositus***	composite dropseed	4	2	FACU	N
SPOCRY	***Sporobolus cryptandrus***	sand dropseed	6	2	FACU	N
SPOHET	***Sporobolus heterolepis***	prairie dropseed	10	1	UPL	N
SYMOCC	***Symphoricarpos occidentalis***	western snowberry	3	1	UPL	N
TAROFF	***Taraxacum officinale***	common dandelion	0	2	FACU	E
TEUCAN	***Teucrium canadense***	Canada germander/wood sage	3	4	FACW	N
THADAS	***Thalictrum dasycarpum***	purple meadow-rue	7	3	FAC	N
THAVEN	***Thalictrum venulosum***	veiny meadow-rue/ early meadow rue	6	4	FACW	N
THLARV	***Thlaspi arvense***	field pennycress	0	2	FACU	E
TILAME	***Tilia americana***	American basswood/ American linden	7	2	FACU	N
TOXRAD	***Toxicodendron radicans***	eastern poison ivy	4	2	FACU	N
TRADUB	***Tragopogon dubius***	yellow salsify/ goat's beard	0	1	UPL	E
TRIPUR	***Triplasis purpurea***	purple sandgrass	9	1	UPL	N
TYPANG	***Typha angustifolia***	narrowleaf cattail	0	5	OBL	E

TYPLAT	***Typha latifolia***	broadleaf cattail	2	5	OBL	N
ULMAME	***Ulmus americana***	American elm	3	3	FAC	N
ULMPUM	***Ulmus pumila***	Siberian elm	0	1	UPL	E
ULMRUB	***Ulmus rubra***	slippery elm	5	3	FAC	N
URTDIO	***Urtica dioica***	stinging nettle	0	4	FACW	N
VERTHA	***Verbascum thapsus***	common mullein	0	1	UPL	E
VERHAS	***Verbena hastata***	swamp verbena/ blue vervain	5	4	FACW	N
VERSTR	***Verbena stricta***	hoary verbena/hoary vervain	2	1	UPL	N
VERURT	***Verbena urticifolia***	white vervain/nettleleaf vervain	3	2	FACU	N
VIOCAN	***Viola canadensis***	Tall white violet	4	1	UPL	N
VIOSOR	***Viola sororia***	common blue violet/ downy blue violet	2	3	FAC	N
VIOSP	***Viola sp***	violet	.	.		N
VITRIP	***Vitis riparia***	riverbank grape	3	3	FAC	N
XANSTR	***Xanthium strumarium***	rough cockleburr	0	3	FAC	N
ZANAME	***Zanthoxylum americanum***	common pricklyash	3	1	UPL	N

2008 ANNUAL REPORT – MISSOURI RIVER COTTONWOOD STUDY

by

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EXECUTIVE SUMMARY

Cottonwood (*Populus* spp.) forests were historically a major component of the floodplain of the Missouri and other Great Plains rivers. On many western rivers, major changes in flow regime occurred following the advent of flow regulation in the mid-20th century, leading to chronic recruitment failure by cottonwood on meandering rivers, with long-term implications for landscape configuration and biodiversity (Johnson et al. 1976, Rood and Mahoney 1990, Johnson 1992, Miller et al. 1995). On the Missouri, the elimination of normal flow and sediment patterns are blamed for a host of natural resource problems, including the lack of sandbar nesting habitat for endangered bird species, poor spawning conditions for native river fishes, reductions in bald eagle nesting habitat, and declines in establishment of new cottonwood stands (NRC 2002).

The overall goal of this project is to assess the current status of cottonwood forests along the Missouri River, including their composition, structure, health, areal extent, and age distribution. Data and conclusions derived from this project will be used by the US Army Corps of Engineers for developing a Cottonwood Community Model using the HEAT methodology for six moderate to high priority Missouri River segments for the Bald Eagle (segments 4, 6, 8, 9, 10, and 13). This model will be used to evaluate the present condition of the cottonwood community and forecast future conditions under a range of alternatives for cottonwood management actions.

This project involves (1) GIS-mapping of present-day and historic land cover, including cottonwood forest extent and age class distribution, and (2) characterization of vegetation structure, composition, wetland affinity, and floristic "quality" within cottonwood, disturbed cottonwood, and non-cottonwood riparian forest stands across a gradient of successional age classes. Study areas included the six priority segments, plus two other segments in Montana, one of which has the closest approximation on the Missouri to an unregulated flow regime. The segments under study include all five of the unchannelized, unimpounded segments below Fort Benton (Wild and Scenic, 2, 4, 8, and 10); two impounded or partially impounded segments (6 and 9); and one channelized segment (13).

Here we report preliminary results from analysis of vegetation data collected within cottonwood, disturbed cottonwood, and non-cottonwood stands sampled in 2007 and 2008 on the eight study segments of the Missouri River. These include data from the herb, shrub, and overstory (tree) strata within different age classes of cottonwood and non-cottonwood stands. In addition, we report GIS analyses of the relative and absolute areas of cottonwood forests in different age classes within each segment. Finally, we also report the results of interpretation and analysis of witness tree records from the General Land Office (GLO) Survey notes for the historic floodplain in segment 10 (Gavins Point Dam to Ponca, Nebraska).

Findings included in this report are as follows:

1. A total of 304 stands - 211cottonwood, 31 disturbed cottonwood, and 62 non-cottonwood - were sampled in 2007-2008.

2. Mean tree species richness per stand decreased from downstream to upstream, from an average of 6 species/stand in segment 13 (Nebraska, Iowa, Kansas, Missouri) to 2.5 in segment 0 (in Montana). Overall tree stem density and basal area, though variable, also was lower in the farthest upstream segments (0, 2, 4). The mean proportion of non-native

tree species (e.g., Russian olive, white mulberry, common buckthorn) was highest in segments 6, 8, and-10, all segments that are below dams in South Dakota and Nebraska, and eastern red cedar (*Juniperus virginiana*), a native invasive species, also was most abundant in these three segments.

3. Mean overall shrub cover generally declined from downstream to upstream, with particularly high cover in segment 10 and particularly low shrub cover in segments 0 and 2. Shrub species richness tended to track the upstream to downstream increase in tree species richness, except for segment 13, which had significantly lower average shrub richness than segment 10 and much lower shrub richness than tree richness.

4. Mean species richness in the herb layer was significantly higher in segments 4 and 10 and significantly lower in segments 6 and 13, then in the western-most segments (0 and 2). Average herbaceous cover appeared to be considerably higher in segments 0, 2, 4, and 6 than the farther downstream segments, with particularly high mean percent cover in mature, old growth, and non-cottonwood stands.

5. Mean total plant species richness per stand was highest in segments 4 and 10 (>35 species/stand) and least in segments 6 and 13 (23 and 25 species/stand, respectively). Across river segments, species richness increased with stand age, with an average of 25 species in stands <25 years old and 32 and 33 species for stands 25-50 and >50 years old, respectively.

6. Mean Coefficient of Conservatism values (C-values) were significantly higher in segments 4 and 10 and dramatically lower in segment 6 than in all other segments. The upstream segments had high average C-values for the shrub and tree layers, but relatively low values for herbs. Segments 4 and 10 had high average C values for herbs and medium to low values for shrubs and trees. C-values for segment 6 were low for all strata. Average C-values significantly increased with stand age. The average proportion of species in a stand that were non-native increased from downstream to upstream, at less than 20% in segments 8/9, 10, and 13, and nearly 40% in segment 0.

7. Average wetland indicator scores (W-scores, e.g., 1 = upland, 5 = obligate wetland) varied significantly by river segment and stand age. Average wetland score declined significantly (lower wetland affinity) from stands <25 years to those >25 years old. Among river segments, average wetland scores were significantly higher for segment 13 than all other segments.

8. Cover-weighted values (weighted by relative cover of each herb species) of mean C- and W-scores were often much lower than unweighted values (average value across the stand species list). Hence, C-values and W-scores weighted by relative cover may be more indicators for tracking the effects of disturbance and flow regulation on vegetation condition.

9. Based on GIS analyses, estimated acreage of cottonwood habitat types was greatest in the two longest river segments, with over 64,000 acres in segment 2 (227 river miles) and 49,000 acres in segment 13 (228 river miles). Cottonwood acreage per river mile exceeded 250 acres on segments 2, 4, and 10, with the largest area per river mile in segments 2 and 4 (approx. 280 acres per river mile). The smallest absolute area and lowest acreage of cottonwood per river mile occurred in segments 6 and 0, with the lowest of each in segment 6 (1851 acres, or 22 acres/river mile).

10. The age distribution of cottonwood habitats varied among river segments. Across segments, 49-89% of the cottonwood area was >50 years old, with >85% in mature (50-114 years) or old growth (>114 years) age classes in segments 0, 4, and 6. The highest proportion of younger forest (<50 years) occurred in the three most downstream segments (8/9, 10, and 13), with 44-51% of the cottonwood forest area establishing since 1956. The proportional coverage of pole and sapling (<25 years old) age classes is much greater on segments downstream of Fort Randall Dam (8/9, 10, 13) than those upstream (segments 6, 4, 2, 0), with particularly low values of recent recruitment (<1% of the total cottonwood area) on segment 0 in the Wild and Scenic reach above Fort Peck Reservoir.

11. The General Land Office Survey notes (1857-69) recorded information on 917 witness trees, across 12 species, within the historic floodplain of the Missouri River in segment 10. Cottonwood was the dominant species, comprising 64% (583) of all of the witness trees and 72% of the total basal area. The mean trunk diameter of cottonwoods used as witness trees was 36.5 cm (approx. 14 inches), with nearly 2/3 (63%) between 10 and 40 cm (4-16 inches), suggesting (based on present-day mean diameters per age class) that the bulk of these trees would likely have been <50 years old.

12. Comparisons of witness tree data to present-day patterns in segments 8 and 10 suggest changes in species composition and relative abundance over the last 150 years. Eastern red cedar and several exotic species (Russian olive, white mulberry, common buckthorn) that are now common understory species in segment 8 and 10, were not mentioned in the GLO notes, while the relative density and basal area of American elm and willow may have decreased from the 1860s to present.

13. Approximately 20% (215 out of 1059) of section and quarter section corners in the historic floodplain of segment 10 had witness trees, suggesting that only about 1/5 of the floodplain was forested in the late 1850s-early 1860s. Approximately 13% of the South Dakota section and quarter section corners had trees and 60% of the Nebraska points. This large discrepancy is likely because the floodplain was much wider on the South Dakota side, with floodplain forest dominating the portion adjacent the river, and prairie dominating areas farther away.

Further work will include analysis of historic changes in landscape composition and riparian forest area, along with analysis of rates of land cover change, particularly in relation to gains or losses of cottonwood forest. Results presented in this report should be considered provisional, as editing and revision of both GIS and vegetation datasets is ongoing. Final results and datasets will be provided with the Final Report on June 30, 2009.

INTRODUCTION

Cottonwood (*Populus* spp.) forests were historically a major component of the floodplain of the Missouri and other Great Plains rivers. Floods maintained the ecological health of these forests by providing moisture to sustain the growth of trees and wetland plants, depositing fine sediments and nutrients that enhance the fertility of floodplain soils, stimulating decomposition of leaves and woody debris, dispersing seeds of floodplain trees, and forming sediment bars that provide seedbeds for establishing new cottonwood and willow (*Salix* spp.) stands. On many western rivers, major changes in flow regime have occurred following the advent of flow regulation in the mid-20th century, leading to chronic recruitment failure by cottonwood on meandering rivers, with long-term implications for landscape configuration and biodiversity (Johnson et al. 1976, Rood and Mahoney 1990, Johnson 1992, Miller et al. 1995). The Bald Eagle may be dependent on large, mature cottonwood trees that occur in older stands for nesting and roosting habitat along the Missouri. Maximal biodiversity in the riparian landscape may occur with a dynamic mix of young, mature, and old cottonwood stands, driven by river flooding and channel migration (Johnson 1992).

In the 1950s and 1960s, the Pick-Sloan Plan resulted in the construction of a series of dams on the upper basin of the Missouri River, drowning forests upstream of the dams and greatly altering flow patterns and sediment transport downstream (NRC 2002). On the lower Missouri, bank stabilization, building of levees, and channelization has greatly altered the river channel itself, as well as landscape patterns in the former floodplain and its forests. The elimination of normal flow and sediment patterns are blamed for a host of natural resource problems along the Missouri, including the lack of sandbar nesting habitat for endangered bird species, poor spawning conditions for native river fishes, reductions in Bald Eagle nesting habitat, and declines in establishment of new cottonwood stands (NRC 2002). Existing forests continue to serve as important habitat for the Bald Eagle, migratory songbirds (Gentry et al. 2006), and many other woodland species. However, present forests are aging, rates of new forest establishment appear to be declining, and other factors, such as clearing and bank erosion, are reducing the area of existing forests (Hesse et al. 1988). Furthermore, changes in flow patterns and the absence of overbank flooding over the last 50 years may be fundamentally changing the species composition, structure, and trajectories of change within these remnant forests.

The system of 6 large mainstem dams in the upper 2/3 of the river and channelization on the lower 1/3 creates unique challenges and unique conditions for cottonwood on different portions of the river, with a relatively free flowing (several smaller dams occur upstream), but canyon-walled segment (our segment 0, in the Wild and Scenic River in Montana) upstream of Fort Peck Reservoir; inter-reservoir segments between Fort Peck and Sakakawea (segment 2), Garrison Dam (Sakakawea) and Oahe (segment 4), Oahe and Big Bend (segment 6), and Fort Randall Dam (Francis Case) and Lewis and Clark Lake (segment 8/9); partially impounded segments 6 and 9; an unimpounded and unchannelized segment downstream from Gavins Point Dam (segment 10), and segments in the channelized and leveed portion of the river, such as segment 13. Johnson (2002) suggested that these different reach types, in terms of management regime, may lead to important ecological differences among reaches and to the creation of novel habitats (e.g., reservoir deltas, etc.) that may contribute to biodiversity in the system.

Forests along all portions of a regulated reach may suffer from lack of a seasonal flood pulse that moves sediment to create recruitment seedbeds, transports and deposits seeds of cottonwood and other species, and moistens floodplain soils. In addition to changes in flow patterns, segments that are downstream from dams may suffer sediment deficits and channel incision, due to sediment storage within the upstream reservoir. Channel incision further isolates the historic floodplain from the river, effectively raising the level of the floodplain relative to the river and reducing the potential for overbank flooding. Sediment deficits may limit the formation of sediment bars that are necessary for cottonwood recruitment, Piping Plover and Least Tern nesting, and other ecological functions. However, at the downstream end of inter-reservoir segments, particularly where a major sediment-bearing tributary enters just upstream of the reservoir (e.g., White River in Lake Francis Case, Bad River upstream of Lake Sharpe, Niobrara River upstream of Lewis and Clark Lake), sediment aggradation and rising water tables may kill or stress existing forests, as reservoir sedimentation and delta formation leads to the creation of aquatic/riparian delta habitats. During prolonged dry periods, the shores and upstream ends of some reservoirs may become exposed, enabling temporary colonization by cottonwood and other riparian species. On the channelized segments on the Lower Missouri, flooding and sediment dynamics are constrained by bank stabilization, wing dikes, and levees. Yet, flooding may still occur here (on either side of the levee) during high flow events, with potential recruitment occurring on farmland and other open habitats.

This project was motivated by the need to assess the current status of cottonwood forests along the Missouri River, including their composition, structure, health, areal extent, and age distribution and is a continuation of an earlier pilot project (Johnson et al. 2006). This work is being conducted in support of the U.S. Fish and Wildlife Service's Biological Opinion on the Missouri River in regard to reasonable and prudent measures for the Bald Eagle. Data and conclusions derived from this project will be used by the US Army Corps of Engineers to develop a Cottonwood Community Model using the HEAT methodology for 6 moderate to high priority Missouri River segments for the Bald Eagle (segments 4, 6, 8, 9, 10, and 13). This model will be used to evaluate the present condition of the cottonwood community and forecast future conditions under a range of alternatives for cottonwood management actions.

Our specific aims were to determine the following:

1. Present-day land cover within the historic Missouri River floodplain, including the distribution of cottonwood forest and early successional cottonwood sites;
2. Historic land cover patterns and forest distribution along the Missouri, particularly baseline pre-dam conditions, and changes from these historic pre-dam patterns to present-day patterns;
3. The present-day successional stage and age distribution of riparian woody vegetation patches, particularly those containing cottonwood;
4. The plant species composition and structure within existing cottonwood stands, disturbed cottonwood, and non-cottonwood riparian shrublands and forests, across a successional gradient from sapling stands to old growth stands;
5. Included in #4, the characteristics of the plant species occurring in these stands, in terms of their affinity for wetland habitats and their affinity or dependence on undisturbed natural habitats (i.e., the floristic "quality" of the vegetation).

6. Reconstruct pre-settlement (1860s) vegetation patterns on segment 10 using the witness tree records of the General Land Office Survey notes.

Here we report preliminary results from analysis of vegetation data collected within cottonwood, disturbed cottonwood, and non-cottonwood stands sampled in 2007 and 2008 on the eight study segments of the Missouri River. These include data from the herb, shrub, and overstory (tree) strata within different age classes of cottonwood and non-cottonwood stands. In addition, we report GIS analyses of the relative and absolute areas of cottonwood forests in different age classes within each segment. Finally, we also report the results of interpretation and analysis of witness tree records from the General Land Office (GLO) Survey notes for the historic floodplain in segment 10 (Gavins Point Dam to Ponca, Nebraska). All results should be considered provisional, as additional edits of the analyses and data may be conducted prior to the final project report (in June 2009).

METHODS

Study Segments

We mapped and sampled 8 Missouri River segments (Table 1), from Kansas City, Missouri to Fort Benton, Montana, including approximately 928 river miles (about 1/3 the length of the entire Missouri). The study area for this effort includes river reaches identified as high and moderate priority sites for bald eagle compliance with the Missouri River Biological Opinion. They are segments 4: Garrison Dam to Lake Oahe Headwaters near Bismarck, ND (RM 1389.9 to RM1304.0), 6: Oahe Dam to Big Bend Dam (RM 1072.3 to RM 987.4), 8: Fort Randall Dam to Niobrara River (RM 880.0 to RM 845.0), 9: Niobrara River to Lewis & Clark Lake and Lewis and Clark Lake (RM 845.0 to RM 811.1), 10: Gavins Point Dam to Ponca, NE (RM 811.1 to RM 753.0) and 13: Platte River mouth to Kansas City, MO (RM 595.5 to 367.5) of the Missouri River. In addition, we also included segment 2: Fort Peck Dam to Lake Sakakawea Headwaters near Williston, ND (RM 1771.2 to RM 1544), and a free-flowing segment within the Wild and Scenic River reach (RM 2075.6 to 1901) upstream of Fort Peck Lake (segment 0). Inclusion of segment 2 means that all inter-reservoir segments below Fort Peck were sampled and mapped, while segment 0 provided a reference reach that was likely less impacted by flow regulation.

On segment 4, we prioritized resampling of stands that had been sampled in 1969-70 by Carter Johnson and Warren Keammerer (Keammerer et al. 1975, Johnson et al. 1976). We resampled 20 of these sites on segment 4 and an additional 12 on the upper end of segment 5, just a few miles downstream of the boundary with segment 4. Data from all of these sites were considered together in our analysis of vegetation patterns in segment 4. However, GIS mapping has not yet been extended to include the land cover in the upper few miles of segment 5.

Because of small numbers of stands in segment 9, data for segments 8 and 9 have been combined (denoted segment 8/9) for most analyses.

GIS Mapping

Cottonwood Age Class Mapping

We mapped current (2006) land cover on each river segment by interpreting and digitizing 2006 county mosaic orthophotography from the National Agricultural Imagery Project (NAIP), obtained from the USDA NRCS Geospatial Data Gateway (http://datagateway.nrcs.usda.gov/). We also interpreted and digitized land cover from the 1892 Missouri River Commission maps and 1950s aerial photography for each river segment. We used imagery from these dates, plus color infrared imagery from the mid-1980s (NHAP project), and, when available, late 1990s imagery, to map approximate cottonwood age classes. We delineated approximate stand age using the following steps: (1) selected polygons on the 2006 land cover that corresponded to cottonwood forest, woodland, shrubland, or vegetated sandbar categories; (2) visually overlaid these polygons in ArcGIS with historic georeferenced maps or photographs from 1997/98, the early to mid-1980s, mid- to late 1950s, and 1892; (3) determined the approximate photograph/map interval during which the present woody vegetation colonized the polygon of interest (e.g., converted from unvegetated sandbar to woody vegetation); (4) assigned the polygon, or portions of it, the age class (1 = >114 years, 2 = 50-114 years, 3 = 25-50 years, 4 = 10-25 years, 5 = <10 years) consistent with that establishment interval. In some cases, different parts of a given polygon differed in age class, and we split the polygon into multiple polygons of woody vegetation with different ages.

Further details on digitizing protocol, photo interpretation, and aerial photography sources are provided in our 2007 Annual Report.

Reconstruction of Pre-settlement Overstory Composition

We obtained, interpreted, and transcribed the witness tree data from the General Land Office Survey notes for the Missouri River historic floodplain in Clay, Union, and Yankton counties, South Dakota and Dixon and Cedar counties, Nebraska, within segment 10. The bulk of the records were from 1857-59 on the Nebraska side and 1860-61 on the South Dakota side, although some supplementary survey data were from other years (1862, 1867, 1869). Data were available for 1059 section or quarter section corners (although not all of these had trees) and witness trees were also recorded at other locations along the survey lines. The dataset included information on 917 witness trees, across 12 species. Stem diameter measurements (diameter at breast height) were available for most of the trees. We tallied the frequency and basal area of all witness trees in the study area and compared them to relative density and basal area data from present-day (2007) vegetation sampling in segments 8 and 10.

Vegetation Sampling

Three methods were used in concert to sample the vegetation of cottonwood stands in the Missouri River floodplain. Sampling included characterization of (1) overstory composition and structure using the point-centered quarter method or (on pole and sapling sites with few tree-sized individuals) fixed radius circular plots, or complete plot census methods; (2) shrub/sapling composition, density, and cover using belt sampling and line intercept methods; and (3) herbaceous species composition and cover using 1 x 1 m quadrats.

Stand and Sampling Point Selection

We stratified each river segment into longitudinally into three subreaches, based on river miles or geomorphic considerations. When possible, we sampled 10 cottonwood stands within each sub-reach, for a total of 30 stands in each river segment. Within each subreach, we sampled 2 stands from each of the following age classes: >114 years (old growth), 50-114 years (mature), 25-50 years (intermediate), 10-25 years (pole), and <10 years (sapling). Approximate stand ages were determined by overlaying historical maps and aerial photographs by the methods outlined above (in the section detailing the GIS mapping methods). In addition, beginning in 2008, we also sampled disturbed cottonwood stands and non-cottonwood stands in the 6 priority segments (4, 6, 8/9, 10, and 13), with a goal of 12 non-cottonwood and 6 disturbed cottonwood stands per segment. In addition, we sought to locate and sample stands from both sapling/pole (<25 years old) and older (>25 year old) size/age classes. Constraints on site availability meant that these goals were not always attained for all of the segments.

Initial (in 2007) criteria for stand selection of undisturbed cottonwood forests included:

- At least 10-15% overstory cover by cottonwood
- An unmanaged or “natural” overstory, shrub, and herbaceous layer
    - No or minimal selective clearing of overstory trees
    - No selective clearing of red cedar, Russian olive, or other species
    - No campgrounds or sites with otherwise managed understories
- Patch size of at least 4-6 hectares (10-15 acres) for pole through old growth stands. Seedling/sapling sites could be smaller, down to 1 ha. (2.5 acres) or less.
- A stand, or the area of the stand included in a given sample, should be relatively homogeneous in terms of age and management
    - No mixture of our age classes
    - Preferably, no mixture of samples across obviously different cohorts of cottonwoods, even if the stand as a whole falls within a single crude age class (as defined above)
    - Avoid mixing portions of a stand with different past management regimes or obviously different vegetation structure (e.g., big differences in tree density, abundance of red cedar, etc.)

Additional disturbed and non-cottonwood stands sampled in 2008 diverged from these criteria in terms of % overhead cover of cottonwood (non-cottonwood sites were <10-15% cottonwood overstory cover) and disturbance (we explicitly selected sites with some degree of anthropogenic disturbance for the “disturbed” cottonwood sites). These stands were sampled to provide a wider range of cottonwood or riparian forest stand conditions and floristic quality and to enable inclusion of these other forests within the cottonwood community model being developed by USACE.

Overstory Sampling

For most stands, we used the point-centered quarter method (Cottam and Curtis 1956) for sampling and characterizing stand-level species composition, density, and basal area. This method provides an efficient technique for rapidly surveying stand characteristics, enabling a crew of three to easily sample a stand in 4-8 hours. These methods are consistent with those used by Carter Johnson (Johnson et al. 1976) on the Garrison to Oahe reach (segment 4) of the Missouri River in North Dakota in 1969-70. We resampled 30 of the 34 stands sampled by Johnson, which will enable us to assess the long-term effects of flow regulation and successional change during the last 39 years in those stands. These analyses will be included in our Final Report.

On sites sampled using the point-centered quarter method, forty points were sampled per stand, with 4 trees per point (160 total per stand). At each point, we divided the area into four 90 degree quadrants, relative to the transect bearing and a line perpendicular to it. Within each of these quadrants, we located the nearest live tree with a trunk diameter at breast height (dbh) ≥ 10 cm, identified it to species, measured the dbh to the nearest centimeter, and measured the distance from the point to the center of the tree trunk to the nearest 0.1 meters or finer. For trees with multiple trunks, we measured and recorded all stems that equaled or exceeded 10 cm dbh. If the nearest tree in a quadrant is dead, we recorded the species (if known), dbh, and distance from point, and then looked for the nearest live tree within the quadrant. In cases where no live tree could be located within a reasonable distance in the quadrant (e.g., > 35 m), the quadrant was recorded as “open.” Distances were measured using an electronic measuring device (Sonin multi-measure), optical rangefinder, or measuring tapes. For sites with open quadrants, we applied a correction factor to estimates of stem density, using the simple correction suggested by Dahdouh-Guebas and Koedam (2006). In addition to measuring trees, we also noted and recorded whether each tree measured had a liana (woody vine) growing on its trunk.

Because many or most of the cottonwoods in sapling and pole stands had stem diameters <10 cm at breast height, these sites often had a large number of points (or all points) with open quadrants where a tree with dbh ≥ 10 cm could not be measured within a reasonable distance and/or the same individual tree would have been measured more than once at multiple points. Similar difficulties occurred in some older sites that were very patchy or open in terms of tree distribution, with sometimes very long distances to the nearest tree. For such sites, a large correction factor would have to have been applied to generate density estimates, and we considered the estimates of density unreliable. Hence, for most sapling and pole sites and a few other sites of various age classes, we sampled tree density using12 fixed radius (15 m) circular plots instead of or in addition to the point-centered quarter sampling. Within each circular plot, we tallied the number of stems and identified and measured the stem diameter for all trees (≥ 10 cm dbh). This enabled us to obtain real density estimates for points with no trees (i.e., 0 stems per unit area), whereas the point-centered quarter method requires that trees be present and cannot yield density estimates of zero.

On some sites in the Wild and Scenic segment in Montana, where cottonwoods often occur in smaller, linear patches paralleling the river, neither point-centered quarter nor fixed radius circular plots were effective, given the geometry of the stands. Hence, strip transects or narrow, rectangular plots were used to sample tree density, with all trees present in these plots sampled in a complete census (Michael Scott, USGS Fort Collins, personal communication).

In the data summaries that follow, we combine data from the point-centered quarter, fixed radius plot, and complete census plot techniques, retaining the point-centered quarter estimates for most stands >25 years old and pole stands with few or no open quadrants.

Understory Sampling

Understory sampling characterized both the shrub and herbaceous layers. In contrast to the overstory sampling, only 12 (for shrubs) and 24 (for herbaceous layer plants) points were sampled per stand. These points were either on completely separate transects from those used in the overstory sampling, or were offset to avoid trampling the herbaceous vegetation. These were generally arranged on four transects, as with the trees, with 6 herb points and 3 shrub points per transect.

Shrub layer (≥ 1 m)

Plants occupying the shrub layer (shrubs and tree saplings > l m tall < 10 cm dbh) were sampled using the line-strip method (Lindsey 1955), using a sampling strip 2 m x 10 m with a tape defining the centerline. This sampling strip began at the point and ran along the bearing of the transect. Woody stem density (#/ha) in the shrub layer was estimated by counting all individual shrubs, saplings, and woody vines found within the sampling strip (1 meter to either side of the 10 m transect). Numbers were tallied for each species.

Percent cover was estimated by recording cover by shrubs (or saplings and woody vines) that intercepted the centerline vertical plane of the plot above 1 m off the ground. We noted the total distance along the 10-meter tape length with overhead shrub cover by each species and summed the contributions of individual species to get total cover. Note that this can exceed 100 percent, as different species can have overlapping coverage over the same length of tape. In 2008, we revised our data recording to enable quantification of overlapping coverage, allowing estimation of total shrub cover (without inflated estimates from overlap) on each plot. However, this correction has not been implemented within the data summaries presented in this report.

Within stands in segment 4 that had been sampled by Johnson and Keammerer in 1969-70, we also sampled the shrub layer with methods that matched those used by Johnson and Keammerer. The principle difference is that woody plants 1 foot (about 0.3 m) tall or greater were considered shrubs in Johnson and Keammerer's sampling, while our criterion was of a minimum height of 1 m. Sites that were resampled using the methods of Johnson and Keammerer were also sampled using the standard criteria that we applied to all other sites, so that shrub comparisons can be made both with the Johnson and Keammerer data from 1969-70 and with other study sites and segments sampled in 2007 and 2008.

Herb layer (< 1 m)

Plants in the herbaceous layer (herbs and woody seedlings < 1 m tall) were sampled using a 1 m x 1 m sampling frame (quadrat) beginning at or centered on the sampling point. Care was taken to avoid trampling on the area prior to sampling. For this reason, we sampled the herbaceous quadrat prior to the shrub sampling. All species of non-woody vascular plants and woody seedlings were noted and recorded and their percent cover within the 1-m^2 quadrat estimated to the nearest 5%. Species with trace occurrence were recorded as 1% cover.

Voucher specimens of plants encountered during sampling were being obtained and submitted to Dr. Gary Larson of South Dakota State University. Specimens were obtained in full flowering condition when possible. When possible, we obtained voucher specimens in duplicate or triplicate, so that at least one specimen could be kept in the herbarium of South Dakota State University, one in the home institution (e.g., University of South Dakota, Benedictine College, USGS), and additional specimens could be donated to US Fish and Wildlife Service or National Park Service collections.

Data Reduction and Analysis

These sampling protocols produced the following basic information: stand-level and complete plant (vascular plant) species lists; frequency and percent cover of each species in the herbaceous layer; frequency, percent cover, and density of each species in the shrub layer; and the frequency, density, basal area (m^2/ha) and importance value (sum of percent relative frequency, density, and basal area, with a maximum value of 300) of each tree species. For complete census plots for trees, there was no way to calculate relative frequency separately from relative density. Hence, for those sites (mostly in segment 0), we computed importance value using relative basal area plus two times the relative density for each species. By assigning published wetland indicator values (Reed 1988) and Coefficients of Conservatism (C-values) (Swink and Wilhelm 1994, Taft et al. 1997, Northern Great Plains Floristic Quality Assessment Panel 2001) to species of plants, estimation was made of the wetland affinity and overall quality of the vegetation in each stand.

Plant Species Data Summaries and Metadata

Each investigator was responsible for submitting a master spreadsheet listing the scientific name of each species encountered during sampling, any code names used to identify that species in the data, whether the species is native or introduced, its wetland indicator status for the relevant region, and its Coefficient of Conservatism. Wetland Indicator status codes (Reed 1988 and later updates) have been standardized by region and may be obtained from the following website: http://www.fws.gov/nwi/plants.htm or from the USDA NRCS Plants Database (http://plants.usda.gov/) (USDA, NRCS 2008). Coefficients of Conservatism (i.e., how indicative is a given species of the "naturalness" or conservation value of a study site) have been developed for the flora of a number of regions (e.g., The Northern Great Plains Floristic Quality Assessment Panel 2001 for North and South Dakota, http://www.npwrc.usgs.gov/resource/plants/fqa/index.htm) and is most often used in Floristic Quality Assessment for calculating the Floristic Quality Index (Swink and Wilhelm 1994, Taft et al. 1997) or FQI. These codes can enable calculation of species- or cover-weighted average estimates of wetland affinity and overall vegetation quality or "naturalness" in each stand.

For segments 6. 8, 9 and 10, we obtained Coefficient of Conservatism (C) values from a software package called Floristic Quality Assessment Computer Program, Version 1.0 (October 2000) by Gerould S. Wilhelm and Linda A. Masters, with the Dakotas database (North and South Dakota). These data were originally derived from the publication by the Northern Great Plains Floristic Quality Assessment Panel (2001), mentioned above. For species that were not found in the Dakotas database, we used the C values from a 2006 draft update of the Nebraska Natural Heritage Program state list (Rolfsmeier and Steinauer 2003). In a limited number of cases (for species not listed in either the Dakotas or Nebraska lists), we used a draft list compiled for Iowa (http://www.public.iastate.edu/%7Eherbarium/coeffici.html). For segment 4, C-values were obtained primarily from the publication by the Northern Great Plains Floristic Quality Assessment Panel (2001) for the Dakotas. For segments 0 and 2, C-values were taken from Lesica and Husby (2001, http://nris.state.mt.us/wis/wetlands/metadata.html). In instances where C-values for particular species could not be obtained from the preferred source for that region, we used C-values for that species from neighboring states. Hence, scores from the Northern Great Plains Floristic Quality Assessment Panel (2001) were used when species encountered in segments 0 or 2 were not listed in Lesica and Husby. For segment 13, the previously mentioned Nebraska list (Rolfsmeier and Steinauer 2003) was the first choice for choice of C-values, with the Missouri list by Ladd (1997) used secondarily and the Iowa list used for any species not found on the other two lists.

We calculated FQI and mean C as in Swink and Wilhelm (1994) and Taft et al. (1997), except that we included all species for which we had C values, and used a value of 0 for non-native species. So, overall mean C and FQI values were computed based on the complete list of species sampled at each stand (across the herb, shrub, and tree strata). For now, these species lists include some occurrences of plants that could only be identified to the genus level, which may be redundant with other, identified species in the same genus on the site. We also computed weighted mean C values that were weighted by relative cover or importance values of the individual species in the herb and shrub strata. We obtained information on native vs. exotic status from the program and from the USDA NRCS Plants Database (USDA, NRCS 2008).

For analyses of Wetland Indicator Status, we obtained indicator scores from the appropriate regional lists (Reed 1988), obtained from the USDA NRCS Plants Database (USDA, NRCS 2008). For segments 6. 8, 9 and 10, we used lists for Regions 4 (South Dakota), 5 (Nebraska), and 3 (Iowa), in that order of preference. Region 4 scores were also used for segments 2 (downstream of Fort Peck) and 4 (downstream from Garrison) in eastern Montana and North Dakota, respectively in North Dakota. For segment 0, in the Wild and Scenic reach in Montana, we used the Region 9 (Northwest) list. For segment 13, we used the Region 5 (Central Plains, including Nebraska) list first, and used the Region 3 list (North Central, including Missouri and Iowa) for species that were not listed for Region 5. As with C values and FQI, we computed both unweighted average WIS scores (average of all of the species encountered at a site) and scores weighted by percent cover or importance value of herbs or shrubs. Overall scores that included both herbaceous and woody species were based only on the unweighted species lists, for mean C, FQI, and WIS.

Our numeric scale for scoring Wetland Indicator Status (W) differed from other investigators (e.g., Stromberg et al. 1996), is that we assigned a value of 5 to wetland obligate plants and a 1 to upland species (this is the opposite of the normal approach). In essence then, higher scores (closer to 5) represent higher wetland affinity in our system. We ignored + or - modifiers in our scoring (e.g., FACU, FACU- and FACU+ are scored as a 2, FAC and FAC- as 3, etc.). As with C values and FQI, we computed overall (across plant strata) average W scores based both on unweighted species lists, but also computed separate estimates weighted by relative cover or importance value for herbs and shrubs.

Data entry, error checking, and production of graphics was done in MS-Excel. Most data manipulation and analysis was done in the Statistical Analysis System software (SAS®, version 9.1).

RESULTS AND DISCUSSION

Vegetation Data

Table 1 indicates the numbers and types of stands sampled in the eight study segments. A total of 211 cottonwood, 31 disturbed cottonwood, and 62 non-cottonwood stands, for a total of 304 stands, were sampled in 2007-2008. Of these, 76 of the cottonwood stands and 11 of the non-cottonwood stands were in the sapling or pole (<25 years) age classes. Very few (2) disturbed stands in the sapling or pole (<25 years) age classes were identified and sampled. 30 stands in segment 4 (8 cottonwood, 8 disturbed cottonwood, 14 non-cottonwood, 1 herbaceous) were resurveys of sites previously sampled in 1969-70 (Keammerer et al. 1975, Johnson et al. 1976).

Trees

In most of our comparisons below, we report changes in relative dominance by different species, expressed by the importance value (IV), which is equal to the sum of relative basal area, relative density, and relative frequency of each species. The total of the importance values for all species at a site equals 300 (100% relative density + 100% relative basal area + 100% relative frequency); a species would achieve an importance value of 300 only on a site with no other species of trees. For complete census plots, there was no way to calculate relative frequency separately from relative density (relative frequency was same for all species that occurred in the single plot that was measured). Hence, for those sites (mostly in segment 0), we computed importance value using relative basal area plus two times the relative density for each species.

Important similarities and differences existed in overstory (tree) vegetation patterns across the segments (Figures 1.1a-1.7). Across segments, the importance value and stem density of cottonwood generally decreases with stand age, while the species richness and importance of other tree species generally increases (Figures 1.1a-1.7, Tables 2.1-2.7). Spatially, important differences occur in overstory tree composition and stand structure among the study segments. In terms of stand structure, overall tree stem density and basal area, though variable, tends to be lower in the upstream three segments (0, 2, 4) (Tables 2.5-2.7). Average stand-level tree species richness decreases steadily and strongly from downstream to upstream segments (Figure 2). Mean tree species richness per stand varies from 6 species in segment 13 (Nebraska, Iowa, Kansas, Missouri) to about 2.5 in segment 0 (in Montana). These differences appear to be due to higher richness of later successional tree species in intermediate, mature, and old-growth stands in the downstream segments. For instance, in segment 13, sycamore, box elder, hackberry, green ash, American elm, red mulberry, white mulberry, and silver maple are all common tree species in mature and older stands (Figure 1.1a). Of these, only green ash and box elder persist in segments 0 and 2 in Montana (Figures 1.6-1.7). Overall, relative abundance of these two species (especially green ash) increase from the downstream to upstream segments as other late successional species progressively drop out. Similar patterns also appear to occur for disturbed cottonwood and non-cottonwood sites, with dominance by fewer species in the most upstream segments.

The average proportion of non-native tree species peaks in segments 6-10 in South Dakota and Nebraska, with Russian olive *(Elaeagnus angustifolia*) white mulberry (*Morus alba*), and common buckthorn (*Rhamnus cathartica*) relatively common (Figures 3, 1.2a-1.4b). The proportion of tree species that are non-native is considerably lower both in segment 13 and in the upstream segments in North Dakota and Montana (segments 0, 2, and 4) (Figure 3). In addition, the highest relative abundance of eastern red cedar, (*Juniperus virginiana*), a native, but invasive species, also occurs in the three below-dam South Dakota segments (Figures 1.2a-1.4b).

Shrubs

Patterns of shrub cover and species composition of the shrub layer also varied considerably among the study segments from downstream to upstream (Tables 3.1-3.7, Figures 4.1a-4.7). A surprisingly large amount of variation occurred among segments in terms of average shrub cover and how it changed with stand successional age. Overall shrub cover tended to decline from downstream to upstream, with particularly high cover in segment 10 and particularly low shrub cover in segments 0 and 2. There was no consistent pattern in terms of changes in percent shrub cover with stand age. On some segments (e.g., segments 13 and 0), shrub cover was highest in sapling and pole stands, and declined in older stands (Figures 4.1a and 4.7). Segment 10 patterns were opposite, with maximum shrub cover on stands >50 years old (Figure 4.2a). Average shrub cover in mature and old growth stands in segment 10 was higher (averaged >65%) than that found in any other age classes on any other segment. On some segments, shrub cover peaked in intermediate aged stands (segments 2 and 6), while on others it was least in that age class (segments 8/9, 4, 2). Disturbed cottonwood stands often had very low shrub cover, as these included campgrounds where all or most of the understory had been cleared.

Across segments, cottonwood and willow comprised most of the shrub cover on stands <25 years old and species richness tended to increase with stand age (Figures 4.1a-4.7, Tables 3.1-3.7). Shrub cover on intermediate (25-50) and older stands was a composite of saplings of later successional tree species and some species that attain only shrub or small tree stature. Much of the shrub cover in these older segment 10 stands was composed of the exotic shrub, common buckthorn (*Rhamnus cathartica*) or the native shrub, rough dogwood (*Cornus drummondii*) (Figures 4.2a and 4.2b). Eastern red cedar was a relatively common component of the shrub layer on the South Dakota segments, 6, 8/9, and 10 (Figures 4.2a-4.4b). Shrub species richness tended to track the upstream to downstream increase in tree species richness (which makes sense, as most of the tree species also occurred in the shrub layer as saplings), except for segment 13, which had significantly lower average shrub richness than segment 10 and much lower shrub richness than tree richness (Figure 2).

Herbaceous Quadrats

Patterns of herbaceous species richness varied considerably among study segments, but there was no consistent upstream-downstream pattern (Figure 5). Mean species richness was significantly higher in segments 4 and 10 and significantly lower in segments 6 and 13, then in the western-most segments (0 and 2). Average herbaceous cover appeared to be considerably higher in segments 0, 2, 4, and 6 than the farther downstream segments, with particularly high mean percent cover in mature, old growth, and non-cottonwood stands (Tables 4.1-4.7). We have not analyzed changes in abundance of particular herbaceous species, but herbaceous species comprise the majority of all plant species at the stand and segment level and hence tend to drive overall patterns in mean Coefficient of Conservatism, wetland indicator, and % exotic species values.

Patterns of Diversity, Floristic Quality, and Wetland Status

As with herbaceous richness alone, total stand-level plant species richness was highest in segments 4 and 10, with an average of more than 35 species per stand, and least in segments 6 and 13 (average of 23 and 25 species, respectively) (Figure 5). Species richness increased with stand age, across river segments, with an average of 25 species in stands <25 years old and 32 and 33 species, respectively for stands 25-50 and >50 years old (Figure 6).

Differences occurred among river segments in terms of the average Coefficient of Conservatism (C-values) overall and by vertical stratum (herbaceous, shrub, tree). Average C-values across all layers were significantly higher in segments 4 and 10 than all other segments and were dramatically lower in segment 6 than all others (Figures 7 and 8). So, the segments with higher species richness (Figure 5) also had a higher proportion of species that tend to occur in less disturbed environments, while segment 6 had both low species richness and was dominated by ruderal, weedy species with low C-values. Breaking out average C-values by plant stratum, the upstream segments (0, 2) had high average C-values for the shrub and tree layers, but relatively low values for herbs (Figure 8). Segments 4 and 10 had high average C values for herbs and medium to low values for shrubs and trees. C-values for segment 6 were low for all strata. Across river segments, average C-values also significantly increased with stand age (Figure 9).

The average proportion of species in a stand that were non-native increased from downstream to upstream, at less than 20% in segments 8/9, 10, and 13, and nearly 40% in segment 0 (Figure 10).

These influenced the mean C-values, as exotic species were assigned a C-value of zero. Segment 6 had a higher proportion of exotic species than the next upstream (4) and downstream (8/9) segments. Interestingly, the proportion of tree species that were exotic had a nearly opposite pattern, peaking in segments 6, 8/9, and 10, but with very low values in segment 13 (Figure 3). There was a weak increase in the average proportion of exotic species between <25 year old and older stands (Figure 11).

Average wetland indicator scores (W-scores), which ranged from 1 (upland species) to 5 (obligate wetland species) varied significantly by river segment and stand age (Tables 5.1-5.7, Figures 12 and 13). Average wetland score dropped significantly from stands <25 years to those >25 years old (Figure 13). Among river segments, average wetland scores were significantly higher for segment 13 than all other segments (Figure 12). Segment 13 scores averaged over 3, suggesting an average score coinciding with FAC wetland indicator status, while other segments averaged 2.48-2.75, suggesting a score intermediate between FACU and FAC. Although channelized and leveed, segment 13 still experiences periodic flooding during high flow years. Flooding on that segment in 2008 could be in part responsible for the higher average W-scores there.

Contrary to the preliminary findings in the 2007 Annual Report, cover-weighted values of mean C- and W-values based on relative cover of herbaceous plants (Tables 4.1-4.7) were often substantially lower than the unweighted mean values calculated on the stand-level species list (Tables 5.1-5.7). Using cover-weighted estimates, mean C-values for segment 6 were very low, averaging 0.10 for disturbed cottonwood sites, 0.37 for non-cottonwood stands, 0.45 for old-growth (>114 years) stands, and 0.47 for pole (10-25 years) stands, with the highest values in mature stands (50-114 years), at 1.84 (Table 4.4). Cover-weighted mean C values were much lower than unweighted estimates for the three most upstream sites as well (Tables 4.5-4.7, 5.5-5.7). Segment 4, which, along with segment 10, had the highest overall unweighted C-values among all segments, had substantially lower weighted C-values (Tables 4.5 and 5.5). The sensitivity of these average C-value estimates to weighting by relative cover suggests that dominance by a small number of native ruderal species or exotics (e.g., smooth brome, *Bromus inermis*) or may be driving down the cover-weighted estimates. Cover-weighted average herbaceous C-values also appeared to differ substantially between disturbed and undisturbed cottonwood stands. In terms of wetland scores, cover-weighted values for the herbaceous layer were particularly low for older (>50 years) stands in the upstream study segments (Tables 4.5-4.7). Hence, it appears that C-values and W-scores weighted by relative herbaceous (or shrub or tree) cover may be more sensitive metrics for tracking the effects of disturbance and flow regulation on the condition of the flora.

Cottonwood Area and Age Distribution across River Segments

Analysis of recent (2006) aerial photography, along with field reconnaissance, yielded estimates of the total acreage of habitat with cottonwood as a major component (approx. >15% cottonwood coverage) in each study segment (Figure 14). Total area of cottonwood habitat types was greatest in the two longest river segments, with over 64,000 acres in segment 2 (227 river miles) and 49,000 acres in segment 13 (228 river miles). When adjusted for segment length (Figure 15), cottonwood acreage per river mile exceeded 250 acres on segments 2, 4, and 10, with the largest area per river mile in segments 2 and 4 (approx. 280 acres per river mile). The smallest absolute area and lowest acreage per river mile of cottonwood occurred in segments 6 and 0, with the lowest of each in segment 6 (1851 acres, or 22 acres/river mile).

The age distribution of cottonwood habitats varied across the study segments (Figure 16). The combined area of old growth (>114 years) and mature (50-114 yrs) forest ranged from 49% to nearly 89% of the total cottonwood area, with segments 0, 4, and 6 all having over 85% coverage of mature and old growth, and hence <15% of the cottonwood area was composed of stands <50 years old. Forests mapped as old growth (>114 years) occupied the largest relative area in segments 0 and 4, at approximately 40% of the total cottonwood area, but comprised less than 17% of the cottonwood area in all other segments (minimum in segment 13, at 6.5%). The highest proportion of younger forest (<50 years) occurred in the three most downstream segments (8/9, 10, and 13), with 44-51% of the cottonwood forest establishing since 1956. The majority of the area of younger forest in each segment is in the 25-50 year age class, although 15-23% of the cottonwood area is <25 years old (saplings and poles) in these three downstream segments. The proportion of the cottonwood area that is in poles and saplings (<25 years old) is much greater on the three downstream segments than the four upstream ones (segments 6, 4, 2, and 0), with recruitment over the last 25 and 50 years very low on segments 4 and 6 and nearly nonexistent (<1% of total cottonwood area) on segment 0 in the Wild and Scenic reach upstream of Fort Peck Reservoir.

Overall, the relative areas of younger vs. older stands in each segment suggest that more recruitment of cottonwood has occurred over the last 50 years in the most downstream three segments (below Fort Randall) than the upstream segments, with the possible exception of segment 2 (Figure 16). However, it is also possible that this higher proportion of young forest in these segments may also reflect higher rates of clearing of older forests for agricultural fields, urban expansion, etc. Further analyses of historic land cover transitions will be needed to assess this question.

Pre-settlement Vegetation of Segment 10

We transcribed the witness tree data from the General Land Office Survey notes (1857-69) for portions of the Missouri River historic floodplain in Clay, Union, and Yankton counties, South Dakota and Dixon and Cedar counties, Nebraska. The bulk of the records were from 1857-59 on the Nebraska side and 1860-61 on the South Dakota side, although some supplementary survey data were from other years (1862, 1867, 1869). The dataset included information on 917 witness trees, across 12 species (Table 6). Cottonwood was the dominant species, comprising 64% (583) of all of the witness trees and 72% of the total basal area (Table 6, Figure 17). The mean trunk diameter of cottonwoods used as witness trees was 36.5 cm (approx. 14 inches) (Table 6), with nearly 2/3 (63%) between 10 and 40 cm (4-16 inches) (Figure 18). Based on present-day mean cottonwood diameters in our different age classes (Tables 2.1-2.7), the bulk of the cottonwoods recorded as witness trees would likely have been <50 years old in the mid-1800s. The largest cottonwood recorded, out of 580 with diameter measurements, had a trunk diameter of 127 cm (50 inches). Overall, the largest tree measured was an American elm with a trunk diameter of 178 cm (70 inches) (Table 6).

Of the section corners and quarter section corners in the study area, about 20% had witness trees (215 out of 1059), suggesting that approximately 1/5 of the floodplain was forested in the late 1850s and early 1860s along segment 10. Approximately 13% of the South Dakota section and quarter section corners had trees and 60% of the Nebraska points. This large discrepancy is likely because the floodplain was much wider on the South Dakota side, with floodplain forest dominating the portion adjacent the river, and prairie dominating areas farther away.

Comparisons of witness tree relative basal area and relative density with present-day data for segments 8 and 10 suggest that important changes in tree composition have occurred over the last 150 years (Figure 17). In particular, eastern red cedar and several exotic species (Russian olive, white mulberry, common buckthorn) now are common understory species within cottonwood forests, but were not present or mentioned in the GLO notes. In addition, the relative abundance and particularly the relative basal area of elm (probably mostly *Ulmus americana*) appears to have decreased since the 1860s, likely linked to Dutch Elm Disease. Willow (probably mostly *Salix amygdaloides*) also appears to have decreased in relative abundance.

FUTURE ANALYSES FOR FINAL REPORT

Because of ongoing editing of the GIS data, comparisons of present land cover, historic changes in land cover, and transition probabilities between different land cover types have not been presented here. In that vein, the area totals for cottonwood age classes presented in this report should be considered provisional and may change slightly with further editing and revision of the GIS data. Final results will be presented in the Final Report due on June 30, 2009. Electronic GIS files for all site locations, as well as historic (1892, 1950s, 2006) land cover and forest age class maps will be made available along with the Final Report at that time. In addition, some additional revision (e.g., possible reassignment of some sites to different age classes) of the vegetation data may also occur, so that the vegetation results presented in this report should also be considered provisional. Final data analyses and summaries will be provided in the Final Report.

We will also expand our vegetation analyses for the Final Report. In particular, we plan to assess changes in plant species composition and stand structure that have occurred in stands in segment 4 that were originally sampled by Johnson and Keammerer (Johnson et al. 1976) in 1969-70 and were subsequently resampled by us in 2008. This will be provide a unique opportunity to assess the chronic effects of flow regulation on riparian vegetation composition over a nearly 40-year period.

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TABLE LEGENDS

Table 1. Description of study segments and number of stands sampled per segment. Numbers of stands of cottonwood, disturbed cottonwood, and non-cottonwood that are <25 years old (sapling and pole) are indicated in parentheses.

Tables 2.1 – 2.7 summarize overstory (tree) stand characteristics, by age class and forest type, across each of the study reaches.

Table 2.1. Summary of overstory (tree) stand characteristics, by age class, across river segment 13 (Plattsmouth, Nebraska to Kansas City). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Table 2.2. Summary of overstory (tree) stand characteristics, by age class, across river segment 10 (Gavins Point Dam to Ponca, Nebraska). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Table 2.3. Summary of overstory (tree) stand characteristics, by age class, across river segments 8 and 9 (Fort Randall Dam to Lewis and Clark Reservoir). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Table 2.4. Summary of overstory (tree) stand characteristics, by age class, across river segment 6 (Oahe Dam to Big Bend Dam). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Table 2.5. Summary of overstory (tree) stand characteristics, by age class, across river segment 4 (Garrison Dam to upper end of Lake Oahe). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Table 2.6. Summary of overstory (tree) stand characteristics, by age class, across river segment 2 (Fort Peck Dam to upper end of Sakakawea Reservoir). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Table 2.7. Summary of overstory (tree) stand characteristics, by age class, across river segment 0 (Wild and Scenic reach, Fort Benton to upper end of Fort Peck Lake). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Tables 3.1 – 3.7 summarize shrub data, by age class and forest type, across each of the study reaches.

Table 3.1. Summary of shrub data, by age class, across river segment 13 (Plattsmouth, Nebraska to Kansas City). Numbers are means, with range of stand values (minimum – maximum) in parentheses. Note that for shrub IV, scores have been scaled to 100% (instead of 300 as with the tree data).

Table 3.2. Summary of shrub data, by age class, across river segment 10 (Gavins Point Dam to Ponca, Nebraska). Numbers are means, with range of stand values (minimum – maximum) in parentheses. Note that for shrub IV, scores have been scaled to 100% (instead of 300 as with the tree data).

Table 3.3. Summary of shrub data, by age class, across river segments 8 and 9 (Fort Randall Dam to Lewis and Clark Reservoir). Numbers are means, with range of stand values (minimum – maximum) in parentheses. Note that for shrub IV, scores have been scaled to 100% (instead of 300 as with the tree data).

Table 3.4. Summary of shrub data, by age class, across river segment 6 (Oahe Dam to Big Bend Dam). Numbers are means, with range of stand values (minimum – maximum) in parentheses. Note that for shrub IV, scores have been scaled to 100% (instead of 300 as with the tree data).

Table 3.5. Summary of shrub data, by age class, across river segment 4 (Garrison Dam to upper end of Lake Oahe). Numbers are means, with range of stand values (minimum – maximum) in parentheses. Note that for shrub IV, scores have been scaled to 100% (instead of 300 as with the tree data).

Table 3.6. Summary of shrub data, by age class, across river segment 2 (Fort Peck Dam to upper end of Sakakawea Reservoir). Numbers are means, with range of stand values (minimum – maximum) in parentheses. Note that for shrub IV, scores have been scaled to 100% (instead of 300 as with the tree data).

Table 3.7. Summary of shrub data, by age class, across river segment 00 (Wild and Scenic reach, Fort Benton to upper end of Fort Peck Lake). Numbers are means, with range of stand values (minimum – maximum) in parentheses. Note that for shrub IV, scores have been scaled to 100% (instead of 300 as with the tree data).

Tables 4.1 – 4.7 summarize herbaceous quadrat data, by age class and forest type, across each of the study reaches.

Table 4.1. Summary of herbaceous quadrat data, by stand age class, across river segment 13 (Plattsmouth, Nebraska to Kansas City). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Table 4.2. Summary of herbaceous quadrat data, by stand age class, across river segment 10 (Gavins Point Dam to Ponca, Nebraska). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Table 4.3. Summary of herbaceous quadrat data, by stand age class, across river segments 8 and 9 (Fort Randall Dam to Lewis and Clark Reservoir). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Table 4.4. Summary of herbaceous quadrat data, by stand age class, across river segment 6 (Oahe Dam to Big Bend Dam). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Table 4.5. Summary of herbaceous quadrat data, by stand age class, across river segment 4 (Garrison Dam to upper end of Lake Oahe). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Table 4.6. Summary of herbaceous quadrat data, by stand age class, across river segment 2 (Fort Peck Dam to upper end of Sakakawea Reservoir). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Table 4.7. Summary of herbaceous quadrat data, by stand age class, across river segment 0 (Wild and Scenic reach, Fort Benton to upper end of Fort Peck Lake). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Tables 5.1 – 5.7 summarize stand-level species richness, native and exotic, floristic quality, and wetland affinity, by age class and forest type, across each of the study reaches.

Table 5.1. Summary of stand-level data on species richness, native and exotic abundance, floristic

quality, and wetland affinity, by cottonwood forest age class on river segment 13. Numbers are means within each stand age class, with range (low and high stand values) in parentheses.

Table 5.2. Summary of stand-level data on species richness, native and exotic abundance, floristic quality, and wetland affinity, by cottonwood forest age class on river segment 10. Numbers are means within each stand age class, with range (low and high stand values) in parentheses.

Table 5.3. Summary of stand-level data on species richness, native and exotic abundance, floristic quality, and wetland affinity, by cottonwood forest age class on river segments 8 and 9. Numbers are means within each stand age class, with range (low and high stand values) in parentheses.

Table 5.4. Summary of stand-level data on species richness, native and exotic abundance, floristic quality, and wetland affinity, by cottonwood forest age class on river segment 6. Numbers are means within each stand age class, with range (low and high stand values) in parentheses.

Table 5.5. Summary of stand-level data on species richness, native and exotic abundance, floristic quality, and wetland affinity, by cottonwood forest age class on river segment 4. Numbers are means within each stand age class, with range (low and high stand values) in parentheses.

Table 5.6. Summary of stand-level data on species richness, native and exotic abundance, floristic quality, and wetland affinity, by cottonwood forest age class on river segment 2. Numbers are means within each stand age class, with range (low and high stand values) in parentheses.

Table 5.7. Summary of stand-level data on species richness, native and exotic abundance, floristic quality, and wetland affinity, by cottonwood forest age class on river segment 00. Numbers are means within each stand age class, with range (low and high stand values) in parentheses.

Table 6. Relative density, basal area, and trunk diameter of witness trees recorded in the General Land Office Survey for the historic Missouri River floodplain along segment 10 (59 mile MNRR) from 1857-1869.

Table 1. Description of study segments and number of stands sampled per segment. Numbers of stands of cottonwood, disturbed cottonwood, and non-cottonwood that are <25 years old (sapling and pole) are indicated in parentheses.

Segment	Description	River Miles	Type of Segment	Total Stands	Cottonwood	Disturbed Cottonwood	Non-cottonwood
0	Wild and Scenic reach, Fort Benton to Fort Peck Reservoir	1901-2705.6	Free-flowing (FF)*	29	29 (11)	0	0
2	Fort Peck Dam to Lake Sakakawea	1544-1771.2	Inter-reservoir (IR)	30	30 (13)	0	0
4	Garrison Dam to Lake Oahe**	1304-1389.9**	Inter-reservoir (IR)	66	37 (13)	9 (0)	20 (6)
6	Oahe Dam to Big Bend Dam (includes Lake Sharpe)	987.4-1072.3	Inter-reservoir (IR)/ Reservoirs and Headwaters (R&H)	27	16 (1)	4 (0)	7 (0)
8	Fort Randall Dam to Niobrara River	845-880	Inter-reservoir (IR)	44	30 (10)	4 (0)	10 (1)
9	Niobrara River to Gavins Point Dam (includes Lewis & Clark Reservoir)	811.1-845	Reservoirs & Headwaters (R&H)	8	7 (3)	1 (0)	0
10	Gavins Point Dam to Ponca, Nebraska	753-811.1	Unchannelized (UC)	52	32 (13)	7 (2)	13 (4)
13	Plattsmouth, Nebraska to Kansas City	367.5-595.5	Channelized (C)	48	30 (12)	6 (?)	12 (?)
	TOTAL			304	211 (76)	31 (2)	62 (11)

*Segment 0 is not truly free-flowing as Hauser, Holter, Canyon Ferry, and Totson dams all occur upstream; but it is upstream of the 6 largest reservoirs on the Missouri.

**Twelve sites included in the segment 4 totals were from the upstream 10 miles of segment 5. One of these sites was unforested and is not included in the vegetation analyses, nor in the totals in the table above.

Table 2.1. Summary of overstory (tree) stand characteristics, by age class, across river segment 13 (Plattsmouth, Nebraska to Kansas City). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Stand age (yrs)	# stands	# species	# trees/ha	Basal area (m^2/ha)	CW IV	Mean CW dbh	Max CW dbh	CW trees/ha	Prop vines
Cottonwood									
≤10	6(1)*	1*	3.1 (0-18.9)	0.05 (0-0.28)	300*	13.5*	22*	3.1 (0-18.9)	0*
10-25	6	1.83 (1-3)	303.7 (18.9-710.9)	5.38 (0.23-12.08)	287.7 (248.7-300)	14.3 (12.2-15.4)	30.42 (18-57.2)	287.6 (18.9-693.0)	0.01 (0-0.03)
25-50	6	6.17 (2-9)	419.8 (34.9-843.1)	15.13 (3.08-24.58)	188.5 (59.4-296.5)	24.3 (13.9-29.9)	49.23 (31-62)	292.0 (10.6-832.4)	0.29 (0.08-0.62)
50-114	6	7.83 (6-10)	355.4 (192.0-565.4)	34.32 (13.09-43.15)	75.1 (46.90-135.8)	64.0 (48.2-113.5)	127.95 (97.2-208.2	48.3 (12.0-104.5)	0.29 (0-0.59)
>114	6	9 (7-12)	376.4 (92.7-555.2)	45.87 (13.89-71.69)	103.7 (76.6-146.1)	60.1 (34.7-98.8)	149.08 (110-191.7)	93.5 (6.7-89.5)	0.47 (0.23-0.68)
Disturbed Cottonwood									
Unknown	6	6.17 (4-8)	239.8 (60.6-459.8)	20.14 (7.03-37.75)	152.0 (62.1-257.5)	49.4 (13.2-69.7)	84.3 (23-130.1)	114.7 (27.7-422.4)	0.09 (0-0.53)
Non-cottonwood									
Unknown	12(8)*	10.5* (7-17)	198.1 (0-517.2)	16.88 (0-43.19)	53.2* (0-167.4)	52.30* (25.58-94.50)	94.6* (36.2-185)	16.1 (0-50.2)	0.35* (0.03-0.88)

*Stands without trees > 10 cm dbh were excluded from calculations.

Table 2.2. Summary of overstory (tree) stand characteristics, by age class, across river segment 10 (Gavins Point Dam to Ponca, Nebraska). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Stand age (yrs)	# stands	# species	# trees/ha	Basal area (m^2/ha)	CW IV	Mean CW dbh	Max CW dbh	CW trees/ha	Prop vines
Cottonwood									
≤10	6(2)*	2.00* (2-2)	29.3 (0-103.7)	0.35 (0-1.37)	239.1* (215.5-262.8)	12.8* (12.4-13.3)	20* (18-22)	25.90 (0-100.2)	0*
10-25	7	2.29 (1-3)	194.7 (92.0-413.9)	4.62 (1.15-11.33)	255.3 (208.6-300)	15.4 (11.7.1-17.6)	31.0 (20-37)	180.2 (74.3-382.9)	0
25-50	6	4.17 (1-7)	483.0 (127.2-924.6)	18.17 (12.35-27.30)	219.2 (90.0-300)	24.0 (15.8-33.4)	51.5 (30-77)	356.7 (106.5-744.3)	0.05 (0-0.20)
50-114	6	6.00 (3-8)	509.9 (273.7-881.3)	53.37 (39.23-67.51)	177.8 (109.5-261.8)	50.2 (43.9-65.0)	95.5 (76-128)	217.2 (124.0-291.9)	0.23 (0-0.58)
>114	6	7.83 (7-9)	636.7 (352.7-824.5)	99.0 (35.2-150.3)	128.7 (69.7-172.1)	73.7 (48.6-107.7)	139.3 (118-186)	190.7 (51.3-331.1)	0.15 (0-0.35)
Disturbed Cottonwood									
<25	2	1.50 (1-2)	13.0 (5.9-20.0)	0.17 (0.07-0.26)	132.4 (0-264.8)	12.7*	18*	9.4 (0-18.9)	0
>25	5	5.20 (1-8)	154.4 (49.1-266.0)	25.58 (6.80-44.28)	170.0 (68.9-300)	57.5 (41.0-82.6)	112.4 (70-163)	86.7 (12.2-215.4)	0.07 (0.03-.02)
Non-cottonwood									
<25	4(3)*	5.00 (2-8)	30.9 (0-87.2)	2.56 (0-8.73)	28.4* (0-67.7)	52* (49.5-54.5)	57*	1.2 (0-2.4)	0.07* (0-0.11)
>25	9	6.40 (2-10)	401.1 (13.0-771.1)	27.54 (0.79-49.33)	9.8 (0-26.3)	99.3 (32-178)	99.3 (32-178)	2.5 (0-8.1)	0.03 (0-0.13)

*Stands without trees > 10 cm dbh were excluded from calculations.

Table 2.3. Summary of overstory (tree) stand characteristics, by age class, across river segments 8 and 9 (Fort Randall Dam to Lewis and Clark Reservoir). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Stand age (yrs)	# stands	# species	# trees/ha	Basal area (m^2/ha)	CW IV	Mean CW dbh	Max CW dbh	CW trees/ha	Prop vines
Cottonwood									
≤10	6(1)* (2)**	1*	1.8 (0-10.6)	0.03 (0-0.15)	300*	12.1*	19.0*	1.8 (0-10.6)	0
10-25	7(5)* (3)**	2.40* (1-4)	94.6 (0-470.0)	3.32 (0-19.14)	264.0* (204.5-300)	14.9* (11.9-20.3)	26.6* (15-40)	89.6 (0-452.4)	0.01 (0-0.02)
25-50	9(5)*	4.22* (2-7)	265.8 (28.3-1182.9)	15.26 (0.48-26.16)	189.4* (77.2-233.0)	28.6* (13.0-49.6)	58.4* (22-92)	145.1 (5.9-421.4)	0.05* (0.01-0.08)
50-114	10	6.90 (5-8)	607.6 (274.7-995.4)	61.11 (34.2-88.2)	124.8 (51.2-248.4)	60.8 (38.6-93.1)	121.2 (73-181)	160.6 (15.5-437.8)	0.08 (0-0.22)
>114	5	7.20 (5-9)	707.7 (389.3-996.6)	74.61 (29.2-140.5)	92.6 (62.4-148.6)	85.9 (52.8-140.3)	140.6 (80-183)	97.2 (24.9-281.1)	0.06 (0-0.16)
Disturbed Cottonwood									
>25	5(4)*	6.00* (4-8)	92.4 (48.3-195.5)	16.80 (12.49-21.64)	128.3* (48.3-224.1)	65.6* (57.1-77.2)	109.6* (82-127)	27.7 (8.3-50.4)	0.02* (0-0.08)
Non-cottonwood									
<25	1(0)*		0	0				0	
>25	9(8)**	5.44 (2-9)	450.6 (34.2-732.4)	24.00 (0.64-43.00)	13.1 (0-59.1)	54.5* (10.0-76.2)	71.3* (10-104)	7.4 (0-45.2)	0.04 (0-0.11)

*Stands without trees > 10 cm dbh were excluded from calculations.

**Number of stands sampled for vines.

Table 2.4. Summary of overstory (tree) stand characteristics, by age class, across river segment 6 (Oahe Dam to Big Bend Dam). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Stand age (yrs)	# stands	# species	# trees/ha	Basal area (m^2/ha)	CW IV	Mean CW dbh	Max CW dbh	CW trees/ha	Prop vines
Cottonwood									
10-25	1		0	0				0	
25-50	6(5*) (3)**	3.67* (3-5)	461.6 (18.9-985.5)	20.32 (1.34-43.99)	147.5* (0-264.4)	20.6* (13.6-25.5)	43.2* (22-65)	279.3 (0-660.6)	0.01 (0-0.025)
50-114	7(6)*	4.43* (3-7)	438.8 (269.5-685.9)	34.50 (10.64-46.60)	167.8* (79.8-243.2)	43.7* (17.6-71)	82* (44-129)	195.4 (60.0-460.4)	0.13* (0-0.29)
>114	2	6 (4-8)	438.0 (418.7-457.3)	56.69 (46.58-66.80)	130.8 (115.7-145.9)	70.2 (58.0-82.3)	140 (114-166)	97.9 (65.7-139.0)	0.05 (0.01-0.09)
Disturbed Cottonwood									
>25	4	5.75 (5-7)	56.2 (28.3-87.2)	12.60 (3.5-21.4)	144.2 (18.7-252.4)	59.8 (24-86.2)	94.5 (26-127)	28.6 (2.6-78.9)	0
Non-cottonwood									
>25	7(5)* (6)**	4.14* (3-5)	288.7 (52.7-739.6)	14.38 (3.27-46.37)	48.6* (0-103.6)	58.3* (20.13-102.5)	111* (73-131)	20.0 (0-84.9)	0.003 (0-0.01)

*Stands without trees > 10 cm dbh were excluded from calculations.

**Number of stands sampled for vines.

Table 2.5. Summary of overstory (tree) stand characteristics, by age class, across river segment 4 (Garrison Dam to upper end of Lake Oahe). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Stand age (yrs)	# stands	# species	# trees/ha	Basal area (m^2/ha)	CW IV	Mean CW dbh	Max CW dbh	CW trees/ha	Prop vines
Cottonwood									
≤10	6(0)*		0	0				0	
10-25	7	1.86 (1-6)	98.6 (19.5-237.7)	3.5 (0.17-17.26)	236.4 (71.6-300)	25.6 (10.5-102.4)	41.3 (12-138)	57.6 (12.9-212.4)	0.04 (0-0.26)
25-50	7	2.29 (1-5)	107.1 (23.3-229.3)	6.82 (0.74-16.7)	288.1 (271.5-300)	25.7 (18.7-31.6)	53 (34-66)	104.5 (22.6-222.1)	0
50-114	8	4.63 (3-9)	221.1 (68.9-391.8)	25.07 (12.68-32.19)	214.0 (103.6-292.2	49.3 (32.1-68.3)	102.1 (70-151.5)	136.1 (43.9-350)	0.06 (0-0.18)
>114	9	4.56 (2-8)	320.6 (144.0-467.1)	24.84 (16.9-36.87)	85.5 (0-214.7)	74.8 (49.7-82.3)	118.9 (80.5-151)	37.5 (0-103.2)	0.22 (0-0.35)
Disturbed Cottonwood									
>25	9	5 (3-7)	130.1 (16.1-291.9)	15.97 (4.55-30.53)	183.5 (62.8-249.2)	68.1 (38.6-109.8)	117.7 (67-165)	66.6 (5.1-231.6)	0.07 (0-0.22)
Non-cottonwood									
<25	6(0)*	0	0	0				0	
>25	14	4.2 (2-6)	372.5 (195.6-709.8)	18.59 (5.57-33.74)	20.2 (0-89.9)	80.4 (40.5-106.8)	103.6 (40.5-189)	5.0 (0-23.4)	0.08 (0-0.54)

*Stands without trees > 10 cm dbh were excluded from calculations.

Table 2.6. Summary of overstory (tree) stand characteristics, by age class, across river segment 2 (Fort Peck Dam to upper end of Sakakawea Reservoir). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Stand age (yrs)	# stands	# species	# trees/ha	Basal area (m^2/ha)	CW IV	Mean CW dbh	Max CW dbh	CW trees/ha	Prop vines
				Cottonwood					
≤10	6(0)*		0	0				0	
10-25	7(6)*	1.83* (1-3)	239.5 (0-574.1)	5.98 (0-13.32)	249.4* (111.4-300)	16.9* (11.6-27.8)	45.6* (11.6-27.8)	194.4 (0-562.4)	
25-50	5	2.80 (1-4)	310.7 (72.8-654.3)	10.98 (2.41-21.78)	266.7 (231.6-300)	19.5 (16.4-24.4)	63.6 (43-104)	300.8 (55.7-654.3)	0 (0-0)
50-114	6	4.00 (4-7)	147.9 (83.4-207.4)	22.51 (13.15-34.03)	201.3 (124.6-258.9)	49.6 (40.3-63.0)	92.4 (75.5-104.5)	88.5 (47.9-131.5)	0.01 (0-0.04)
>114	6	3.17 (2-5)	321.0 (19.9-889.8)	29.85 (7.92-67.45)	137.2 (79.9-220.4)	80.4 (59.4-97.0)	120.0 (71.5-170)	40.9 (12.7-66.9)	0 (0-0)

*Stands without trees > 10 cm dbh were excluded from calculations.

Table 2.7. Summary of overstory (tree) stand characteristics, by age class, across river segment 0 (Wild and Scenic reach, Fort Benton to upper end of Fort Peck Lake). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Stand age (yrs)	# stands	# species	# trees/ha	Basal area (m^2/ha)	CW IV	Mean CW dbh	Max CW dbh	CW trees/ha	Prop vines
Cottonwood									
≤10	7(0)*		0	0				0	0
10-25	4	1.75 (1-2)	417.0 (112-588)	8.23 (2.36-12.85)	282.1 (238.8-300)	15.1 (14.3-16.0)	33.4 (29.5-38.5)	402.4 (110-588)	0
25-50	6	2.17 (1-4)	419.0 (120-770.8)	33.62 (11.99-73.39)	280.9 (231.8-300)	30.0 (24.2-37.6)	63.8 (50-89)	398.5 (120-758.3)	0.001 (0-.005)
50-114	6	3.17 (1-6)	263.4 (91.5-563.3)	42.10 (13.23-24.87)	251.6 (188.4-300)	44.1 (36.1-56.4)	96 (62-164)	203.9 (85.6-447.5)	0.007 (0-0.02)
>114	6	2.67 (1-5)	90.6 (20.6-257.5)	21.61 (6.74-37.63)	255.8 (137.9-300)	64.8 (46.0-77.3)	133.6 (121.5-159.5)	53.8 (18.8-88)	0.004 (0-0.02)

*Stands without trees > 10 cm dbh were excluded from calculations.

Table 3.1. Summary of shrub data, by age class, across river segment 13 (Plattsmouth, Nebraska to Kansas City). Numbers are means, with range of stand values (minimum – maximum) in parentheses. Note that for shrub IV, scores have been scaled to 100% (instead of 300 as with the tree data).

Stand age (yrs)	# stands	# species	Shrub Cover	Shrub Density	Exotic Species	Native Species	Exotic Cover	Natural Cover	Exotic Shrub IV	Native Shrub IV
Cottonwood										
≤10	6	1.8 (1-3)	0.39 (0.03-1.11)	4715 (708-9208)	0.17 (0-1)	1.67 (1-3)	0.0001 (0-0.0008)	0.39 (0.03-1.11)	1.5 (0-8.9)	98.5 (91.1-100)
10-25	6	2.5 (1-4)	0.57 (0.38-0.98)	3542 (1500-7708)	0.17 (0-1)	2.33 (1-4)	0.02 (0-0.14)	0.55 (0.25-0.98)	4.6 (0-27.6)	95.4 (72.4-100)
25-50	6	5.2 (3-13)	0.39 (0.07-0.90)	2549 (167-6208)	0.50 (0-1)	4.50 (2-11)	0.04 (0-0.23)	0.35 (0.06-0.67)	7.2 (0-20.9)	92.6 (79.2-100)
50-114	6	3.0 (1-6)	0.20 (0.07-0.22)	632 (167-1208)	0.33 (0-1)	2.67 (0-6)	0.02 (0-0.07)	0.18 (0-0.33)	26.0 (0-100)	74.0 (0-100)
>114	6	4.0 (1-6)	0.23 (0.09-0.53)	715 (167-1542)	0.17 (0-1)	3.83 (1-6)	0.0001 (0-0.0008)	0.23 (0.09-0.53)	1.7 (0-10.0)	98.3 (90.0-100)
Disturbed Cottonwood										
Unknown	6	2.0 (0-4)	0.13 (0-0.46)	715 (0-3208)	0	2.00 (0-4)	0	0.13 (0-0.46)	0	83.3 (0-100)
Non-cottonwood										
Unknown	12	3.6 (0-13)	0.54 (0-1.17)	5701 (0-21542)	0.17 (0-1)	3.33 (0-11)	0.008 (0-0.09)	0.53 (0-1.17)	1.51 (0-14.34)	90.3 (0-100)

Table 3.2. Summary of shrub data, by age class, across river segment 10 (Gavins Point Dam to Ponca, Nebraska). Numbers are means, with range of stand values (minimum – maximum) in parentheses. Note that for shrub IV, scores have been scaled to 100% (instead of 300 as with the tree data).

Stand age (yrs)	# stands	# species	Shrub Cover	Shrub Density	Exotic Species	Native Species	Exotic Cover.	Natural Cover	Exotic Shrub IV	Native Shrub IV
Cottonwood										
≤10	6	4.3 (1-7)	0.31 (0.18-0.48)	10549 (7042-14500)	0.17 (0-1)	4.17 (1-7)	0.003 (0-0.017)	0.30 (0.18-0.48)	1.2 (0-7.3)	98.8 (92.7-100)
10-25	7	5 (3-9)	0.29 (0.09-0.66)	5815 (583-15750)	0.43 (0-2)	4.57 (2-7)	0.003 (0-0.019)	0.29 (0.07-0.66)	2.7 (0-12.6)	97.3 (87.4-100)
25-50	7	6.3 (2-9)	0.31 (0.02-0.75)	4065 (375-5833)	0.57 (0-1)	5.71 (2-8)	0.01 (0-0.03)	0.30 (0.02-0.75)	2.1 (0-5.2)	97.9 (94.8-100)
50-114	6	7.5 (1-15)	0.72 (0.31-1.05)	8611 (3833-17333)	0.67 (0-2)	6.83 (1-13)	0.19 (0-0.68)	0.52 (0.31-0.86)	19.2 (0-64.6)	80.8 (35.4-100)
>114	6	6.3 (2-10)	0.66 (0.29-0.92)	8597 (3125-14083)	1.66 (1-2)	4.66 (1-9)	0.37 (0.03-0.88)	0.29 (0.02-0.49)	58.1 (11.0-94.5)	41.9 (5.5-89.0)
Disturbed Cottonwood										
<25	2	2 (2-2)	0.14 (0.12-0.15)	1688 (958-2417)	0	2.00 (2-2)	0	0.14 (0.12-0.15)	0	100 (100-100)
>25	5	1.6 (0-3)	0.16 (0-0.50)	1817 (333-1425)	0.40 (0-1)	1.20 (0-2)	0.006 (0-0.026)	0.16 (0-0.50)	14.9 (0-68.4)	65.1 (0-100)
Non-cottonwood										
<25	4	4.5 (1-7)	0.26 (0.07-0.60)	2604 (292-5083)	0.75 (0-1)	3.75 (0-6)	0.02 (0-0.07)	0.24 (0-0.60)	29.1 (0-100)	70.9 (0-100)
>25	9	3 (1-6)	0.31 (0-0.81)	2565 (42-10083)	0.67 (0-3)	2.33 (0-6)	0.14 (0-0.78)	0.16 (0-0.43)	38.8 (0-100)	57.5 (0-100)

Table 3.3. Summary of shrub data, by age class, across river segments 8 and 9 (Fort Randall Dam to Lewis and Clark Reservoir). Numbers are means, with range of stand values (minimum – maximum) in parentheses. Note that for shrub IV, scores have been scaled to 100% (instead of 300 as with the tree data).

Stand age (yrs)	# stands	# species	Shrub Cover	Shrub Density	Exotic Species	Native Species	Exotic Cover.	Natural Cover	Exotic Shrub IV	Native Shrub IV
Cottonwood										
≤10	6	2.8 (2-4)	0.27 (0.04-0.63)	13507 (4458-36417)	0.17 (0-1)	2.67 (1-4)	0 (0-0)	0.27 (0.04-0.63)	0.9 (0-5.3)	99.1 (94.7-100.0)
10-25	7	3.9 (2-6)	0.35 (0.08-0.75)	11976 (750-31792)	0.29 (0-1)	3.57 (2-5)	0.001 (0-0.005)	0.35 (0.08-0.75)	1.4 (0-5.2)	98.6 (94.8-100.0)
25-50	9	3.6 (2-6)	0.22 (0.01-0.47)	3981 (375-5833)	0.33 (0-1)	3.22 (1-5)	0.01 (0-.07)	0.21 (0.01-0.47)	5.7 (0-24.2)	94.3 (75.8-100.0)
50-114	10	5.7 (1-14)	0.31 (0.02-0.76)	3342 (42-10583)	0.80 (0-2)	4.90 (1-12)	0.02 (0-0.05)	0.29 (0.02-0.76)	6.8 (0-28.4)	93.2 (71.6-100.0)
>114	5	5.4 (3-11)	0.30 (0.16-0.51)	2100 (667-4292)	1.40 (0-4)	4.00 (3-7)	0.06 (0-0.11)	0.25 (0.08-0.43)	19.6 (0-42.1)	80.4 (57.9-100.0)
Disturbed Cottonwood										
>25	5(2)*	1.4* (0-6)	0.02 (0-0.09)	133 (0-625)	0* (0-0)	1.40* (0-6)	0 (0-0)	0.02 (0-0.09)	0* (0-0)	40.0* (0-100.0)
Non-cottonwood										
<25	1	1.0	0.03	250	1.00	0	0.03	0	100.0	0
>25	9 (8)*	3.0* (0-7)	0.16 (0-0.44)	1222 (0-3292)	0.33* (0-1)	2.67* (0-6)	0.07 (0-0.43)	0.09 (0-0.25)	18.1* (0-95.9)	70.8* (0-100.0)

*Sites with no shrubs were excluded from analysis.

Table 3.4. Summary of shrub data, by age class, across river segment 6 (Oahe Dam to Big Bend Dam). Numbers are means, with range of stand values (minimum – maximum) in parentheses. Note that for shrub IV, scores have been scaled to 100% (instead of 300 as with the tree data).

Stand age (yrs)	# stands	# species	Shrub Cover	Shrub Density	Exotic Species	Native Species	Exotic Cover.	Natural Cover	Exotic Shrub IV	Native Shrub IV
Cottonwood										
10-25	1	2.0	0.29	2750	0	2.00	0	0.29	0	100 (100-100)
25-50	6	4.6 (1-10)	0.33 (0.04-0.63)	6215 (250-23625)	1.16 (0-2)	3.50 (1-8)	0.06 (0-0.16)	0.28 (0-0.59)	31.5 (0-80.1)	68.5 (19.9-100)
50-114	7	5.4 (3-8)	0.18 (0.04-0.38)	2553 (833-9167)	1.28 (0-3)	4.14 (2-7)	0.06 (0-0.26)	0.12 (0.04-0.17)	23.6 (0-60.7)	76.4 (39.3-100)
>114	2	4.5 (3-6)	0.15 (0.12-0.17)	1500 (792-2208)	1.50 (1-2)	3.00 (2-4)	0.03 (0.01-0.06)	0.12 (0.11-0.12)	19.4 (14.5-24.3)	80.6 (75.7-85.5)
Disturbed Cottonwood										
>25	4	0	0	0	0	0	0	0	0	0
Non-cottonwood										
>25	7	2.4 (1-5)	0.10 (0.02-0.31)	708 (208-1708)	0.71 (0-2)	1.71 (0-4)	0.07 (0-0.25)	0.03 (0-0.06)	46.7 (0-100	53.3 (0-100)

Table 3.5. Summary of shrub data, by age class, across river segment 4 (Garrison Dam to upper end of Lake Oahe). Numbers are means, with range of stand values (minimum – maximum) in parentheses. Note that for shrub IV, scores have been scaled to 100% (instead of 300 as with the tree data).

Stand age (yrs)	# stands	# species	Shrub Cover	Shrub Density	Exotic Species	Native Species	Exotic Cover.	Natural Cover	Exotic Shrub IV	Native Shrub IV
Cottonwood										
≤10	6	2.2 (1-5)	0.27 (0-0.66)	9472 (83-21417)	0.16 (0-1)	2.00 (1-4)	0.005 (0-0.03)	0.26 (0-0.65)	0.5 (0-3.2)	93.9 (66.7-100)
10-25	7	4.6 (1-8)	0.26 (0.02-0.53)	6494 (83-13458)	0.43 (0-2)	4.14 (1-7)	0.01 (0-0.07)	0.24 (0.02-0.51)	4.4 (0-27.8)	95.6 (72.2-100)
25-50	7	3.1 (0-7)	0.07 (0-0.21)	1232 (0-4667)	0.29 (0-1)	2.86 (0-7)	0.29 (0-1)	0.07 (0-0.21)	26.0 (0-100)	59.7 (0-100)
50-114	8	2.4 (0-4)	0.19 (0-0.88)	1469 (0-5583)	0.38 (0-4)	2.00 (0-4)	0.09 (0-0.50)	0.09 (0-0.38)	20.1 (0-100)	59.1 (0-100)
>114	9	6.8 (0-13)	0.23 (0-0.76)	2644 (0-12083)	0.44 (0-2)	6.22 (0-12)	0.06 (0-0.46)	0.18 (0-0.44)	7.3 (0-54)	81.1 (0-100)
Disturbed Cottonwood										
>25	9	4.7 (0-11)	0.05 (0-0.16)	630 (0-1958)	0.44 (0-2)	4.22 (0-9)	0.01 (0-0.04)	0.04 (0-0.12)	11.4 (0-73.3)	62.7 (0-100)
Non-cottonwood										
<25	6	4.0 (2-5)	0.23 (0.06-0.34)	13333 (3417-20542)	0.17 (0-1)	3.67 (2-5)	0.004 (0-0.02)	0.22 (0.06-0.34)	1.3 (0-7.6)	98.3 (94.4-100)
>25	14	4.5 (1-11)	0.12 (0.03-0.34)	1542 (83-3500)	0.36 (0-2)	4.07 (1-9)	0.0001 (0-0.002)	0.12 (0.03-0.34)	0.7 (0-3.1)	98.8 (93.6-100)

Table 3.6. Summary of shrub data, by age class, across river segment 2 (Fort Peck Dam to upper end of Sakakawea Reservoir). Numbers are means, with range of stand values (minimum – maximum) in parentheses. Note that for shrub IV, scores have been scaled to 100% (instead of 300 as with the tree data).

Stand age (yrs)	# stands	# species	Shrub Cover	Shrub Density	Exotic Species	Native Species	Exotic Cover.	Natural Cover	Exotic Shrub IV	Native Shrub IV
Cottonwood										
≤10	6	2.2 (1-3)	0.01 (0-0.04)	13924 (4375-31833)	0 (0-0)	2.17 (1-3)	0 (0-0)	0.01 (0-0.04)	0 (0-0)	77.8 (66.7-100)
10-25	7	1.9 (1-3)	0.05 (0-0.18)	2768 (167-8875)	0.14 (0-1)	1.71 (1-3)	0 (0-0)	0.05 (0-0.18)	3.6 (0-25)	86.9 (66.7-100)
25-50	5	2.6 (1-6)	0.16 (0.01-0.54)	4042 (42-14375)	0.20 (0-1)	2.40 (1-5)	0 (0-0)	0.16 (0.01-0.54)	0.4 (0-1.9)	99.6 (98.1-100)
50-114	6	3.3 (1-6)	0.03 (0-0.10)	847 (42-1958)	0 (0-0)	3.33 (1-6)	0 (0-0)	0.03 (0-0.10)	0 (0-0)	88.9 (66.7-100)
>114	6	0.3 (0-4)	0.08 (0-0.23)	1313 (0-4292)	0 (0-0)	2.33 (0-4)	0 (0-0)	0.08 (0-0.23)	0 (0-0)	83.3 (0-100)

Table 3.7. Summary of shrub data, by age class, across river segment 0 (Wild and Scenic reach, Fort Benton to upper end of Fort Peck Lake). Numbers are means, with range of stand values (minimum – maximum) in parentheses. Note that for shrub IV, scores have been scaled to 100% (instead of 300 as with the tree data).

Stand age (yrs)	# stands	# species	Shrub Cover	Shrub Density	Exotic Species	Native Species	Exotic Cover.	Natural Cover	Exotic Shrub IV	Native Shrub IV
Cottonwood										
≤10	7	3.3 (2-7)	0.16 (0-0.60)	17649 (958-52333)	0 (0-0)	3.29 (2-7)	0 (0-0)	0.16 (0-0.60)	0 (0-0)	80.1 (60.9-100.0)
10-25	4	2.0 (0-5)	0.18 (0-0.56)	6542 (0-24583)	0.25 (0-1)	1.75 (0-5)	0.01 (0-0.05)	0.17 (0.1-0.5)	8.9 (0-5.5)	57.8 (0-100.0)
25-50	6	1.8 (0-4)	0.02 (0-0.07)	347 (0-750)	0.33 (0-1)	1.50 (0-4)	0.01 (0-.07)	0.008 (0-0.03)	31.8 (0-100.0)	46.0 (0-100.0)
50-114	6	3.0 (1-5)	0.02 (0-0.06)	2132 (292-6958)	0 (0-0)	3.00 (1-5)	0 (0-0)	0.02 (0-0.06)	0 (0-0)	94.4 (66.7-100.0)
>114	6	2.5 (1-6)	0.06 (0-0.25)	1653 (42-7250)	0.17 (0-1)	2.33 (0-6)	0.003 (0-0.2)	0.05 (0-0.25)	16.7 (0-100.0)	77.8 (0-100.0)

Table 4.1. Summary of herbaceous quadrat data, by stand age class, across river segment 13 (Plattsmouth, Nebraska to Kansas City). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Stand age (yrs)	# stands	# species	Native species	Exotic species	Mean herb cover (%)	Relative cover native herbs (%)	Relative cover exotic herbs (%)	Mean C weighted by relative cover	Mean W weighted by relative cover	FQI (herbs only)
Cottonwood										
≤10	6	21.2 (15-40)	14.3 (11-24)	6.0 (2-16)	86.3 (39.1-127.4)	79.4 (40.3-98.8)	24.1 (1.2-59.6)	2.99 (1.51-5.86)	3.29 (2.33-4.56)	7.7 (6.3-8.9)
10-25	6	20.7 (13-32)	15.7 (9-25)	3.8 (2-5)	50.9 (26.6-68.2)	64.3 (23.1-70.0)	31.6 (0.9-76.9)	1.93 (0.38-3.72)	3.43 (1.72-4.41)	8.2 (6.7-11.5)
25-50	6	23.2 (13-33)	18 (10-27)	4.7 (1-9)	73.2 (26.6-125.6)	80.4 (49.1-99.4)	24.2 (0.6-50.9)	2.18 (1.48-3.89)	3.17 (2.61-3.96)	10.5 (6.9-14.3)
50-114	6	17 (13-20)	13 (11-16)	3.7 (1-6)	35.2 (20.5-74.8)	82.1 (40.5-98.4)	17.7 (46.8-83.5)	2.57 (1.28-3.79)	3.29 (3.16-3.54)	9.6 (6.6-11.9)
>114	6	17.7 (12-20)	14 (9-16)	2.5 (2-3)	30.2 (17.2-39.6)	83.5 (50.3-96.6)	15.5 (3.2-44.4)	2.35 (1.95-2.79)	3.12 (2.32-3.90)	10.0 (8.3-11.6)
Disturbed Cottonwood										
Unknown	6	16.8 (12-23)	13.7 (8-20)	2.8 (2-5)	64.9 (18.2-113.2)	51.0 (7-96.7)	46.5 (3.3-97.3)	1.49 (0.17-2.90)	3.75 (2.15-4.70)	8.9 (5.0-11.5)
Non-cottonwood										
Unknown	12	24.5 (12-55)	19.6 (9-43)	4.3 (1-9)	68.0 (21.0-132.5)	76.5 (27.0-106.4)	26.4 (3.2-73.0)	2.51 (0.62-3.96)	3.62 (2.26-4.23)	10.8 (6.9-17.8)

Table 4.2. Summary of herbaceous quadrat data, by stand age class, across river segment 10 (Gavins Point Dam to Ponca, Nebraska). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Stand age (yrs)	# stands	# species	Native species	Exotic species	Mean herb cover (%)	Relative cover native herbs (%)	Relative cover exotic herbs (%)	Mean C weighted by relative cover	Mean W weighted by relative cover	FQI (herbs only)
Cottonwood										
≤10	6	30.5 (14-45)	26.8 (12-40)	3.3 (2-4)	29.4 (18.4-54.9)	88.4 (84.4-94.6)	11.5 (5.4-15.6)	3.25 (2.27-4.07)	2.58 (2.03-3.51)	15.4 (9.9-19.5)
10-25	7	32.4 (16-41)	29 (15-36)	3.3 (0-8)	31.2 (22-44)	93.1 (72.1-100)	6.8 (0-27.9)	2.9 (2.2-4.4)	2.7 (1.9-3.1)	16.1 (10.8-18.8)
25-50	7	39.1 (22-57)	34.6 (22-51)	4.4 (0-8)	31.3 (17.4-49.5)	85.3 (76.5-100)	14.5 (0-22.6)	2.98 (2.59-4.22)	2.73 (2.08-3.10)	18.9 (11.6-25.4)
50-114	6	33 (20-43)	27.3 (13-36)	5.5 (4-7)	33.3 (18.3-47.1)	79.6 (26.2-95.3)	20.2 (4.7-72.7)	3.3 (0.94-4.53)	2.5 (2.09-2.97)	17.9 (9.0-23.8)
>114	6	33 (26-41)	26 (22-30)	6.6 (2-11)	29.75 (22.2-43.0)	69.8 (31.1-74.2)	30.0 (9.7-68.9)	2.7 (1.05-3.89)	2.34 (2.08-2.49)	17.8 (16-20.2)
Disturbed Cottonwood										
<25	2	15.5 (10-21)	11.5 (8-15)	3.5 (1-6)	37.8 (35.1-40.4)	69.9 (64.2-75.8)	19.6 (15.1-24.2)	1.79 (1.03-2.55)	2.15 (1.95-2.35)	6.8 (6.3-7.3)
>25	5	24.6 (14-40)	19 (9-34)	5.6 (4-7)	55.6 (38.1-78.3)	40.1 (7.3-65.7)	59.9 (34.3-92.7)	1.41 (0.22-2.26)	1.79 (1.16-2.11)	12.2 (6.4-20.1)
Non-cottonwood										
<25	4	26 (19-37)	18.3 (5-11)	7.3 (5-11)	54.9 (37.7-67.8)	60.3 (50.5-73.9)	39.6 (26.0-49.4)	1.57 (1.08-1.94)	2.53 (2.29-3.09)	10.0 (9.0-11.3)
>25	9	31.7 (18-47)	24.7 (14-39)	6.4 (3-11)	63.3 (28.8-97.6)	63.6 (16.5-92.6)	36.2 (7.4-83.5)	2.63 (0.71-4.53)	2.23 (1.98-2.74)	16.6 (10.1-24.1)

Table 4.3. Summary of herbaceous quadrat data, by stand age class, across river segments 8 and 9 (Fort Randall Dam to Lewis and Clark Reservoir). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Stand age (yrs)	# stands	# species	Native species	Exotic species	Mean herb cover (%)	Relative cover native herbs (%)	Relative cover exotic herbs (%)	Mean C weighted by relative cover	Mean W weighted by relative cover	FQI (herbs only)
Cottonwood										
≤10	6	20.7 (14-31)	17.7 (11-26)	2.8 (2-5)	25.1 (14.3-34.0)	84.7 (71.0-98.0)	14.9 (2.0-29.0)	2.18 (1.38-3.60)	2.81 (2.57-3.15)	9.3 (3.6-15.4)
10-25	7	26.1 (16-35)	20.6 (12-26)	5.3 (2-9)	43.9 (15.1-85.6)	76.9 (47.2-90.1)	23.0 (9.9-52.7)	1.88 (1.05-2.49)	2.70 (1.93-3.85)	11.0 (7.5-13.6)
25-50	9	28.6 (20-44)	23.1 (14-37)	5.0 (3-7)	33.4 (15.8-52.5)	80.3 (21.8-94.1)	19.2 (5.9-78.3)	2.43 (0.70-3.78)	2.60 (1.58-3.56)	13.4 (5.5-17.9)
50-114	10	34.3 (19-45)	27.7 (17-37)	6.2 (2-9)	35.6 (21.7-70.4)	73.0 (31.4-95.5)	26.7 (4.5-68.6)	2.66 (0.82-4.45)	2.44 (1.71-3.01)	17.7 (13.4-21.8)
>114	5	33.8 (23-44)	26.8 (18-35)	6.0 (4-8)	50.1 (38.5-64.8)	86.4 (81.6-93.9)	12.3 (5.7-17.9)	3.58 (3.26-3.82)	2.44 (2.15-2.62)	18.2 (15.5-20.1)
Disturbed Cottonwood										
>25	5	22.8 (7-57)	15.0 (4-40)	7.2 (3-16)	73.1 (55.1-93.3)	20.9 (1.1-58.3)	78.5 (41.6-98.9)	0.62 (0.32-2.51)	1.67 (1.11-2.13)	7.7 (2.4-21.9)
Non-cottonwood										
<25	1	16.0	12.0	4.0	67.3	63.8	36.2	1.88	2.13	8.3
>25	9	26.2 (6-38)	18.4 (4-29)	7.0 (2-11)	65.7 (35.3-84.9)	49.3 (1.1-84.1)	50.2 (15.7-98.9)	2.18 (0.38-3.59)	1.78 (1.01-2.76)	12.7 (6.3-19.2)

Table 4.4. Summary of herbaceous quadrat data, by stand age class, across river segment 6 (Oahe Dam to Big Bend Dam). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Stand age (yrs)	# stands	# species	Native species	Exotic species	Mean herb cover (%)	Relative cover native herbs (%)	Relative cover exotic herbs (%)	Mean C weighted by relative cover	Mean W weighted by relative cover	FQI (herbs only)
Cottonwood										
10-25	1	10	8	2	31.0	89.4	10.6	0.47	2.96	4.3
25-50	6	23.2 (12-33)	14 (6-23)	9 (6-11)	55.3 (29.6-69.5)	30.2 (6.6-64.4)	69.7 (35.6-93.4)	1.07 (0.22-2.10)	1.94 (1.45-2.45)	8.8 (4.9-12.7)
50-114	7	32.6 (21-40)	21.7 (13-27)	10.3 (8-14)	52.2 (35.8-81.6)	58.3 (33.0-85)	41.4 (14.5-66.8)	1.84 (0.75-3.28)	2.27 (1.89-2.68)	12.1 (8.1-15.5)
>114	2	21.5 (17-26)	12 (9-15)	9 (8-10)	36.7 (29.4-44.0)	28.7 (13.4-44.1)	71.1 (55.7-86.6)	0.45 (0.34-0.57)	1.61 (1.29-1.94)	7.5 (6.1-9.0)
Disturbed Cottonwood										
>25	4	8.5 (5-12)	2.5 (1-4)	5.5 (4-7)	75.3 (46.8-97.9)	2.7 (0.04-7.5)	96.9 (92.4-100)	0.10 (0.002-0.26)	1.99 (1.92-2.05)	2.3 (1.3-3.5)
Non-cottonwood										
>25	7	16.3 (10-24)	8.3 (4-13)	7.6 (5-10)	68.7 (21.9-90.4)	14.5 (0.5-44.8)	85.5 (55.2-99.5)	0.37 (0.005-1.40)	1.54 (1.08-2.83)	4.8 (1.5-6.8)

Table 4.5. Summary of herbaceous quadrat data, by stand age class, across river segment 4 (Garrison Dam to upper end of Lake Oahe). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Stand age (yrs)	# stands	# species	Native species	Exotic species	Mean herb cover (%)	Relative cover native herbs (%)	Relative cover exotic herbs (%)	Mean C weighted by relative cover	Mean W weighted by relative cover	FQI (herbs only)
Cottonwood										
≤10	6	23.0 (12-33)	16.2 (9-25)	6.3 (3-12)	29.3 (4.2-63.6)	58.0 (24.8-96.9)	41.6 (2.9-75.2)	1.73 (0.72-2.71)	2.78 (1.98-4.04)	9.0 (6.6-14.3)
10-25	7	33.3 (21-53)	24.7 (14-41)	7.9 (7-10)	63.1 (24.3-96.2)	49.6 (31.5-74.7)	50.1 (24.4-68.5)	1.79 (1.03-3.01)	2.40 (2.02-2.61)	16.4 (11.2-22.9)
25-50	7	34.9 (21-57)	28 (14-48)	6.6 (4-10)	70.1 (58.1-98.0)	44.2 (22.1-77.3)	55.7 (22.3-77.9)	1.35 (0.68-2.64)	2.24 (1.53-3.05)	18.6 (11.9-26.3)
50-114	8	34.5 (26-43)	26.3 (16-31)	7.6 (5-11)	79.2 (56.9-113.5)	26.7 (3.2-54.3)	75.1 (45.7-96.8)	0.94 (0.14-1.77)	1.66 (1.18-2.05)	19.1 (13.6-22.4)
>114	9	40 (15-53)	30.1 (8-44)	9 (3-15)	86.3 (56.5-106.5)	37.6 (2.2-78)	63.0 (28.5-97.8)	1.54 (0.08-3.32)	1.82 (1.30-2.41)	21.1 (7.5-31.0)
Disturbed Cottonwood										
>25	9	32.9 (22-49)	21.9 (10-35)	10.1 (2-18)	78.6 (34.4-105.9)	28.3 (2.9-60.3)	72.2 (45.3-96.5)	0.84 (0.06-2.01)	1.94 (1.15-2.57)	14.8 (5.0-22.8)
Non-cottonwood										
<25	6	38.3 (22-72)	27.8 (15-55)	9.3 (5-15)	62.2 (32.5-90.6)	64.1 (35.9-91.4)	35.7 (7.7-64.1)	1.93 (1.43-2.34)	2.95 (2.36-3.56)	13.0 (7.7-20.4)
>25	14	35.8 (7-54)	25.8 (3-43)	8.6 (4-11)	81.5 (63.8-106.7)	36.8 (0.2-79.4)	62.8 (15.9-99.9)	1.32 (0.01-3.75)	1.76 (1.07-2.84)	18.4 (5.3-30.4)

Table 4.6. Summary of herbaceous quadrat data, by stand age class, across river segment 2 (Fort Peck Dam to upper end of Sakakawea Reservoir). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Stand age (yrs)	# stands	# species	Native species	Exotic species	Mean herb cover (%)	Relative cover native herbs (%)	Relative cover exotic herbs (%)	Mean C weighted by relative cover	Mean W weighted by relative cover	FQI (herbs only)
Cottonwood										
≤10	6	32.0 (22-40)	22.3 (17-30)	7.2 (5-11)	42.2 (22.5-64.0)	60.1 (33.9-89.3)	37.1 (6.7-64.2)	2.12 (1.22-3.57)	2.90 (2.36-3.93)	13.4 (11.2-16.3)
10-25	7	25.0 (17-33)	16.1 (9-21)	7.6 (5-11)	31.4 (11.7-58.6)	44.3 (17.4-65.0)	54.9 (34.6-81.6)	1.32 (0.43-2.31)	2.45 (1.77-3.29)	11.7 (6.1-14.7)
25-50	5	28.8 (22-35)	18.6 (16-21)	8.0 (5-11)	27.0 (13.5-43.2)	31.6 (25-44.4)	67.2 (55.4-74.7)	1.01 (0.78-1.45)	2.30 (1.84-3.19)	12.9 (10.8-14.8)
50-114	6	26.2 (21-30)	17.0 (15-19)	7.2 (5-9)	58.3 (33.4-88.3)	46.6 (9.2-85.1)	53.0 (14.7-90.4)	1.57 (0.44-2.72)	1.62 (1.39-1.78)	13.6 (12.2-14.4)
>114	6	28.8 (18-43)	16.8 (8-24)	11.0 (8-16)	50.3 (21.6-79.1)	45.0 (5.3-93.8)	54.7 (6.0-94.7)	1.56 (0.21-3.11)	2.10 (1.25-4.49)	11.7 (6.8-14.1)

Table 4.7. Summary of herbaceous quadrat data, by stand age class, across river segment 0 (Wild and Scenic reach, Fort Benton to upper end of Fort Peck Lake). Numbers are means, with range of stand values (minimum – maximum) in parentheses.

Stand age (yrs)	# stands	# species	Native species	Exotic species	Mean herb cover (%)	Relative cover native herbs (%)	Relative cover exotic herbs (%)	Mean C weighted by relative cover	Mean W weighted by relative cover	FQI (herbs only)
Cottonwood										
≤10	7	30.3 (18-44)	20 (11-30)	8.3 (2-12)	70.7 (23.5-118.8)	62.9 (35.3-90.1)	38.5 (8.0-64.0)	1.87 (1.03-2.99)	3.54 (2.94-4.26)	13.1 (7.1-19.4)
10-25	4	28.5 (15-39)	15 (7-23)	12.8 (8-15)	52.6 (34.46-85.58)	17.8 (8.3-43.0)	81.1 (54.8-91.7)	0.47 (0.29-0.89)	1.89 (1.37-2.72)	9.6 (6.5-13)
25-50	6	27.2 (21-35)	14.3 (10-20)	11.8 (11-14)	59.4 (40.6-83.8)	40.7 (17.8-65.0)	58.7 (35.0-82.1)	1.58 (0.74-2.80)	1.93 (1.50-2.14)	11.8 (8.7-14.1)
50-114	6	26. 3 (22-30)	13.8 (11-18)	10.7 (8-13)	72.8 (59.5-94.6)	40.5 (4.8-65.7)	58.2 (32.5-95.1)	1.44 (0.19-2.29)	1.76 (1.41-2.09)	12.4 (10.2-14.7)
>114	6	24.2 (18-33)	11.3 (7-18)	11.7 (9-14)	74.8 (52.8-101.6)	50.0 (37.6-67.2)	49.2 (32.3-62.4)	1.80 (1.19-2.46)	1.82 (1.39-2.73)	9.9 (6.8-13.0)

Table 5.1. Summary of stand-level data on species richness, native and exotic abundance, floristic quality, and wetland affinity, by cottonwood forest age class on river segment 13. Numbers are means within each stand age class, with range (low and high stand values) in parentheses.

Stand age (yrs)	# stands	Total species	Native species	Exotic species	% native	% exotic	Mean C	Mean W	FQI
Cottonwood									
≤10	6	22.3 (15-41)	15.5 (11-25)	6 (2-16)	71.4 (60.9-88.9)	23.9 (11.1-39.0)	1.9 (1.1-2.8)	2.9 (2.3-3.6)	8.7 (6.9-11.8)
10-25	6	22 (13-34)	16.7 (9-25)	4.2 (2-6)	75.7 (60-85)	19.8 (15-33.3)	1.9 (1.8-2.3)	3.2 (2.4-3.7)	9 (6.7-11.7)
25-50	6	29.3 (19-45)	23.7 (15-37)	5 (1-9)	81.4 (75-95.5)	16.7 (4.5-25)	2.5 (2.1-3.5)	3.1 (2.7-3.4)	13.5 (9.2-19.2)
50-114	6	23.3 (21-26)	19.2 (17-22)	3.8 (1-7)	82.4 (68-95.2)	16.2 (4.8-28)	2.7 (1.8-3.2)	3.2 (2.8-3.7)	12.8 (8.8-14.9)
>114	6	24.5 (19-28)	20.2 (16-22)	3.2 (2-5)	82.6 (73.1-91.3)	12.7 (8.7-17.9)	2.8 (2.4-3.1)	3.2 (3-3.5)	13.7 (12.1-14.4)
Disturbed Cottonwood									
Unknown	6	21.8 (18-31)	18.7 (14-28)	2.8 (2-5)	84.8 (73.7-91.7)	13.5 (8.3-26.3)	2.5 (1.8-2.8)	3.2 (2.6-3.4)	11.8 (8.0-15.1)
Non-cottonwood									
Unknown	12	30.8 (14-59)	25.3 (12-47)	4.8 (2-9)	82.4 (72.2-91.7)	15.3 (8.3-22.2)	2.6 (2-3.1)	3.3 (2.4-4.2)	13.8 (8.5-20.5)

Table 5.2. Summary of stand-level data on species richness, native and exotic abundance, floristic quality, and wetland affinity, by cottonwood forest age class on river segment 10. Numbers are means within each stand age class, with range (low and high stand values) in parentheses.

Stand age (yrs)	# stands	Total species	Native species	Exotic species	% native	% exotic	Mean C	Mean W	FQI
Cottonwood									
≤10	6	31.3 (14-48)	27.5 (12-42)	3.5 (2-5)	87.6 (85.3-91.4)	11.6 (8.6-14.3)	2.9 (2.4-3.4)	2.7 (2.5-3.2)	16.0 (10.4-20.5)
10-25	7	34.9 (18-42)	30.6 (16-37)	4.1 (1-10)	88.3 (76.2-97.4)	11.4 (2.6-23.8)	2.9 (2.5-3.3)	2.5 (2.1-2.9)	16.8 (10.8-19.5)
25-50	7	41.4 (24-60)	36 (24-54)	5.3 (0-9)	87.6 (80-100)	12.1 (0-20)	3.0 (2.4-3.5)	2.4 (2-2.8)	19.6 (11.9-26.9)
50-114	6	35.3 (23-46)	29.7 (16-39)	5.5 (4-7)	83.1 (69.6-88.9)	16.2 (11.1-26.1)	3.2 (2.5-3.8)	2.4 (2.3-2.7)	19.3 (11.9-24.5)
>114	6	37 (29-46)	30 (25-35)	6.7 (2-11)	81.7 (76.1-94.1)	17.4 (5.9-23.9)	3.2 (2.7-3.8)	2.4 (2.3-2.7)	19.4 (17.1-21.9)
Disturbed Cottonwood									
<25	2	17 (11-23)	13 (9-17)	3.5 (1-6)	77.9 (73.9-81.8)	17.6 (9.1-26.1)	2.0 (1.5-2.5)	2.3 (2.1-2.6)	7.9 (7.4-8.3)
>25	5	28.4 (15-41)	22 (10-35)	6.4 (5-8)	75.6 (66.7-85.4)	24.4 (14.6-33.3)	2.5 (2.1-3.3)	2.0 (1.8-2.2)	13.7 (8.3-20.9)
Non-cottonwood									
<25	4	28 (19-41)	19 (11-28)	8.5 (7-12)	67.0 (57.9-72.4)	31.5 (24.1-42.1)	2.0 (1.9-2.1)	2.3 (2-2.8)	10.5 (8.7-12.9)
>25	9	35.3 (21-53)	27.3 (16-42)	7.4 (4-11)	76.8 (69.6-90.5)	22.1 (9.5-30.4)	3.0 (2.0-4.1)	2.3 (2.1-2.8)	17.8 (9.8-26.4)

Table 5.3. Summary of stand-level data on species richness, native and exotic abundance, floristic quality, and wetland affinity, by cottonwood forest age class on river segments 8 and 9. Numbers are means within each stand age class, with range (low and high stand values) in parentheses.

Stand age (yrs)	# stands	Total species	Native species	Exotic species	% native	% exotic	Mean C	Mean W	FQI
Cottonwood									
≤10	6	21.3 (15-31)	18.2 (11-26)	3 (2-5)	84.4 (73.3-91.7)	14.9 (7.7-26.7)	2.1 (0.9-3.3)	2.6 (2.3-2.9)	9.8 (3.6-15.9)
10-25	7	27.9 (17-37)	22.1 (13-27)	5.4 (2-9)	79.5 (68-93.1)	19.5 (6.9-28)	2.3 (2-2.6)	2.7 (2.4-3.2)	12 (8.2-14.5)
25-50	9	31.4 (23-46)	25.1 (16-39)	5.9 (5-7)	78.9 (69.6-84.8)	19.5 (13.9-26.1)	2.5 (1.5-3.2)	2.6 (2.1-3.3)	14.3 (7.3-19.4)
50-114	10	38.3 (24-49)	30.8 (20-40)	7.1 (4-9)	80.4 (73.7-86.5)	18.7 (13.5-24.1)	3.1 (2.6-3.7)	2.4 (2.2-2.7)	18.9 (14.1-23.9)
>114	5	37.8 (29-47)	30 (23-37)	6.8 (5-9)	79.2 (75.7-85.4)	18.0 (12.2-21.6)	3.3 (2.9-3.7)	2.4 (2.3-2.5)	19.9 (17.4-21.5)
Disturbed Cottonwood									
>25	5	26.8 (13-59)	18.2 (8-42)	8 (5-16)	66.1 (59.1-73.9)	31.5 (26.1-38.5)	1.9 (1.3-3)	2.2 (2-2.5)	10.2 (6.0-23.0)
Non-cottonwood									
<25	1	16	12	4	75	25	2.2	2.2	8.9
>25	9	29.2 (10-42)	20.7 (8-31)	7.8 (2-12)	70.3 (59.1-80.6)	27.3 (16.7-38.9)	2.5 (1.5-3.3)	2.2 (1.9-2.3)	13.6 (6.8-19.6)

Table 5.4. Summary of stand-level data on species richness, native and exotic abundance, floristic quality, and wetland affinity, by cottonwood forest age class on river segment 6. Numbers are means within each stand age class, with range (low and high stand values) in parentheses.

Stand age (yrs)	# stands	Total species	Native species	Exotic species	% native	% exotic	Mean C	Mean W	FQI
Cottonwood									
10-25	1	10	8	2	80	20	1.4	3.3	4.6
25-50	6	25.5 (15-37)	16.2 (8-27)	9.2 (7-11)	60.8 (50-72.9)	38.6 (27.0-50)	1.9 (1.4-2.4)	2.5 (2.2-2.9)	9.9 (5.8-14.5)
50-114	7	36.1 (23-44)	24.4 (15-29)	11.1 (8-15)	67.3 (61.5-75.7)	31.1 (21.6-38.5)	2.2 (1.5-2.6)	2.3 (2.1-2.6)	13.3 (9.2-16.4)
>114	2	24.5 (19-30)	14 (11-17)	10 (8-12)	57.3 (56.7-57.9)	41.1 (40-42.1)	1.6 (1.5-1.7)	2.0 (1.9-2.1)	8.0 (6.7-9.4)
Disturbed Cottonwood									
>25	4	13 (11-16)	6 (4-8)	6.5 (6-7)	45.6 (36.4-50)	50.9 (43.8-63.6)	1.8 (1.4-2.5)	2.3 (2.2-2.4)	6.5 (5.1-8.7)
Non-cottonwood									
>25	7	18.9 (13-27)	10.6 (7-16)	7.9 (5-11)	55.9 (46.7-61.5)	42.0 (37.0-46.7)	1.5 (1.1-1.7)	2.1 (1.9-2.3)	6.3 (4.4-7.9)

Table 5.5. Summary of stand-level data on species richness, native and exotic abundance, floristic quality, and wetland affinity, by cottonwood forest age class on river segment 4. Numbers are means within each stand age class, with range (low and high stand values) in parentheses.

Stand age (yrs)	# stands	Total species	Native species	Exotic species	% native	% exotic	Mean C	Mean W	FQI
Cottonwood									
≤10	6	23.2 (12-33)	16.2 (8-25)	6.5 (3-12)	69.5 (61.5-78.1)	27.9 (18.8-36.4)	1.9 (1.4-2.5)	2.9 (1.9-3.9)	8.9 (6-14.3)
10-25	7	34.7 (22-55)	26 (15-42)	8 (7-11)	74.0 (67.9-80.5)	24.1 (19.4-31.8)	2.9 (2.3-3.6)	2.5 (2.2-2.9)	17 (12.2-23.3)
25-50	7	37.1 (24-59)	30.1 (18-50)	6.7 (4-9)	80.7 (75-86.2)	18.4 (13.6-23.1)	3.2 (2.5-3.8)	2.5 (2.1-3)	19.5 (14.7-26.9)
50-114	8	37.1 (30-46)	28.4 (19-33)	8.3 (5-12)	76.4 (63.3-84.4)	22.2 (15.6-33.3)	3.2 (2.6-3.7)	2.5 (2.4-2.7)	19.3 (14.2-22.6)
>114	9	42.7 (16-54)	32.4 (11-46)	9.2 (3-15)	74.5 (61.1-86.8)	22.2 (13.2-33.3)	3.4 (2.2-4.4)	2.4 (2.3-2.5)	21.9 (9.2-30.9)
Disturbed Cottonwood									
>25	9	36.0 (24-53)	24.9 (12-38)	10.2 (2-18)	67.8 (42.4-88.9)	29.5 (5.6-54.5)	2.6 (1.1-4.0)	2.5 (2.2-2.9)	15.6 (5.8-24.2)
Non-cottonwood									
<25	6	38.7 (22-73)	27.8 (14-56)	9.5 (6-15)	70.2 (63.6-78.6)	25.9 (20.5-34.4)	2.2 (1.7-3.1)	2.9 (2.3-3.5)	13.4 (8.8-20.4)
>25	14	37.9 (10-55)	28.0 (6-44)	8.5 (4-12)	72.5 (60-85.4)	24.3 (8.3-40)	3.1 (2.1-4.5)	2.4 (2.1-2.6)	19.5 (6.6-30.9)

Table 5.6. Summary of stand-level data on species richness, native and exotic abundance, floristic quality, and wetland affinity, by cottonwood forest age class on river segment 2. Numbers are means within each stand age class, with range (low and high stand values) in parentheses.

Stand age (yrs)	# stands	Total species	Native species	Exotic species	% native	% exotic	Mean C	Mean W	FQI
					Cottonwood				
≤10	6	31.3 (22-38)	22 (17-30)	7 (5-11)	70.7 (60.5-78.9)	22.2 (18.4-28.9)	2.5 (1.8-2.8)	3.1 (2.9-3.4)	13.8 (11.1-16.5)
10-25	7	26 (18-34)	17.1 (10-22)	7.7 (5-11)	65.6 (55.6-77.8)	30.5 (18.5-44.4)	2.4 (1.6-3)	2.9 (2.3-3.3)	12.4 (6.8-15.6)
25-50	5	30.4 (25-37)	20 (18-23)	8.2 (5-11)	66.4 (58.1-76)	26.6 (20-29.7)	2.6 (2.1-2.9)	2.8 (2.3-3.1)	14.1 (12.9-15.4)
50-114	6	29.3 (24-34)	19.8 (18-22)	7.5 (5-10)	68.1 (58.8-75.9)	25.3 (20.7-29.4)	2.8 (2.5-3)	2.6 (2.3-2.8)	15 (14.6-15.6)
>114	6	30.3 (18-45)	18.7 (9-26)	10.7 (8-16)	60.8 (50-72.4)	36.2 (27.6-44.4)	2.3 (1.8-2.7)	2.4 (1.8-3.1)	12.5 (7.7-15.0)

Table 5.7. Summary of stand-level data on species richness, native and exotic abundance, floristic quality, and wetland affinity, by cottonwood forest age class on river segment 0. Numbers are means within each stand age class, with range (low and high stand values) in parentheses.

Stand age (yrs)	# stands	Total species	Native species	Exotic species	% native	% exotic	Mean C	Mean W	FQI
Cottonwood									
≤10	7	30.4 (18-44)	20.1 (11-30)	8.3 (2-12)	66.4 (55.2-81.8)	27.2 (9.1-38.9)	2.5 (1.7-3.1)	3.2 (2.7-3.6)	13.7 (7.1-19.9)
10-25	4	29 (16-41)	15.5 (8-24)	12.8 (8-15)	52.3 (44.4-58.5)	45.7 (36.6-55.6)	1.9 (1.6-2.2)	2.4 (2.0-2.7)	10.3 (7.3-14.3)
25-50	6	28.8 (22-39)	16 (11-23)	11.8 (11-15)	54.9 (50-58.9)	41.8 (35.5-50)	2.5 (2-3.0)	2.3 (2.1-2.5)	13.3 (9.4-16.1)
50-114	6	29.2 (25-38)	16.7 (13-22)	10.7 (8-14)	56.9 (50-62.5)	36.6 (32-42.3)	2.8 (2.5-3.2)	2.4 (2.1-2.5)	15.1 (12.5-16.6)
>114	6	27.3 (19-38)	14.2 (8-21)	11.8 (9-14)	50.7 (42.1-60.7)	44.6 (32.1-57.9)	2.3 (1.7-3.2)	2.2 (7.6-16.7)	12.1 (7.6-16.7)

Table 6. Relative density, basal area, and trunk diameter of witness trees recorded in the General Land Office Survey for the historic Missouri River floodplain along segment 10 (59 mile MNRR) from 1857-1869.

Species	#	Relative Density	Relative Basal Area	Mean dbh (cm)	Median dbh (cm)	Max dbh (cm)
Green Ash	47	5.1%	2.2%	24.6	25.4	45.7
American Basswood	4	0.4%	0.6%	45.7	45.7	61.0
Box Elder	15	1.6%	0.5%	22.7	25.4	25.4
Kentucky Coffee Tree	1	0.1%	0.1%	30.5	30.5	30.5
Eastern Cottonwood	583	63.6%	72.2%	36.5	30.5	127.0
Elm (American and Slippery)	110	12.0%	16.5%	41.3	35.6	177.8
Hackberry	24	2.6%	1.2%	25.1	22.9	50.8
Ironwood	2	0.2%	0.1%	30.5	30.5	30.5
Bur Oak	40	4.4%	3.6%	33.5	30.5	76.2
Walnut	1	0.1%	0.2%	50.8	50.8	50.8
Willow sp.	90	9.8%	2.8%	19.1	15.2	45.7
All species	**917**					

FIGURE CAPTIONS

Figures 1.1a-1.7 show relative importance values of different tree species within cottonwood, disturbed cottonwood, and non-cottonwood stands across the different study segments (in downstream to upstream order).

Figure 1.1a. Relative importance value (sum of relative frequency, density, and basal area) of different tree species by cottonwood forest age class in segment 13.

Figure 1.1b. Relative importance value (sum of relative frequency, density, and basal area) of different tree species within disturbed cottonwood and non-cottonwood forests in segment 13.

Figure 1.2a. Relative importance value (sum of relative frequency, density, and basal area) of different tree species by cottonwood forest age class in segment 10.

Figure 1.2b. Relative importance value (sum of relative frequency, density, and basal area) of different tree species within disturbed cottonwood and non-cottonwood forests in segment 10.

Figure 1.3a. Relative importance value (sum of relative frequency, density, and basal area) of different tree species by cottonwood forest age class in segments 8 and 9.

Figure 1.3b. Relative importance value (sum of relative frequency, density, and basal area) of different tree species within disturbed cottonwood and non-cottonwood forests in segments 8 and 9.

Figure 1.4a. Relative importance value (sum of relative frequency, density, and basal area) of different tree species by cottonwood forest age class in segment 6.

Figure 1.4b. Relative importance value (sum of relative frequency, density, and basal area) of different tree species within disturbed cottonwood and non-cottonwood forests in segment 6.

Figure 1.5a. Relative importance value (sum of relative frequency, density, and basal area) of different tree species by cottonwood forest age class in segment 4.

Figure 1.5b. Relative importance value (sum of relative frequency, density, and basal area) of different tree species within disturbed cottonwood and non-cottonwood forests in segment 4.

Figure 1.6. Relative importance value (sum of relative frequency, density, and basal area) of different tree species by cottonwood forest age class in segment 2.

Figure 1.7. Relative importance value (sum of relative frequency, density, and basal area) of different tree species by cottonwood forest age class in segment 0.

Figure 2. Adjusted mean (± standard error) overall shrub-layer and tree species richness for cottonwood stands (disturbed stands excluded) across Missouri River study segments.

Figure 3. Adjusted mean % (± standard error) of tree species that are non-native for cottonwood stands (disturbed stands excluded) across Missouri River study segments.

Figures 4.1a-4.7 show mean % shrub cover by different species within cottonwood, disturbed cottonwood, and non-cottonwood stands across the different study segments (in downstream to upstream order).

Figure 4.1a. Mean percent shrub cover by different species and overall mean shrub cover by cottonwood forest age class in segment 13. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

Figure 4.1b. Mean percent shrub cover by different species and overall mean shrub cover within disturbed cottonwood and non-cottonwood forests in segment 13. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

Figure 4.2a. Mean percent shrub cover by different species and overall mean shrub cover by cottonwood forest age class in segment 10. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

Figure 4.2b. Mean percent shrub cover by different species and overall mean shrub cover within disturbed cottonwood and non-cottonwood forests in segment 10. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

Figure 4.3a. Mean percent shrub cover by different species and overall mean shrub cover by cottonwood forest age class in segments 8 and 9. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

Figure 4.3b. Mean percent shrub cover by different species and overall mean shrub cover within disturbed cottonwood and non-cottonwood forests in segment 8 and 9. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

Figure 4.4a. Mean percent shrub cover by different species and overall mean shrub cover by cottonwood forest age class in segment 6. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

Figure 4.4b. Mean percent shrub cover by different species and overall mean shrub cover within disturbed cottonwood and non-cottonwood forests in segment 6. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

Figure 4.5a. Mean percent shrub cover by different species and overall mean shrub cover by cottonwood forest age class in segment 4. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

Figure 4.5b. Mean percent shrub cover by different species and overall mean shrub cover within disturbed cottonwood and non-cottonwood forests in segment 4. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

Figure 4.6. Mean percent shrub cover by different species and overall mean shrub cover by cottonwood forest age class in segment 2. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

Figure 4.7. Mean percent shrub cover by different species and overall mean shrub cover by cottonwood forest age class in segment 0. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

Figures 5-13 show adjusted mean (± standard error) values of plant community species richness, exotic species proportion, floristic quality (Coefficient of Conservatism values), or wetland affinity (WIS-scores) by segment or forest age class within cottonwood stands (disturbed stands excluded).

Figure 5. Adjusted mean (± standard error) overall stand and herb-layer plant species richness for cottonwood stands (disturbed stands excluded) across Missouri River study segments.

Figure 6. Adjusted mean (± standard error) overall stand plant species richness for cottonwood stands (disturbed stands excluded) by stand age class (aggregated).

Figure 7. Overall stand (all layers) adjusted mean (± standard error) Coefficient of Conservatism values for cottonwood stands (disturbed stands excluded) across Missouri River study segments.

Figure 8. Adjusted mean (± standard error) Coefficient of Conservatism values the herb-layer, shrub-layer, and overstory (trees) for cottonwood stands (disturbed stands excluded) across Missouri River study segments.

Figure 9. Overall stand (all layers) adjusted mean (± standard error) Coefficient of Conservatism values for cottonwood stands (disturbed stands excluded) by stand age class (aggregated).

Figure 10. Adjusted mean % (± standard error) of plant species (all layers) that are non-native for cottonwood stands (disturbed stands excluded) across Missouri River study segments.

Figure 11. Adjusted mean % (± standard error) of plant species (all layers) that are non-native for cottonwood stands (disturbed stands excluded) by stand age class (aggregated).

Figure 12. Adjusted mean (± standard error) Wetland score (1 = UPL, 2 = FACU, 3 = FAC, 4 = FACW, 5 = OBL) of plant species within cottonwood stands (disturbed stands excluded) across study segments.

Figure 13. Adjusted mean (± standard error) Wetland score (1 = UPL, 2 = FACU, 3 = FAC, 4 = FACW, 5 = OBL) of plant species within cottonwood stands (disturbed stands excluded) by stand age class (aggregated).

Figures 14-16 show absolute or relative areas different cottonwood age classes by Missouri River study segment.

Figure 14. Total cottonwood area (acres), by age class, on each Missouri River segment.

Figure 15. Acreage of cottonwood area per river mile, by age class, on each Missouri River segment.

Figure 16. Relative area of different cottonwood age classes on each Missouri River segment.

Figures 17-18 show data from the witness tree records of the General Land Office Survey for segment 10 (1857-69)

Figure 17. Relative density and basal area of different tree species from the witness tree records of the General Land Office Survey for segment 10 vs. 2007 field data (weighted by relative area of different age classes) for segments 8 and 10.

Figure 18. Diameter distribution of witness trees listed as cottonwood in the General Land Office Survey along segment 10.

Figures are in separate, attached document.

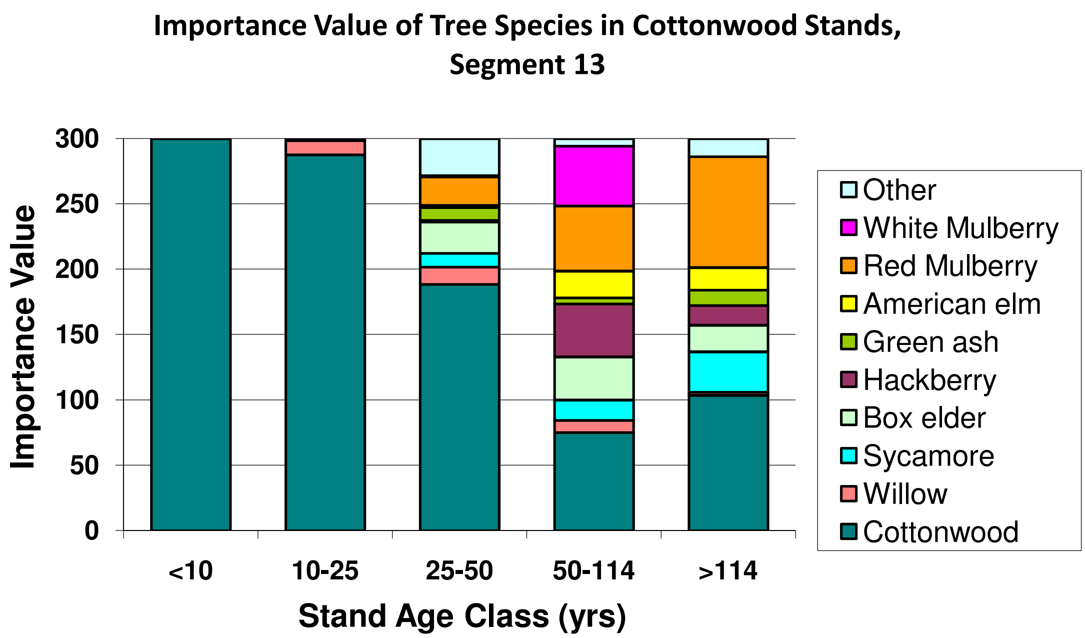


Figure 1.1a. Relative importance value (sum of relative frequency, density, and basal area) of different tree species by cottonwood forest age class in segment 13.

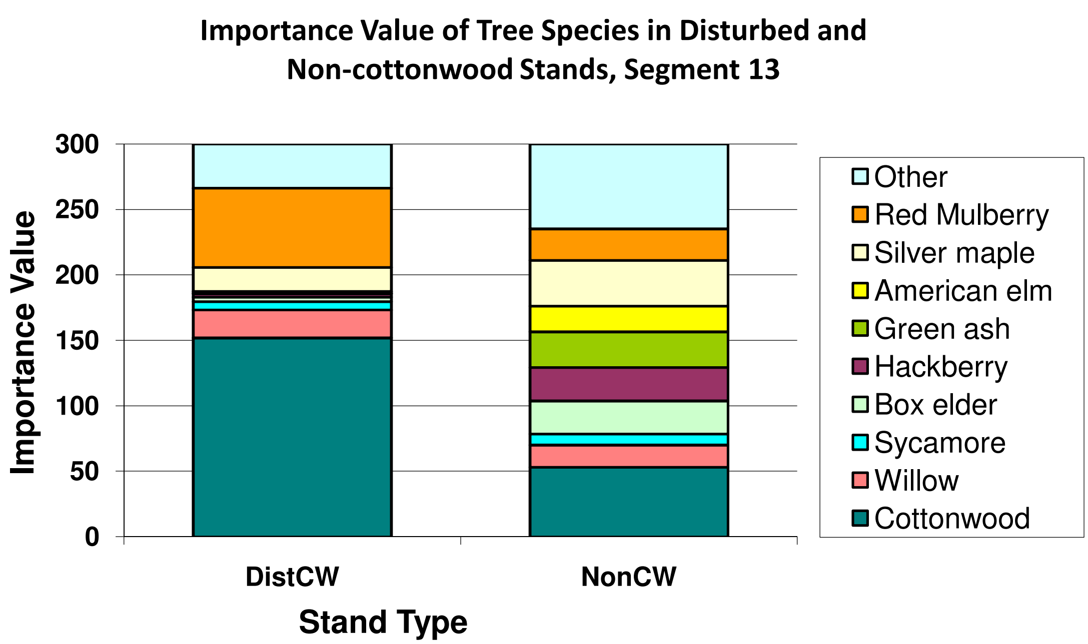


Figure 1.1b. Relative importance value (sum of relative frequency, density, and basal area) of different tree species within disturbed cottonwood and non-cottonwood forests in segment 13.

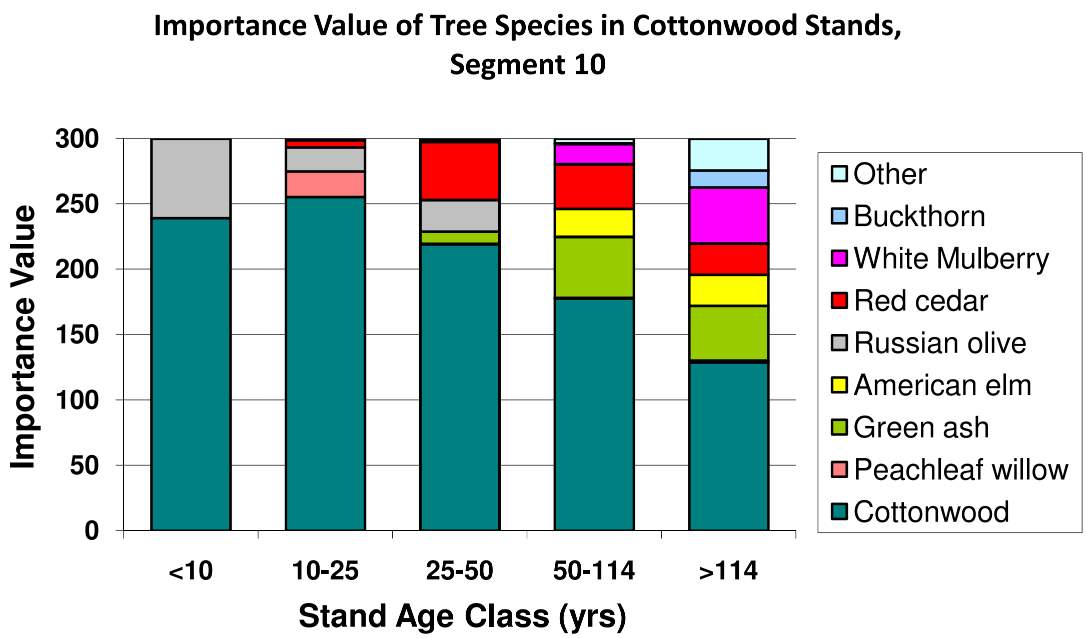


Figure 1.2a. Relative importance value (sum of relative frequency, density, and basal area) of different tree species by cottonwood forest age class in segment 10.

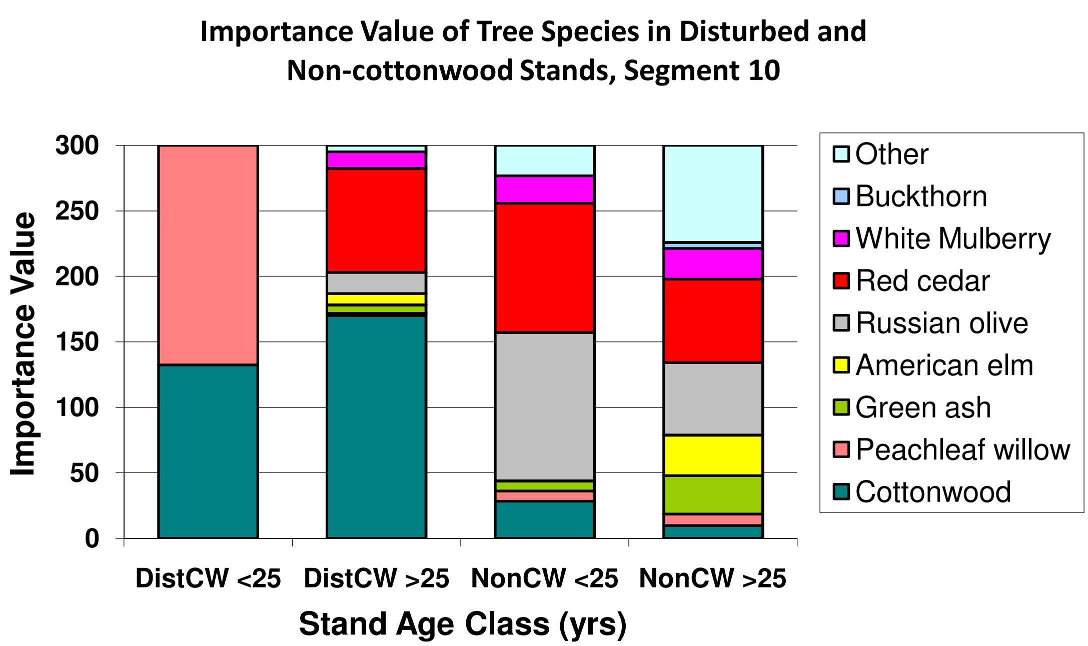


Figure 1.2b. Relative importance value (sum of relative frequency, density, and basal area) of different tree species within disturbed cottonwood and non-cottonwood forests in segment 10.

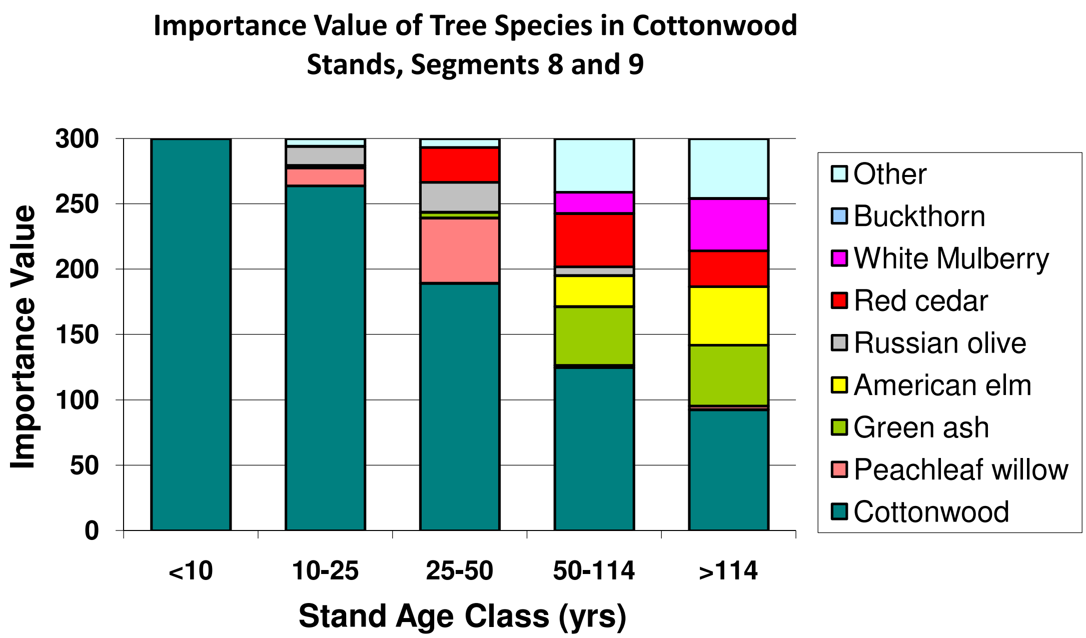


Figure 1.3a. Relative importance value (sum of relative frequency, density, and basal area) of different tree species by cottonwood forest age class in segments 8 and 9.

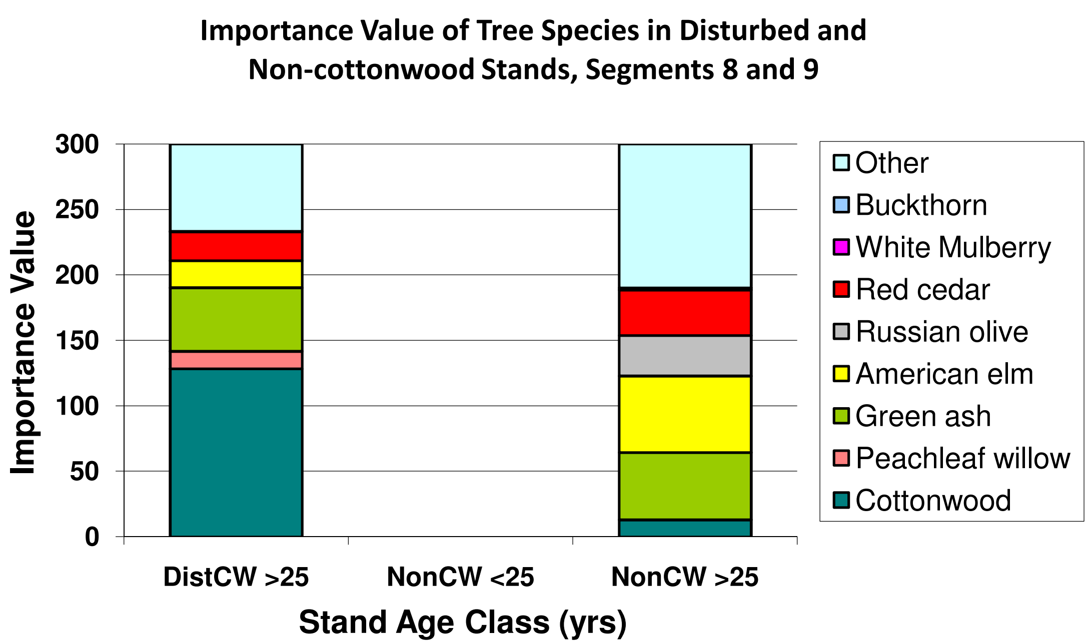


Figure 1.3b. Relative importance value (sum of relative frequency, density, and basal area) of different tree species within disturbed cottonwood and non-cottonwood forests in segments 8 and 9.

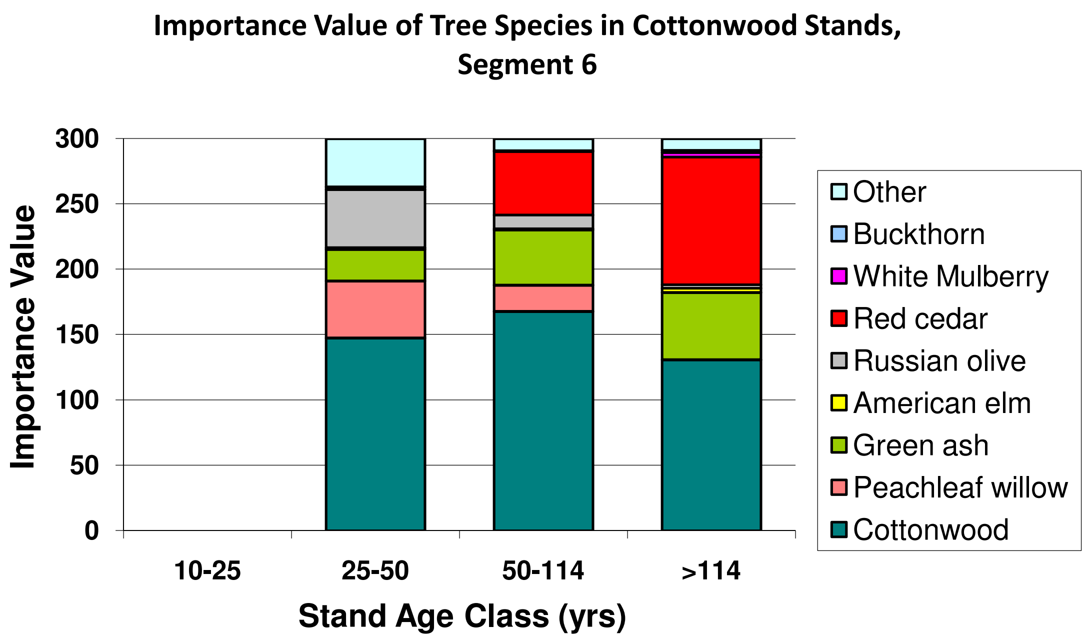


Figure 1.4a. Relative importance value (sum of relative frequency, density, and basal area) of different tree species by cottonwood forest age class in segment 6.

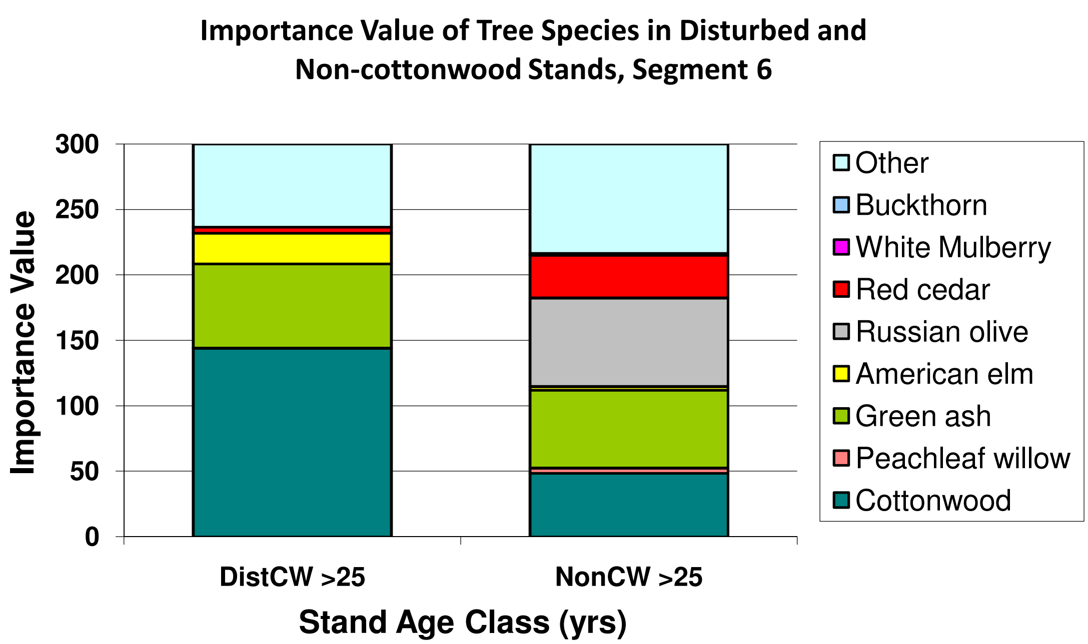


Figure 1.4b. Relative importance value (sum of relative frequency, density, and basal area) of different tree species within disturbed cottonwood and non-cottonwood forests in segment 6.

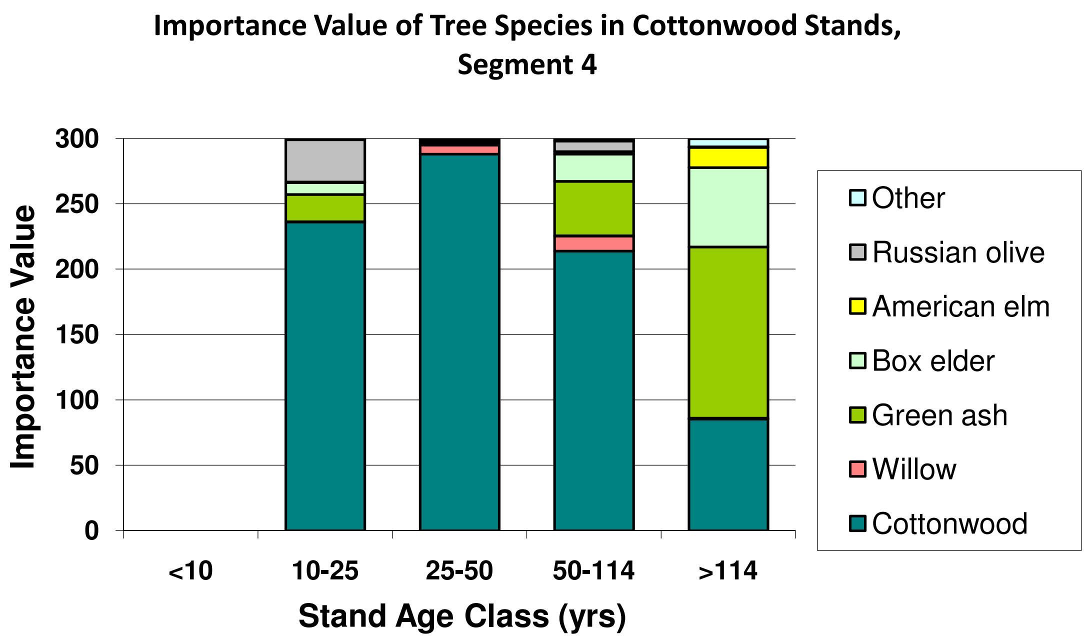


Figure 1.5a. Relative importance value (sum of relative frequency, density, and basal area) of different tree species by cottonwood forest age class in segment 4.

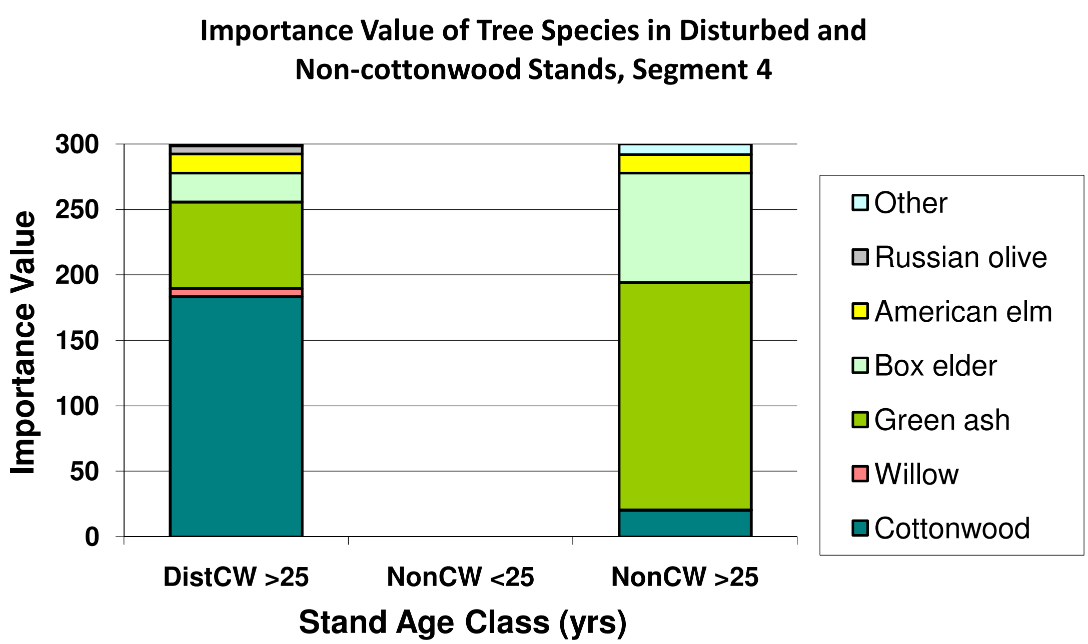


Figure 1.5b. Relative importance value (sum of relative frequency, density, and basal area) of different tree species within disturbed cottonwood and non-cottonwood forests in segment 4.

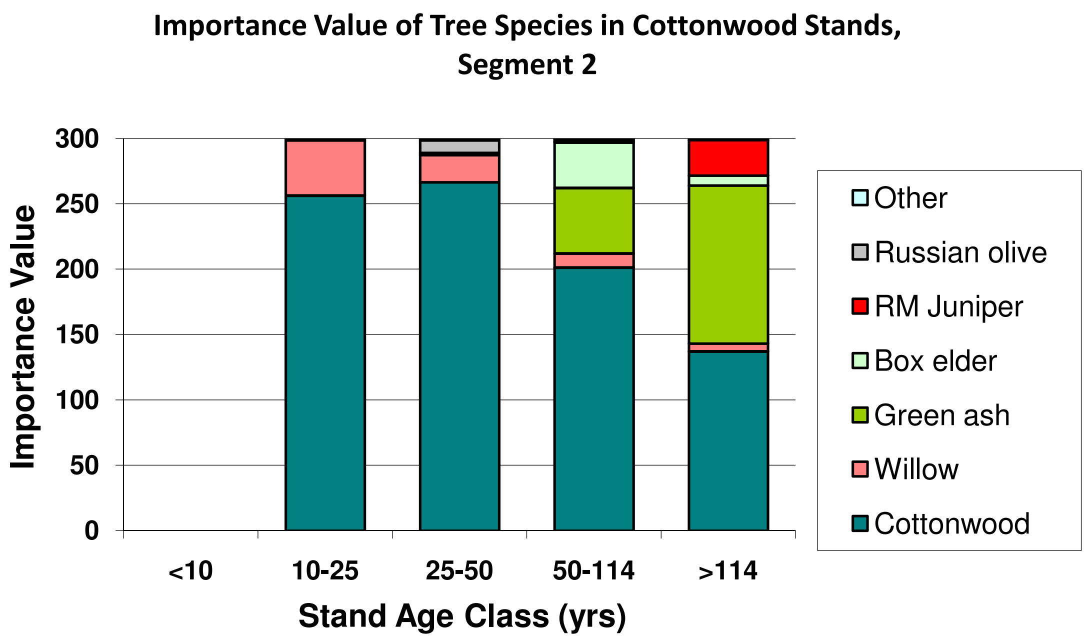


Figure 1.6. Relative importance value (sum of relative frequency, density, and basal area) of different tree species by cottonwood forest age class in segment 2.

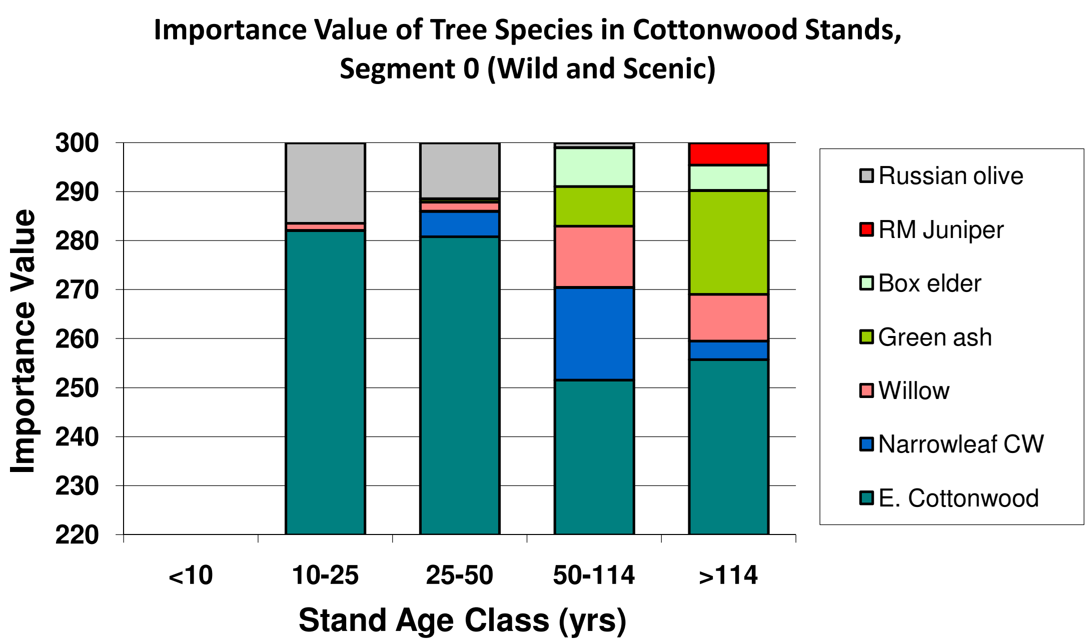


Figure 1.7. Relative importance value (sum of relative frequency, density, and basal area) of different tree species by cottonwood forest age class in segment 0.

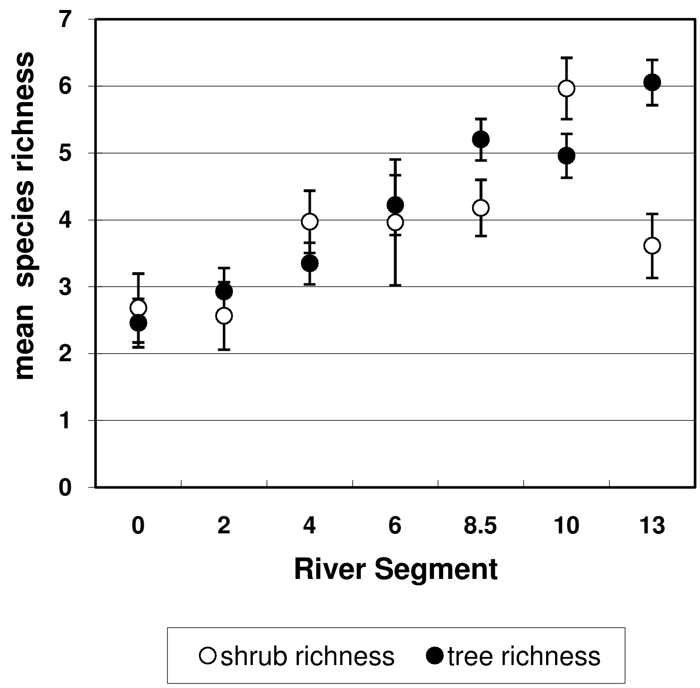


Figure 2. Adjusted mean (± standard error) overall shrub-layer and tree species richness for cottonwood stands (disturbed stands excluded) across Missouri River study segments.

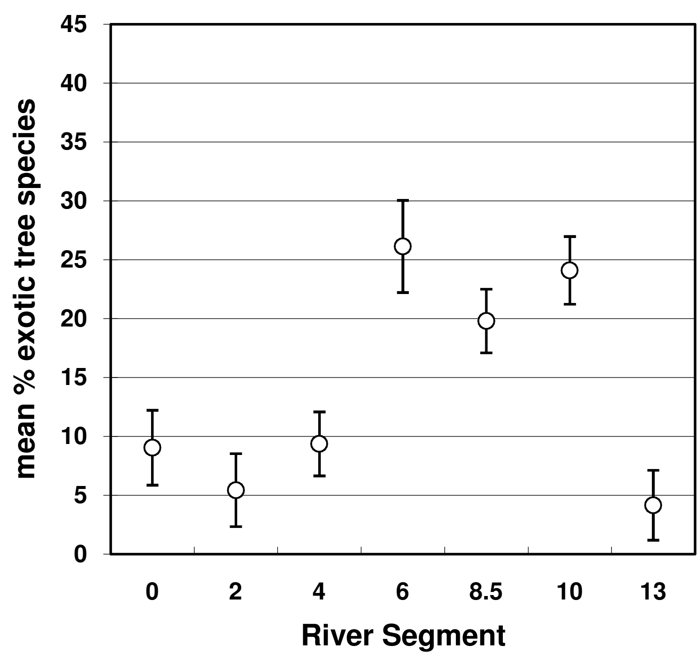


Figure 3. Adjusted mean % (± standard error) of tree species that are non-native for cottonwood stands (disturbed stands excluded) across Missouri River study segments.

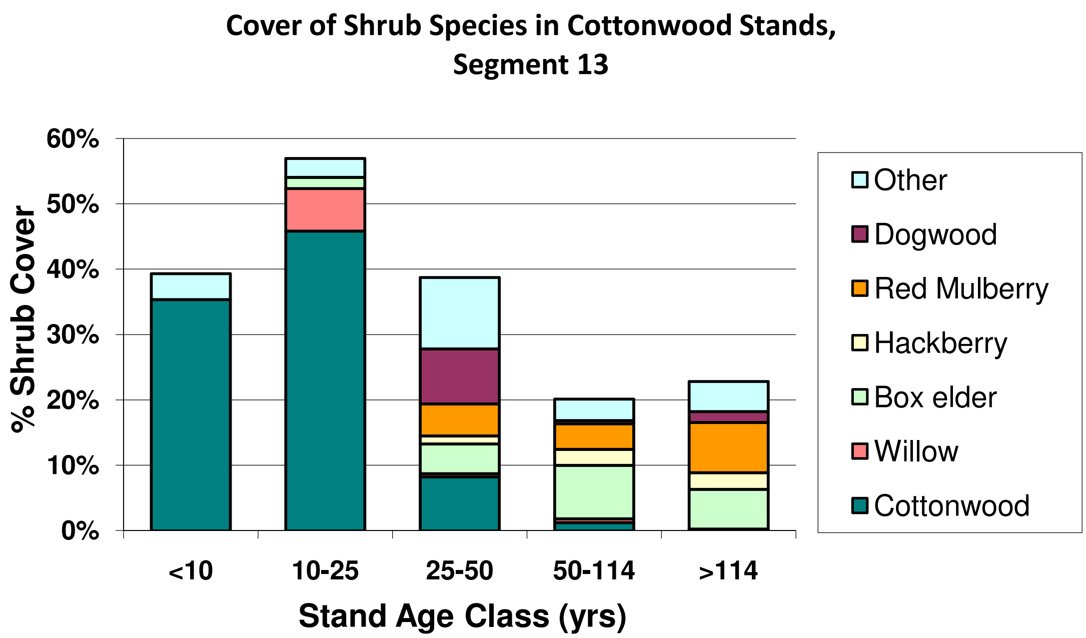


Figure 4.1a. Mean percent shrub cover by different species and overall mean shrub cover by cottonwood forest age class in segment 13. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

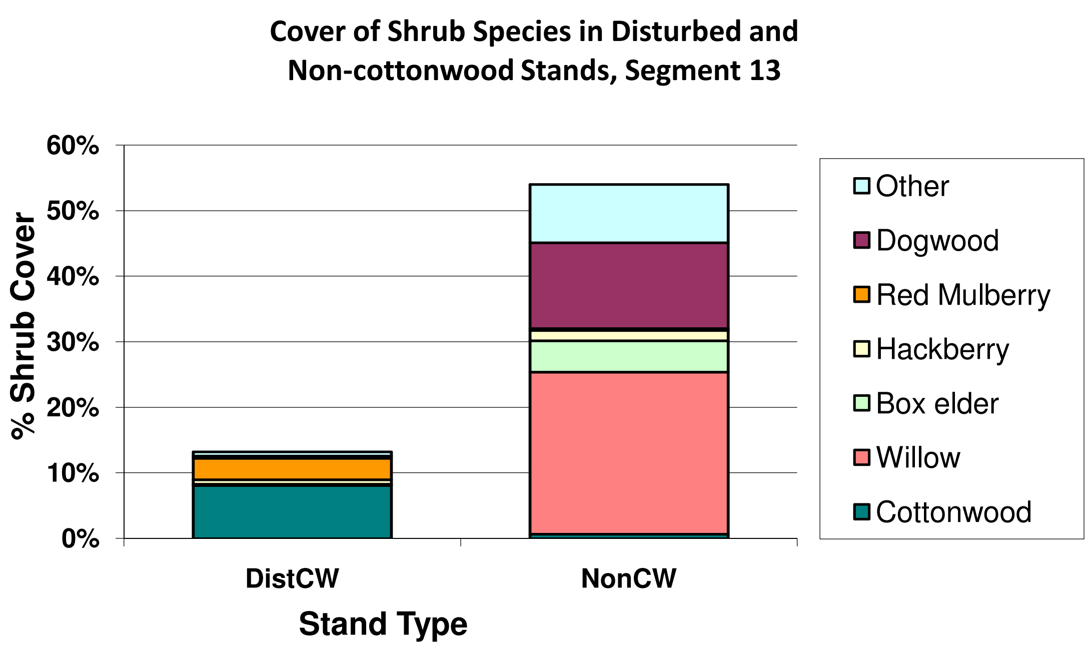


Figure 4.1b. Mean percent shrub cover by different species and overall mean shrub cover within non-cottonwood and disturbed cottonwood forests in segment 13. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

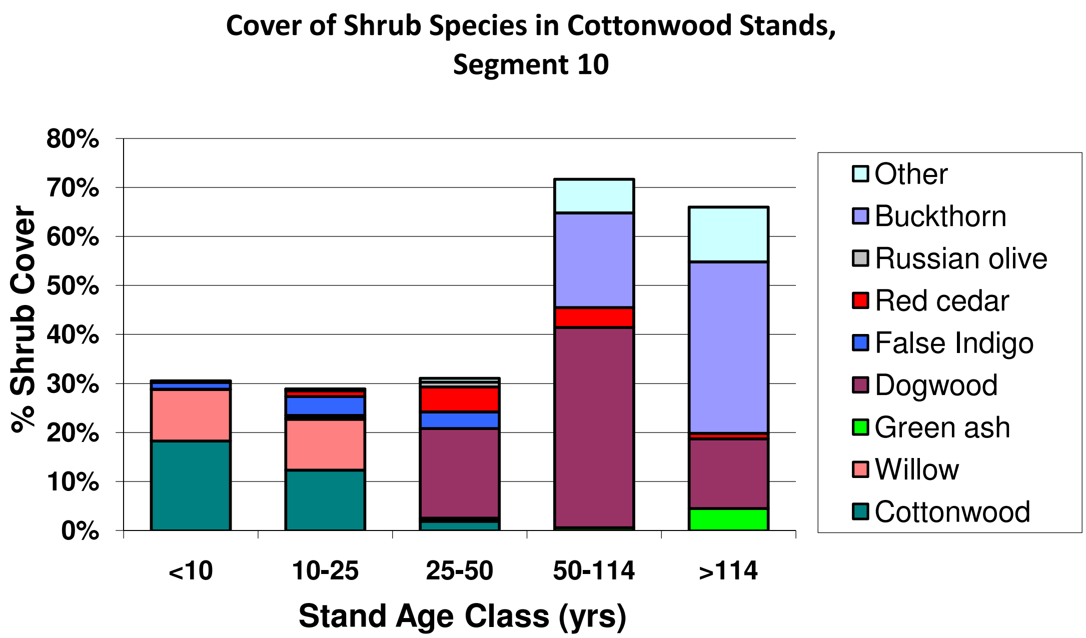


Figure 4.2a. Mean percent shrub cover by different species and overall mean shrub cover by cottonwood forest age class in segment 10. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

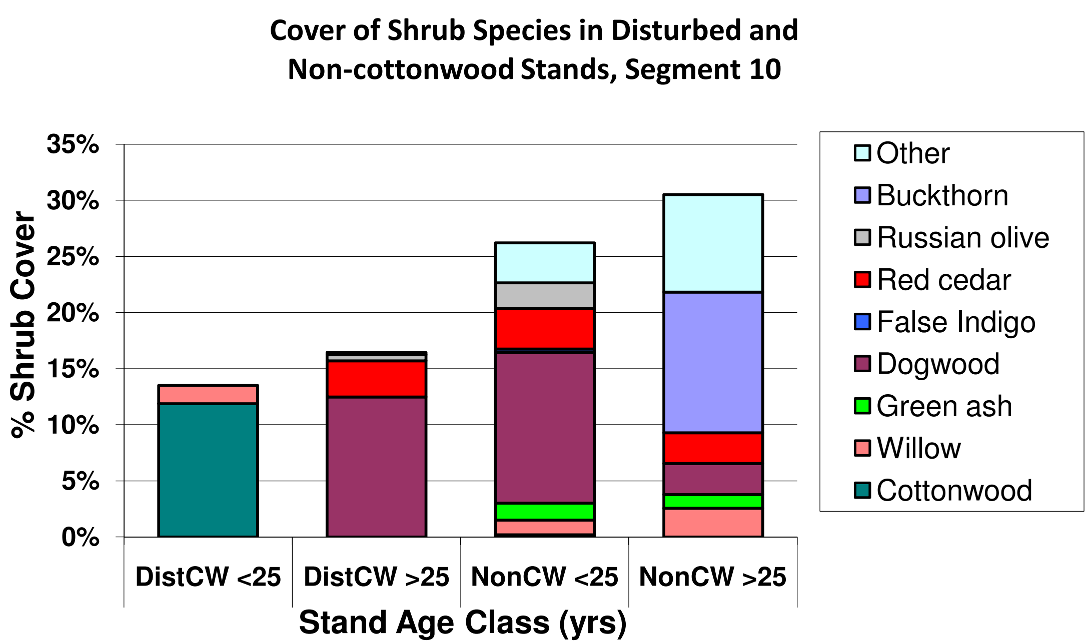


Figure 4.2b. Mean percent shrub cover by different species and overall mean shrub cover within non-cottonwood and disturbed cottonwood forests in segment 10. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

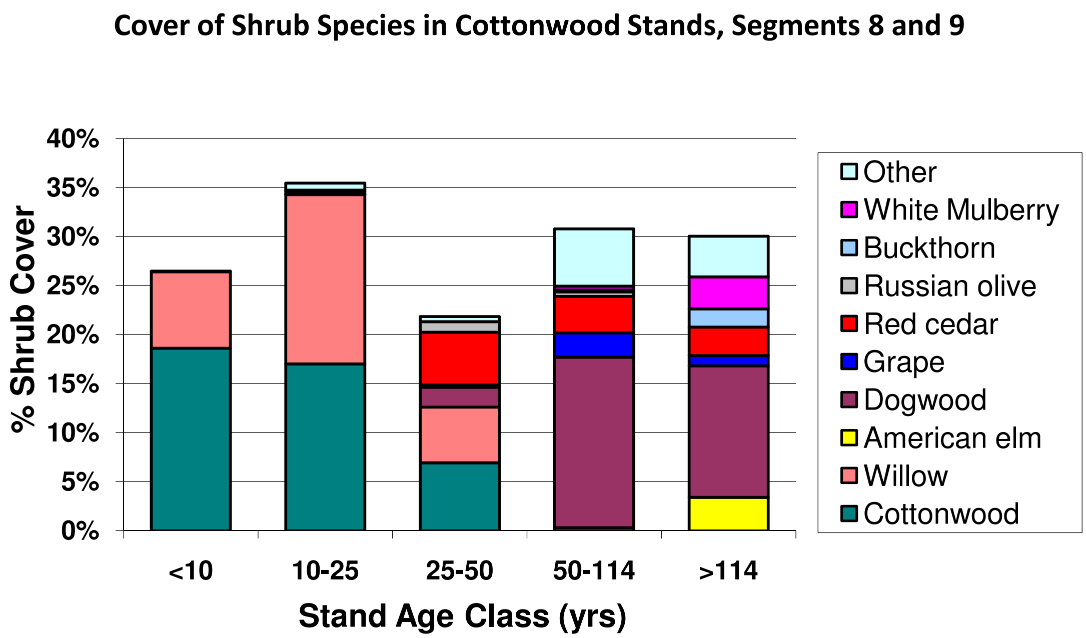


Figure 4.3a. Mean percent shrub cover by different species and overall mean shrub cover by cottonwood forest age class in segments 8 and 9. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

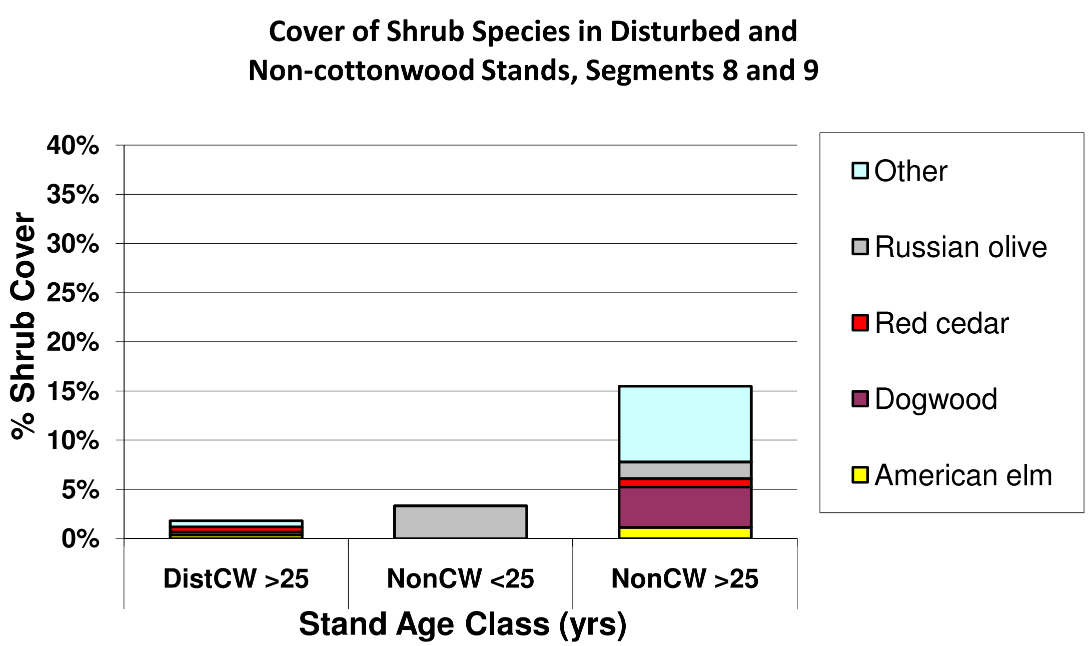


Figure 4.3b. Mean percent shrub cover by different species and overall mean shrub cover within non-cottonwood and disturbed cottonwood forests in segment 8 and 9. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

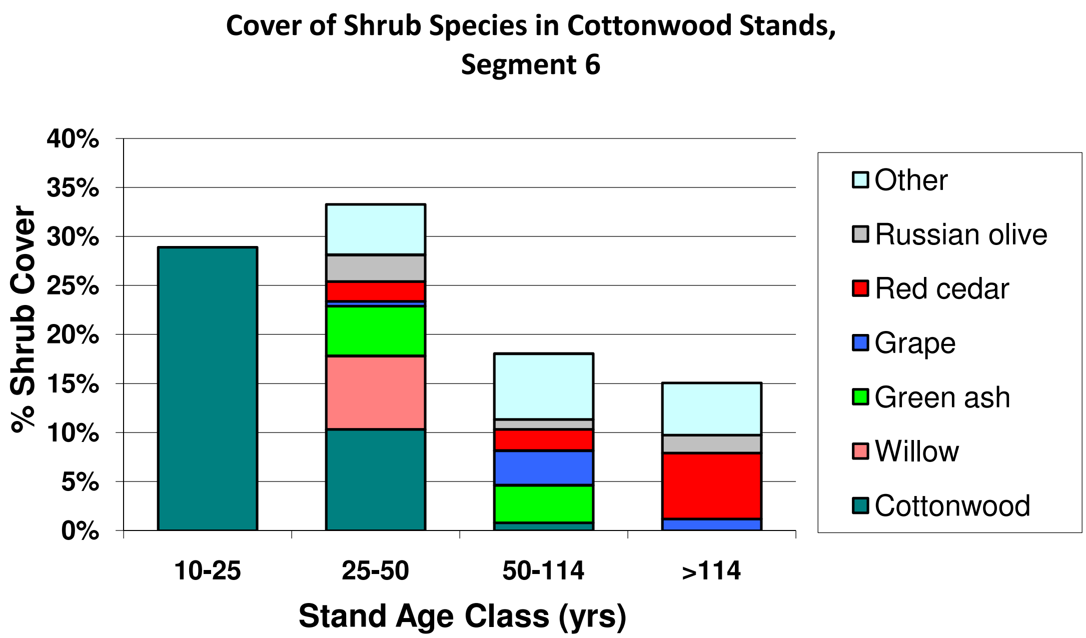


Figure 4.4a. Mean percent shrub cover by different species and overall mean shrub cover by cottonwood forest age class in segment 6. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

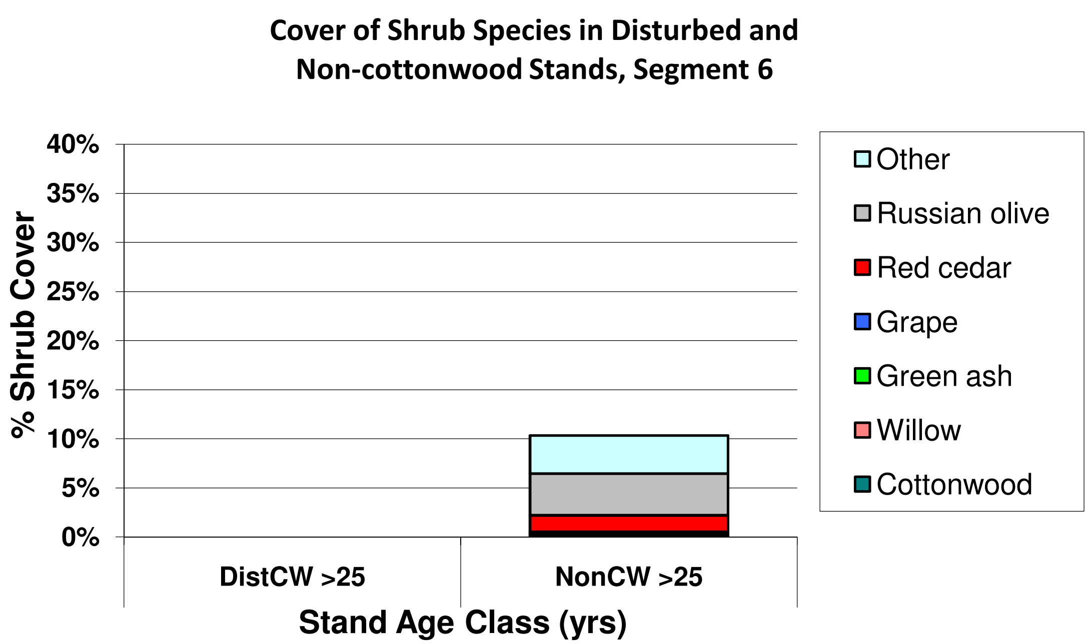


Figure 4.4b. Mean percent shrub cover by different species and overall mean shrub cover within non-cottonwood and disturbed cottonwood forests in segment 6. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

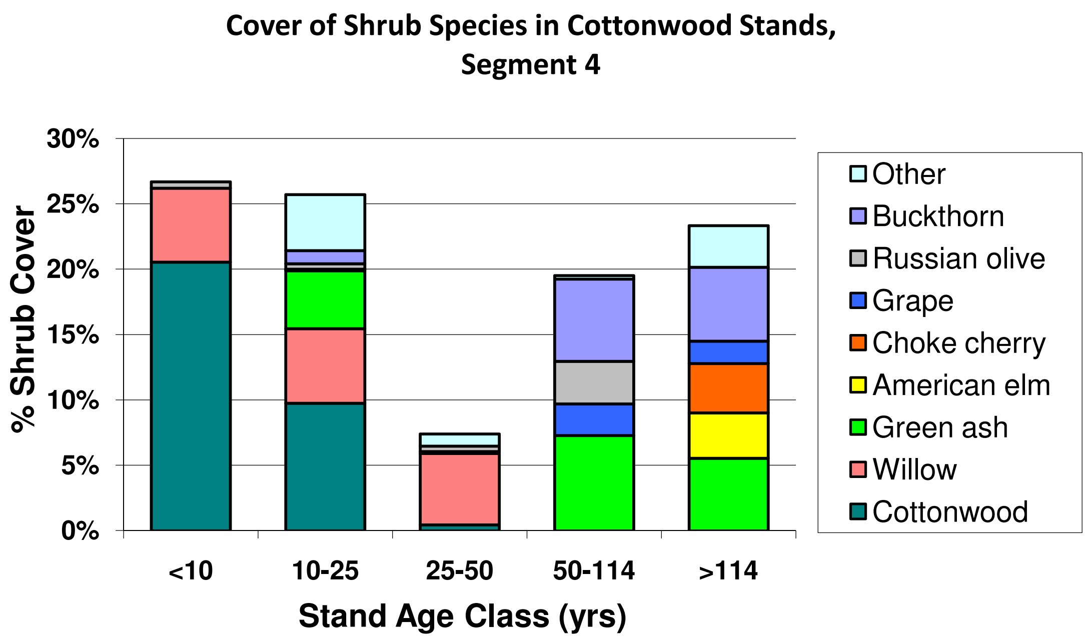


Figure 4.5a. Mean percent shrub cover by different species and overall mean shrub cover by cottonwood forest age class in segment 4. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

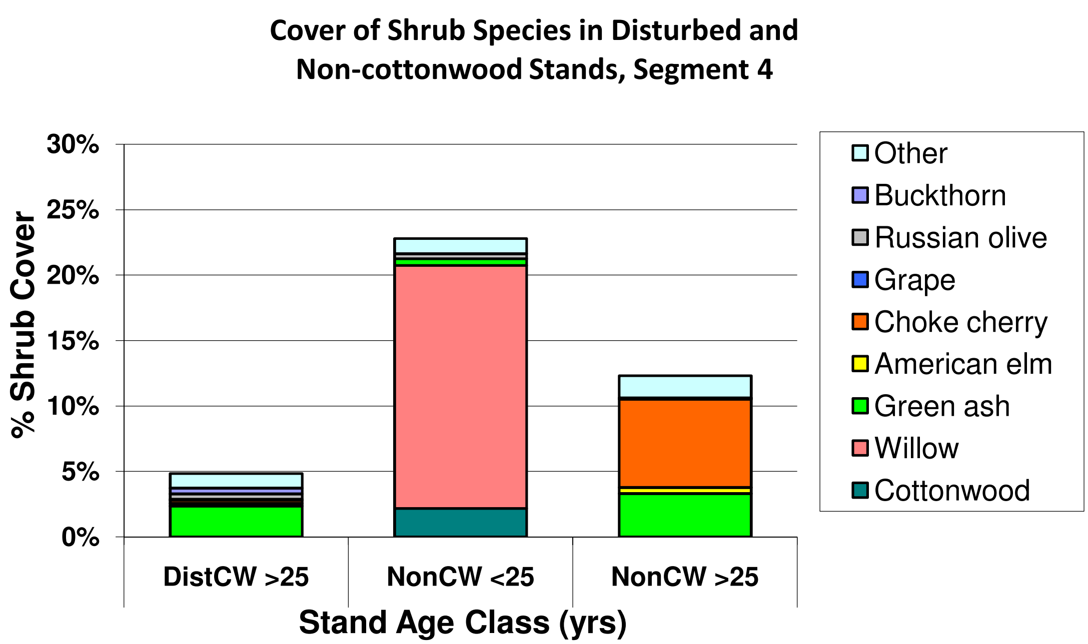


Figure 4.5b. Mean percent shrub cover by different species and overall mean shrub cover within non-cottonwood and disturbed cottonwood forests in segment 4. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

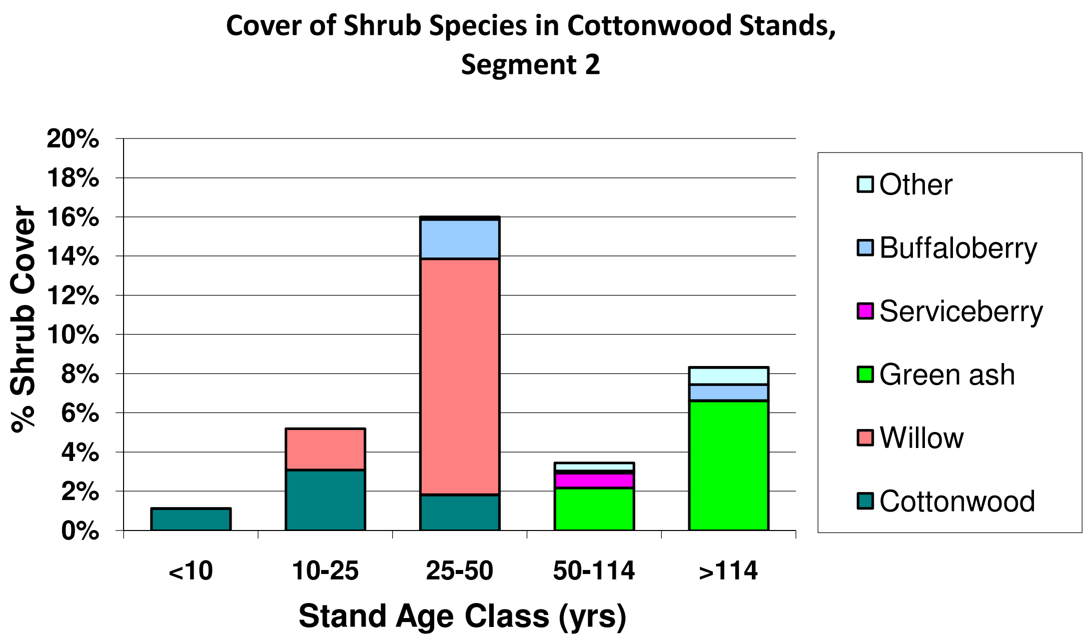


Figure 4.6. Mean percent shrub cover by different species and overall mean shrub cover by cottonwood forest age class in segment 2. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

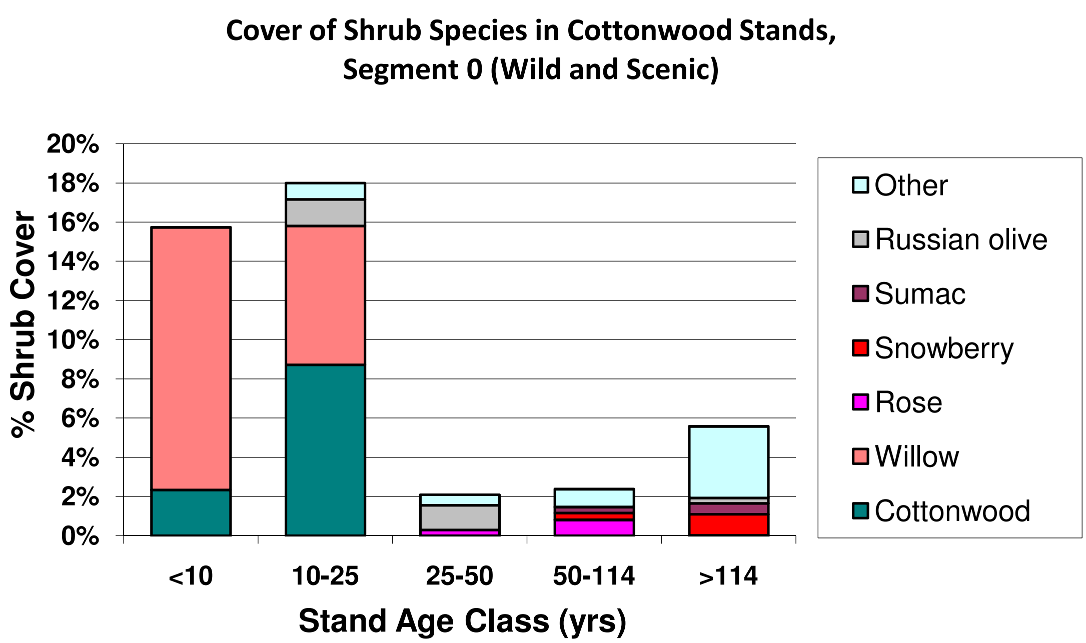


Figure 4.7. Mean percent shrub cover by different species and overall mean shrub cover by cottonwood forest age class in segment 0. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

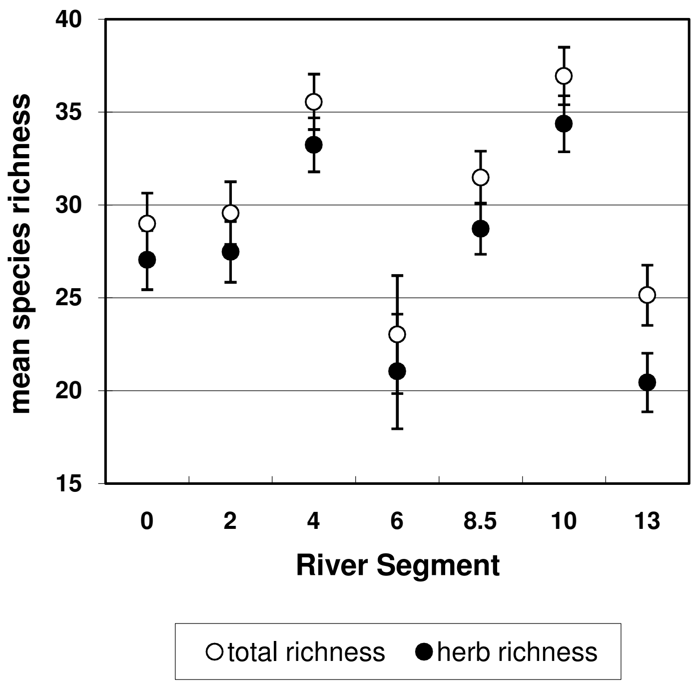


Figure 5. Adjusted mean (± standard error) overall stand and herb-layer plant species richness for cottonwood stands (disturbed stands excluded) across Missouri River study segments.

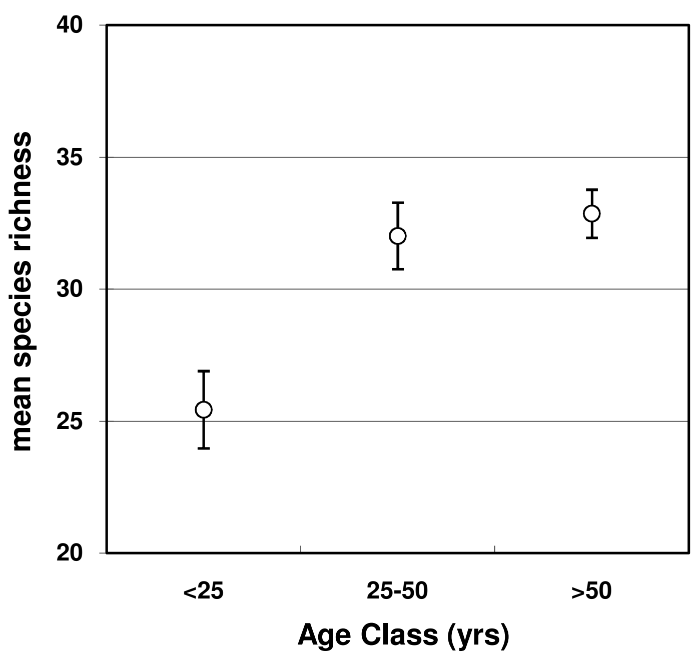


Figure 6. Adjusted mean (± standard error) overall stand plant species richness for cottonwood stands (disturbed stands excluded) by stand age class (aggregated).

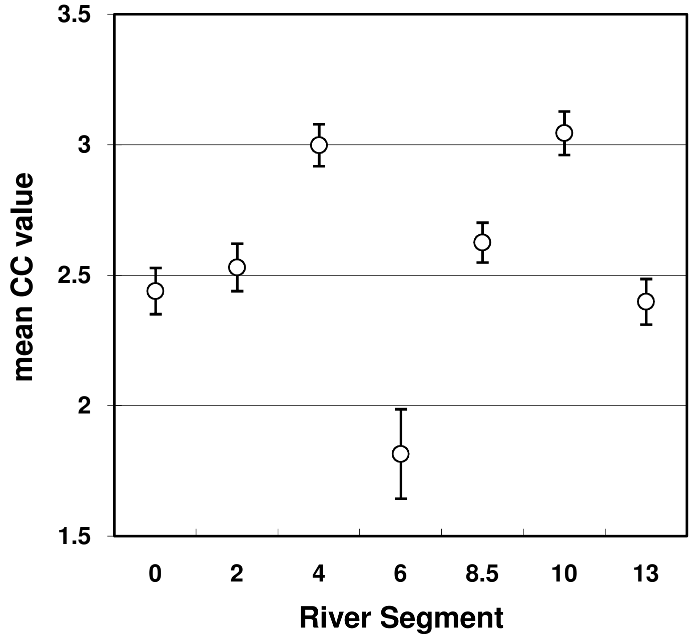


Figure 7. Overall stand (all layers) adjusted mean (± standard error) Coefficient of Conservatism values for cottonwood stands (disturbed stands excluded) across Missouri River study segments.

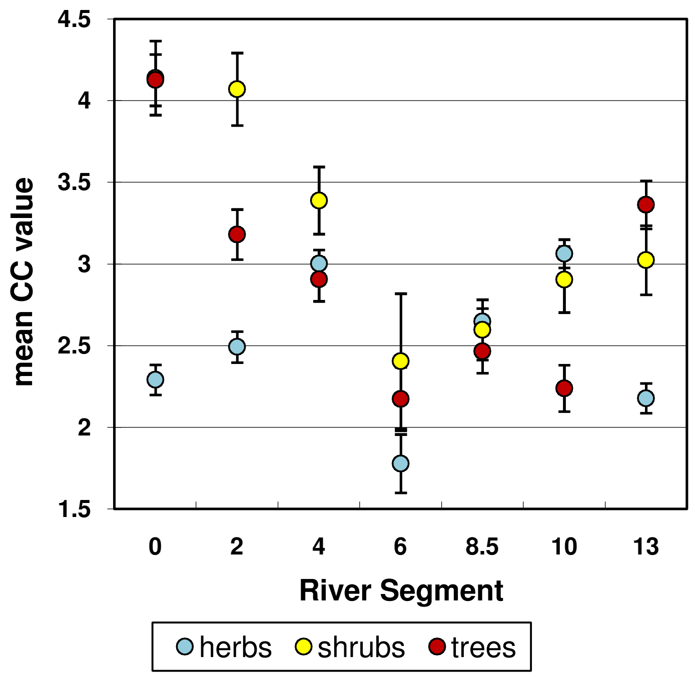


Figure 8. Adjusted mean (± standard error) Coefficient of Conservatism values the herb-layer, shrub-layer, and overstory (trees) for cottonwood stands (disturbed stands excluded) across Missouri River study segments.

Figure 9. Overall stand (all layers) adjusted mean (± standard error) Coefficient of Conservatism values for cottonwood stands (disturbed stands excluded) by stand age class (aggregated).

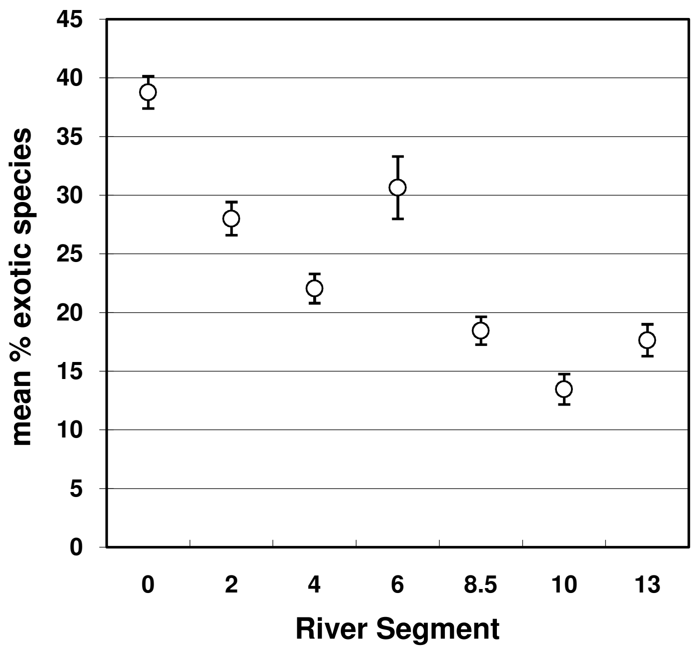


Figure 10. Adjusted mean % (± standard error) of plant species (all layers) that are non-native for cottonwood stands (disturbed stands excluded) across Missouri River study segments.

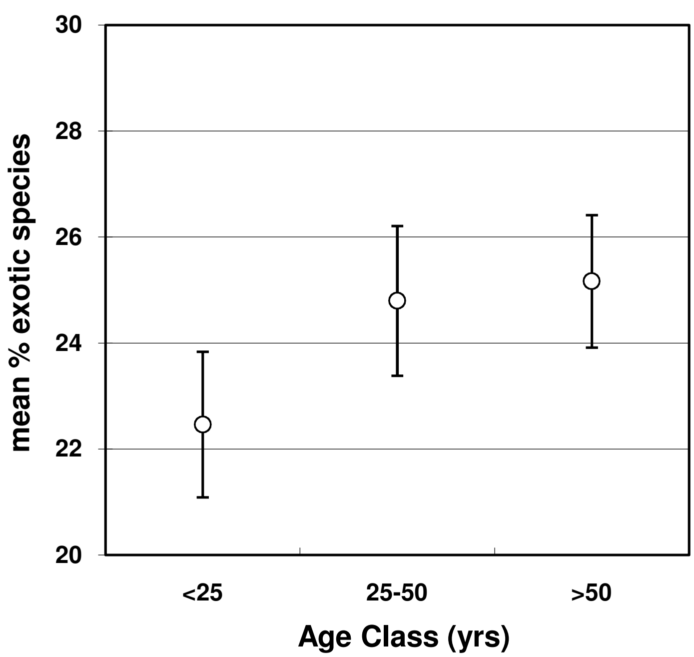


Figure 11. Adjusted mean % (± standard error) of plant species (all layers) that are non-native for cottonwood stands (disturbed stands excluded) by stand age class (aggregated).

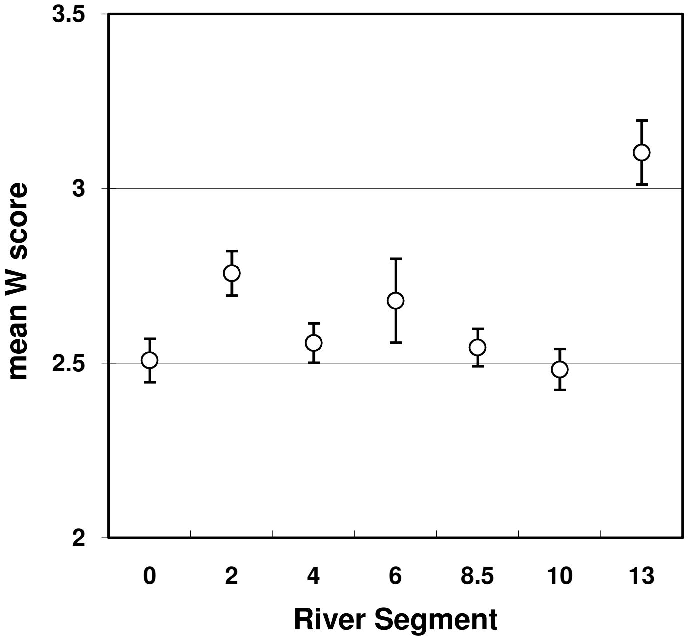


Figure 12. Adjusted mean (± standard error) Wetland score (1 = UPL, 2 = FACU, 3 = FAC, 4 = FACW, 5 = OBL) of plant species within cottonwood stands (disturbed stands excluded) across study segments.

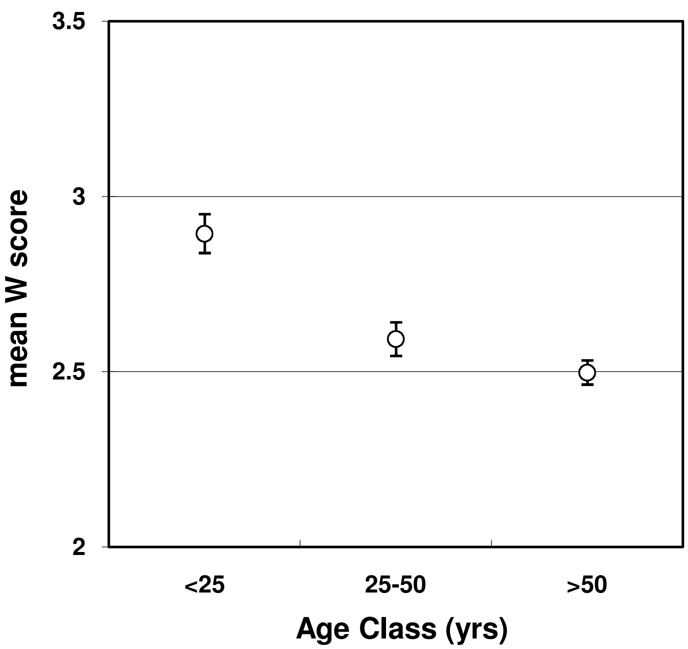


Figure 13. Adjusted mean (± standard error) Wetland score (1 = UPL, 2 = FACU, 3 = FAC, 4 = FACW, 5 = OBL) of plant species within cottonwood stands (disturbed stands excluded) by stand age class (aggregated).

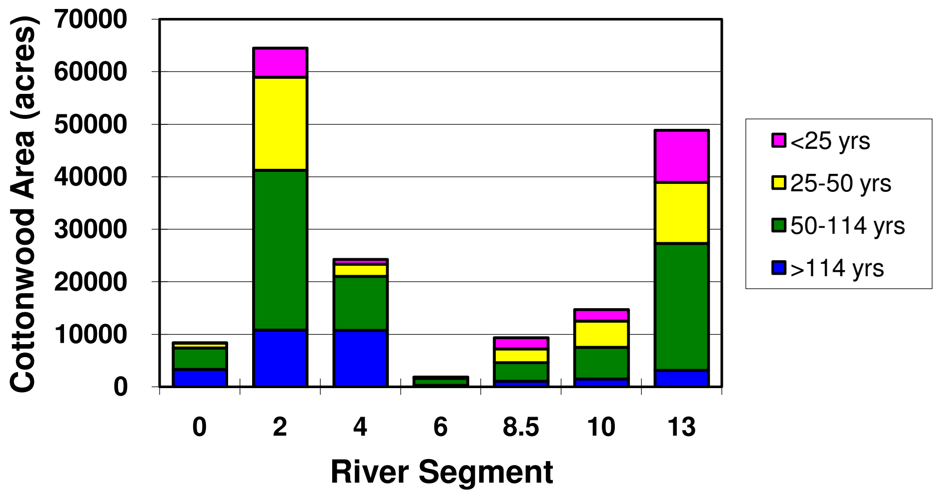


Figure 14. Total cottonwood area (acres), by age class, on each Missouri River segment.

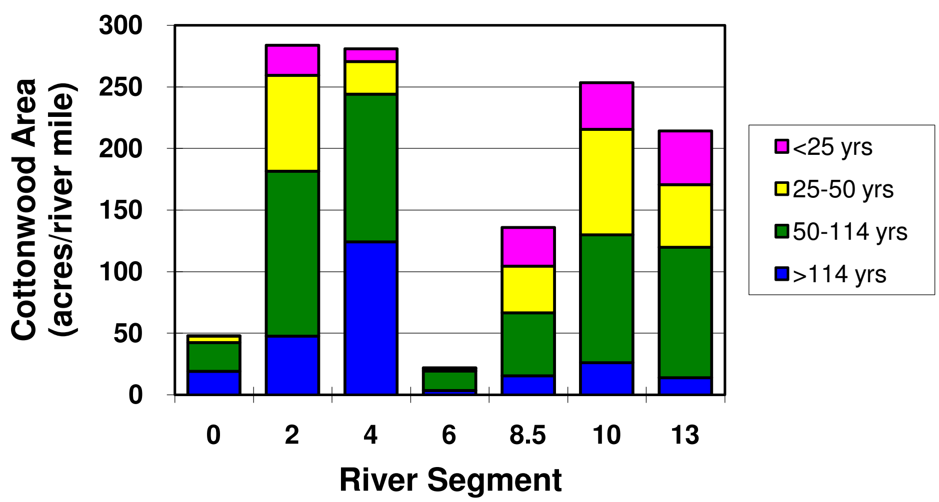


Figure 15. Acreage of cottonwood area per river mile, by age class, on each Missouri River segment.

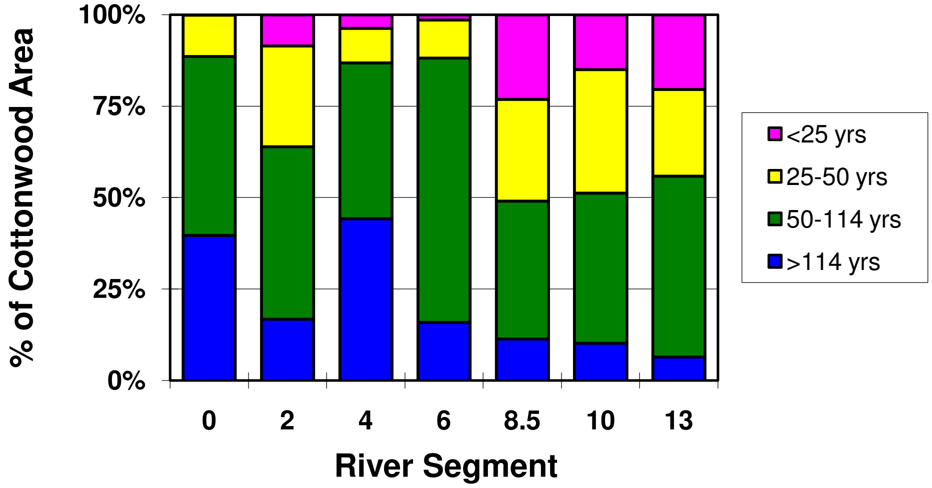
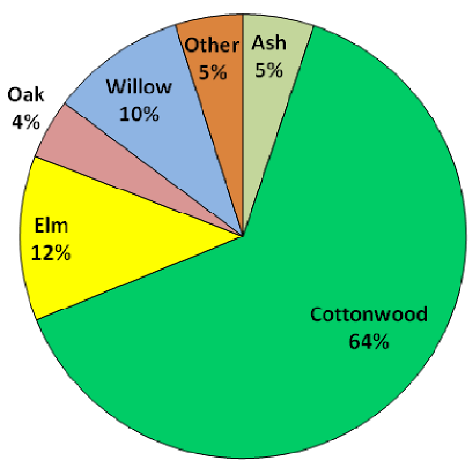


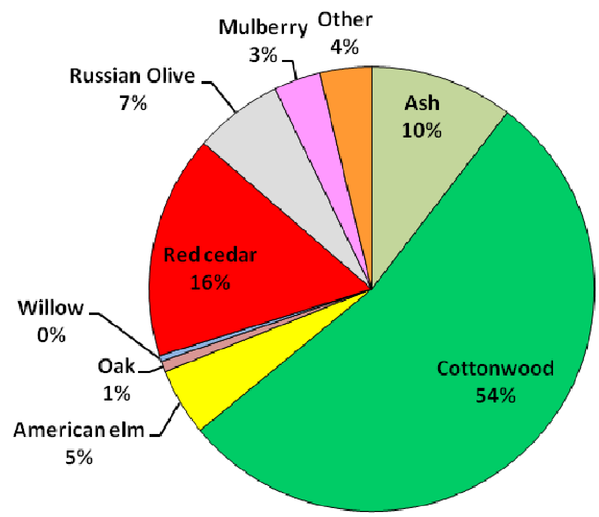
Figure 16. Relative area of different cottonwood age classes on each Missouri River segment.

Relative Density

1857-1869 (GLO Survey, segment 10)

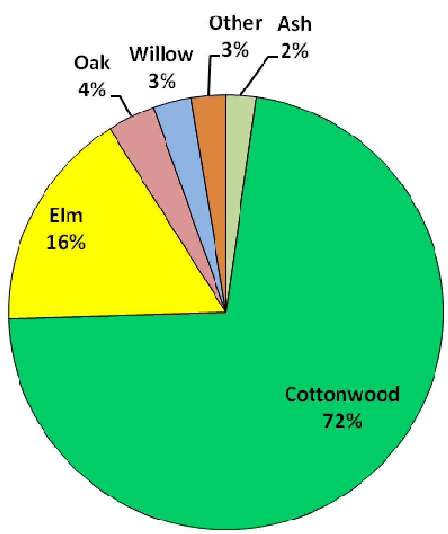


2007 Field Data (segments 8 and 10)

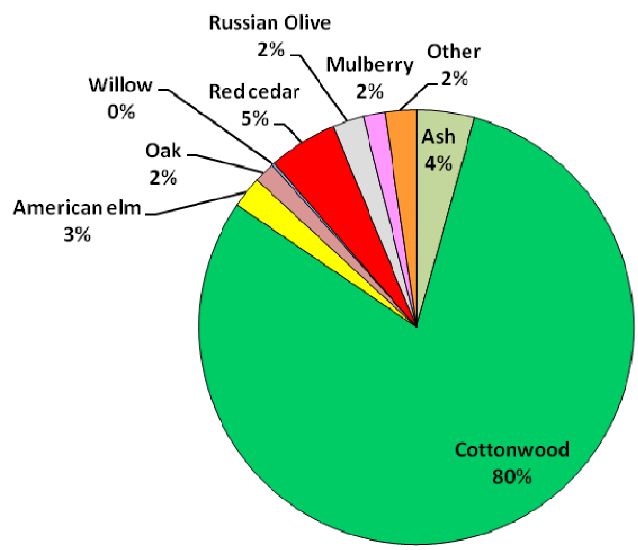


Relative Basal Area

1857-1869 (GLO Survey, segment 10)



2007 Field Data (segments 8 and 10)



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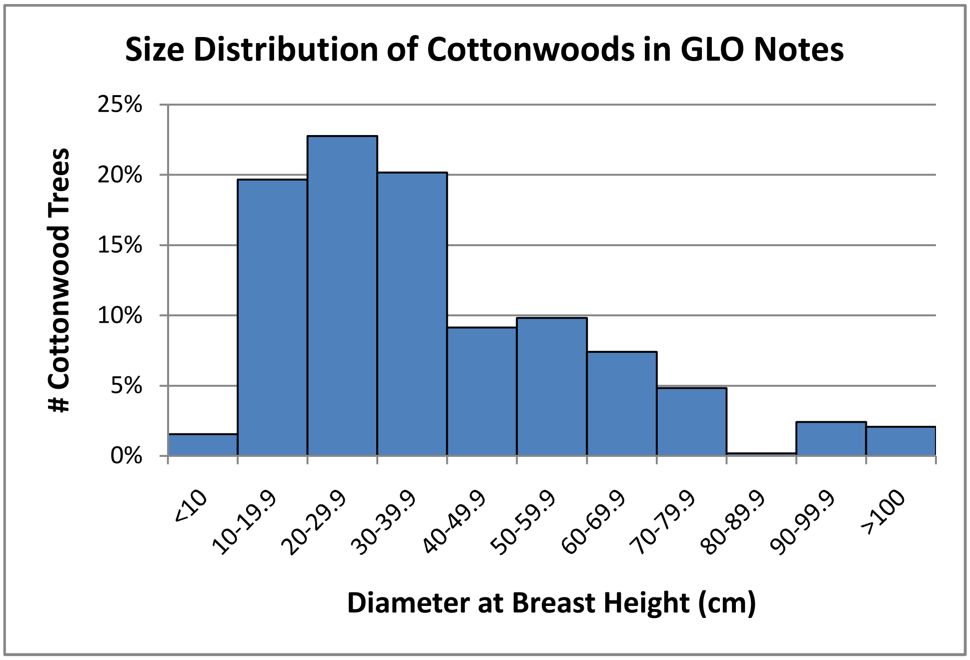

Figure 18. Diameter distribution of witness trees listed as cottonwood in the General Land Office Survey along segment 10.

STATUS AND TREND OF COTTONWOOD FORESTS ALONG THE MISSOURI RIVER

Final Report to U.S. Army Corps of Engineers

Mark D. Dixon, W. Carter Johnson, Michael L. Scott, and Daniel Bowen

March 3, 2010

CONTRACT # W9912DQ-07-C-0011

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STATUS AND TREND OF COTTONWOOD FORESTS ALONG THE MISSOURI RIVER

by

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March 3, 2010

PROSPECTUS

- We used GIS-based mapping and field sampling to assess the current extent, historic change, age distribution, and vegetation composition of cottonwood stands along eight Missouri River segments. Study segments included all of the unchannelized and unimpounded segments (0, 2, 4, 6, 8, 10) between Fort Benton, MT and Kansas City, MO, along with one channelized (13) and two partially impounded segments (6, 9). We sampled vegetation in a total of 332 sites, of which 216 were intact cottonwood stands.

- The Missouri River valley has been transformed since 1892 from a landscape dominated by floodplain forest and grassland, to one dominated by agricultural cropland and river impoundments. The areas of forest, shrubland, grassland, and sandbars have declined sharply on most study segments.

- Forest and shrubland vegetation declined steeply (47%) from 1892 to 2006, primarily due to agricultural conversion (on unimpounded reaches) and reservoir filling (on partially impounded reaches). These estimates do not include the areas of the larger reservoirs on the system (Sakakawea, Oahe, Fort Peck). If these were included, the total percentage loss of forest would be much greater.

- Most current cottonwood stands are >50 years old (62%), with only 14% of stands establishing in the last 25 years. Regeneration is not keeping pace with loss of cottonwoods due to senescence or land use conversions under current management regimes, as reduced rates of channel migration and sandbar formation limit opportunities for new cottonwood seedling establishment.

- In a sense, the large cottonwood forests remaining across much of the floodplain are a legacy of the past and could be thought of as "the living dead", currently helping support a high diversity of plants and animals, but unlikely to be replaced by regeneration in the future. Reversing this trend will require innovative thinking coupled with actions to restore or replicate the dynamic river processes that originally formed and sustained the cottonwood ecosystem.

ABSTRACT

From 2007-2009, we studied the current (2006) and historic (1892, mid-1950s) extent, current age distribution, and plant species composition of plains cottonwood (*Populus deltoides*) and non-cottonwood riparian stands along eight study segments of the Missouri River between Fort Benton, Montana and Kansas City Missouri, covering 930 river miles (1500 km) or over 1/3 of the river's length. These segments included all of the unchannelized and unimpounded segments below Fort Benton, as well as portions of two impounded and one channelized segment. Based on GIS analyses of historic maps and aerial photography, the combined area of forests, woodlands, and shrublands in the historic floodplain declined 47% across all study segments from 1892 to 2006, with losses linked to clearing for human land uses (primarily agricultural cropland) or inundation by reservoirs. Most forest loss occurred between 1892 and the 1950s, while most shrubland loss has occurred from the 1950s to 2006. As of 2006, we estimate that a total of 75,600 hectares (186,900 acres) of shrubland, woodland, and forest occurred within the mapped area of the eight study segments, with 66,800 hectares (165,000 acres) or 88% of the total, composed of patch types which contain cottonwood as a significant component. Most (62%) of the cottonwood area is composed of stands >50 years old, and only 14% is from stands that have recruited in the last 25 years. These patterns, along with significant historic declines in shrubland and sandbar area on most segments, indicate that the fluvial geomorphic dynamics that drive cottonwood recruitment have been reduced, and cottonwood regeneration compromised, under the river management practices of at least the last 25-30 years. A significant proportion (24%) of forest in the 25-50 year age class, however, suggested that a temporary pulse in recruitment accompanied geomorphic adjustments in the channel during the first 2-3 decades after dam closure on some segments. We sampled plant species composition and vegetation structure across an age gradient of cottonwood and non-cottonwood riparian stands in each study segment, with a total of 332 stands sampled, of which 216 were relatively intact natural cottonwood stands. Indices of plant species richness, wetland affinity, and floristic quality differed among stands and study segments, providing possible metrics for evaluating stand- and segment-level differences in biotic integrity. Segments 4 (below Garrison Dam) and 10 (below Gavins Point

Dam) had the highest stand-level species richness (~35 species per stand) and highest floristic quality (Coefficient of Conservatism values) of all segments, while segment 6 (below Oahe Dam) had the lowest of each. Stressors that may influence segment-level vegetation and landscape patterns include land management (e.g., grazing, vegetation management); forest clearing for agricultural cropland and urban or exurban expansion; channel incision and cessation of overbank flooding below dams; disruption of sediment supply and transport, with resultant declines in formation of alluvial surfaces needed for cottonwood recruitment; and aggradation with resultant water table rise adjacent to river-reservoir delta areas. In the report that follows, we provide summaries of current and historic land cover, cottonwood age distribution, and vegetation patterns for each of the eight study segments, as well as an overview across all segments.

INTRODUCTION

Plains cottonwood (*Populus deltoides* Marsh. Subsp. *monilifera* (Ait.) Eckenw.) forests were historically a major component of the floodplain of the Missouri and other Great Plains rivers. Floods maintained the ecological health of these forests by providing moisture to sustain the growth of trees and wetland plants, depositing fine sediments and nutrients that enhanced the fertility of floodplain soils, stimulating decomposition of leaves and woody debris, dispersing seeds of floodplain trees, and forming sediment bars that provided seedbeds for establishing new cottonwood and willow (*Salix* spp.) stands. On many western rivers, major changes in flow regime occurred following the advent of flow regulation in the mid-20th century, leading to chronic recruitment failure by cottonwood on meandering rivers, with long-term implications for landscape configuration and biodiversity (Johnson et al. 1976, Rood and Mahoney 1990, Johnson 1992, Miller et al. 1995). The Bald Eagle (*Haliaeetus leucocephalus*) may be dependent on large, mature cottonwood trees that occur in older stands for nesting and roosting habitat along the Missouri. Maximal biodiversity in the riparian landscape may occur with a dynamic mix of young, mature, and old cottonwood stands, driven by river flooding and channel migration (Johnson 1992).

In the 1950s and 1960s, the Pick-Sloan Plan resulted in the construction of a series of dams on the upper basin of the Missouri River, drowning forests upstream of the dams and greatly altering flow patterns and sediment transport downstream (Schneiders 1999, NRC 2002). On the lower Missouri, bank stabilization, building of levees, and channelization have greatly altered the river channel itself, as well as landscape patterns in the historic floodplain and its forests. The elimination of normal flow and sediment patterns are blamed for a host of natural resource problems along the Missouri, including the lack of sandbar nesting habitat for endangered bird species, poor spawning conditions for native river fishes, reductions in Bald Eagle nesting habitat, and declines in establishment of new cottonwood stands (NRC 2002). Existing forests continue to serve as important habitat for the Bald

Eagle, migratory songbirds (Gentry et al. 2006), and many other woodland species. However, present forests are aging, rates of new forest establishment appear to be declining, and other factors, such as clearing and bank erosion, are reducing the area of existing forests (Hesse et al. 1988). Furthermore, changes in flow patterns and the absence of overbank flooding over the last 50 years may be fundamentally changing the species composition, structure, and trajectories of change within these remnant forests.

The system of 6 large mainstem dams in the upper 2/3 of the river and channelization on the lower 1/3 creates unique challenges and unique conditions for cottonwood on different portions of the river, with a relatively free-flowing (several smaller dams occur upstream), but geologically-constrained segment (our segment 0, in the Wild and Scenic River in Montana) upstream of Fort Peck Reservoir; inter-reservoir segments between Fort Peck and Sakakawea (segment 2), Garrison Dam (Sakakawea) and Oahe (segment 4), Oahe and Big Bend (segment 6), and Fort Randall Dam (Francis Case) and Lewis and Clark Lake (segment 8/9); partially impounded segments 6 and 9; an unimpounded and unchannelized segment downstream from Gavins Point Dam (segment 10), and segments in the channelized and leveed portion of the river, such as segment 13. Johnson (2002) suggested that these different reach types, in terms of management regime, may lead to important ecological differences among reaches and to the creation of novel habitats (e.g., reservoir deltas, etc.) that may contribute to biodiversity in the system.

Forests along all portions of a regulated reach may suffer from lack of a seasonal flood pulse that moves sediment to create recruitment seedbeds, transports and deposits seeds of cottonwood and other species, and moistens floodplain soils. In addition to changes in flow patterns, segments that are downstream from dams may suffer sediment deficits and channel incision, due to sediment storage within the upstream reservoir. Channel incision further isolates the historic floodplain from the river, effectively raising the level of the floodplain relative to the river and reducing the potential for overbank flooding. Sediment deficits may limit the formation of sediment bars that are necessary for cottonwood recruitment, Piping Plover (*Charadrius melodus*) and Interior Least Tern (*Sternula antillarum athalassos*) nesting, and other ecological functions. However, at the downstream end of inter-reservoir segments, particularly where a major sediment-bearing tributary enters just upstream of the reservoir (e.g., White River in Lake Francis Case, Bad River upstream of Lake Sharpe, Niobrara River upstream of Lewis and Clark Lake), sediment aggradation and rising water tables may kill or stress existing forests, as reservoir sedimentation and delta formation leads to the creation of aquatic/riparian delta habitats. During prolonged dry periods, the shores and upstream ends of some reservoirs may become exposed, enabling temporary colonization by cottonwood and other riparian species (but lost when reservoirs fill up again). On the channelized segments on the Lower Missouri, flooding and sediment dynamics are constrained by bank stabilization, wing dikes, and levees. Yet, flooding may still occur here on either side of the levee during high flow events, with potential recruitment occurring on farmland and other open habitats.

This project was conducted in support of the U.S. Fish and Wildlife Service's Biological Opinion on the Missouri River in regard to reasonable and prudent measures for the Bald Eagle, and was motivated by the need to assess the current status of cottonwood forests along the Missouri River, including their composition, structure, health, areal extent. Data and conclusions derived from this project will be used by the US Army Corps of Engineers to develop a Cottonwood Community Model using the HEAT methodology for 6 moderate to high priority Missouri River segments for the Bald Eagle (segments 4, 6, 8, 9, 10, and 13). This model will be used to evaluate the present condition of the cottonwood community and forecast future conditions under a range of alternatives for cottonwood management actions.

Our specific aims were to determine the following:

1. Present-day land cover within the historic Missouri River floodplain, including the distribution of cottonwood forest and early successional cottonwood sites;
2. Historic land cover patterns and forest distribution along the Missouri, particularly baseline pre-dam conditions, and changes from these historic pre-dam patterns to present-day patterns;
3. The present-day successional stage and age distribution of riparian woody vegetation patches, particularly those containing cottonwood;
4. The plant species composition and structure within existing cottonwood stands, disturbed cottonwood, and non-cottonwood riparian shrublands and forests, across a successional gradient from sapling stands to old growth stands;
5. Included in #4, the characteristics of the plant species occurring in these stands, in terms of their affinity for wetland habitats and their affinity or dependence on undisturbed natural habitats (i.e., the floristic "quality" of the vegetation) and use these as indices of stand-level and segment-level biological integrity.

Here we summarize our findings for the eight study segments in terms of current (2006) and historic (1892, 1950s) land cover, the absolute and relative area of different age classes of cottonwood stands, and analysis of vegetation (trees, shrubs, herbs) data collected within each age class of cottonwood, disturbed cottonwood, and non-cottonwood stands sampled in 2007-2009.

METHODS

Study Segments

We mapped and sampled 8 Missouri River segments (Table 1, Figure 1), from Kansas City, Missouri to Fort Benton, Montana, including approximately 930 river miles (1500 km), which constitutes roughly 1/3 the length of the entire river. The study area for this effort includes river reaches identified as high and moderate priority sites for Bald Eagle compliance with the Missouri River Biological Opinion. They are segments 4: Garrison Dam to Lake Oahe Headwaters south of Bismarck, ND (RM 1390 to RM 1286), 6: Oahe Dam to Big Bend Dam (RM 1072.3 to RM 987.4), 8: Fort Randall Dam to the Running Water Bridge (near Springfield, SD), just below the Niobrara River confluence (RM 880.0 to RM 841.0), 9: Running Water Bridge to Gavins Point Dam, including Lewis & Clark Reservoir (RM 841.0 to RM 811.1), 10: Gavins Point Dam to Ponca, NE (RM 811.1 to RM 753.0) and 13: Platte River mouth to Kansas City, MO (RM 595.5 to 365.5) of the Missouri River. In addition, we also included segment 2: Fort Peck Dam to Lake Sakakawea Headwaters near Williston, ND (RM 1771.3 to RM 1543.3), and a free-flowing segment within the Wild and Scenic River reach (RM 2073.4 to 1917) upstream of Fort Peck Lake (segment 0). Inclusion of segment 2 means that all inter-reservoir segments below Fort Peck were sampled and mapped, while segment 0 potentially provided a reference reach that was less impacted by flow regulation (Galat and Lipkin 2000). Our study segment boundaries may differ slightly from other published definitions of these segments and are based on 1960s river miles.

For mapping purposes, study area boundaries on each segment were defined by the extent of the segment, in river miles (see above) and laterally by the valley wall. The lateral boundary was determined by digitizing the break between the low topographic relief of the valley and the steep slopes of the bluffs, using county mosaic Digital Raster Graphic (DRG) scans of the USGS 7.5 minute quarter quadrangle maps (obtained from USDA NRCS Geospatial Data Gateway, http://datagateway.nrcs.usda.gov/). These lateral boundaries were sometimes adjusted to account for minor registration problems or lateral shifting of the river channel or reservoir, or to include sampling sites that occurred at the bluff-valley boundary or in tributaries.

On segment 10, the valley was very wide (>16 km) in places and the 1892 Missouri River Commission (MRC) maps did not always extend to the valley wall. Because of this, we truncated the lateral boundary of the study segment at the lateral extent of the 1892 MRC maps, or the valley wall, whichever was closer. Exceptions to this lateral boundary were in the vicinity of the towns of Vermillion and Yankton, SD. Because we were interested in mapping historic urban expansion in these two areas, we extended the study area boundary to include portions of the upland within or adjacent to the 2006 extent of Vermillion and Yankton.

Segment 13 was a very long segment (230 miles), within a wide valley, and with similar limitations on the width of coverage of the 1892 MRC maps and our aerial photography. Because of these constraints, we limited the mapped area of segment 13 to within 4.8 km (3 miles) on each side of the river centerline or to the valley wall, whichever was closer.

GIS Mapping

Land Cover Mapping

We mapped current (2006) land cover on each river segment by interpreting and digitizing 2006 county mosaic orthophotography from the National Agricultural Imagery Project (NAIP), obtained from the USDA NRCS Geospatial Data Gateway (http://datagateway.nrcs.usda.gov/). In the case of segment 10 (Figure 2), these were supplemented with 2008 NAIP imagery for delineation of particular features (e.g., constructed sandbars and backwaters). The NAIP imagery was in natural color, and had a pixel size of 2 m (1 m for 2008) and horizontal positional accuracy of approximately 10 m. The projection for the imagery and for all subsequent shapefiles and geodatabases in ArcGIS 9.2 was NAD 1983 with UTM Zones 12N (segment 0), 13N (segment 2), 14N (segments 4, 6, 8, 9, 10), or 15N (segment 13). Digitizing was done on the screen ("heads-up" digitizing) with the image at a scale of 1:10,000. For particularly large and simple polygons (e.g., agricultural cropland), we sometimes zoomed out to a resolution of 1:24,000 for interpretation and digitizing, and sometimes zoomed in to scales finer than 1:10,000 for particularly complex polygons or for vegetation types that were difficult to discern. A minimum mapping unit of 1 hectare (2.47 acres) was used, although all polygons were retained in a vector format. Hence, for the most part, patches < 1 hectare were not mapped, but were effectively merged with the surrounding dominant land cover (e.g., agricultural cropland). We developed our own land cover classification system specifically for the vegetation types encountered along the Missouri River and based upon our study goals and the resolution of our imagery. A list and short description of the land cover categories are given in Table 2.

We also interpreted and digitized land cover from the 1892 maps and 1950s aerial photography (USDA) for each river segment, and 1983/84 (NHAP) for segment 10. The 1892 land cover was based on digitizing the vegetation type designations on the Missouri River Commission (MRC) maps, published in 1895. We obtained digital, georeferenced images of the MRC maps from the U.S. Army Corps of Engineers, Omaha District (Jon Kragt, USACE, Omaha, personal communication). These maps were originally at a scale of 1:63,360 with a scanned pixel resolution in ArcGIS of 4.6 m. Original maps were in latitude-longitude, and scanned georeferenced images were in the Albers projection. Some adjustments were necessary for the MRC maps on segment 0 to correct for lateral shifting of the images (Tammy Fancher, USGS, Fort Collins, CO, personal communication). Because of the coarser nature of these images, we interpreted and screen-digitized at a scale of 1:24,000 for most polygons. Land cover classes in the 1892 map differed somewhat from what we used for the

2006 land cover. Because of this, comparisons between the 2006 and 1892 landscape composition required determination of comparable patch types and lumping of others. For some patch types (e.g., willows, bushes, sandbar), it was difficult to discern unambiguously what criteria were used in classification in the MRC maps, and whether our classes were completely comparable (e.g., some young recruitment sites for cottonwood could have been coded as 'sandbar' in the 1890s imagery). These limitations should be taken into account when interpreting historic changes in vegetation between the 1892 maps and the 2006 orthophotographs.

For our forest age class mapping, and for mapping of 1950s and (for segment 10) 1980s land cover, we obtained and geo-rectified aerial photography from the mid- to late-1950s (1955-57 when possible) and the 1980s (NHAP1 project, 1980-87). For segment 10, we also had access to fine-resolution (0.3 m) natural color digital orthophotography from 1997, supplied by the US Army Corps of Engineers, with similar imagery for 1998 on segments 8 and 9. For segment 13, we acquired black-and-white digital orthophotography (USGS) from 1999. These 1990s imagery were not digitized, but were used for interpreting younger forest/shrubland age classes in our age class mapping (see next section). 1950s imagery was black-and-white aerial photography flown for the USDA Commodity Stabilization Service of the FSA (Farm Service Administration), originally at 1:20,000 scale, and was obtained principally through the USDA Aerial Photography Field Office (http://www.apfo.usda.gov/). These images were obtained as 25 micron digital scans, with a pixel resolution of approximately 0.5-0.6 m. For segment 10, we also used some 1950s imagery that we had available as hard copy photographs, and scanned these to a pixel resolution of 2.8 meters. A few coarser scans of 1953 imagery from the USDA Soil Conservation Service (also FSA), originally shot at 1:63,360 scale and scanned at 200 dpi, were used to fill in gaps in coverage of the finer resolution 1955/56 imagery. Aerial photography from the 1980s was obtained from the USGS NHAP1 project. The imagery was color-infrared, shot at an original scale of 1:60,000 and scanned at 21 microns, for a resulting pixel resolution of approximately 1.3 m. Imagery was obtained from the USDA APFO and the USGS EROS Data Center (http://eros.usgs.gov/).

For geo-rectification, we used the 2006 NAIP orthophotography as our base map and referenced historical imagery to it. We used the geo-rectification tool in ArcGIS and selected approximately 5-20 points common to both images (e.g., road intersections, corners of buildings, trees, bridges, etc.) as control points for geo-referencing the historic image to the base map. We applied 1st order or 2nd order transformations in the geo-rectification process, depending on the degree of distortion in the image and the RMS (root mean square) error of the rectification process, aiming for an error less than 5 m, and preferably closer to 2-3 m. All interpretation and digitizing were done on the rectified images.

Land cover maps and age class maps (see below) were improved by field reconnaissance (ground-truthing). Ground-truthing consisted of boating the river or driving roads in the floodplain and comparing classified land cover with observations on the ground. Field ground-truthing was the primary means of differentiated cottonwood from non-cottonwood shrubland and forest sites, rather than trying to determine species composition in woodlands and forest from the aerial imagery. The only major exceptions were on more remote portions of the downstream end (subreach 4) of segment 4, where differentiation of some cottonwood vs. non-cottonwood shrubland and young forest stands had to be done using the imagery alone. Because distinguishing cottonwood and non-cottonwood sites was the main aim of the ground-truthing, and because any observed discrepancies were corrected in the GIS files, we did not calculate estimates of classification error.

Age Class Mapping

We used the 1892 MRC maps, aerial photography from the mid-1950s (black-and-white) and 1980s (color infrared), 2006 NAIP orthophotography (in true color), and, when available, late 1990s orthophotography (black-and-white or color infrared), to map approximate age classes of cottonwood and non-cottonwood shrubland, woodland, and forest. We delineated approximate stand age (see Figure 3 for an example of an age class map) using the following steps: (1) selected polygons on the 2006 land cover that corresponded to cottonwood forest, woodland, shrubland, or vegetated sandbar categories; (2) visually overlaid these polygons in ArcGIS with historic georeferenced maps or photographs from 1997/98, the early to mid-1980s, mid- to late 1950s, and 1892; (3) determined the approximate photograph/map interval during which the present woody vegetation colonized the polygon of interest (e.g., converted from unvegetated sandbar to woody vegetation); (4) assigned the polygon, or portions of it, the age class (1 = >114 years, 2 = 50-114 years, 3 = 25-50 years, 4 = 10-25 years, 5 = <10 years) consistent with that establishment interval. All ages were expressed relative to the year 2006. In some cases, different parts of a given polygon differed in age class, and we split the polygon into multiple polygons of woody vegetation with different ages. Further refinement and correction of stand ages were accomplished via field reconnaissance. In some cases, particularly on segments 0, 2, and 4, this included aging stands via tree-coring.

Land Cover Transitions on Segment 10

On segment 10, we supplemented our other, polygon-based land cover mapping by examining land cover transitions across a series of points distributed in a grid across the study area. Using Excel and ArcGIS, we created a shapefile containing a grid of approximately 3000 points (spaced 250 m apart in the North-South direction and 1000 m in the East-West) within a 3-mile (4.8 km) buffer of the river thalweg along segment 10. We clipped this point grid to the study area boundaries, excluding grid points that occurred outside the boundary. Overlaying this grid on top of georeferenced imagery from 1892, 1955/56, 1983/84, 1997, and 2006, we then identified the land cover class that was present at that point on all of the different image years. For each point, we entered the land cover class for each of the five dates as attributes in the ArcGIS point shapefile. Analysis of change was based on tallying the number of transitions from one land cover class to another (e.g., the proportion of points that changed from riparian forest to agriculture between dates). Because of missing imagery, data were not available from all points for all years. Hence, land cover transitions were assessed using only points that were in common among the 1950s, 1980s, and 2006 imagery (2114 total points). In this report, we only focus on land cover transitions that have occurred in the post-dam period: the intervals 1956-1984, 1984-2006, and 1956-2006. The emphasis on the post-dam dates was so that estimates of recent land cover transition rates could be determined and potentially used to forecast future landscape change using state-and-transition matrix models or other approaches. Follow up work may include projecting future landscape composition based on these recent trajectories and analyzing rates of land cover change over other intervals (e.g., 1892-1956, 1984-1997, etc.).

Reconstruction of Pre-settlement Overstory Composition

We obtained, interpreted, and transcribed the witness tree data from the General Land Office Survey notes for the Missouri River historic floodplain in Clay, Union, and Yankton counties, South Dakota and Dixon and Cedar counties, Nebraska, within segment 10. The bulk of the records were from 1857-59 on the Nebraska side and 1860-61 on the South Dakota side, although some supplementary survey data were from other years (1862, 1867, 1869). Data were available for 1059 section or quarter section corners (although not all of these had trees) and witness trees were also recorded at other locations along the survey lines. The dataset included information on 917 witness trees, across 12 species. Stem diameter measurements (diameter at breast height) were available for most of the trees. We tallied the frequency and basal area of all witness trees in the study area and compared them to relative density and basal area data from present-day (2007) vegetation sampling within cottonwood stands in segments 8 and 10 (Figure 4).

Vegetation Sampling

Three methods were used in concert to sample the vegetation of cottonwood stands in the Missouri River floodplain. Sampling included characterization of (1) overstory composition and structure using the point-centered quarter method or (on pole and sapling sites with few tree-sized individuals) fixed radius circular plots, or complete plot census methods; (2) shrub/sapling composition, density, and cover using belt sampling and line intercept methods; and (3) herbaceous species composition and cover using 1 x 1 m quadrats.

Stand and Sampling Point Selection

We stratified each river segment into longitudinally into three subreaches, based on river miles or geomorphic considerations. Segments 2 and 4 were exceptions, with each divided into four subreaches. On both of these segments, subreach 4 represented a downstream extension of the original study area extent. When possible, we sampled 10 cottonwood stands within each sub-reach, for a total of 30 stands in each river segment. Within each subreach, we attempted to sample 2 stands from each of the following age classes: >114 years (old growth), 50-114 years (mature), 25-50 years (intermediate), 10-25 years (pole), and <10 years (sapling). Approximate stand ages were determined by overlaying historical maps and aerial photographs by the methods outlined above (in the section detailing the GIS mapping methods), and in some cases by coring and aging trees. Beginning in 2008, we also sampled disturbed cottonwood stands and non-cottonwood stands in the 6 priority segments (4, 6, 8/9, 10, and 13), with a goal of 12 non-cottonwood and 6 disturbed cottonwood stands per segment, and attempted to obtain at least some stands in each of the same age classes. Constraints on site availability meant that these goals were not always attained for all of the segments. Because of small numbers of stands in segment 9, data for segments 8 and 9 were combined (denoted segment 8/9) for most analyses.

Initial (in 2007) criteria for stand selection of undisturbed cottonwood forests included:

- At least 10-15% overstory cover by cottonwood
- An unmanaged or "natural" overstory, shrub, and herbaceous layer
    - No or minimal selective clearing of overstory trees
    - No selective clearing of red cedar, Russian olive, or other species
    - No campgrounds or sites with otherwise managed understories
- Patch size of at least 4-6 hectares (10-15 acres) for pole through old growth stands. Seedling/sapling sites could be smaller, down to 1 ha. (2.5 acres) or less.
- A stand, or the area of the stand included in a given sample, should be relatively homogeneous in terms of age and management
    - No mixture of our age classes
    - Preferably, no mixture of samples across obviously different cohorts of cottonwoods, even if the stand as a whole falls within a single crude age class (as defined above)
    - Avoid mixing portions of a stand with different past management regimes or obviously different vegetation structure (e.g., big differences in tree density, abundance of red cedar, etc.)

Additional disturbed and non-cottonwood stands sampled in 2008 diverged from these criteria in terms of % overhead cover of cottonwood (non-cottonwood sites were <10-15% cottonwood overstory cover) and disturbance (we explicitly selected sites with some degree of anthropogenic disturbance for the “disturbed” cottonwood sites). These stands were sampled to provide a wider range of cottonwood or riparian forest stand conditions and indices of floristic quality and to enable inclusion of these other forests within the cottonwood community model being developed by USACE.

In 2009 we added additional cottonwood and non-cottonwood sites on the South Dakota study segments (6, 8, 9, and 10), in part to improve sample size in under-sampled age and stand type categories. We also sampled several (10) planted cottonwood stands on segments 6 and 8. Data from planted cottonwood sites were collected to enable comparison between planted and naturally occurring stands in terms of stand structure and overstory and understory species composition (e.g., richness, floristic quality, etc.). Analyses of the planted stand data, however, are not included in this report.

Table 1 indicates the numbers and types of stands sampled in the eight study segments. A total of 216 cottonwood, 32 disturbed cottonwood, 74 non-cottonwood, and 10 planted cottonwood stands, for a total of 332 sites (plus one herbaceous former cottonwood site), were sampled in 2007-2009. Of these, 80 of the cottonwood stands, 23 of the non-cottonwood stands, and 8 of the planted cottonwood stands were in the sapling or pole (<25 years) age classes. Very few (3) disturbed stands in the sapling or pole (<25 years) age classes were identified and sampled. 30 stands in segment 4 were resurveys of sites previously sampled in 1969-70 (Keammerer et al. 1975, Johnson et al. 1976).

Overstory Sampling

For most stands, we used the point-centered quarter method (Cottam and Curtis 1956) for sampling and characterizing stand-level tree species composition, density, and basal area. This method provides an efficient technique for rapidly surveying stand characteristics, enabling a crew of three to easily sample a stand in 4-8 hours. These methods are consistent with those used by Carter Johnson (Johnson et al. 1976) on the Garrison to Oahe reach (segment 4) of the Missouri River in North Dakota in 1969-70. We resampled 30 of the 34 stands originally sampled by Johnson and Keammerer (Johnson et al. 1976, Keammerer et al. 1975). Further analysis of these data will enable assessment of the long-term effects of flow regulation and successional change during the last 39 years within this segment.

On sites sampled using the point-centered quarter method, forty points were sampled per stand, with 4 trees per point (160 total per stand). At each point, we divided the area into four 90 degree quadrants, relative to the transect bearing and a line perpendicular to it. Within each of these quadrants, we located the nearest live tree with a trunk diameter at breast height (dbh) ≥ 10 cm, identified it to species, measured the dbh to the nearest centimeter, and measured the distance from the point to the center of the tree trunk to the nearest 0.1 meters or finer. For trees with multiple trunks, we measured and recorded all stems that equaled or exceeded 10 cm dbh. If the nearest tree in a quadrant was dead, we recorded the species (if known), dbh, and distance from point, and then looked for the nearest live tree within the quadrant. In cases where no live tree could be located within a reasonable distance in the quadrant (e.g., > 35 m), the quadrant was recorded as "open." Distances were measured using an electronic measuring device (Sonin multi-measure), optical rangefinder, or measuring tapes. For sites with open quadrants, we applied a correction factor to estimates of stem density, using the simple correction suggested by Dahdouh-Guebas and Koedam (2006). In addition to measuring trees, we also noted and recorded whether each tree measured had a liana (woody vine) growing on its trunk.

Because many or most of the cottonwoods in sapling and pole stands had stem diameters <10 cm at breast height, these sites often had a large number of points (or all points) with open quadrants where a tree with dbh ≥ 10 cm could not be measured within a reasonable distance and/or the same individual tree would have been measured more than once at multiple points. Similar difficulties occurred in some older sites that were very patchy or open in terms of tree distribution, with sometimes very long distances to the nearest tree. For such sites, a large correction factor would had to have been applied to generate density estimates, and we considered the estimates of density unreliable. Hence, for most sapling and pole sites and a few other sites of various age classes, we sampled tree density using12 fixed radius (15 m) circular plots instead of or in addition to the point-centered quarter sampling. Within each circular plot, we measured and recorded the stem diameter for all tree stems ≥ 10 cm dbh. This enabled us to obtain real density estimates for points with no trees (i.e., 0 stems per unit area), whereas the point-centered quarter method requires that trees be present and cannot yield density estimates of zero.

On some sites, particularly in the Wild and Scenic segment (segment 0) in Montana, where cottonwoods often occur in smaller, linear patches paralleling the river, neither point-centered quarter nor fixed radius circular plots were effective, given the geometry of the stands. Hence, strip transects or narrow, rectangular plots were used to sample tree density, with all trees present in these plots sampled in a complete census (Michael L. Scott, USGS Fort Collins, CO, personal communication).

In the data summaries that follow, we combine data from the point-centered quarter, fixed radius plot, and complete census plot techniques, retaining the point-centered quarter estimates for most stands >25 years old and pole stands with few or no open quadrants.

Understory Sampling

Understory sampling characterized both the shrub and herbaceous layers. In contrast to the overstory sampling, only 12 (for shrubs) and 24 (for herbaceous layer plants) points were sampled per stand. These points were either on completely separate transects from those used in the overstory sampling, or were offset from the overstory transects to avoid trampling the herbaceous vegetation. These were generally arranged on four transects, as with the trees, with 6 herb points and 3 shrub points per transect.

Plants occupying the shrub layer (shrubs and tree saplings > 1 m tall and < 10 cm dbh) were sampled using the line-strip method (Lindsey 1955), using a sampling strip 2 m x 10 m with a tape defining the centerline. This sampling strip began at the point and ran along the bearing of the transect. Woody stem density (#/ha) in the shrub layer was estimated by counting all individual shrubs, saplings, and woody vines found within the sampling strip (1 meter to either side of the 10 m transect). Numbers were tallied for each species.

Percent cover was estimated by recording cover by shrubs (or saplings and woody vines) that intercepted the vertical plane of the plot centerline above 1 m off the ground. We noted the total distance along the 10-meter tape length with overhead shrub cover by each species and summed the contributions of individual species to get total cover. Note that this can exceed 100 percent, as different species can have overlapping coverage over the same length of tape. In 2008, we revised our data recording to enable quantification of overlapping coverage, allowing estimation of total shrub cover (without inflated estimates from overlap) on each plot. For this report, however, we have retained the data obtained from the former approach, so as to include consistent data from all sampled stands.

Plants in the herbaceous layer (herbs and woody seedlings < 1 m tall) were sampled using a 1 m x 1 m sampling frame (quadrat) beginning at or centered on the sampling point. Care was taken to avoid trampling on the area prior to sampling. For this reason, we sampled the herbaceous quadrat prior to the shrub sampling. All species of non-woody vascular plants and woody seedlings were noted and recorded and their percent cover within the 1-m^2 quadrat estimated to the nearest 5%. Species with trace occurrence were recorded as 1% cover.

Voucher specimens of plants encountered during sampling were obtained and submitted to Dr. Gary Larson of South Dakota State University. Specimens were obtained in full flowering condition when possible. When possible, we obtained voucher specimens in duplicate or triplicate, so that at least one specimen could be deposited in the C. A. Taylor Herbarium of South Dakota State University, one in the home institution (e.g., University of South Dakota, Benedictine College, USGS), and additional specimens could be donated to US Fish and Wildlife Service or National Park Service collections.

Data Reduction and Analysis

These sampling protocols produced the following basic information: stand- and segment-level plant (vascular plant) species lists; frequency and percent cover of each species in the herbaceous layer; frequency, percent cover, and density of each species in the shrub layer; and the frequency, density, basal area (m^2/ha) and importance value (sum of percent relative frequency, density, and basal area, with a maximum value of 300) of each tree species. For complete census plots for trees, there was no way to calculate relative frequency separately from relative density. Hence, for those sites (mostly in segment 0), we computed importance value using relative basal area plus two times the relative density for each species. By assigning published wetland indicator values (Reed 1988) and Coefficients of Conservatism (C-values) (Swink and Wilhelm 1994, Taft et al. 1997, Northern Great Plains Floristic Quality Assessment Panel 2001) to species of plants, estimation was made of the wetland affinity and overall floristic quality of the vegetation in each stand.

Plant Species Data Summaries and Metadata

Each investigator was responsible for submitting a master spreadsheet listing the scientific name of each species encountered during sampling, any code names used to identify that species in the data, whether the species is native or introduced, its wetland indicator status for the relevant region, and its Coefficient of Conservatism. Wetland Indicator status codes (Reed 1988 and later updates) have been standardized by region and may be obtained from the following website: http://www.fws.gov/nwi/plants.htm or from the USDA NRCS Plants Database (http://plants.usda.gov/) (USDA, NRCS 2008). Coefficients of Conservatism (i.e., how indicative is a given species of the "naturalness" or conservation value of a study site) have been developed for the flora of a number of regions (e.g., The Northern Great Plains Floristic Quality Assessment Panel 2001 for North and South Dakota, http://www.npwrc.usgs.gov/resource/plants/fqa/index.htm) and is most often used in Floristic Quality Assessment for calculating the Floristic Quality Index (Swink and Wilhelm 1994, Taft et al. 1997) or FQI. These codes can enable calculation of species- or cover-weighted average estimates of wetland affinity and overall vegetation quality or "naturalness" in each stand.

For segments 6. 8, 9 and 10, we obtained Coefficient of Conservatism (C) values from a software package called Floristic Quality Assessment Computer Program, Version 1.0 (October 2000) by Gerould S. Wilhelm and Linda A. Masters, with the Dakotas database (North and South Dakota). These data were originally derived from the publication by the Northern Great Plains Floristic Quality Assessment Panel (2001), mentioned above. For species that were not found in the Dakotas database, we used the C values from a 2006 draft update of the Nebraska Natural Heritage Program state list (Rolfsmeier and Steinauer 2003). In a limited number of cases (for species not listed in either the Dakotas or Nebraska lists), we used a draft list compiled for Iowa (http://www.public.iastate.edu/%7Eherbarium/coeffici.html). For segment 4, C-values were obtained primarily from the publication by the Northern Great Plains Floristic Quality Assessment Panel (2001) for the Dakotas. For segments 0 and 2, C-values were taken from Lesica and Husby (2001, http://nris.state.mt.us/wis/wetlands/metadata.html). In instances where C-values for particular species could not be obtained from the preferred source for that region, we used C-values for that species from neighboring states. Hence, scores from the Northern Great Plains Floristic Quality Assessment Panel (2001) were used when species encountered in segments 0 or 2 were not listed in Lesica and Husby. For segment 13, the previously mentioned Nebraska list (Rolfsmeier and Steinauer 2003) was the first choice for assigning C-values, with the Missouri List by Ladd (1997) used secondarily and the Iowa list used for any species not found on the other two lists.

We calculated FQI and mean C as in Swink and Wilhelm (1994) and Taft et al. (1997), except that we included all species for which we had C values, and used a value of 0 for non-native species. So, overall mean C and FQI values were computed based on the complete list of species sampled at each stand (across the herb, shrub, and tree strata). These species lists include some occurrences of plants that could only be identified to the genus level, which may be redundant with other, identified species in the same genus on the site. We also computed weighted mean C values that were weighted by relative cover or importance values of the individual species in the herb and shrub strata. We obtained information on native vs. exotic status from the program and from the USDA NRCS Plants Database (USDA, NRCS 2008).

For analyses of Wetland Indicator Status, we obtained indicator scores from the appropriate regional lists (Reed 1988), obtained from the USDA NRCS Plants Database (USDA, NRCS 2008). For segments 6. 8, 9 and 10, we used lists for Regions 4 (South Dakota), 5 (Nebraska), and 3 (Iowa), in that order of preference. Region 4 scores were also used for segments 2 (downstream of Fort Peck) and 4 (downstream from Garrison) in eastern Montana and North Dakota, respectively. For segment 0, in the Wild and Scenic reach in Montana, we used the Region 9 (Northwest) list. For segment 13, we used the Region 5 (Central Plains, including Nebraska) list first, and used the Region 3 list (North Central, including Missouri and Iowa) for species that were not listed for Region 5. As with C-values and FQI, we computed both unweighted average WIS scores (average of all of the species encountered at a site) and scores weighted by percent cover or importance value of herbs or shrubs. Overall scores that included both herbaceous and woody species were based only on the unweighted species lists, for mean C, FQI, and WIS.

Our numeric scale for scoring Wetland Indicator Status (W) differed from other investigators (e.g., Stromberg et al. 1996), is that we assigned a value of 5 to wetland obligate plants and a 1 to upland species (this is the opposite of the normal approach). In essence then, higher scores (closer to 5) represent higher wetland affinity in our system. We ignored + or - modifiers in our scoring (e.g., FACU, FACU- and FACU+ are scored as a 2, FAC and FAC- as 3, etc.). As with C-values and FQI, we computed overall (across plant strata) average W scores based both on unweighted species lists, but also computed separate estimates weighted by relative cover or importance value for herbs and shrubs.

For the analysis of differences among segments or cottonwood age classes in stand-level W scores, C-values, and species richness values, we used a factorial ANOVA, with segment and stand age (and the interaction between the two) as explanatory variables. These analyses were conducted only for cottonwood stands; both non-cottonwood and disturbed cottonwood stands were excluded. Because of small sample sizes for some stand age classes, we grouped younger age classes (<10 and 10-25 years) into a <25 year age class, and mature and old growth stands (50-114 and >114 years) into a >50 year age class for analysis. Comparisons among the different segments were then made using LSMEANS, as depicted in Figures 14--20.

Data entry, error checking, and production of graphics was done in MS-Excel. Most data manipulation and analysis was done in the Statistical Analysis System software (SAS®, version 9.1).

FINDINGS AND DISCUSSION

Below, we describe and interpret findings for each study segment, including present land cover, historic land cover change, cottonwood age distribution, and vegetation patterns in sampled stands. Maps of each study segment, including both historic land cover changes and forest age classes, are provided in Appendix A.

Segment 13 (RM 595-365)

Segment 13 (RM 595 to 365) occurs within the Missouri River Bank Stabilization and Navigation Project, which maintains the lower 732 miles (1178 km) of the river, from Sioux City to St. Louis, as a channel for barge navigation. The segment extends from the mouth of the Platte River, which enters below Omaha, to the mouth of the Kansas River, which enters in Kansas City. Although the river in this segment has been significantly modified due to channelization, the degree of hydrologic alteration is somewhat less than on inter-reservoir segments upstream (Galat and Lipkin 2000). This is because of flows contributed by tributaries, particularly the Platte, that join the Missouri downstream from the last dam (Gavins Point) near Yankton, South Dakota. Tributary contributions are even more significant, and flow regimes less impacted by upstream dams, on segments downstream from the Kansas River confluence at Kansas City. In addition, much of segment 13 (from Plattsmouth, NE to St. Joseph, MO) has experienced 0.5-1.8 m of channel bed aggradation, and with it, increases in flood stages for a given discharge (USACE 2004, Jacobson et al. 2009). Under regulated river flows, large scouring flows no longer occur that are sufficient to transport accumulated sediments from the Platte and other tributaries. These factors contribute to nearly annual spring flooding of areas on the riverward side of the levees, and much land on the protected side also floods during this time because gravity flow cannot remove the runoff. In addition, overbank flooding beyond the levees occurred during large flood events in 1993 and the mid-to-late 1990s.

In 1804 it took almost one month for the Lewis and Clark expedition to cover modern segment 13. Then the floodplain was mostly prairie with interspersed groves of trees, protected by the meanders. Currently (as of 2006), 70% of the floodplain within a 5-km (3-mile) buffer of the river channel is agricultural cropland, with forest comprising 9%, grassland 7%, and urban (including portions of St. Joseph and Kansas City, Missouri) about 4% (Figure 3). Industrial parks cover much of the modern floodplain near Kansas City, while agricultural lands extend from Fort Leavenworth to near the Platte River. Only relatively minor land use changes occurred from the 1950s to present, with cropland area increasing from 61% to 70% and forest declining approximately 20% relative to its 1950s area (Figures 5, 6a, 8). The strongest changes from the mid-1950s to present were major declines in shrubland area (nearly 75% loss) and grassland (39% loss) (Figures 5, 6a). Changes from 1892 to later dates are difficult to interpret, as the Missouri River Commission maps for this segment did not designate cover types for a large portion of the interior of the floodplain. We designated a land cover class of "other" for these areas in our mapping and analysis, but suspect that most of these unclassified areas had already been converted to agricultural cropland. This river segment had already long been settled by the 1890s, and substantial habitat conversion had already likely occurred (Bragg and Tatschl 1977). Total area mapped as river sandbar declined precipitously from 1892 to the 1950s, and had nearly completely disappeared by 2006 (only 1 hectare mapped along the entire 230 mile segment) (Figures 5, 6a).

With only a few exceptions (e.g., at sampling locations), we were unable to reliably differentiate cottonwood from non-cottonwood stands in our GIS mapping of this segment. Field reconnaissance, however, suggested that cottonwoods were present in the vast majority of all woody stands in the floodplain. Nearly half (46%) of the cottonwood area was occupied by mature stands (50-114 years) (Figure 11). Less than 5% of the forest area was judged to be >114 years old, although it was often difficult to determine due to the previously mentioned lack of detail on many of the 1892 Missouri River Commission maps. Areas of these mature and old forests are still being harvested on lands not protected by government or conservation group ownership. The remaining forest area was divided between 25-50 year old stands (27%) and stands less than 25 years old (6% poles, 10-25 years old; 16% saplings, <10 years old). Most of the 25-50 year old forest was on the river side of the levees, having formed in tandem with channel narrowing induced by wing dikes. Conversely, with the nearly complete absence of sandbars on the segment, many of the sapling and pole stands occurred on the landward side of the levees. These recruitment patches were sometimes quite extensive and occurred on abandoned farmland and other open areas, as has occurred on the Big Muddy National Wildlife Refuge much farther downstream (Thogmartin et al. 2009). Recent recruitment was likely linked to overbank flooding from the large flood of 1993 and subsequent floods later in the 1990s. Flooding has occurred periodically in subsequent years as well, including during the middle of our field season in 2008. Many of these young stands are being actively removed via habitat management activities (e.g., burning of grassland) by natural resource agencies, including on Corps lands. Alternatively, if protected, these recent recruitment areas could produce significant areas of cottonwood forest within a few decades.

Average stand-level tree species richness is significantly higher in segment 13 than all other segments (Figure 14). More than 6 tree species were sampled, on average, per cottonwood stand, with a maximum of 12 species in one old growth stand and as much as 17 species in a young (<25 year old) non-cottonwood stand. Fewer than half as many tree species, on average, were sampled in a typical cottonwood stand within the North Dakota (segment 4) and Montana (segments 0 and 2) study areas. Most of the decline is because of progressive loss of later successional tree species as one moves upstream, with only green ash and box elder still common in the western- and northern-most segments. Numerous later successional species occur in segment 13 stands, increasing in dominance with stand age (Figure 21a,b). These include hackberry (*Celtis occidentalis*), box elder (*Acer negundo*), red and white mulberry (*Morus rubra* and *M. alba*, respectively), pecan (*Carya illinoinensis*), American sycamore (*Platanus occidentalis*), silver maple (*Acer saccharinum*), green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*), and others. A mix of these same species, along with roughleaf dogwood (*Cornus drummondii*), comprise the shrub layer in mature and older stands, while cottonwood or willow dominate the shrub layer of younger stands (Figure 22a,b). Willows (*Salix exigua, S. nigra*) were particularly an important component of the shrub layer on young (<25 years) non-cottonwood stands. Shrub cover was highest in younger (<25 year old) cottonwood or non-cottonwood stands, but averaged <30% on mature and old growth stands.

On average, stand-level plant species richness, particularly of herbaceous plants, was low on segment 13, when compared to other study segments (Figure 15), although most that were present were native (Figure 16). Overall floristic "quality" as indicated by average Coefficient of Conservatism values (C-values) was intermediate compared with other study segments (Figure 17, 18). Notably, the average wetland affinity scores (numeric score for Wetland Indicator status, with OBL = 5 and UPL = 1) for stands in segment 13 were significantly higher than in all other segments (Figure 19). This may reflect the fact that many of the stands in this segment still flood regularly, as occurred in 2008. In addition, it is possible that the flooding that occurred during the 2008 growing (and sampling) season may have temporarily influenced both the wetland affinity scores (increasing them) and the herbaceous species richness values (decreasing them).

Segment 10 (RM 811.1-753)

Segment 10 is the downstream section (59-mile) of the Missouri River National Recreational River, administered by the National Park Service. Because it occurs below the farthest downstream dam (Gavins Point) in the system and is an unchannelized reach, this segment is often considered one of the more natural or least altered sections of the lower Missouri, with some physical features characteristic of the pre-regulation river (Schneiders 1999). However, flow patterns are greatly influenced by the cumulative effects of the six mainstem upstream dams. In a study comparing pre- and post-regulation flow patterns at 10 gauging stations (inter-reservoir, channelized, and upstream) on the Missouri, flows at Yankton exhibited the most extreme composite scores for hydrologic alteration, with significant declines in annual peak flows, increases in minimum flows, and shifts in flow timing (Galat and Lipkin 2000).

An important additional effect of these upstream dams and reservoirs has been to trap sediment, greatly diminishing downstream sediment load (NRC 2002) and leading to significant degradation of the channel bed, especially immediately downstream from Gavins Point and other dams. In contrast to inter-reservoir segments (e.g., 2, 4, 6, 8) on the Missouri, there is no reservoir downstream from Gavins Point Dam. With no downstream reservoir slackwater effect on segment 10, significant channel degradation (measured via changes in water surface elevation) occurred along the entire length of the segment between 1960 and 2002, ranging from more than 3.0 m immediately below the dam (RM 808-810) to 1.4 m midway within the segment (RM 786) and increasing again to 2.6 m at the downstream end of the segment (RM 753) (WEST Consultants, Inc. 2002, USACE 2004). Declines in bed elevation and water surface elevations (at flows of 30,000 cfs) from 1956-2001 averaged approximately 2 meters over the entire segment (WEST Consultants, Inc. 2002). Further degradation has likely occurred since 2002, with total degradation immediately below Gavins Point Dam now estimated at approximately 12 feet (3.5 m) (Jacobson et al. 2009).

Segment 10 runs primarily west to east, from Yankton, South Dakota to Ponca, Nebraska, and has a wide valley (over 10 miles or 16 km in places), bounded by bluffs in Nebraska and South Dakota (Figure 2). Most of the segment runs closer to the bluffs on the south (Nebraska) side, with a much wider valley and more extensive historic floodplain on the north (South Dakota side). Present-day land cover (Figures 5, 6b) is dominated by agricultural cropland (77%), with the proportion of cropland increasing from upstream to downstream. Other major categories include floodplain forest (both cottonwood and non-cottonwood), the river itself, and urban/developed areas with the larger towns of Vermillion, Yankton, and Elk Point, and smaller communities of Gayville, Meckling, and Burbank. The areas of forest and river channel are nearly equal, at approximately 5000 hectares or 6-7% of the study area, with urban land cover at 5%.

Large changes in land cover have occurred since 1892 and 1955/56 (Figure 2). Much of this cumulative change had occurred by 1983/84, with generally more modest changes over the next 22-23 years. The area of agricultural cropland increased dramatically (over 3-fold), largely at the expense of grassland and forest, with most of the increase occurring between 1892 and 1956 (Figures 2, 5, 6b). Area of grassland, shrubland, forest, and particularly sandbars has declined strongly over time, with grassland and sandbars representing a negligible percentage of the landscape in 2006/2008. Urban expansion has also occurred in the towns (or via exurban development) in or adjacent to the river valley. Forest area has declined nearly 50% since 1892 (Figure 9), primarily due to land use conversion to agricultural cropland (Figure 10). Declines in both sandbar area and shrubland (Figure 6b), which includes regenerating cottonwood stands, suggest that the effects of river regulation (including channel bed degradation, reduced sediment load, and flow alteration) are decreasing opportunities for new establishment of cottonwood stands. Interestingly, total forest and woodland area increased 21% between1983/84 and 2006, while grassland (-50%), shrubland (-51%), and sandbar (-48%) all declined sharply (Figure 6b). Hence, although forest area increased during that interval, the total area of woody vegetation (forest plus shrubland) was virtually unchanged from 1983/84 to 2006, decreasing by 1.5%. Increases in forest area over the last 25 years appear to be primarily due to conversion of sapling and pole stands (mapped as shrublands) present in 1983/84 to forest by 2006 through growth and maturation (Figure 10). This change is reflected in the fairly high proportion of the total cottonwood stand area that is in the 25-50 year old age class (see below), with these stands having established during the 1956 - 1983/84 interval (Figure 11).

The age structure of the cottonwood population on segment 10 is dominated by mature (50-114 years) and intermediate-aged (25-50 years) stands, with smaller areas of old growth (>114 years) and recent (last 25 years) recruitment (Figure 11). Despite the perceived negative effect of flow regulation on cottonwood recruitment, nearly half of the present-day forest on segment 10 established after closure of Gavins Point Dam in 1956. The relatively large proportion of forest in the 25-50 year age class (30%) contrasts with some other study segments (e.g., segments 4, 6) and suggests that significant cottonwood recruitment occurred in the 25 years following dam closure on segment 10 (Figure 11). Although many studies have documented declines in cottonwood recruitment below dams on meandering rivers in western North America (e.g., Rood and Mahoney 1990, Friedman et al. 1998), including on segment 4 in North Dakota (Johnson et al. 1976; Johnson 1992, 1998), others have shown that flow regulation may lead to channel narrowing, and with it, a short-lived increase in recruitment and persistence of riparian vegetation, on braided, sandbed rivers like the Platte (Johnson 1994, 1998; Scott et al. 1996; Friedman et al. 1998). Segment 10 may represent a channel morphology and geomorphic response intermediate between that of a meandering and a braided river, resulting in minor channel narrowing and a temporary recruitment pulse for cottonwood in the decades immediately following dam closure. The occurrence of historic flood of record in 1952 (peak of 480,000 cfs at Yankton) suggests that considerable sediment reworking and bar formation may have occurred just prior to dam closure. After dam closure, channel degradation initially could have increased the availability of sites for recruitment by exposing bars that were previously part of the channel bed. Reductions in peak flows and ice scour following dam closure would likely have led to increased survival of established vegetation on bars, enabling persistence of these cohorts. The lower proportion of stands <25 years old suggests, however, that this post-dam recruitment pulse was temporary, with subsequently lower rates of recruitment. The somewhat higher proportion of saplings (11%) than poles (7%) is likely a legacy of the high flows in 1997, that moved considerable sediment and formed sandbars, providing nursery sites for recruitment by cottonwood and willow, as well as creating habitat for Interior Least Tern and Piping Plover nesting (Greg Pavelka, USACE, Yankton, SD, personal communication). One important consideration, however, in comparing the proportions of stand area established in the pre- and post-dam time periods is that considerable loss of older forests due to land use conversion occurred after 1892 and 1955/56 (Figures 7- 10). If the area of older lost forest was included, then the area of forest <50 years old would represent a much smaller percentage of total forest area.

Besides plains cottonwood, other common tree species in cottonwood stands included later successional species green ash, American elm, hackberry, white mulberry, and eastern redcedar (*Juniperus virginiana*). Russian olive (*Elaeagnus angustifolia*) and willows (*Salix amygdaloides* and *S. lutea*) frequently occurred as shrubs or small trees in younger cottonwood and non-cottonwood stands (Figure 23a,b). Tree species richness, although higher than segments farther upstream, averaged significantly lower than in segment 13, with a weighted average of 4.45 species per sampled stand (Figure 14). Average shrub cover increased with stand age and was particularly high in mature and old growth cottonwood stands (Figure 24a,b). Roughleaf dogwood (*Cornus drummondii*) and buckthorn (*Rhamnus cathartica*) dominated the shrub cover in older stands, while cottonwood and willow species (*S. amygdaloides, S. lutea, S. exigua*) dominated younger sites.

Compared with other study segments, cottonwood stands within segment 10 had high plant species richness (mean of 35 species/stand) (Figure 15) and high floristic quality (Figures 17, 18), as measured by average Coefficient of Conservatism values, with exotics averaging only 14% of the species sampled per stand (Figure 16). Conversely, a significantly higher proportion of tree species per stand were exotics in the three South Dakota segments (6, 8/9, 10) than in the other study segments (Figure 20). These species included Russian olive, white mulberry, and common buckthorn. Eastern redcedar, a native shrub/tree species often considered invasive in the region, also appeared to have higher abundance in segment 10 (and perhaps segment 8) than in the other study segments. Among these species, Russian olive was primarily found on stands that established in the post-dam era (<50 years old), white mulberry and buckthorn primarily in mature and older stands (>50 years), and redcedar primarily in stands >25 years old (Figures 23, 24). Native later successional species, including green ash and American elm, were notably scarce on stands less than 50 years old (Figures 23, 24). Redcedar, Russian olive, and white mulberry comprise a significant component of the current tree density and basal area, but were absent from witness tree records from the 1850s-1860s Public Land Surveys for portions of the study area in Clay, Yankton, and Union counties in South Dakota and Dixon and Cedar counties in Nebraska (Figure 4). The scarcity of native later successional species on sites established in the post-dam period and the increase of redcedar and exotic shrubs/trees in the historic floodplain may both reflect the chronic hydrologic decoupling of the historic floodplain from the river, due to flow regulation by dams and significant channel degradation. This is also suggested by the relatively low average wetland affinity score of the flora within segment 10 stands, particularly relative to segment 13 (Figure 19).

Segments 8 and 9 (RM 880-841 and 841-811.1)

Segment 8 runs from northwest to southeast, beginning at Fort Randall Dam (RM 880) and ending at the Running Water Bridge (RM 841) just downstream of the confluence with the Niobrara River. It is the upstream section (39-mile) of the Missouri River National Recreational River, administered by the National Park Service. Segment 9 is contiguous with segment 8, beginning at the Running Water Bridge (RM 841), continuing through Lewis and Clark Reservoir, and ending at Gavins Point Dam (RM 811.1).

As in segment 10, flows in segment 8 are impacted by upstream dams. Unlike segment 10, but similar to other inter-reservoir segments on the river, the lower part of segment 8 and the adjacent upper part of segment 9 are greatly influenced by the presence of the downstream Lewis and Clark Reservoir and substantial sediment inputs by the Niobrara River. Sediments from the Niobrara and other sources have contributed to delta formation, significant loss of storage capacity (>20%) within Lewis and Clark Reservoir, and significant aggradation of the channel bed both upstream and downstream of its confluence with the Missouri. As a result, the channel bed in the upstream third (subreach 1) of segment 8 has degraded (RM 880-867), while the lower half (RM 860-841) of segment 8 and the delta area of segment 9 have significantly aggraded. Channel bed aggradation has led to significant increases in river and groundwater levels, particularly downstream from the Niobrara confluence, necessitating the relocation of the town of Niobrara, Nebraska to higher ground in 1977 (Schneiders 1999, Coker et al. 2009). Increases in stage of 6 feet (1.8 m) or more have occurred for flows of 20,000 cfs downstream of Niobrara (USACE 2004). These increases in water levels have permanently flooded areas of the floodplain, killing cottonwood and other trees and converting large areas to marsh. Most deposits in the delta area appear to be too wet to support recruitment and survival by cottonwood and other riparian forest species, although Russian olive has colonized locally higher microsites within the flooded area.

Segment 8 is constrained by a narrower valley than segments 10 and 13, with bluffs on the Nebraska and South Dakota sides. Land cover in the valley is dominated by the river/reservoir and agricultural cropland, although the proportion composed of cropland (30%) is much less than in segments 10 and 13 (Figure 5). Riparian forest comprises approximately 15% of the area in the valley, with wetlands (mostly in the delta) occupying 10%. Very little of the area is urban, although shoreline development (cabins, etc.) is significant in some areas (e.g., Sunshine Bottoms and Verdel, Nebraska areas). Land cover in segment 9 is dominated the reservoir/river (72%) and by wetland vegetation (25%) in the delta and adjacent flooded mainland areas (Figure 5). Very little area of cottonwood or other riparian forest or shrub vegetation is present in segment 9, limiting the availability of stands for vegetation sampling.

Historic changes (Figures 5, 6d) in segment 8 have been less dramatic than in segments 10 and 13, with relatively modest forest loss (16% decline since 1892) (Figure 9). Grassland area has declined dramatically (96%) since 1892, with most of the loss occurring by the mid-1950s, while agricultural cropland has displayed the converse pattern. As with the segments discussed previously, the area of sandbar habitat has declined precipitously, such that it only comprises a tiny fraction of the entire landscape (<1%). In segment 9, nearly all (~95%) of the forest, shrubland, grassland, and agricultural cropland areas present in 1892 have disappeared, as the area has converted almost wholesale to reservoir (here not differentiated from river) and wetlands (Figures 5, 6c).

With a narrower valley and more constrained floodplain in segment 8, the area of cottonwood shrubland and forest per river kilometer is lower than in segments 10 and 13 (Figure 13). Existing forest is dominated by the mature (50-114 year) age class (47%), with about 67% of the forest in all from stands that established prior to dam closure (>50 years old) (Figure 11). Twenty three percent of the forest is in the 25-50 year age range, with 10% in the <25 year age range (saplings and poles). Very little cottonwood shrubland and forest is present in segment 9 (Figures 12, 13), but stands <25 years old comprise 40% of the cottonwood area (Figure 11). These occur primarily in the delta area at the upstream end of the segment. The long-term fate of these sites is uncertain, given ongoing channel aggradation, delta formation, and rising water levels.

Because of the scarcity of cottonwood and other riparian forest or shrubland stands in segment 9, only eight stands were located and sampled. Hence, our vegetation analyses lump segments 8 (where we had 54 additional stands) and 9 together. Patterns of tree species composition were generally similar to segment 10, with American elm, green ash, eastern redcedar, box elder, hackberry, and white mulberry present in cottonwood and non-cottonwood stands over 50 years old (Figure 25a,b). Russian olive and willows were common within younger cottonwood stands. Younger non-cottonwood stands (<25 years) were of two basic types, dominated by either Russian olive or by willow (*S. amygdaloides, S. lutea*) (Figure 25b). Across cottonwood and non-cottonwood sites, dominant species of shrubs (Figure 26a,b) included cottonwood, willow, and Russian olive in younger stands (esp. <25 years) and dogwood (*Cornus drummondii*) and redcedar in older ones (>25 years). Total shrub cover averaged lower in segment 8/9 stands than segment 10, particularly for mature and old growth stands. Overall, indices of species richness and floristic quality were somewhat lower in segment 8/9 than in segment 10 (Figures 15, 17, 18) .

Segment 6 (RM 1072.3-987.4)

Segment 6 is wholly contained in South Dakota, starting at Oahe Dam, transitioning into and including Lake Sharpe, and ending at Big Bend Dam at Fort Thompson. Hence, the majority of the segment is reservoir. The upper 11 km (7 miles) below Oahe Dam (subreach 1) has a slightly degraded to stable channel bed (USACE 1999). At the lower end of this 11-km reach is the confluence of the Bad River with the Missouri at Fort Pierre. Sediment inputs from the Bad River and slackwater effects from Lake Sharpe have contributed to reductions in channel capacity, a bed level rise in the river, and increases in river stage just downstream of the confluence. This aggradation of the channel bed has resulted in an increased susceptibility to flooding in Fort Pierre, particularly from ice jams (USACE 1999, NRC 2002, USACE 2004). These and other factors have led to concerns that the cottonwood forests on La Framboise Island, a large forested island adjacent to the city of Pierre, are rapidly dying out (Ode 2004). Based on field reconnaissance, there appears to be a rather steep gradient of change from intact cottonwood stands at the upstream end of La Framboise Island (adjacent to Pierre, SD) to flooded areas with marsh vegetation, dead cottonwoods, and scattered Russian olive stands only a few kilometers downstream (e.g., at Farm Island). Woody riparian vegetation becomes increasingly scarce downstream and nearly absent on the reservoir, with the exception of tree plantings (some including cottonwood), wooded tributary junctions, and some Russian olive stands.

Because the bulk of segment 6 is in Lake Sharpe, river/reservoir constitutes more than 80% of the land cover in the former Missouri River floodplain (Figures 5, 6e), with minor components of grassland, forest, and urban (Pierre, Fort Pierre, Lower Brule). Historic change has resulted in the loss of approximately 65% of the forest present in 1892 (Figure 9), although forest and shrubland coverage increased sharply from 1892 to the mid-1950s (Figure 7). Sandbar area has declined dramatically, with virtually no sandbar coverage present in 2006 (Figures 5, 6e). As on segment 9, the reservoir also inundated significant areas of agricultural cropland, leading to loss of 97% of the cropland that was present in the mid-1950s within the historic floodplain.

Also as with segment 9, the other reservoir-dominated segment, the area of cottonwood patch types per river mile is very low (about 5 hectares/river km) (Figure 13), with virtually all of it in the upper 20 km (12 river miles) of the segment. Existing cottonwood forests are dominated by stands greater than 50 years old (91%), with 72% in the mature (50-114 years) age class (Figure 11). Stand area from cohorts establishing in the last 50 years is only 9% of the total cottonwood area, with nearly all of it in the 25-50 year age class. Stands arising in the last 25 years (saplings and poles) comprise only 0.5% of the total cottonwood area, with saplings almost completely absent. Stands that have recruited in the last 25 years are generally very small and occur at unusual locations, such as in drained ponds (which may have represented intentional restoration) and a low spot in the interior of La Framboise Island. Extremely stable flow levels maintained by control of Lake Sharpe, destructive wave action along the reservoir, lack of geomorphic conditions needed to create sediment bars, and increasing water levels that drown out existing forests combine to make conditions essentially unsuitable for cottonwood recruitment along the river and reservoir. The lack of successful natural recruitment has likely provided the impetus for numerous cottonwood plantings in the area, with the area of young (<25 years old) planted stands (not included in the above total) far exceeding the area of natural cottonwood stands in that age range.

The scarcity of cottonwood stands, and of woody riparian vegetation in general over much of the segment, constrained our ability to adequately sample stands of all age classes and types. We located no cottonwood sapling stands that were of sufficient size for sampling, and only three natural pole-aged stands. Very few stands of any kind were available farther than 20-25 kilometers (12-15 miles) downstream from the dam, and those that were present were dominated by older age classes. We did, however, sample six of the sapling/pole aged planted cottonwoods stands on this segment (and four more planted stands on segment 8), although the data from these stands are not included in the summaries in this report.

Cottonwood stands on segment 6 average significantly fewer tree species per stand than segments 8/9, 10 (0.5-1 species less per stand) and 13 (2.5 species fewer) (Figure 14), and had the highest percentage of exotic tree species (1/3 of the species in a typical stand were exotics) of any segment (Figure 20). Other tree species commonly found in cottonwood stands included Russian olive and willows in younger (<25 years old) stands and green ash, redcedar, some willows and Russian olive in older (>25 year old) stands (Figure 27a). Non-cottonwood stands were dominated by Russian olive and green ash, with willows, Siberian elm (*Ulmus pumila*), and redcedar as well (Figure 27b). “Cedars” (junipers) on this segment and possibly on the other South Dakota segments may include hybrids between eastern redcedar (*Juniperus virginiana*) and Rocky Mountain juniper (*J. scopulorum*) (Fassett 1944; Van Haverbeke 1968, cited in Ode 2004). Shrub species composition mirrored that of the dominant trees, with cottonwood, willow, Russian olive, redcedar, green ash, and Siberian elm (Figure 28a,b). Notably, roughleaf dogwood, an important shrub species in segments 8/9, 10, and 13 was only a minor component of the shrub cover in segment 6.

Overall, vegetation indicators of stand condition suggest that segment 6 has the poorest condition of all sampled study segments. Average species richness (herbs, shrubs, trees) per cottonwood stand was significantly lower than in all other segments except segment 13 (Figure 15), and the proportion of all species that were exotic was higher than on segments 8, 10, and 13 (Figure 16). Floristic quality, as measured by mean Coefficient of Conservatism values per stand, was dramatically lower in cottonwood stands in segment 6 than in all others, averaging 1.9 (on a 0 to 10 scale) (Figures 17, 18). Somewhat surprisingly, given the rising water levels on at least part of the segment, even the stand-level wetland affinity scores of the flora averaged lower than on all other segments (Figure 19).

Segment 4 (RM 1390-1304 and 1304-1286)

Segment 4 begins at approximately River Mile 1390 at Garrison Dam and flows south and east to just south of Bismarck, North Dakota, at approximately River Mile 1304. The Missouri River in Segment 4 is entrenched within the Missouri Plateau Section of the Great Plains Physiographic Province and flanked by four recognized terrace flights of late Pleistocene and Holocene age, which contribute to a constrained meandering planform to the river. In part because we wanted to resample stands previously surveyed by Johnson and Keammerer in 1969 and 1970 (Keammerer et al. 1975, Johnson et al. 1976), we extended the segment an additional 18 miles (29 km) downstream to River Mile 1286, for a total segment length of 104 River Miles (167 km). This extension (subreach 4) includes areas that have been greatly impacted in the past by fluctuations in the level and extent of Lake Oahe, including channel bed aggradation, rising water levels, and mortality to cottonwood stands from flooding and fire. In addition, the portion of the segment downstream from Bismarck historically was much more geomorphically active, with higher lateral migration rates than more constrained upstream portions (Johnson et al. 1976).

As with some other inter-reservoir segments, segment 4 includes an upstream reach (RM 1389-1330) that has experienced net channel degradation (approximately 3 m immediately below the dam), although rates appear to have diminished in recent decades (USACE 2000, USACE 2004); a more or less stable reach (RM 1330-1310), and an aggrading reach downstream (RM 1310-1286). Our subreaches 1 (RM 1390-1360) and 2 (RM 1360-1332.5) conform roughly to the degrading reach, the upper 2/3 of our subreach 3 (RM 1332.5-1310) is approximately stable, and the lower 1/3 of subreach 3 (RM 1310-1304) and all of subreach 4 (RM 1304-1286) are in the aggrading reach.

Previous work by Johnson documented floodplain forest species composition (Johnson et al. 1976) and historic change, and simulated the negative effects of continuing flow regulation on cottonwood recruitment and cottonwood abundance in the landscape (Johnson 1992). His analysis of historic aerial photography, maps, and Public Land Survey notes suggested that installation and operation of Garrison Dam (in 1953) resulted in significant declines in river channel migration, leading to reduced formation of the sediment bars needed by cottonwood for successful germination and establishment. Projection of successional trends suggested that long-term flow regulation would lead to a declining diversity of stand ages, with a landscape dominated by older forests of late successional species (e.g., ash, elm, box elder) rather than cottonwood (Johnson 1992). Similar results to these simulation projections have been found on other meandering rivers in western North America (e.g., Rood and Mahoney 1990, Friedman et al. 1998), although braided rivers (Johnson 1994, 1998; Friedman et al. 1998), and canyon-constrained rivers (Scott et al. 1996, 1997) may show different responses to flow regulation.

Current land cover in segment 4 is dominated by forest (29%) and agricultural cropland (25%) (Figures 5, 6f). The river itself comprises 17% of the area, and grassland (15%) and urban land uses (6% of each) make up most of the rest of the landscape. Our analyses of historic (mid-1950s) and recent (2006) aerial photography and the Missouri River Commission maps (1892) suggest moderate changes in land cover between the 1950s and 2006, with declines in agricultural cropland (22% decline) and forest (9% decline), steep decreases in shrubland (-53%) and sandbar area (-94%), and dramatic increases in urban and grassland areas. Cumulative changes from 1892 to present were more dramatic, with a 26% decline in forest area (Figure 9), steep declines in shrubland (-74%), and sandbar area (-96%), and increases in agricultural cropland from 0% to 25% (32% in the 1950s) of the landscape (Figures 5, 6f). Hence, proportional loss of forest area on segment 4 since 1892 is comparable to that estimated on segments 8 and 13, and substantially lower than that estimated for the other inter-reservoir and reservoir segments (2, 6, 9, 10) (Figure 9).

Total cottonwood area per river kilometer is nearly 70 hectares on segment 4, reflecting the high proportion of floodplain forest remaining in the landscape, and comparable to segments 2 and 10 (Figure 13). The age distribution of cottonwood forests on segment 4, however, is different from segments 2 and 10, with a much higher proportion of old growth (>114 years old) forest in segment 4 (42% of the forest area), and a much lower proportion in forest less than 50 years old (15% on segment 4, vs. 35-50% on segments 2 and 10) (Figure 11). The proportional coverage of old growth forest is substantially greater (more than 2-fold for most) on segment 4 than any other study segment (next nearest was segment 9 with 25%). Average hectares of younger (<50 years old) forest per river kilometer (10 hectares/km) is also substantially lower than that on segments 2 and 10 (24 and 31 hectares/km, respectively) (Figure 13). So, although part of the difference in cottonwood age distribution among segments may be because less of the older forest area has been lost to clearing on segment 4, the area of new forest added (on a per river kilometer basis) has been less as well.

Plains cottonwood was dominant in cottonwood stands <114 years old, with importance values averaging greater than 225 (out of 300 possible) (Figure 29a). In old growth (>114 years) cottonwood stands, the mean importance value of cottonwood declined to 110, with a greater composite importance of later successional species, particularly green ash and box elder, along with minor contributions of bur oak (*Quercus macrocarpa*) and American elm. Species co-occurring with cottonwood on younger stands included Russian olive and peach-leaf willow (*Salix amygdaloides*). Trees in older (>50 years) non-cottonwood stands (Figure 29b) were dominated almost completely by green ash and box elder, as expected in Johnson's successional model for the Garrison reach (Johnson 1992). Shrub species within mature and old growth cottonwood stands included Dahurian buckthorn (*Rhamnus davurica*), green ash, chokecherry (*Prunus virginiana*), and some Russian olive (Figure 30a). Younger cottonwood (all sapling stands, and some pole stands) stands were dominated by shrubs rather than trees, with cottonwood and willows as the dominant species. Younger non-cottonwood sites (<50 years old) were dominated by shrub-sized willows (*S. exigua, S. eriocephala, S. lutea*), with more minor contributions by green ash saplings and false wild indigo (*Amorpha fruticosa*) (Figure 30b). Shrub cover within older non-cottonwood stands (>50 years old) was dominated by green ash, chokecherry, and American elm (*Ulmus americana*). In contrast to inter-reservoir segments in South Dakota (segments 6, 8, and 10), segment 4 stands had a much lower average percentage of exotic tree species (11% rather than 20-33%) (Figure 20) and had very little cover by eastern redcedar (*Juniperus virginiana*).

Average stand-level species richness (overall and of herbaceous plants) and mean Coefficient of Conservatism values were high in segment 4, comparable to those found in segment 10 (Figures 15, 17, 18). Previous analyses (Dixon et al. 2009a) suggested, however, that C-values weighted by relative cover of different herbaceous species were substantially lower on segment 4 than on segment 10, suggesting that, despite high species richness values and moderately low numbers of exotic species (Figure 16), much of the herbaceous cover within segment 4 stands may be dominated by a few exotic species or weedy species with low C-values (such as smooth brome, *Bromus inermis*).

Field observations suggest that successful cottonwood recruitment on much of segment 4 appears limited to channel islands and narrow, bank-edge strips of recently deposited alluvium. Ice scour and beaver herbivory are suspected to be limiting successful, longer-term survival. On the lower, extended portion of the segment below Bismarck (RM 1304-1286), where reservoir effects are strong, post-dam reservoir-induced flooding and fire appear to be important mortality factors for cottonwood forest. While direct mortality of established cottonwood forest due to flooding is likely an important mechanism, there may also be indirect effects of flooding on cottonwood mortality through interactions with fire. We conjecture that during high reservoir levels, understory vegetation - particularly grasses such as reed canary grass (*Phalaris arundinacea*) - may become dense and highly productive. When reservoir levels fall, the dense understory vegetation dries out and provide fuel for ground fires, which burn hotter and perhaps more frequently than would have occurred under pre-dam conditions.

Segment 2 (RM 1771.3-1543.3)

The Segment 2 study area was defined as an approximately 228 mile segment of the Missouri River in eastern Montana, extending from Fort Peck Reservoir (RM 1771.3) to the headwaters of Lake Sakakawea near Williston, North Dakota (RM 1543.3), and including the confluence with the Yellowstone River in western North Dakota (approx. RM 1581). While we mapped the entire segment, our vegetation sampling extended only to the confluence with the Yellowstone because of the dramatic differences in conditions downstream, including more natural flows out of the unregulated Yellowstone River, significant channel aggradation (1.8-4.3 m) and a dramatic rise in stage-discharge relationships since filling of Sakakawea in 1965 (USACE 1990, USACE 2004). Bed elevation (and stage-discharge relationships) on most of the segment upstream of the Yellowstone confluence has been relatively stable over the last 35 years.

Above the confluence with the Yellowstone, the river in this segment is entrenched within the moderately rolling shortgrass steppe of eastern Montana and western North Dakota. The channel is between 244 and 366 m wide, set within a floodplain and low terraces that are from 3–5 km wide, and flanked by gently sloping uplands to the north and steeper bluffs on the south. Valley confinement prevents the channel from developing extensive, true meanders and several straight-channel reaches alternate with sinuous braided reaches along with confined and unconfined meanders in wider valley sections. Channel islands and numerous bars are common throughout the segment (Wei 1997). There are several minor tributaries in this reach such as the Milk River, Poplar River, and Redwater River, but their total contribution to main stem discharge is generally less than about five percent. Bank heights in this reach generally range from about 3 to 12 m with an average bank height of about 5.5 m. The Yellowstone is the major tributary to the system. As described above, ecological and fluvial geomorphic conditions change at the confluence with the Yellowstone River. However, the patterns described above generally hold true for this lower portion of the segment as well, although the valley and channel are wider.

The climate in the region is semi-arid with about 350 mm of annual precipitation, cold winters, and hot summers. Segment 2 is set in a Great Plains Steppe landscape, sometimes called shortgrass prairie, consisting primarily of short grasses usually bunched and sparsely distributed. Grasses and herbs typical of this region include buffalo grass (*Buchloë dactyloides* (Nutt.) Engelm.), blue grama (*Bouteloua gracilis*), western wheatgrass (*Agropyron smithii*), and green needlegrass (*Stipa viridula* Trin.). Common herbs include blazingstar (*Liatris* spp.), sunflower species (*Helianthus* spp.), white prickly poppy (*Argemone squarrosa* Greene) and locoweed (*Oxytropis* spp.).

Present-day land cover (Figures 5, 6g) in the river valley is composed primarily (in descending order) of agricultural cropland (41%), grassland (23%), forest (18%), the river itself (8%), and shrubland (7%).

Land cover change has been moderate since the mid-1950s (Figures 5, 6g), with steep declines in shrubland (-54%) and sandbar area (-98%) and increases by riparian forest (+31%) (Figure 8). As with segment 10, much of this increase in forest and loss of shrubland over the last 50 years may have been from maturation of sapling and pole stands that were mapped as shrubland in the 1950s, as the total area of woody vegetation (forest, woodland, and shrubland) decreased 12% between the 1950s and 2006 (Figure 6g). More dramatic changes occurred between the 1892 and 1950s. The Missouri River Commission maps of this segment indicate that much of the bottomland in 1892 consisted of riparian forest stands interspersed with prairie grassland at the outer edges of the floodplain. By the 1950s and 2006, many of these forest stands had been fragmented by agricultural clearing although some extensive tracts still remain, especially within the Fort Peck Indian Reservation. Much of the upland adjacent to the bottomland has also been converted to agriculture. Both grassland area and forest area (Figures 6g, 9) in the floodplain have declined since 1892 as agricultural cropland has expanded. Forest area declined 66% between 1892 and the 1950s (Figure 7). Despite the moderate increase in forest area between the 1950s and 2006 (Figure 8), there has been a net loss of 55% of the forest area present in 1892 (Figure 9).

Segments 2, 4, and 10 had the largest areas of cottonwood patch types per river kilometer (65-68 hectares/km), compared to other segments (Figure 13). Mature forests (50-114 years) comprised 49% of the total cottonwood area on segment 2 and old growth another 14%. Hence, approximately 37% of the cottonwood area was composed of stands <50 years old, with most in the 25-50 age range (27%) and 11% in the pole (3%) and sapling (8%) classes. The proportion and total area of post-1950s recruitment was substantially higher on segment 2 than the inter-reservoir segments below Garrison (segment 4) and Oahe Dams (segment 6) (Figures 11-13). Age distribution of cottonwood patches within segment 2 was quite similar to that found in the comparatively "free-flowing" segment in the Wild and Scenic River upstream of Fort Peck Reservoir, but total cottonwood area per river kilometer was more than 8-fold greater on segment 2, suggesting a significantly less constrained and more geomorphically dynamic river channel.

As mentioned previously, species richness of later successional tree species declined from the most downstream (segment 13) to the most upstream (segment 0) river segments (Figure 14). Cottonwood stands in segment 2 averaged 2.6 species of trees. Stands less than 50 years old were dominated by plains cottonwood and peach-leaf willow (Figure 31). Box elder and green ash occurred as successional understory trees in old cottonwood stands and dominated older successional stands (Johnson et al. 1976, Scott et al. unpublished data). In our samples, Rocky Mountain juniper (*Juniperus scopulorum*) was also a common species in the understory of some old growth cottonwood stands. American elm occurs sparsely on this segment, making its first appearance about mid-segment (it is not present farther upstream on segment 2, nor on segment 0), and becoming increasingly more common downstream to the confluence with the Yellowstone.

Understory shrubs or shrubs on low, active alluvial surfaces include yellow willow (*Salix lutea*), sandbar willow (*Salix exigua*), western snowberry (*Symphoricarpos occidentalis*), Wood's rose (*Rosa woodsii*), silver buffalo berry (*Shepherdia argentea*), common chokecherry (*Prunus virginiana*), service berry (*Amelanchier* spp.) and rarely, red-osier dogwood (*Cornus stolonifera*) (Figure 32). In mature and old growth stands, saplings of green ash dominated the shrub layer, with lesser contributions of service berry and buffalo berry. Average total shrub cover was relatively low (averaged <10% for most age classes) within our sampled stands. Overall, mean values of herbaceous and total species richness (Figure 15), floristic quality (Figures 17, 18), wetland affinity (Figure 19), and proportions of exotic species (Figure 16) are intermediate in this segment.

This reach is regulated by Fort Peck Dam, which was constructed by the US Army Corps of Engineers between 1933 and 1940. In general, the operation of Fort Peck Dam reduced the amount of sediment delivered to downstream reaches and significantly altered the natural hydrograph by decreasing the magnitude of peak flows 60-70%, increasing the magnitude and variability of low flows, and shifting the timing and duration of high flows from the spring and early summer to the winter months. As a consequence, a number of important downstream physical changes have occurred, which have important ecological implications for aquatic and riparian resources. These physical changes include: 1) lowering of the channel bed elevation by an average of 1.7 m in a 75 km reach below the dam; 2) additional areas of bed degradation in reaches 70-95 km and 120-140 km below the dam; and 3) a four-fold reduction in lateral channel migration from 6.6 m/yr^{-1} to 1.8 m/yr^{-1} (Shields et al. 2000).

Significant public concerns in segment 2 involve channel bank erosion and associated loss of agricultural land, irrigation pumping stations and pipelines, and damage to streamside infrastructure. Specific concerns point to the significant rates of flow and flow-rate fluctuations that Fort Peck Dam imposes on the Missouri River during winter. Winter flows are much larger, and fluctuate more frequently in the post-dam period. Increased magnitudes of ice-covered flow, increased vertical ice movement along banks, and more frequent freeze-thaw cycles imposed on bank materials are seen as severely aggravating bank erosion. In contrast to the pre-dam period, bank failure now occurs primarily as a result of toe-slope scour and over-steepening by water and ice-related bank erosion (Pokrefke et al. 1998, Simon et al. 2002). Little notable bank stabilization currently exists within segment 2. However there also are concerns related to the overall possible cumulative impacts of future bank stabilization efforts on fish and wildlife resources. Such efforts could impose additional limits on natural fluvial geomorphic processes that maintain riparian and aquatic habitat - including the formation and persistence of non-vegetated sandbars, which serve as habitat for threatened and endangered bird species.

Segment 0 (RM 2073.4-1917)

The Segment 0 (Wild and Scenic River reach) study area was defined as an approximately 156 mile (251 km) segment of the upper Missouri River extending from Fort Benton, MT (RM 2073), downstream to the full pool elevation of Fort Peck Reservoir (RM 1917). Thus, the study reach is largely contained within the Missouri Breaks National Monument and that portion of the Charles M. Russell National Wildlife Refuge above Fort Peck Reservoir. Within this portion of the upper basin, the Missouri River traverses Western Great Plains grasslands and the highly dissected topography of the Missouri Breaks. The study reach includes constrained and unconstrained channel reaches that reflect a complex geologic history (Scott and Auble 2002). From RM 2073 to 2027, the Missouri River flows within a comparatively wide drift-filled, pre-glacial valley. Channel form is meandering to braided with a number of large, in-channel islands. Cottonwood-dominated forests were more extensive in this reach as described by the Lewis and Clark expedition (Coues 1893, Scott et al. 1996), although some of these forests were cleared during settlement. From approximately RM 2027 to 1932 the river occupies a relatively narrow, post-glacial valley incised from 150 to 560 m below the surrounding landscape (Alden, 1932). Here, side valley exposures of shales and sandstones constrain channel movement. The channel is dominantly single-threaded, relatively straight and the majority of cottonwood forest patches are small and scattered, matching pre-settlement descriptions of riparian forest by the Lewis and Clark Expedition (Coues 1893). Below RM 1932, the Missouri River encounters broad exposures of easily erodible Bear Paw shale near river level, and the valley widens and the channel becomes a series of constrained meanders and larger, more continuous stands of willow and cottonwood occupy the channel point bars (Scott and Auble 2002).

This reach of the Missouri River has a snow-melt hydrograph with annual flow peaks typically occurring in May or June. The natural flow regime has been influenced by irrigation withdrawals and upstream dams. Two large upstream dams, Canyon Ferry on the Missouri River and Tiber on the Marias River, a major tributary, were constructed in 1953 and 1956. Whereas the seasonal timing of flows have not been altered, the magnitude of peak flows has been reduced up to 40% and portions of the low flow hydrograph have increased (Scott et al. 1997, Bovee and Scott 2002). Whereas cottonwood recruitment is not strictly flood dependent, the majority of forest area (62%) downstream of the USGS gage at Virgelle (RM 2032) was established in association with a small percentage of flood years (29%), in which flows equaled or exceeded a discharge of 1850 m^3/sec for the period of record at the Virgelle gage. Flows of this magnitude position seedlings above the zone of frequent ice-drive disturbance (Auble and Scott 1998). Ice-drive disturbance has been shown to limit or preclude the establishment of cottonwood forest patches in ice-prone reaches along northern Great Plains rivers (Smith 1980).

Modern agricultural development within the river corridor is limited (14% of the study area in 2006, Figure 5) and primarily confined to old Missouri River terraces. More than half of the area of the study area is composed of the river itself (34%) and grassland (21%), with cropland, forest (13%), wetlands (9%), and shrubland (6%) making up most of the rest of the area (Figure 5). Both the river corridor and surrounding uplands have been subject to livestock grazing since settlement in the late 1800s, and currently includes all or parts of 55 permitted grazing areas totaling 92,848 hectares of public land (U.S. Department of the Interior 1993). However, because of a shortage of upland water sources and steep, rugged terrain between the uplands and the bottomland, livestock within the study segment are poorly distributed in most allotments and preferentially concentrate on the river flood plain where water and shade are available. Bureau of Land Management (BLM) monitoring data indicate heavy to severe utilization of the flood plain in most allotments (J. Frazier, BLM, pers. comm.). In contrast, where pastures are permitted for fall and winter grazing only or at sites inaccessible to cattle, portions of the floodplain receive less or no livestock grazing.

Recent GIS analyses comparing the 1890s Missouri River Commission maps with 2006 imagery indicate that the Missouri River channel has narrowed slightly throughout the study segment during this time interval. Coincident with this channel change have been changes in forest area that differ across the three geomorphically distinct sub-segments. In the pre-glacial valley sub-segment (RM 2073-2027) riparian forest area has increased, primarily as a consequence of the establishment of the non-native, Russian olive. Forest area in the constrained channel reach (RM 2027-1932) is limited and has remained largely unchanged as new forest area associated with channel narrowing has off-set losses of older forest on higher alluvial surfaces. Forest in the sub-segment downstream of RM 1932 has decreased, primarily as a consequence of forest clearing subsequent to the 1890s (Auble and Scott unpublished data). Over the entire segment, forest area decreased slightly between 1892 and the 1950s (Figure 7), and then increased between the 1950s and present (Figure 8), for a net gain approximately 9% from 1892-2006 (Figure 9).

Total cottonwood coverage is sparse in segment 0, averaging only about 8 hectares per river kilometer (Figure 13), in part reflecting geologic constraints on channel migration, with small stands forming instead via overbank floods along much of the segment. Age distribution of the forest, however, is similar to that on segment 2, with 61% of the forest area greater than 50 years old (mature 40%, old growth 21%), 30% between 25 and 50 years old, and 10% less than 25 years old (Figure 11).

Upland vegetation within the river corridor consists of relatively undisturbed prairie vegetation dominated by black greasewood, (*Sarcobatus vermiculatus*), big sagebrush (*Artemisia tridentata*) and mixed grasses including western wheat grass (*Agropyron smithii*), blue grama (*Bouteloua gracilis*), downy brome (*Bromus tectorum* L.), quackgrass (*Agropyron repens* (L.) Beauv.), green needlegrass

(*Stipa viridula* Trin.), smooth brome (*Bromus inermis* Leyss.), and needle-and-thread (*Stipa comata* Trin. & Rupr.), which occur on exposed ridges and flats. North-facing slopes contain isolated stands of Douglas fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*) and Rocky Mountain juniper (*Juniperus scopulorum*) whereas south-facing slopes contain scattered grasses, ponderosa pine or bare exposures of shale.

The principal tree species along the Missouri River was plains cottonwood. Box elder, green ash, and peach-leaf willow occurred as less common associates, particularly on islands and in former back-channels that have been filled by alluvial sediments. Russian olive was also a common associate on sampled stands <50 years old. Narrowleaf cottonwood (*Populus angustifolia*) comprised a significant component of several stands >25 years old and Rocky Mountain juniper was a component of some old growth cottonwood stands (Figure 33). Overall, mean tree species richness is lower (2.3 species/stand) than in any other study segment (Figure 14).

Understory shrubs on alluvial surfaces included yellow willow (*Salix lutea*), sandbar willow (*Salix exigua*), western snowberry (*Symphoricarpos occidentalis*), Wood's rose (*Rosa woodsii*), silver sagebrush (*Artemisia cana*), common chokecherry (*Prunus virginiana*), and rarely, red-osier dogwood (*Cornus stolonifera*) (Ross and Hunter 1976, Scott et al. 2003). Average shrub cover in our sampled stands was relatively low for all stand ages (average <20%), and particularly low for stands >25 years old (average <6%). As in segment 2, green ash saplings were the dominant species of the shrub layer within old growth stands in segment 0 (Figure 34).

As with segment 2, stand-level species richness (overall and of herbaceous plants) and average Coefficient of Conservatism (C) values were intermediate relative to other river segments (Figures 15, 17, 18). Despite similar average C-values to other segments, however, the average percentage of the flora composed of exotic species averaged significantly higher for segment 0 stands than for any of the other segments, at nearly 40% (Figure 16). Mean percentage of exotic species rose generally from downstream to upstream segments, with the exception of segment 6, which had higher percent exotics than its adjacent upstream and downstream study segments.

Landscape Changes and Status of Cottonwood across all Segments

Across all segments, significant landscape changes have occurred from 1892 to present. Dramatic increases in agricultural cropland occurred on several segments (which ones), particularly between 1892 and the 1950s (Figures 5, 6). In the two partially impounded segments (6 and 9), area of river/reservoir increased dramatically between the 1950s and present (Figures 5, 6c,e). Significant losses of forest, shrubland, and sandbar area occurred on most segments. Lumped across all segments, total forest and woodland area (excluding planted stands) declined by 34% from 1892-1950s, 12% from the 1950s to 2006, and 42% overall from 1892 to 2006 (Figure 35). Total mapped shrubland area declined 59% over 1892-2006 and 64% since the 1950s (shrubland area actually increased 12% between 1892 and the 1950s overall) (Figure 35). Hence, most loss of forest area occurred between 1892 and the 1950s, while most loss of shrubland area occurred between the 1950s and present. If forest, woodland, and shrubland areas are lumped, then total area of woody patch types (excluding planted trees) declined by 47% since 1892 and 32% since the 1950s (Figure 35). Our study segments included only two partially impounded segments (segment 6 with Lake Sharpe, segment 9 with Lewis and Clark Lake), and hence did not include the large areas of floodplain that were permanently flooded by the larger reservoirs on the system (Fort Peck, Sakakawea, and Oahe reservoirs). If these areas were included in our totals, then the loss of forest area would be dramatically greater.

Despite steep losses since the 1892 and 1950s, significant areas of woody vegetation (mostly forest) still exist (as of 2006) along the eight study segments, comprising 15.8% of the total floodplain area (including the river channel) mapped (Figures 5, 35). Across the eight study segments, we estimate that there are 75,632 ha (about 30,600 acres) of woody patch types (forest and shrubland, excluding planted trees), with 79% mapped as forest or woodland, and 21% mapped as shrubland (Figure 35). Of these, 88.3% or 66,778 ha (about 27,000 acres) were mapped as cottonwood patch types. Geographically, 66% of mapped cottonwood stand area occurred in segments 2 (36%) and 13 (30%), the two longest (each around 230 miles) segments (Figure 12). Other segments containing significant proportions of total cottonwood area were segment 4 (17%), 10 (9.2%), 8 (4%) and 0 (3%), with segments 6 (1%) and 9 (0.4%) having only very proportions of the total remaining cottonwood area.

Currently (as of 2006), stands greater than 50 years old make up the majority of the cottonwood area (62%), with 46% of stand area in mature stands (50-114 years) and 16% in old growth (>114 years) (see Figures 11-13). Almost a quarter (24%) of total stand area is from stands that are 25-50 years old, with only 14% for stands <25 years old (6.4% for pole stands and 7.5% for saplings). So, although there appears to have been a temporary pulse of cottonwood recruitment in the aftermath of dam closure and reservoir filling on many of the segments (indicated by the relatively large proportion of stands 25-50 years old), more recent recruitment rates during the last 25 years have slowed. Similar patterns, including a temporary post-dam recruitment pulse (often accompanying channel narrowing) and subsequent recruitment declines have been observed or predicted on other regulated rivers in the Great Plains (Scott et al. 1996, Friedman et al. 1998, Johnson 1998). Following dam closure, significant channel narrowing and forest expansion often occurs on braided, sandbed rivers. However, in the absence of floods, narrowing eventually ceases and further recruitment of riparian forest slows, occurring mainly along the channel margins (Johnson 1998, Friedman and Lee 2002).

On more strictly meandering rivers with finer sediment loads, flow regulation may lead to declines in channel migration and with it, reductions in point bar formation and cottonwood recruitment (Friedman et al. 1998;, Johnson 1992, 1998). Hence, on strictly meandering rivers or river segments, there may be no, or only a minimal, post-dam narrowing phase. In our study segments, the amount of, and reasons for a recruitment pulse in the mid-1950s through 1980, varied by river segment (Figure 11-13). On some segments, this period followed or bracketed the timing of dam closure immediately upstream (segments 0, 4, 6, 8, 9, 10), although a post-dam recruitment pulse was not apparent on segments 4 or 6. Despite the much earlier closure of Fort Peck Dam (1938), segment 2 also showed a proportion (27%) of 25-50 year old stands that was comparable to segments in which dam closure (segments 0, 8, and 10) or channelization (segment 13) occurred in the 1950s or later (Figure 11). Interestingly, segments 0 and 2, in Montana, both showed increases in forest area from the mid-1950s to present, while all other segments showed declines (Figure 8). In the case of segment 13, recruitment of new forest in the 1950s-1980 occurred largely through the construction of wing dikes designed to narrow and deepen the channel for navigation and barge traffic.

CONCLUSION

Remnant cottonwood stands along the Missouri are a valuable resource that provide habitat for a high diversity of songbirds, other wildlife species, and plants (>530 species sampled in our study). Biological diversity is sustained both through the total area of forest and also by the mosaic of different types and age classes of forest within the landscape. Despite some recruitment within the last 50 years (particularly between the 1950s and 1980), regeneration is not keeping pace with losses of cottonwoods due to land use conversions or senescence and succession under current river management regimes, as reduced rates of channel migration and sandbar formation limit opportunities for new cottonwood seedling establishment. Long-term continuation of these trends will likely result in declines in landscape diversity (e.g., declines in the mix of types and age classes of riparian forest) and reductions in the total forest area, both of which may lead to declines in floodplain biodiversity (Johnson 1992). Under continued chronically poor conditions for recruitment and only limited channel migration and bar formation, cottonwood forests in the long-term may be restricted to the immediate margins of the river channel and will gradually senesce and disappear farther away from the channel (e.g., Dixon et al. 2009b). In a sense, the large cottonwood forests remaining across much of the floodplain are a legacy of the past and could be thought of as "the living dead", currently helping support a high diversity of plants and animals, but unlikely to be replaced by regeneration in the future. Reversing this trend will require innovative thinking coupled with actions to restore or replicate the dynamic river processes that originally formed and sustained the cottonwood ecosystem.

SUGGESTIONS FOR FURTHER STUDY

Future studies are needed to explicitly model the rates of cottonwood forest losses and to examine the conditions under which successful cottonwood recruitment could be re-initiated in the modern river. Predictive, spatially explicit modeling of current and future natural cottonwood regeneration will require linking models of cottonwood recruitment (e.g., Rood et al. 2005, Dixon and Turner 2006, Shafroth et al. 2010) with geomorphic models that realistically represent river dynamics under various flow and sediment management scenarios, climatic trends, and local reach conditions (e.g., Larsen and Greco 2002, Lancaster and Bras 2002, Richards et al. 2002, Larsen et al. 2007). We also suggest that the implications for cottonwood populations and broader ecosystem effects be considered for various flow and sediment release scenarios designed to support endangered species recovery (e.g., the spring pulse for pallid sturgeon) or other purposes (e.g., removal of sediment accumulations at the Lewis and Clark Lake delta). Finally, if planting is chosen as a tool for large-scale regeneration of cottonwood forests, studies should be conducted to evaluate the degree to which planted stands replicate the diversity, structure, and ecological function found in natural cottonwood stands.

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Table 1. Description of study segments and number of stands sampled per segment. Numbers of stands of cottonwood, disturbed cottonwood, and non-cottonwood that are <25 years old (sapling and pole) are indicated in parentheses.

Segment	Description	River Miles	Type of Segment	Total Stands	Cottonwood	Disturbed Cottonwood	Non-cottonwood	Planted Cottonwood
0	Wild and Scenic reach, Fort Benton to Fort Peck Reservoir	2073.4-1917	Free-flowing (FF)	29	29 (11)	0	0	
2	Fort Peck Dam to Lake Sakakawea	1771.3-1543.3	Inter-reservoir (IR)	30	30 (12)	0	0	
4	Garrison Dam to Lake Oahe	1390-1286	Inter-reservoir (IR)	66	35 (12)	10 (0)	21 (5)	
6	Oahe Dam to Big Bend Dam (includes Lake Sharpe)	1072.3-987.4	Inter-reservoir (IR)/ Reservoirs and Headwaters (R&H)	38	17 (3)	4 (0)	11 (2)	6 (6)
8	Fort Randall Dam to Springfield, SD	880-841	Inter-reservoir (IR)	54	33 (12)	4 (0)	13 (6)	4 (2)
9	Springfield, SD to Gavins Point Dam (includes Lewis & Clark Reservoir)	841-811.1	Reservoirs & Headwaters (R&H)	8	7 (4)	1 (0)	0	
10	Gavins Point Dam to Ponca, Nebraska	811.1-753	Unchannelized (UC)	59	34 (11)	7 (2)	18 (5)	
13	Plattsmouth, Nebraska to Kansas City	365.5-595.5	Channelized (C)	48	31 (15)	6 (1)	11 (5)	
	TOTAL			**332**	**216 (80)**	**32 (3)**	**74 (23)**	**10 (8)**

Table 2. Land cover categories used for GIS mapping of 2006 land cover.

1. **Water/bare sandbar**
   11. River main channel (open water, sand, submersed aquatic vegetation)
   12. Oxbow lake/backwater – off channel or connected
   13. Unvegetated sandbar
   14. Farm ponds, other open water habitats
   15. Missouri River reservoir
   16. Tributary river channel
   17. Constructed sandbar (emergent sandbar habitat)
   18. Unvegetated sandbar in tributary

2. **Forest and woodland** (forest has woody plants >6 m tall with >50% cover; woodland has woody plants >6m tall with 25-50% cover)
   20. non-cottonwood (cottonwood <15%) floodplain forest
   21. forest (cottonwood at least 15%)
   22. woodland (cottonwood at least 15%)
   23. planted trees (farm woodlots, shelterbelts, orchards)
   24. upland forest (not in floodplain)
   25. non-cottonwood (cottonwood <15%) woodland
   27. planted cottonwood trees

3. **Shrubland** – woody plants <6 m tall account for 25-100% of cover
   30. shrubland (with cottonwood)
   31. non-cottonwood shrubland

4. **Low vegetation – Herbaceous or woody**
   41. upland grassland, pasture
   42. riparian low shrub with cottonwood (successional sandbar sites, may include a mixture of low woody and herbaceous vegetation)
   43. emergent wetland (off river)
   44. riparian low herbaceous vegetation
   45. riparian low shrub w/o cottonwood
   46. wet meadow / mesic grassland

5. **Planted/cultivated – row crops**
   50. agricultural row crops

6. Developed/urban

61. Town, city (e.g., Vermillion)
62. Farmstead and building complex (excluding woodlots)
63. Commercial/Industrial/Transportation (roads, parking lots, boat landings)
64. Urban/recreational grasses (developed right-of-ways, golf courses)
65. Cabin or managed cottonwood areas

7. **Barren - bare sand, etc.** (not in river channel, but could include island interior)

70. barren

8. **Other** – specify in notes

80. other, disturbed
81. other, abandoned agriculture

9. **Areas inundated by filling reservoir (1950s for segment 9 only)**

91. flooded forest
92. flooded open area (probably agricultural cropland)

FIGURE CAPTIONS

Figure 1. Map of Missouri River basin, indicating study segment locations. Priority bald eagle segments shown in red and other study segments indicated with blue text. Modified from graphic obtained from U.S. Army Corps of Engineers. Original source unknown.

Figure 2. Historic land cover change on segment 10 (Gavins Point Dam to Ponca, Nebraska) based on GIS analysis of 1892 Missouri River Commission maps and aerial photography from 1955-56, 1983-85, and 2006/2008. Pink in 1892 map indicates undefined land cover in 1892 Missouri River Commission maps.

Figure 3. Draft cottonwood age class map, overlaid on 2006 aerial imagery for Vermillion, S.D. vicinity on segment 10. Pink areas are sapling (<10 year old) stands, red are pole (10-25 years old), yellow are intermediate (25-50 years old), green are mature (50-114 years old) and blue are old growth (>114) stands.

Figure 4. Relative density and basal area of different tree species from the witness tree records of the General Land Office Survey for segment 10 (Gavins Point Dam to Ponca, NE) vs. 2007 field data (weighted by relative area of different age classes) within cottonwood stands on segments 8 and 10. Note the increases in relative abundance of red cedar, Russian olive, and white mulberry from the 1850s to present, and the decrease in elm and willow. Increases in red cedar may signify, in part, the effects of flow regulation and channel incision that have disconnected the vegetation of the historic floodplain from flooding. Russian olive and white mulberry are exotic species that were unlikely to have been present in the 1850s in the region. Declines in elm relative abundance are likely related to the impacts of Dutch Elm Disease.

Figure 5. Relative area of different land cover classes, by study segment and image year. Greatest change occurred for most segments in 1892-1950s, with expansion of agriculture. Greatest changes from 1950s to 2006 occurred on segments with reservoirs (segments 6 and 9), with steep declines in most other cover types. General trends across most segments included increases in agricultural cropland and declines in forest, shrubland, grassland, and sandbar.

Figure 6a. Historic changes in relative coverage of major land cover classes, on segment 13 (channelized segment between Plattsmouth, NE and Kansas City, MO).

Figure 6b. Historic changes in relative coverage of major land cover classes on segment 10 (Gavins Point Dam to Ponca, NE). Note that data include land cover from 1983/84 as well.

Figure 6c. Historic changes in relative coverage of major land cover classes on segment 9 (downstream of Niobrara delta to Gavins Point Dam, including Lewis and Clark Reservoir. "River" category includes reservoir.

Figure 6d. Historic changes in relative coverage of major land cover classes on segment 8 (Fort Randall Dam to downstream of Niobrara delta).

Figure 6e. Historic changes in relative coverage of major land cover classes on segment 6 (Oahe Dam to Big Bend Dam, including Lake Sharpe). As with Figure 4c, "river" category includes reservoir.

Figure 6f. Historic changes in relative coverage of major land cover classes on segment 4 (Garrison Dam to upper reaches of Lake Oahe, including Bismarck area).

Figure 6g. Historic changes in relative coverage of major land cover classes on segment 2 (Fort Peck Dam to upper reaches of Sakakawea Reservoir near Williston, ND).

Figure 6h. Historic changes in relative coverage of major land cover classes on segment 0 (Wild and Scenic River reach, Fort Benton to upper reaches of Fort Peck Reservoir).

Figure 7. Percentage change in total forest area per study segment from 1892 through the mid-1950s. Most forest declines were related to agricultural conversion.

Figure 8. Percentage change in total forest area per study segment from mid-1950s through 2006. Largest declines (>80%) are on the two segments with reservoirs – segments 6 (includes Lake Sharpe) and 9 (includes Lewis and Clark Reservoir), while forest area actually increased on the two most upstream segments (0 and 2) in Montana and western North Dakota.

Figure 9. Percentage change in total forest area per study segment from 1892 through 2006. Total forest area includes both cottonwood and non-cottonwood types. The only segment without a decline is the relatively free-flowing Wild and Scenic segment (segment 0), upstream of Fort Peck reservoir in Montana.

Figure 10. Net land cover conversions to or from forest in segment 10 from 1956 and 1984 to 2006. Dominant mode of forest loss was conversion to agricultural cropland, while dominant mode of forest gain was via maturation of shrubs or saplings to forest.

Figure 11. Relative area of different cottonwood age classes on each study segment. Lowest proportion of forest <50 years old occurs on segments 4 (below Garrison) and 6 (below Oahe), signifying little new recruitment of cottonwood forest since dam closure on/upstream of those segments.

Figure 12. Total cottonwood area (hectares), by age class, on each study segment.

Figure 13. Mean cottonwood area (hectares) per river kilometer, by age class, on each study segment. Lowest areas per river kilometer were on two segments with reservoirs (segments 6 and 9) and the relatively free-flowing, but geologically-constrained, Wild and Scenic River segment (segment 0) in Montana.

Figure 14. Adjusted mean (± standard error) overall shrub-layer and tree species richness for cottonwood stands (disturbed stands excluded) across Missouri River study segments. Average number of tree species (particularly for later successional species) declines progressively from most downstream (13) to farthest upstream (0) study segments.

Figure 15. Adjusted mean (± standard error) overall stand and herb-layer plant species richness for cottonwood stands (disturbed stands excluded) across Missouri River study segments. Cottonwood stands with the highest mean number of all species and herbaceous species were in segments 4 (below Garrison) and 10 (below Gavins Point).

Figure 16. Adjusted mean % (± standard error) of plant species (all layers) that are non-native for cottonwood stands (disturbed stands excluded) across Missouri River study segments. As shown above, proportion of exotic species generally increased from downstream to upstream, with the exception of the heavily modified segment 6 (Oahe Dam to Big Bend Dam), which had higher proportions of exotic species than the next segments upstream and downstream.

Figure 17. Overall stand (all layers) adjusted mean (± standard error) Coefficient of Conservatism values for cottonwood stands (disturbed stands excluded) across Missouri River study segments. Highest average C-values were in segments 4 (below Garrison) and 10 (below Gavins Point), signifying highest floristic quality on those sites, with the lowest values (signifying low floristic quality) in segment 6 (Oahe Dam to Big Bend Dam).

Figure 18. Adjusted mean (± standard error) Coefficient of Conservatism values for the herb-layer, shrub-layer, and overstory (trees) in cottonwood stands (disturbed stands excluded) across Missouri River study segments.

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Figure 21a. Relative importance value (sum of relative frequency, density, and basal area) of different tree species by cottonwood forest age class in segment 13. Data for >114 years old age class were from a single stand.

Figure 21b. Relative importance value (sum of relative frequency, density, and basal area) of different tree species within disturbed cottonwood and non-cottonwood forests in segment 13. DCW refers to disturbed cottonwood stands and NCW refers to non-cottonwood stands. Data for DCW<25, DCW 25-50, NCW<25, and NCW 25-50 were from single stands of each type.

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Figure 22b. Mean percent shrub cover by different species and overall mean shrub cover within non-cottonwood and disturbed cottonwood forests in segment 13. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments. DCW refers to disturbed cottonwood stands and NCW refers to non-cottonwood stands. Data for DCW<25, DCW 25-50, and NCW 25-50 were from single stands of each type.

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Figure 24a. Mean percent shrub cover by different species and overall mean shrub cover by cottonwood forest age class in segment 10. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

Figure 24b. Mean percent shrub cover by different species and overall mean shrub cover within non-cottonwood and disturbed cottonwood forests in segment 10. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments. DCW refers to disturbed cottonwood stands and NCW refers to non-cottonwood stands. Data for DCW 25-50 were from a single stand.

Figure 25a. Relative importance value (sum of relative frequency, density, and basal area) of different tree species by cottonwood forest age class in segments 8 and 9. Data for <10 years old age class were from a single stand.

Figure 25b. Relative importance value (sum of relative frequency, density, and basal area) of different tree species within disturbed cottonwood and non-cottonwood forests in segments 8 and 9. DCW refers to disturbed cottonwood stands and NCW refers to non-cottonwood stands. Data for DCW 25-50 and NCW 25-50 were from single stands of each type.

Figure 26a. Mean percent shrub cover by different species and overall mean shrub cover by cottonwood forest age class in segments 8 and 9. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

Figure 26b. Mean percent shrub cover by different species and overall mean shrub cover within non-cottonwood and disturbed cottonwood forests in segment 8 and 9. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments. DCW refers to disturbed cottonwood stands and NCW refers to non-cottonwood stands. Data for DCW 25-50 and NCW 25-50 were from single stands of each type.

Figure 27a. Relative importance value (sum of relative frequency, density, and basal area) of different tree species by cottonwood forest age class in segment 6. No cottonwood stands <10 years old were located that were of sufficient size for sampling.

Figure 27b. Relative importance value (sum of relative frequency, density, and basal area) of different tree species within disturbed cottonwood and non-cottonwood forests in segment 6. DCW refers to disturbed cottonwood stands and NCW refers to non-cottonwood stands. Data for DCW 25-50 were based on a single stand.

Figure 28a. Mean percent shrub cover by different species and overall mean shrub cover by cottonwood forest age class in segment 6. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments. No cottonwood stands <10 years old were located that were of sufficient size for sampling.

Figure 28b. Mean percent shrub cover by different species and overall mean shrub cover within non-cottonwood and disturbed cottonwood forests in segment 6. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments. DCW refers to disturbed cottonwood stands and NCW refers to non-cottonwood stands. Data for DCW 25-50 were based on a single stand.

Figure 29a. Relative importance value (sum of relative frequency, density, and basal area) of different tree species by cottonwood forest age class in segment 4. Sampled cottonwood stands <10 years old did not have any trees (stems >10 cm dbh).

Figure 29b. Relative importance value (sum of relative frequency, density, and basal area) of different tree species within disturbed cottonwood and non-cottonwood forests in segment 4. DCW refers to disturbed cottonwood stands and NCW refers to non-cottonwood stands. Sampled NCW sites <25 and 25-50 years old did not have any trees (stems >10 cm dbh).

Figure 30a. Mean percent shrub cover by different species and overall mean shrub cover by cottonwood forest age class in segment 4. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

Figure 30b. Mean percent shrub cover by different species and overall mean shrub cover within non-cottonwood and disturbed cottonwood forests in segment 4. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments. DCW refers to disturbed cottonwood stands and NCW refers to non-cottonwood stands. Data for NCW 25-50 were based on a single stand.

Figure 31. Relative importance value (sum of relative frequency, density, and basal area) of different tree species by cottonwood forest age class in segment 2. Sampled cottonwood stands <10 years old did not have any trees (stems >10 cm dbh).

Figure 32. Mean percent shrub cover by different species and overall mean shrub cover by cottonwood forest age class in segment 2. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

Figure 33. Relative importance value (sum of relative frequency, density, and basal area) of different tree species by cottonwood forest age class in segment 0. Sampled cottonwood stands <10 years old did not have any trees (stems >10 cm dbh).

Figure 34. Mean percent shrub cover by different species and overall mean shrub cover by cottonwood forest age class in segment 0. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

Figure 35. Composite changes in forest and shrubland area across all study segments from 1892 to the mid-1950s to 2006. Total area of natural woody vegetation declined 47% from 1892 to 2006, with a 42% decline in forest and a 59% decline in shrubland. Note that most forest loss occurred between 1892 and the 1950s, while most shrubland loss occurred between the 1950s and 2006.

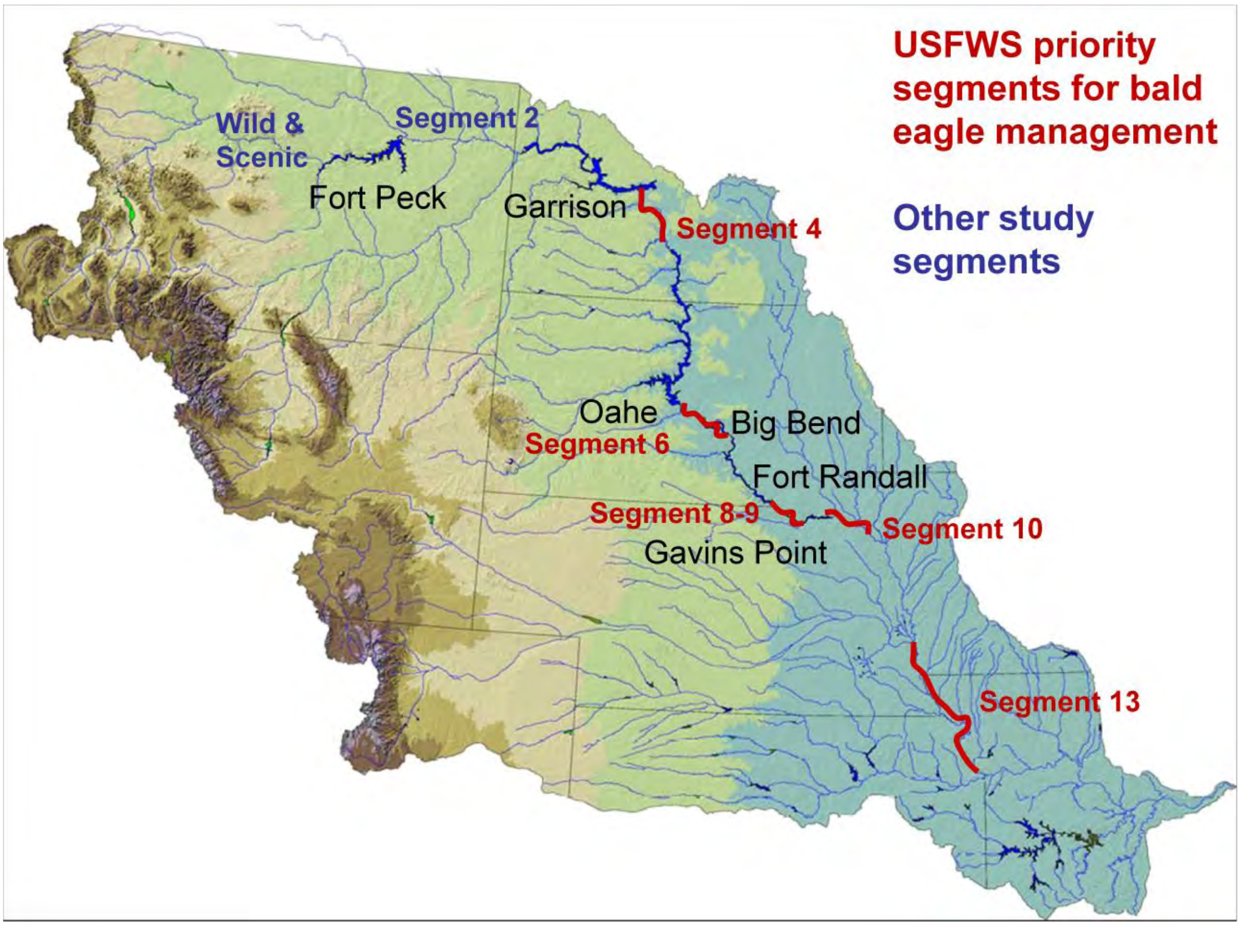


Figure 1. Map of Missouri River basin, indicating study segment locations. Priority bald eagle segments shown in red and other study segments indicated with blue text. Modified from graphic obtained from U.S. Army Corps of Engineers. Original source unknown.

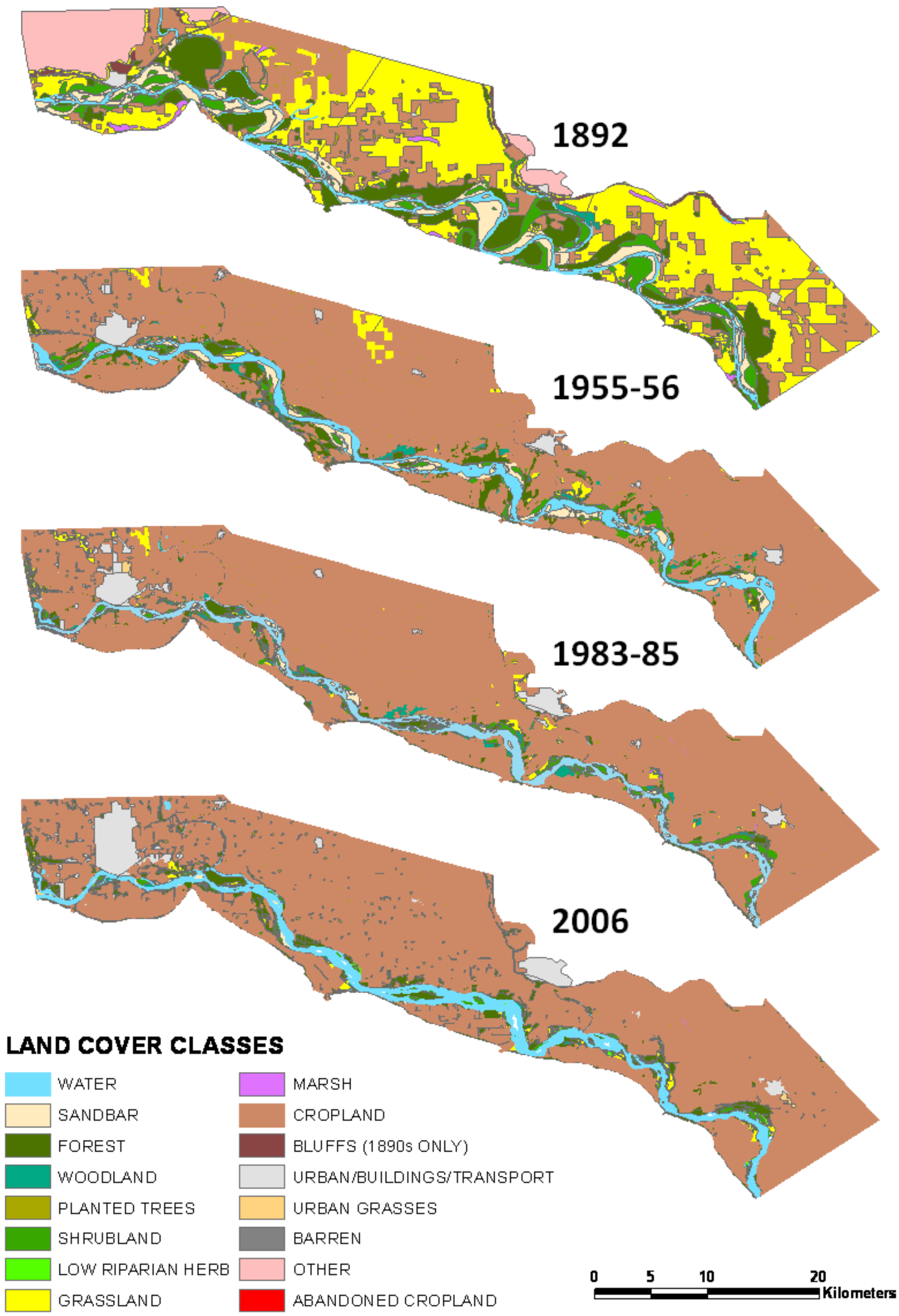


Figure 2. Historic land cover change on segment 10 (Gavins Point Dam to Ponca, Nebraska) based on GIS analysis of 1892 Missouri River Commission maps and aerial photography from 1955-56, 1983-85, and 2006. Pink in 1892 map indicates undefined land cover in 1892 Missouri River Commission maps.

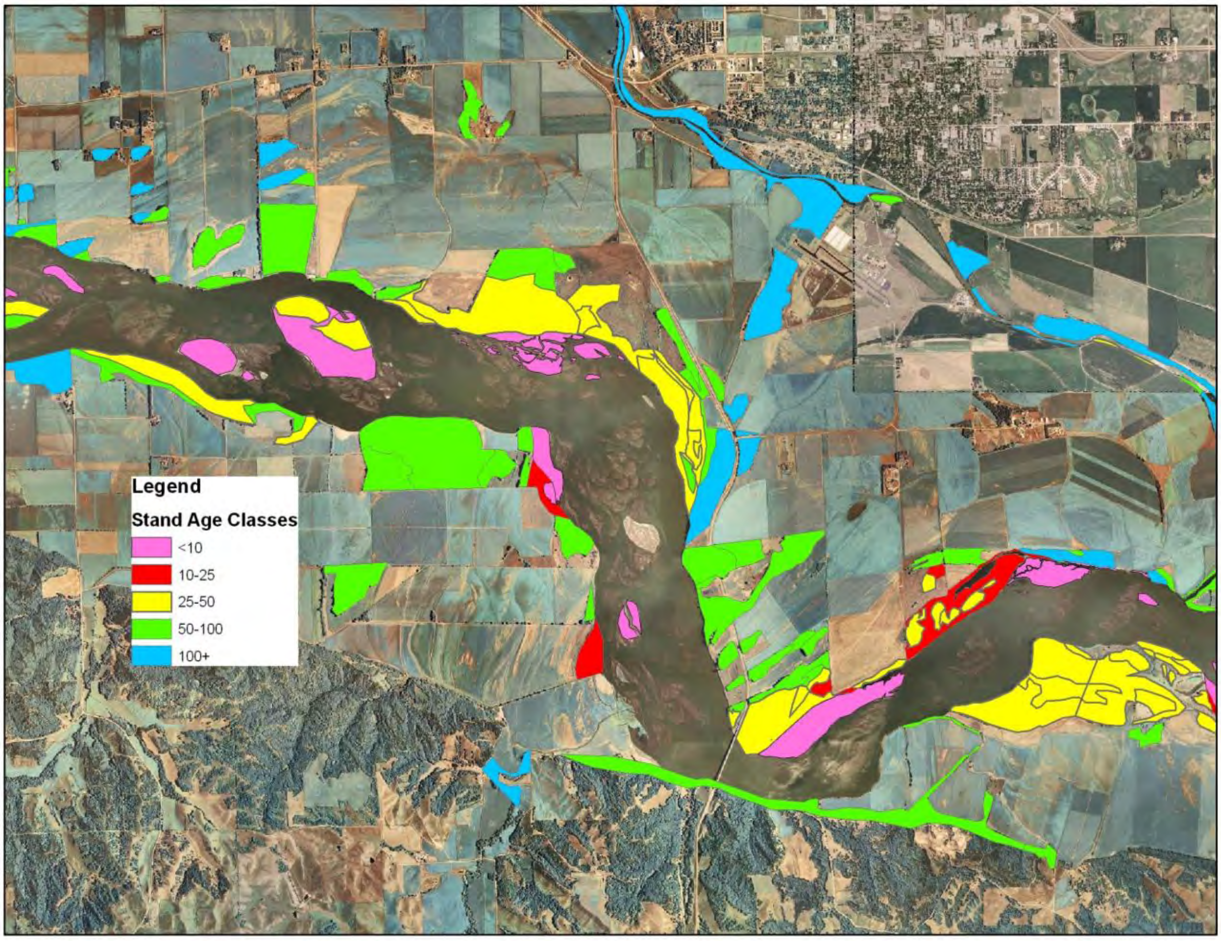


Figure 3. Draft cottonwood age class map, overlaid on 2006 aerial imagery for Vermillion, S.D. vicinity on segment 10. Pink areas are sapling (<10 year old) stands, red are pole (10-25 years old), yellow are intermediate (25-50 years old), green are mature (50-114 years old) and blue are old growth (>114) stands.

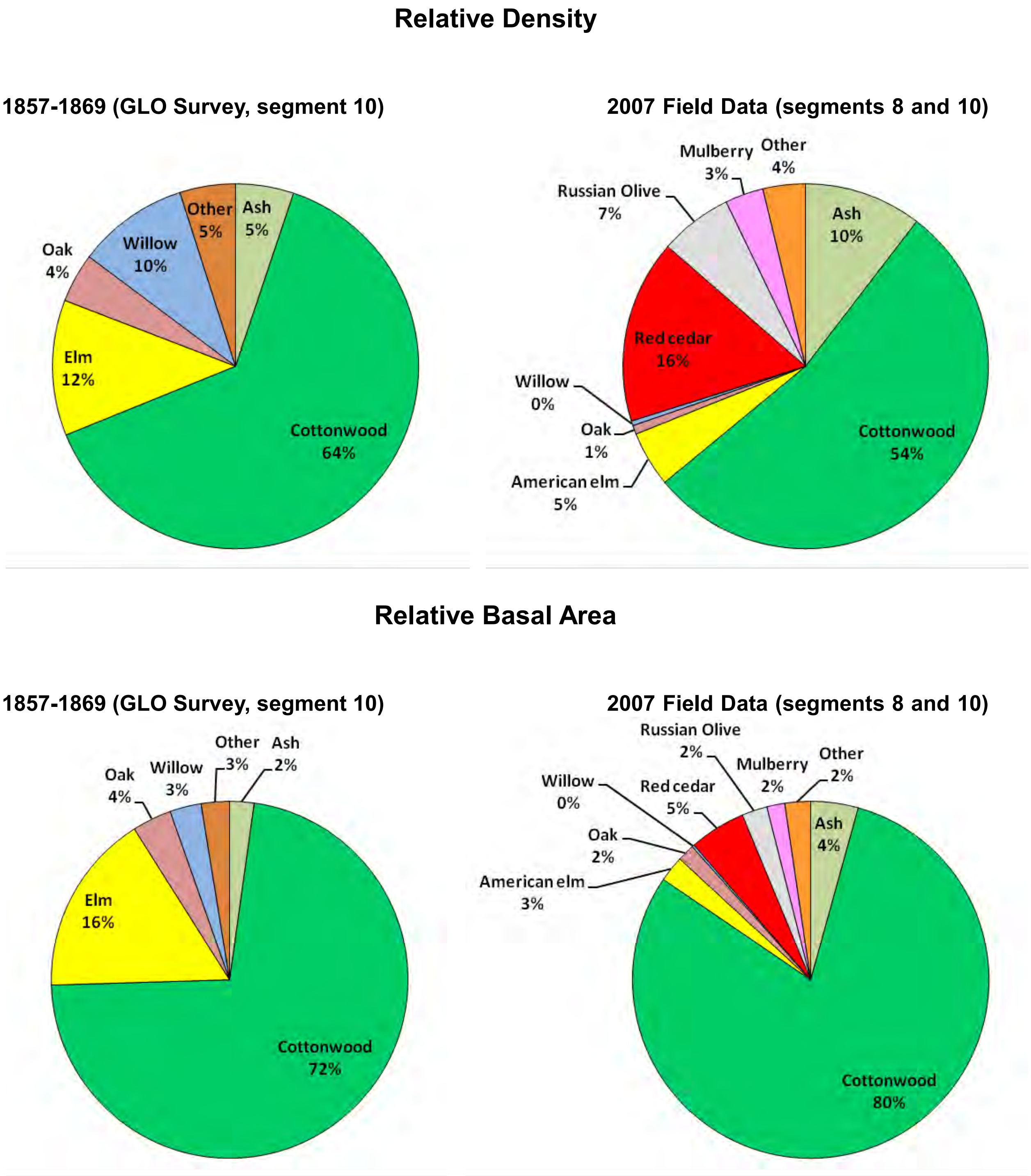


Figure 4. Relative density and basal area of different tree species from the witness tree records of the General Land Office Survey for segment 10 (Gavins Point Dam to Ponca, NE) vs. 2007 field data (weighted by relative area of different age classes) within cottonwood stands on segments 8 and 10. Note the increases in relative abundance of red cedar, Russian olive, and white mulberry from the 1850s to present, and the decrease in elm and willow. Increases in red cedar may signify, in part, the effects of flow regulation and channel incision that have disconnected the vegetation of the historic floodplain from flooding. Russian olive and white mulberry are exotic species that were unlikely to have been present in the 1850s in the region. Declines in elm relative abundance are likely related to the impacts of Dutch Elm Disease.

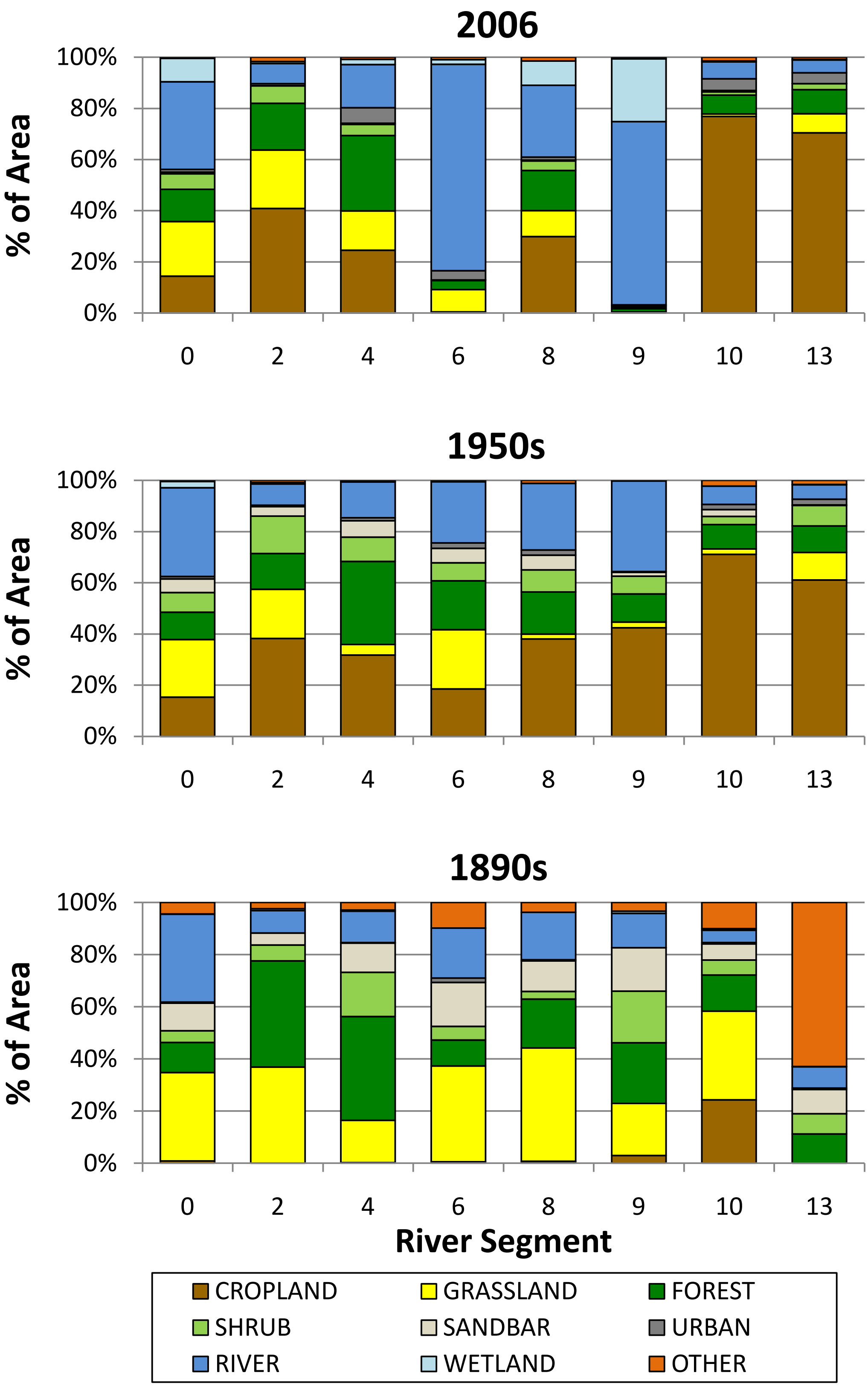


Figure 5. Relative area of different land cover classes, by study segment and image year. Greatest change occurred for most segments in 1892-1950s, with expansion of agriculture. Greatest changes from 1950s to 2006 occurred on segments with reservoirs (segments 6 and 9), with steep declines in most other cover types. General trends across most segments included increases in agricultural cropland and declines in forest, shrubland, grassland, and sandbar.

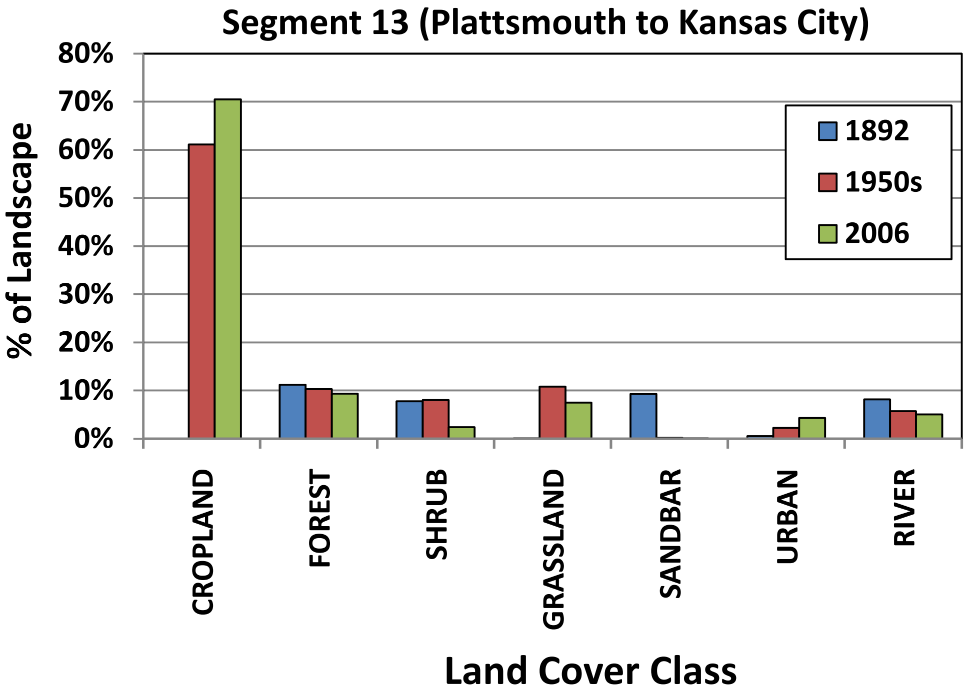


Figure 6a. Historic changes in relative coverage of major land cover classes, on segment 13 (channelized segment between Plattsmouth, NE and Kansas City, MO).

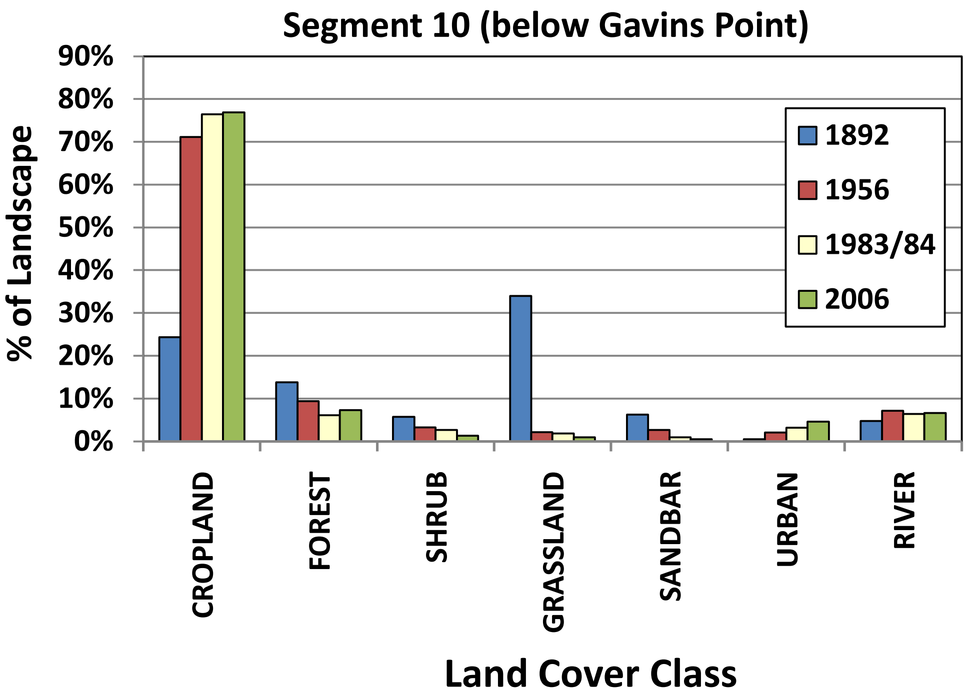


Figure 6b. Historic changes in relative coverage of major land cover classes on segment 10 (Gavins Point Dam to Ponca, NE). Note that data include land cover from 1983/84 as well.

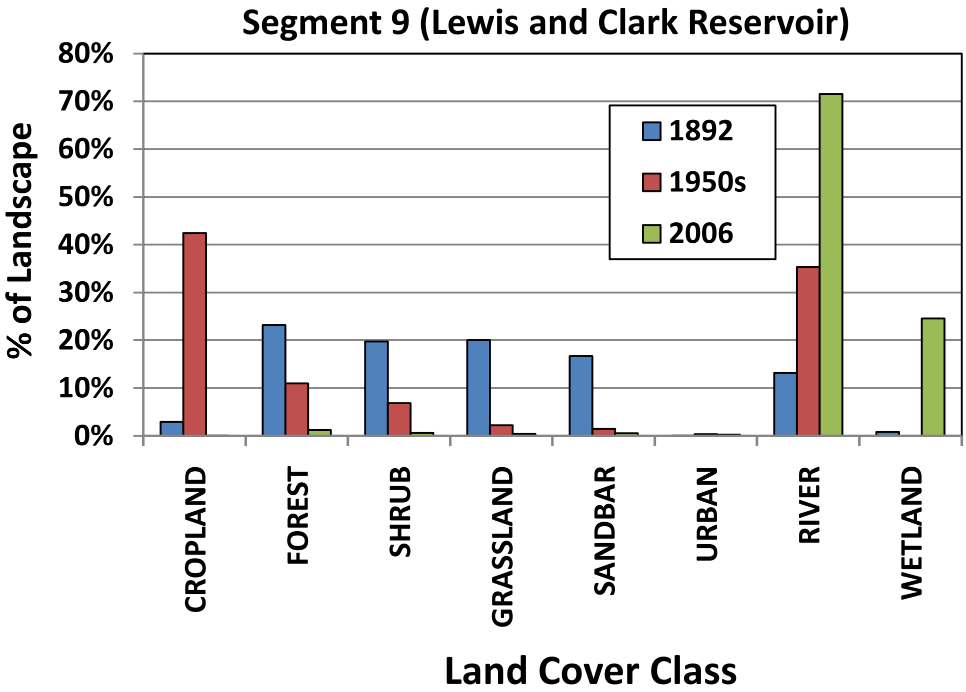


Figure 6c. Historic changes in relative coverage of major land cover classes on segment 9 (downstream of Niobrara delta to Gavins Point Dam, including Lewis and Clark Reservoir. "River" category includes reservoir.

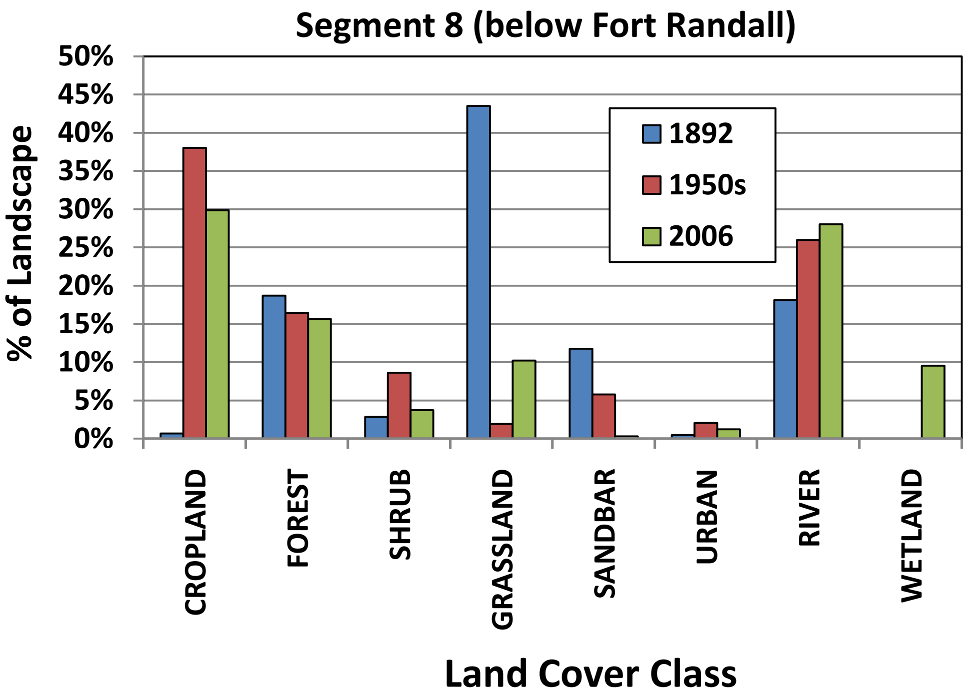


Figure 6d. Historic changes in relative coverage of major land cover classes on segment 8 (Fort Randall Dam to downstream of Niobrara delta).

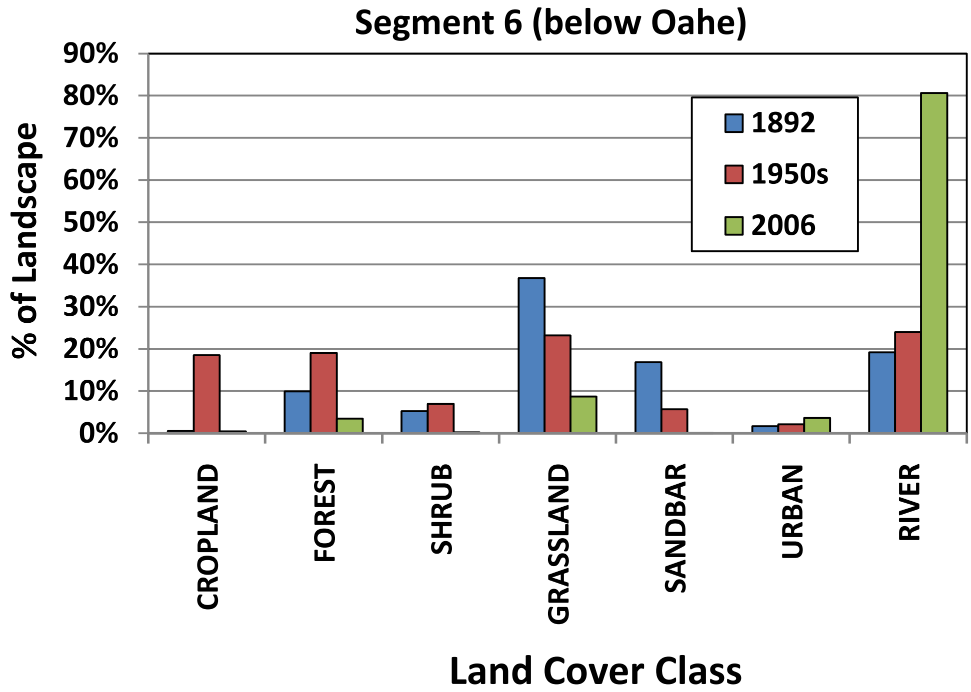


Figure 6e. Historic changes in relative coverage of major land cover classes on segment 6 (Oahe Dam to Big Bend Dam, including Lake Sharpe). As with Figure 4c, "river" category includes reservoir.

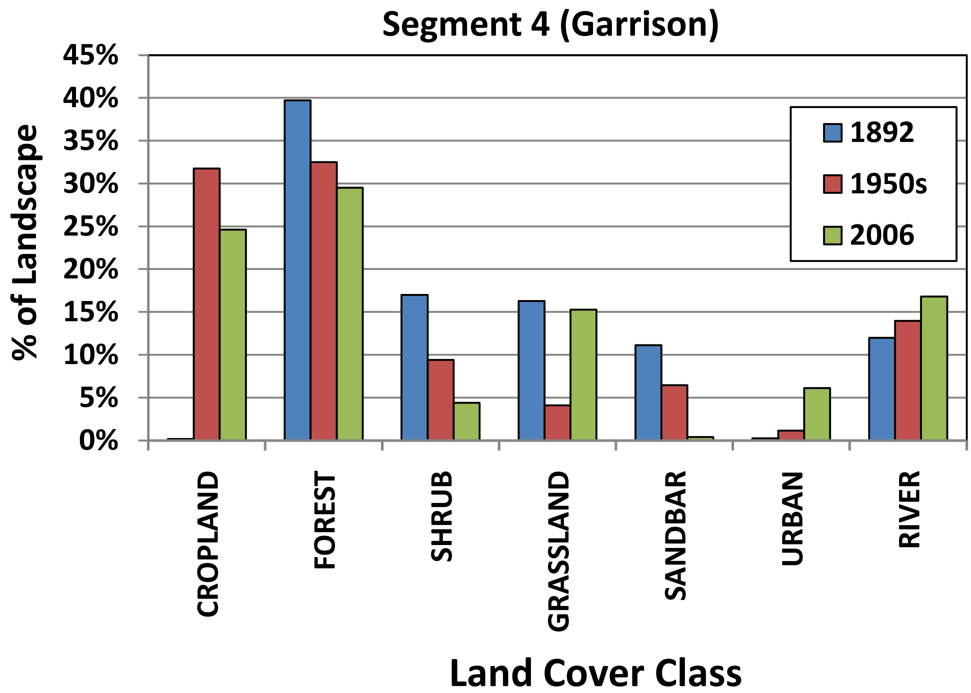


Figure 6f. Historic changes in relative coverage of major land cover classes on segment 4 (Garrison Dam to upper reaches of Lake Oahe, including Bismarck area).

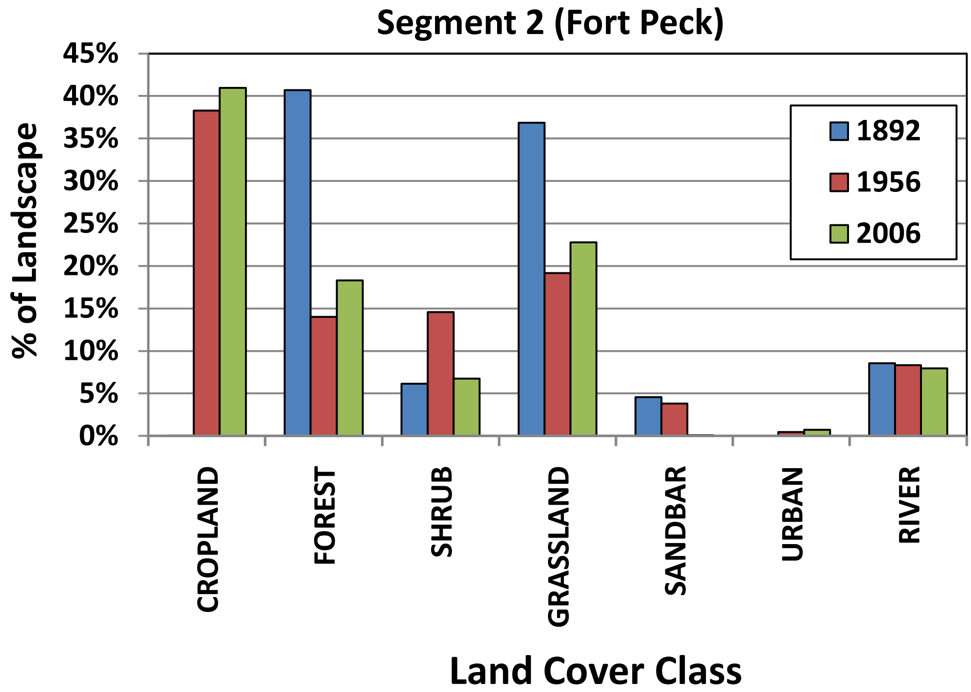


Figure 6g. Historic changes in relative coverage of major land cover classes on segment 2 (Fort Peck Dam to upper reaches of Sakakawea Reservoir near Williston, ND).

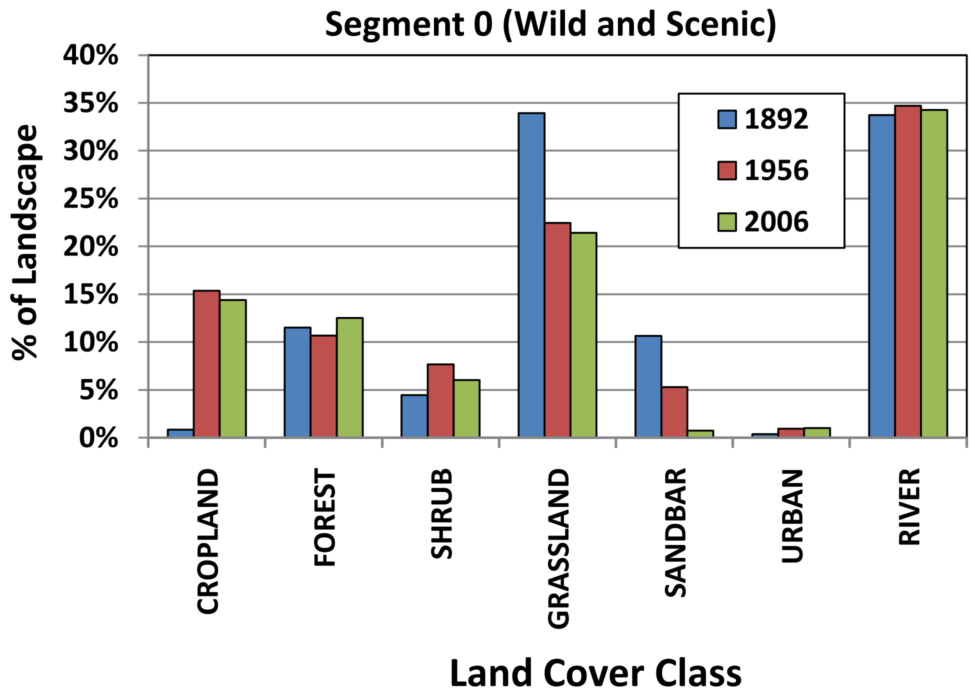


Figure 6h. Historic changes in relative coverage of major land cover classes on segment 0 (Wild and Scenic River reach, Fort Benton to upper reaches of Fort Peck Reservoir).

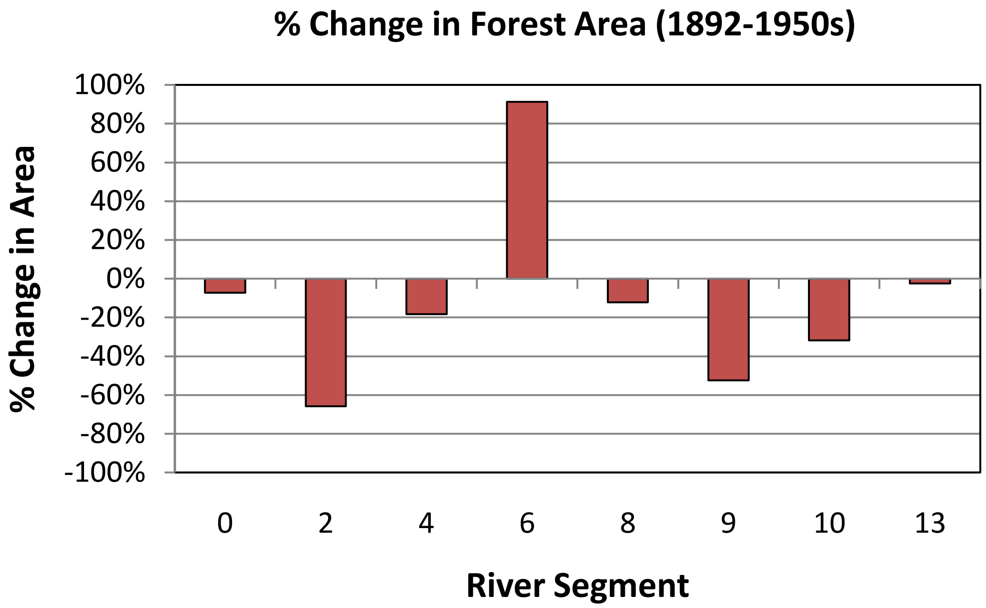
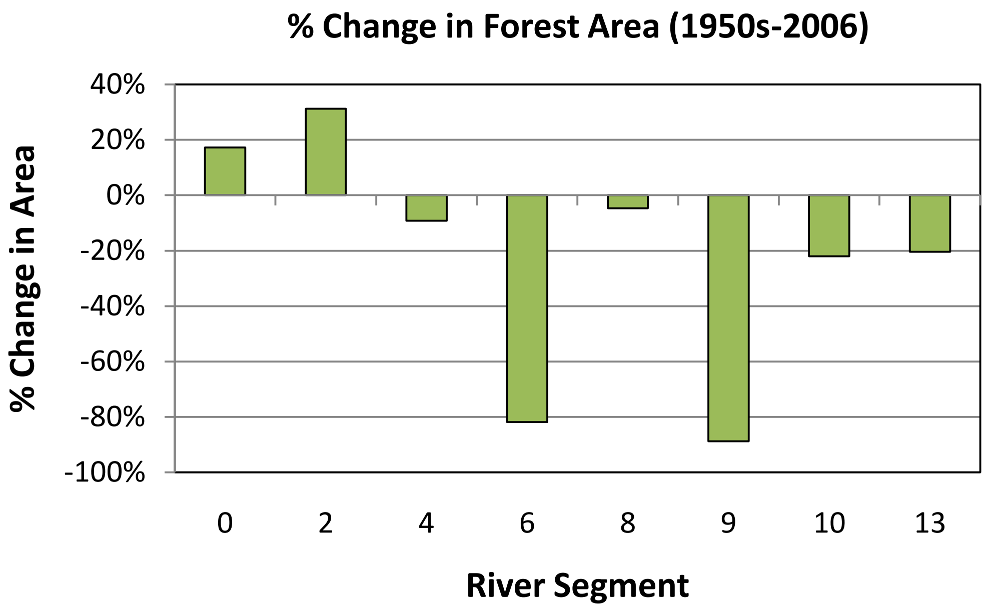


Figure 7. Percentage change in total forest area per study segment from 1892 through the mid-1950s. Most forest declines were related to agricultural conversion.



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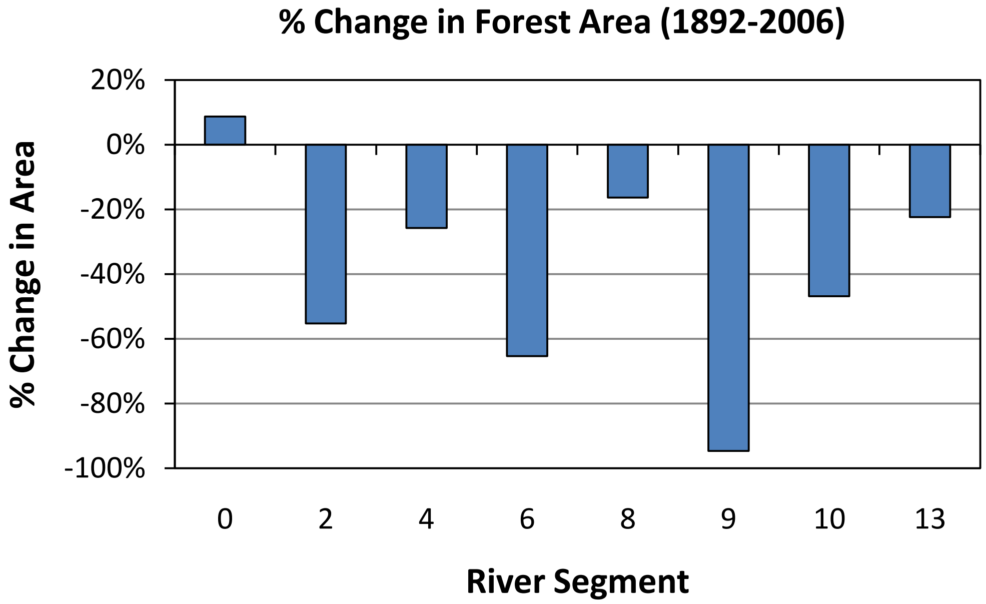

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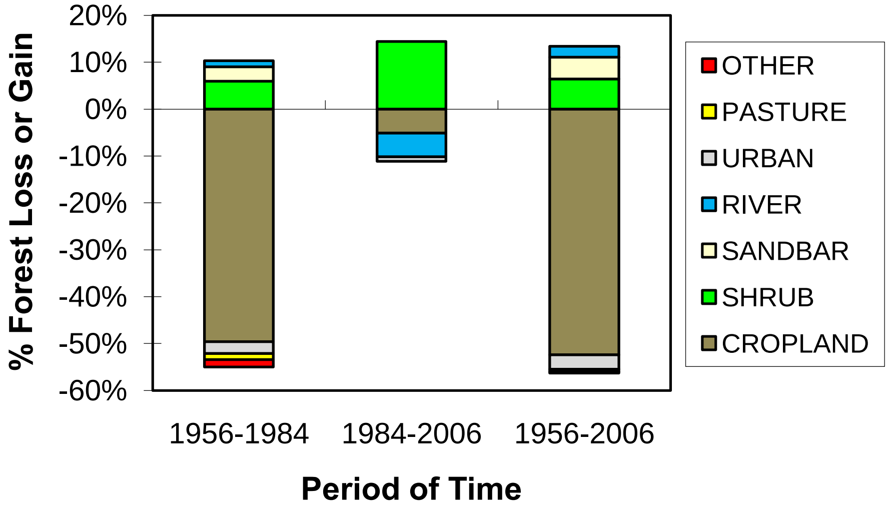

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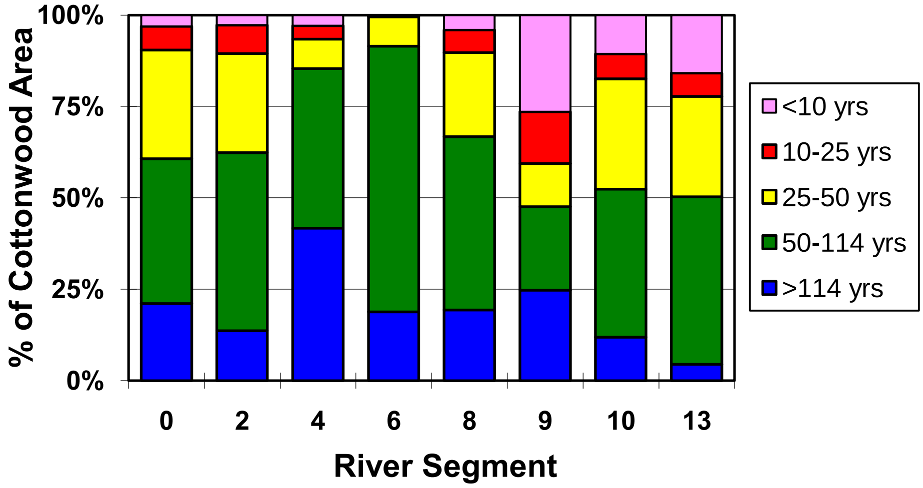

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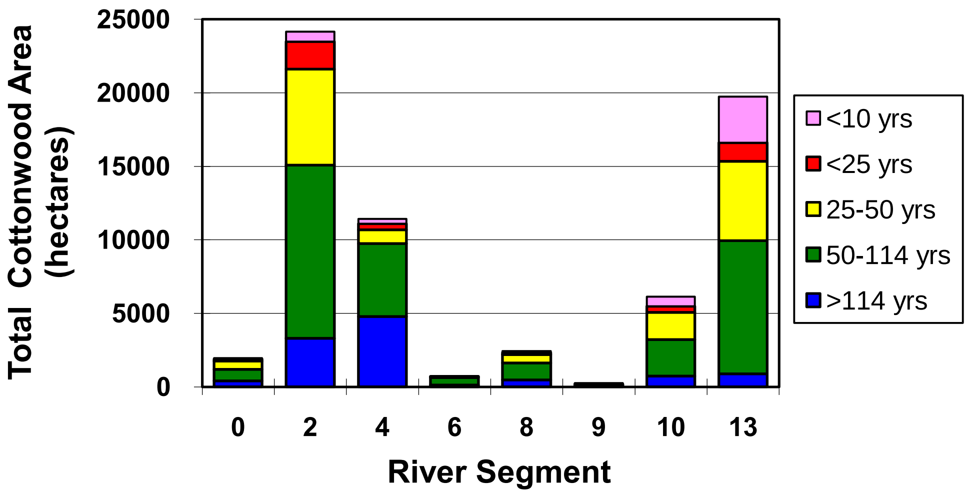
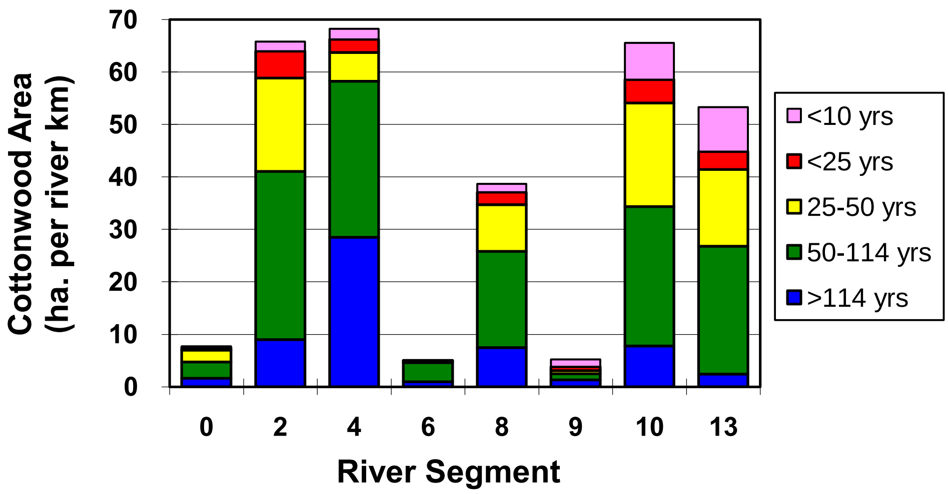


Figure 12. Total cottonwood area (hectares), by age class, on each study segment.



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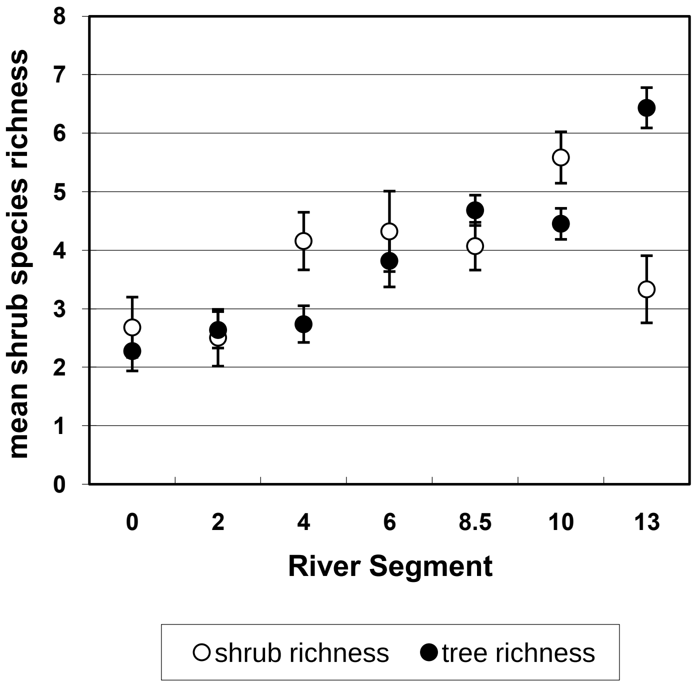

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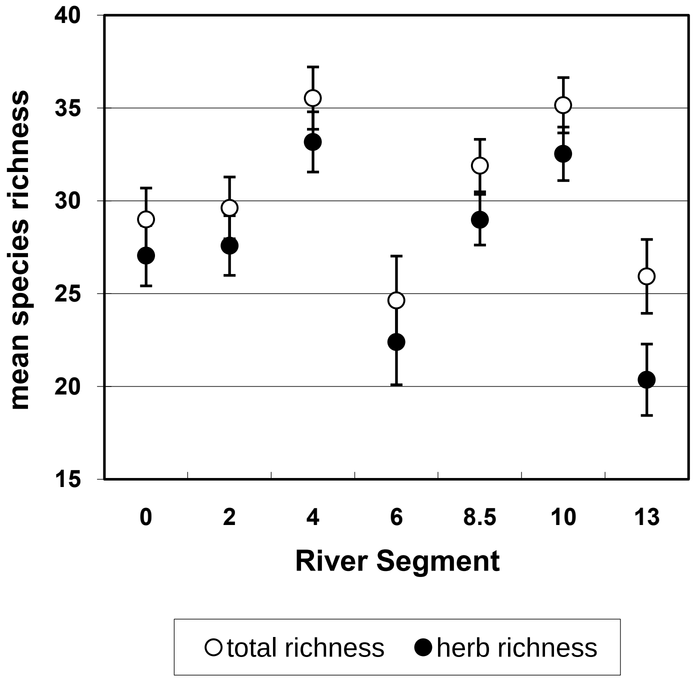

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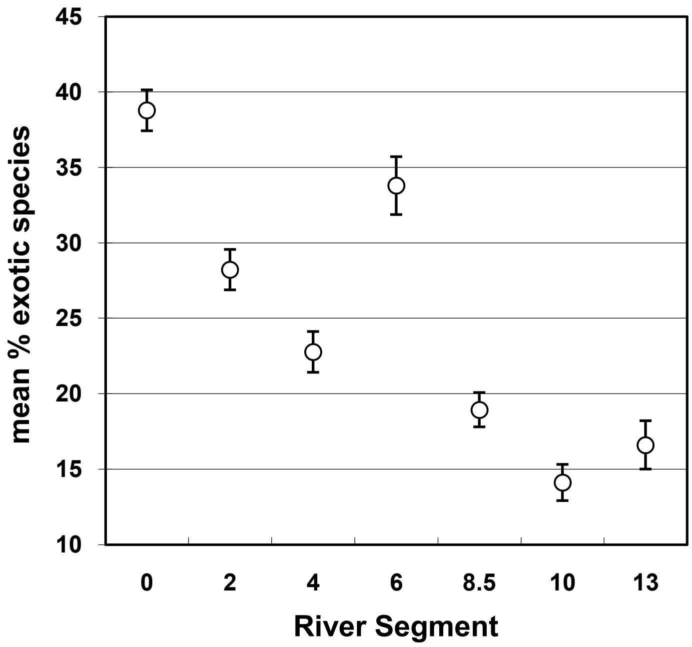

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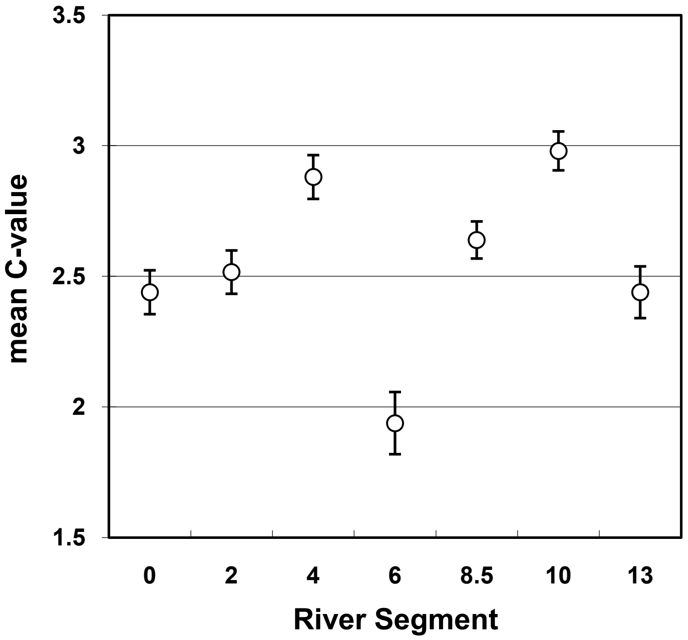

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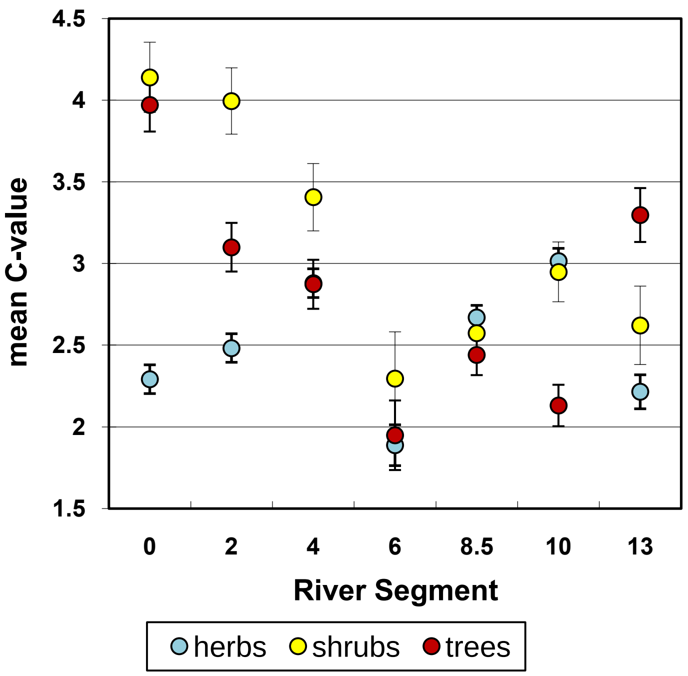

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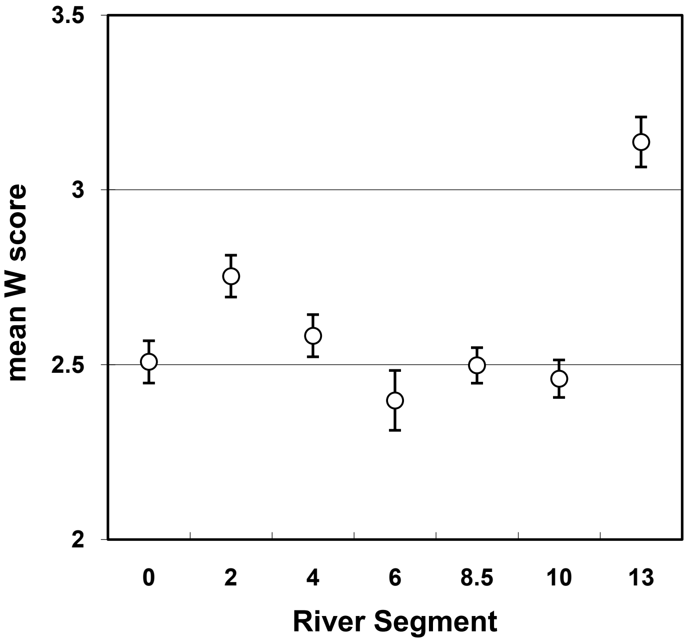

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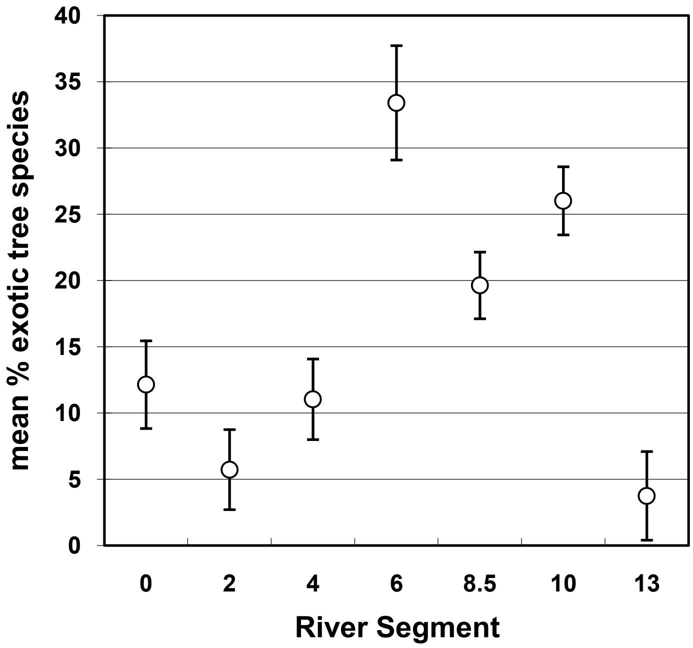

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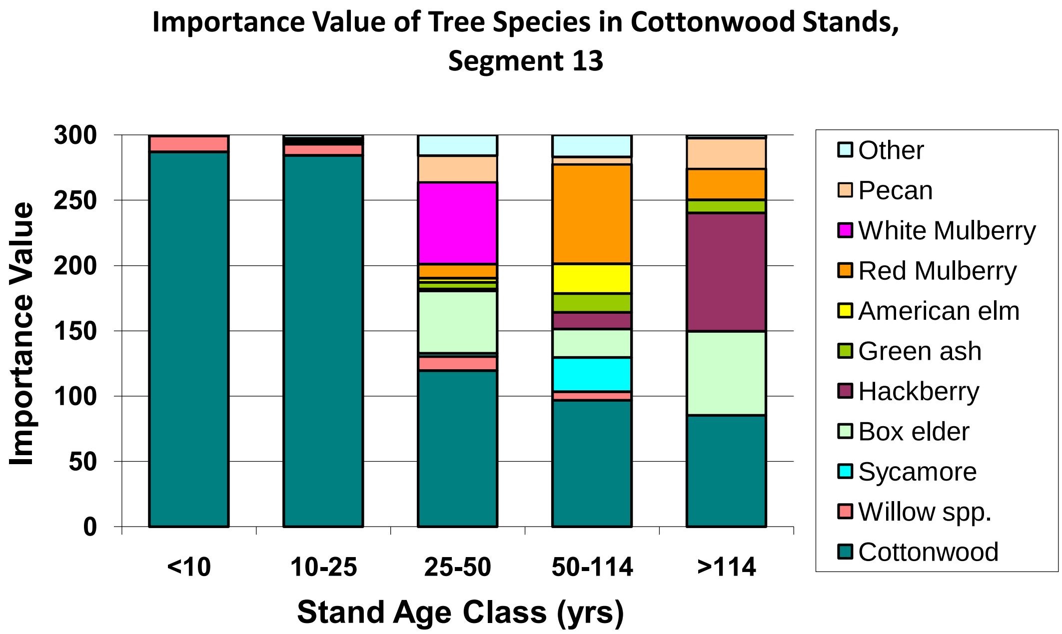

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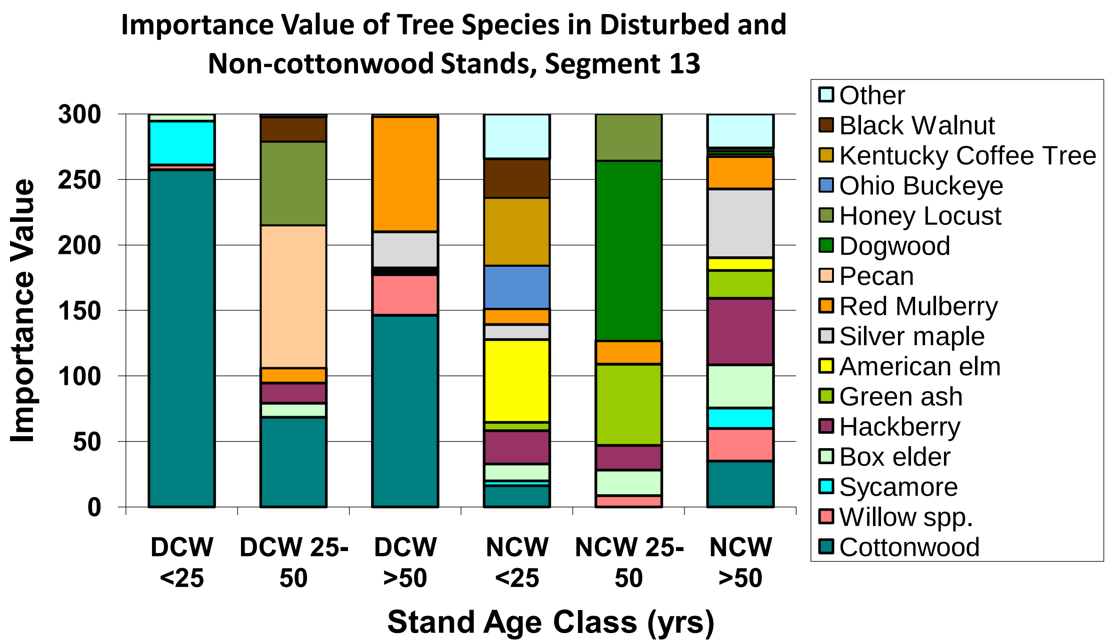

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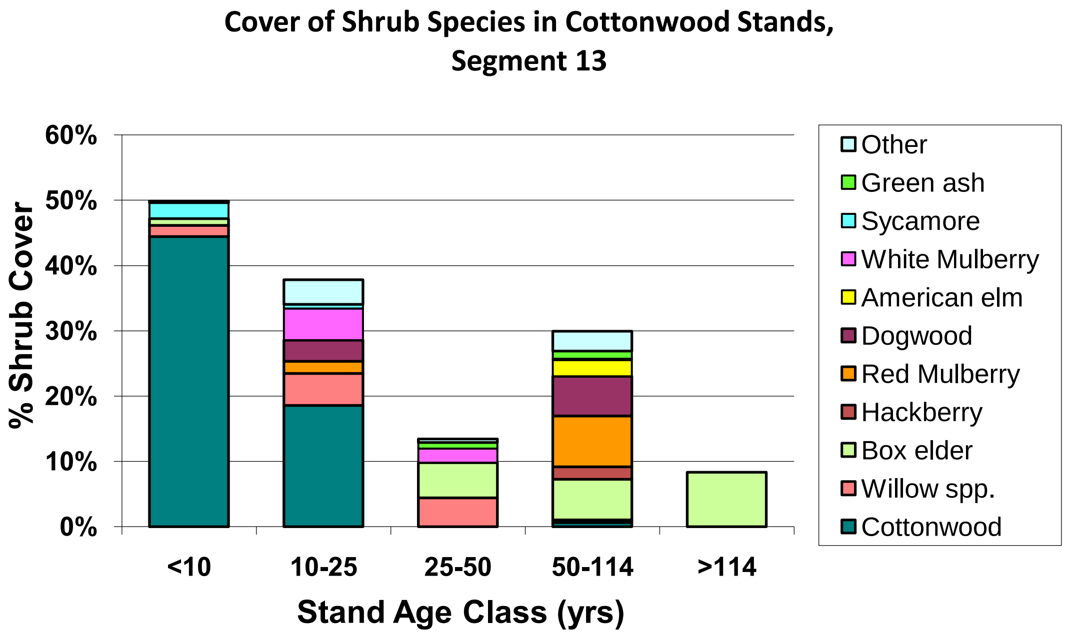

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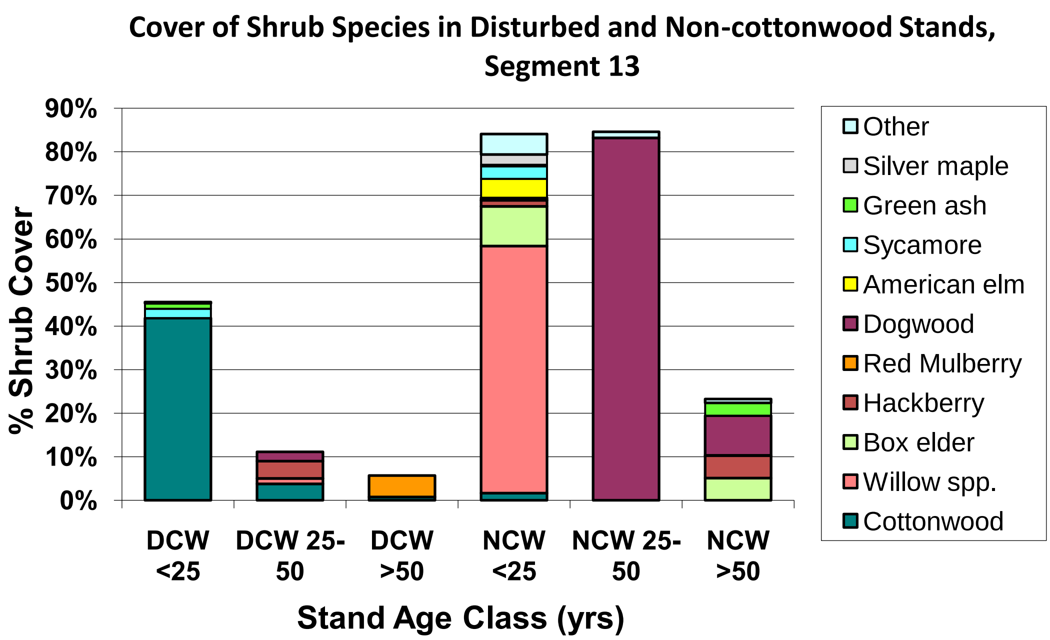

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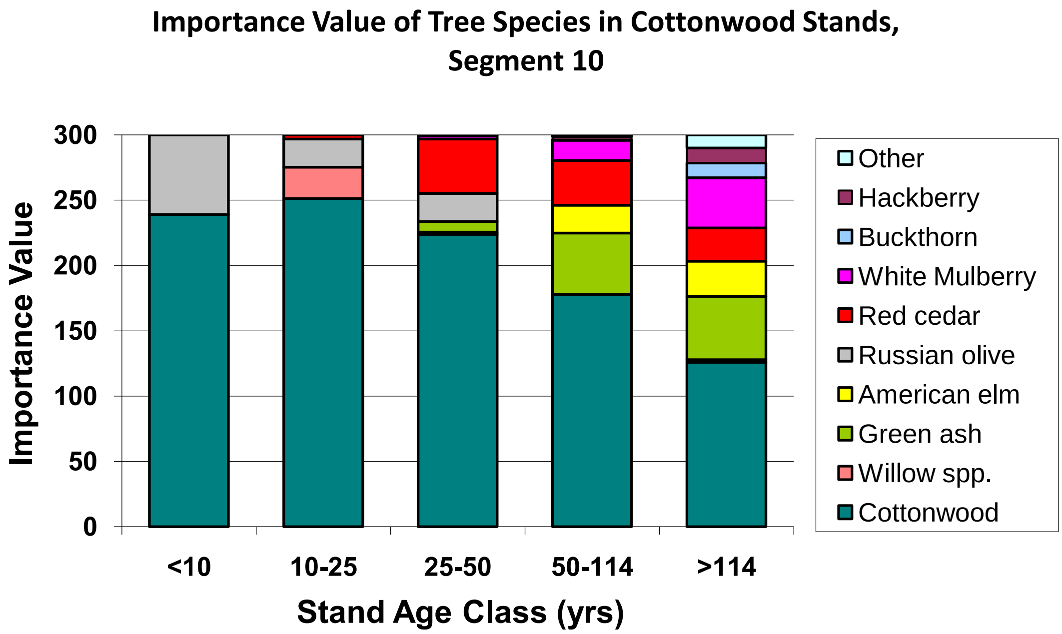


Figure 23a. Relative importance value (sum of relative frequency, density, and basal area) of different tree species by cottonwood forest age class in segment 10.

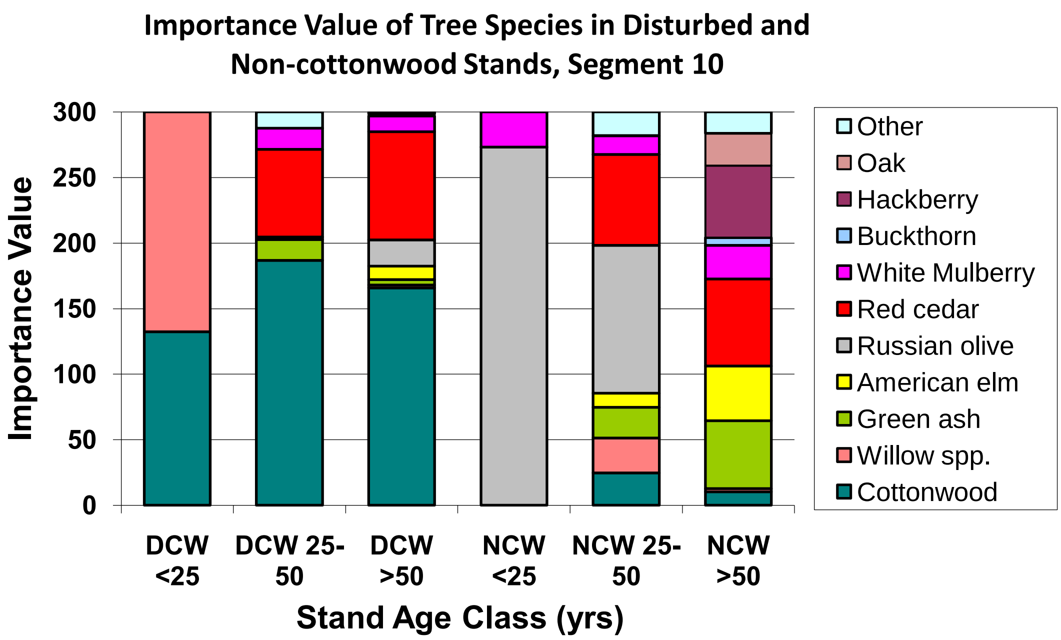


Figure 23b. Relative importance value (sum of relative frequency, density, and basal area) of different tree species within disturbed cottonwood and non-cottonwood forests in segment 10. DCW refers to disturbed cottonwood stands and NCW refers to non-cottonwood stands. Data for DCW 25-50 and NCW <25 were from single stands of each type.

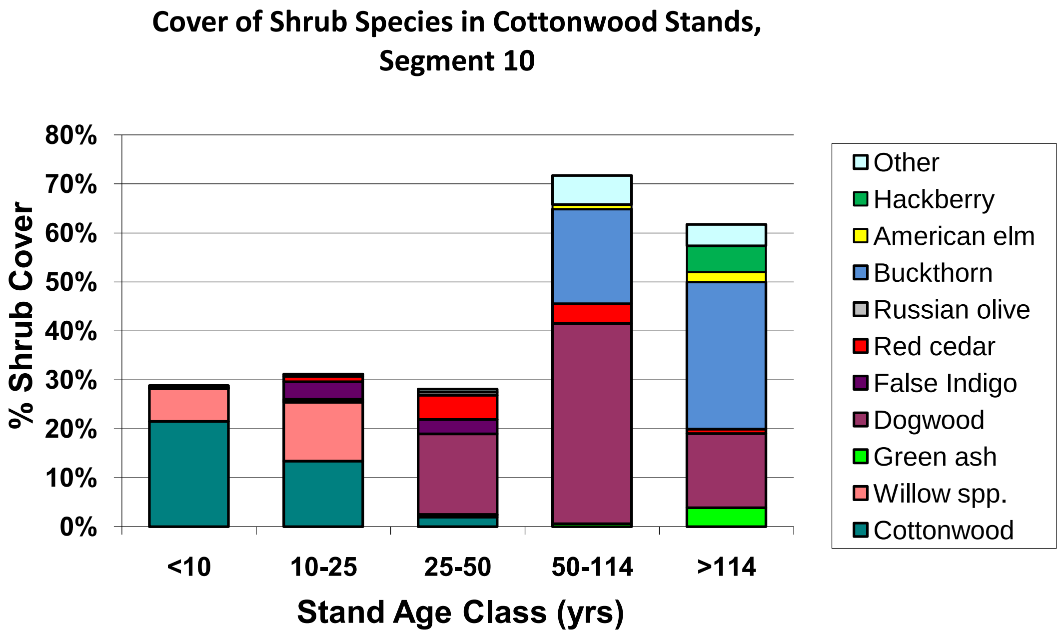


Figure 24a. Mean percent shrub cover by different species and overall mean shrub cover by cottonwood forest age class in segment 10. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

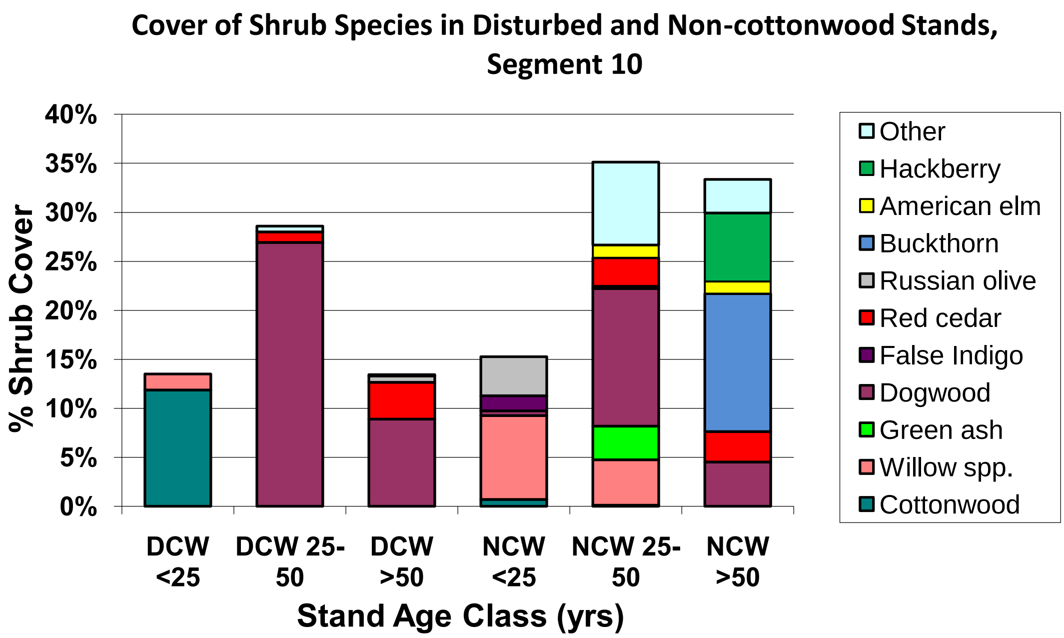


Figure 24b. Mean percent shrub cover by different species and overall mean shrub cover within non-cottonwood and disturbed cottonwood forests in segment 10. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments. DCW refers to disturbed cottonwood stands and NCW refers to non-cottonwood stands. Data for DCW 25-50 were from a single stand.

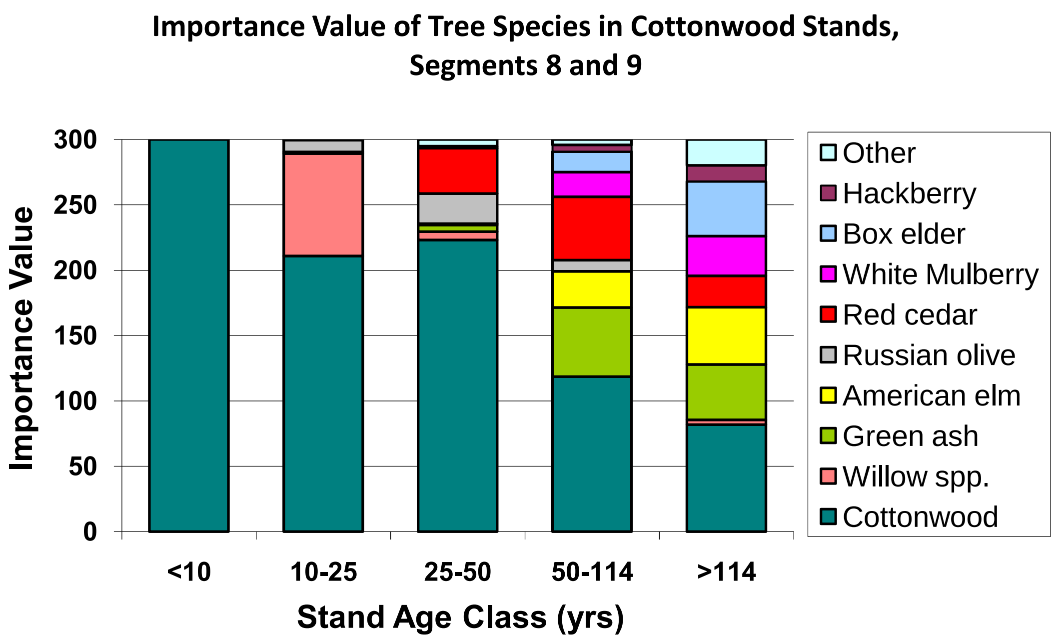


Figure 25a. Relative importance value (sum of relative frequency, density, and basal area) of different tree species by cottonwood forest age class in segments 8 and 9. Data for <10 years old age class were from a single stand.

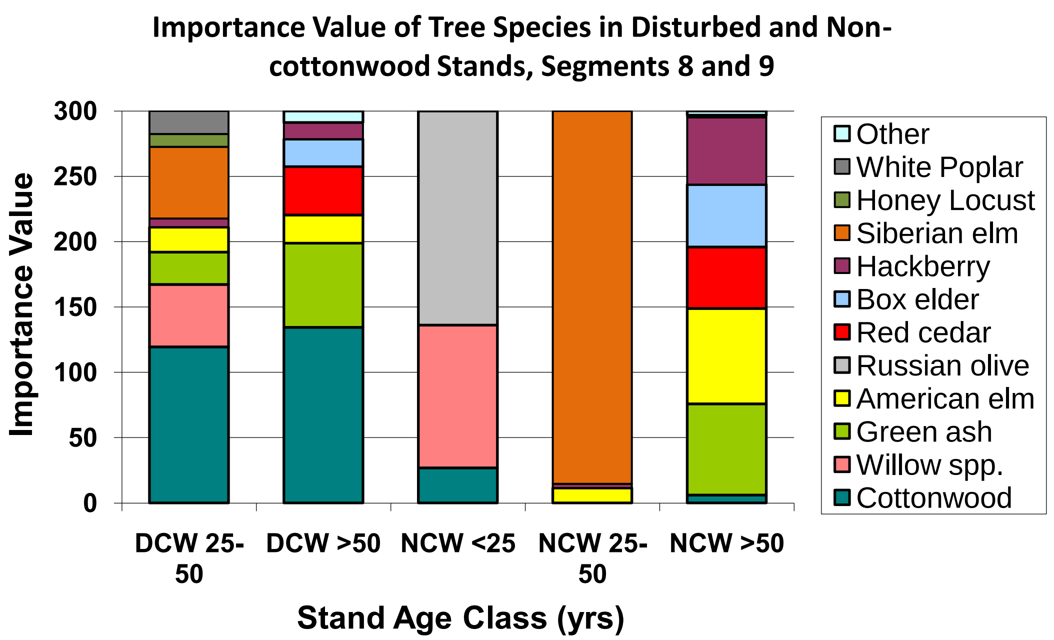


Figure 25b. Relative importance value (sum of relative frequency, density, and basal area) of different tree species within disturbed cottonwood and non-cottonwood forests in segments 8 and 9. DCW refers to disturbed cottonwood stands and NCW refers to non-cottonwood stands. Data for DCW 25-50 and NCW 25-50 were from single stands of each type.

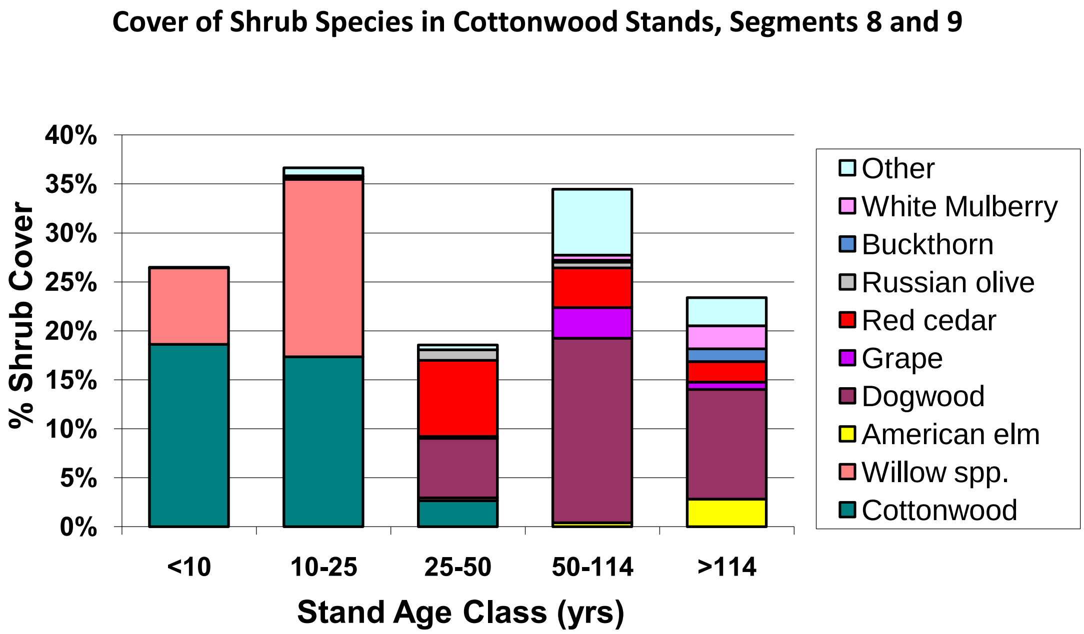


Figure 26a. Mean percent shrub cover by different species and overall mean shrub cover by cottonwood forest age class in segments 8 and 9. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

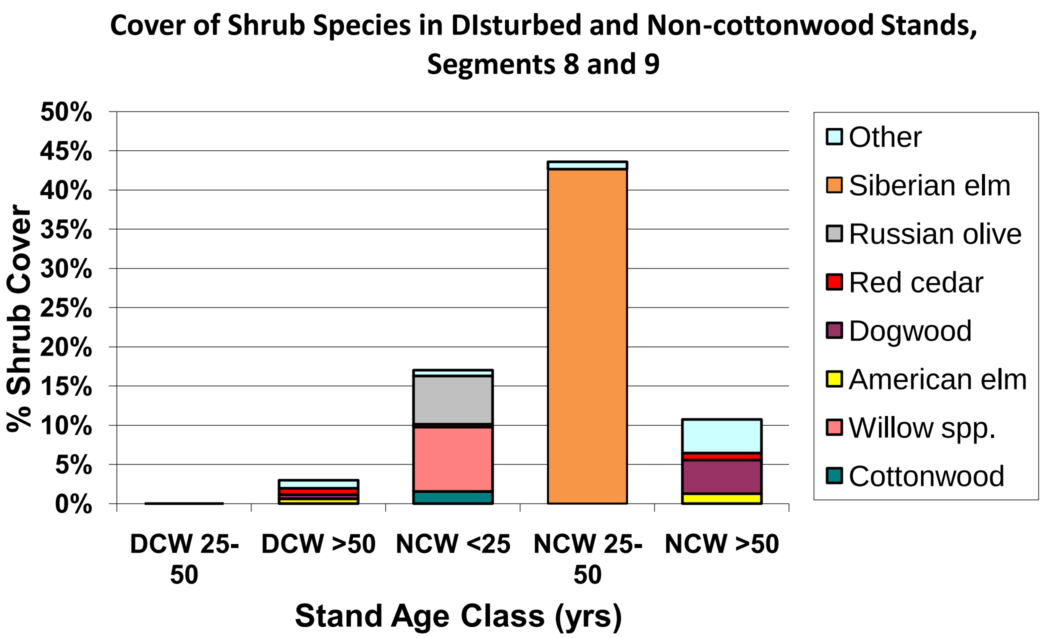


Figure 26b. Mean percent shrub cover by different species and overall mean shrub cover within non-cottonwood and disturbed cottonwood forests in segment 8 and 9. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments. DCW refers to disturbed cottonwood stands and NCW refers to non-cottonwood stands. Data for DCW 25-50 and NCW 25-50 were from single stands of each type.

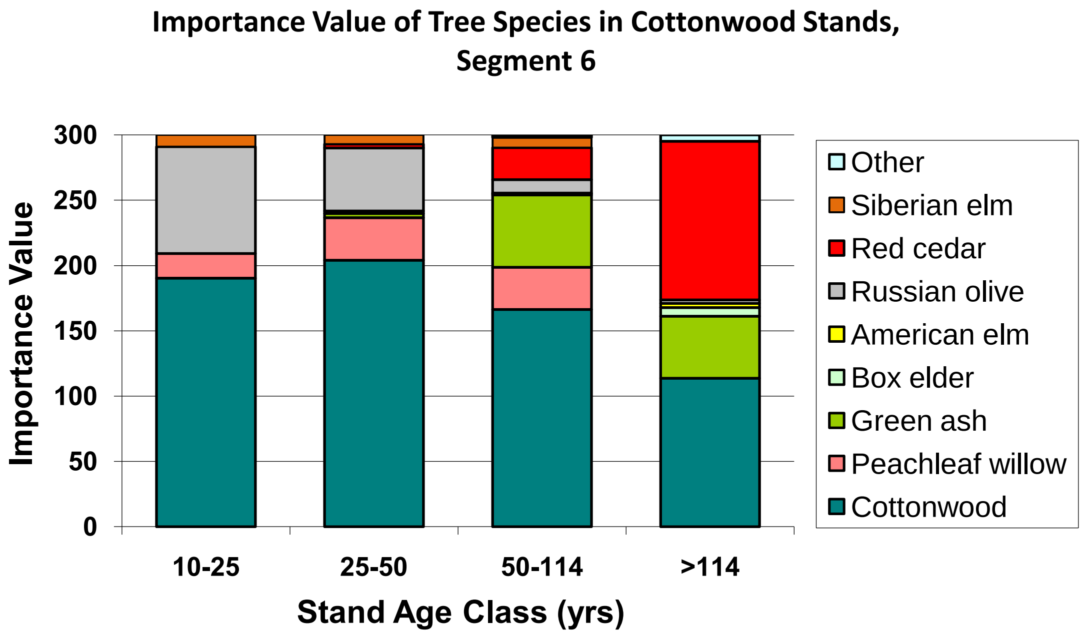


Figure 27a. Relative importance value (sum of relative frequency, density, and basal area) of different tree species by cottonwood forest age class in segment 6. No cottonwood stands <10 years old were located that were of sufficient size for sampling.

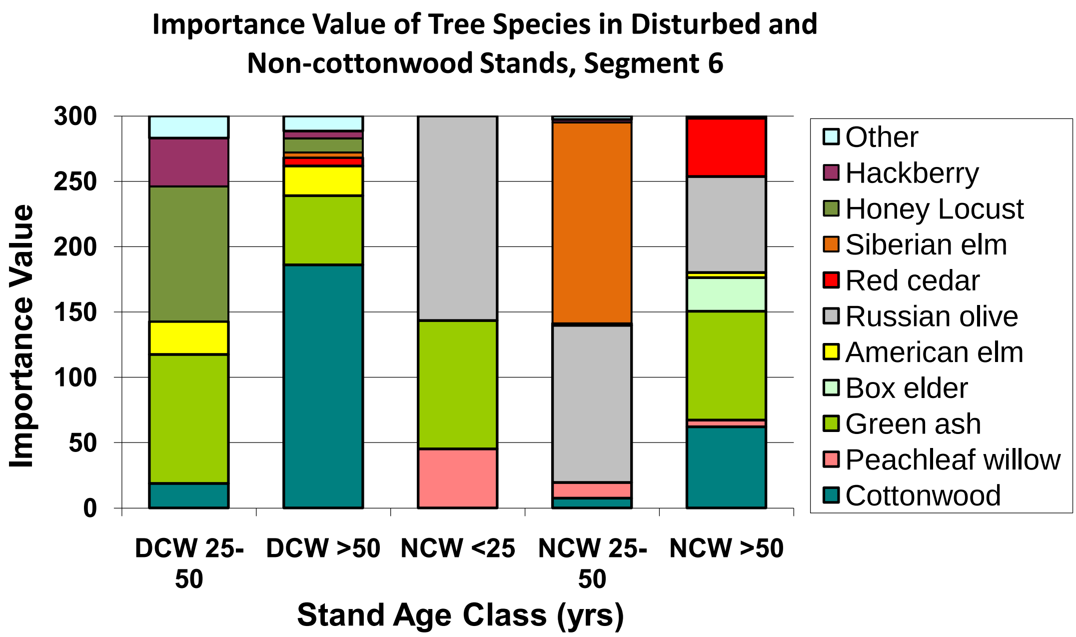


Figure 27b. Relative importance value (sum of relative frequency, density, and basal area) of different tree species within disturbed cottonwood and non-cottonwood forests in segment 6. DCW refers to disturbed cottonwood stands and NCW refers to non-cottonwood stands. Data for DCW 25-50 were based on a single stand.

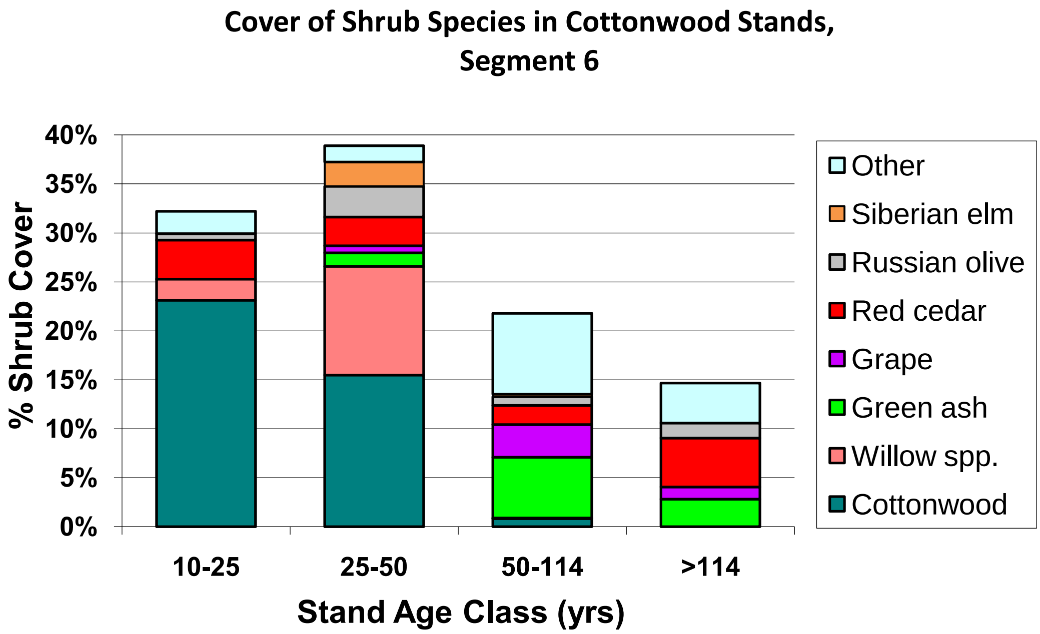


Figure 28a. Mean percent shrub cover by different species and overall mean shrub cover by cottonwood forest age class in segment 6. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments. No cottonwood stands <10 years old were located that were of sufficient size for sampling.

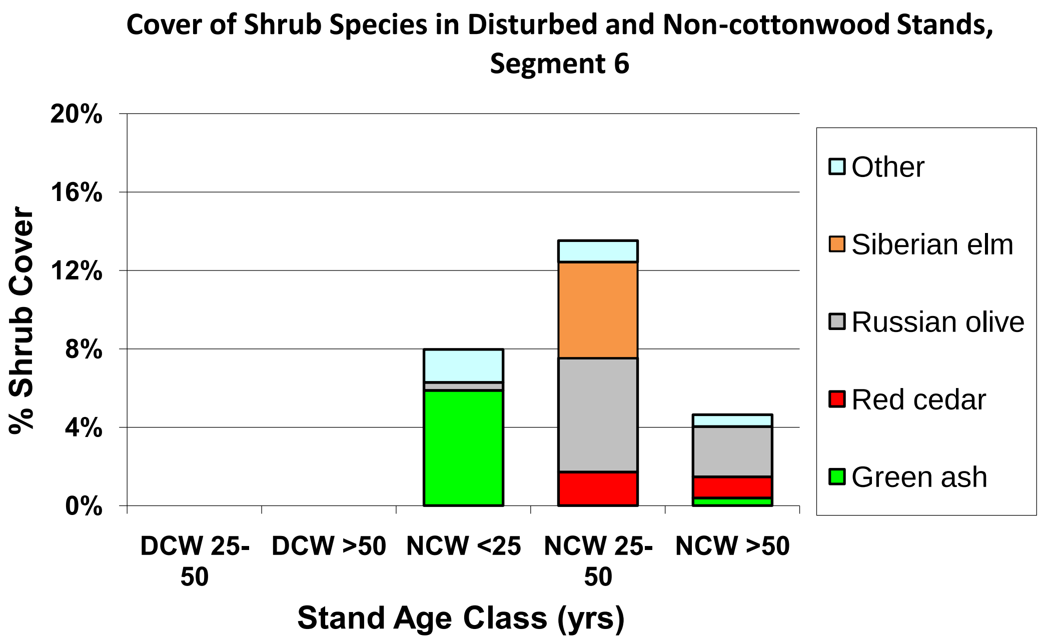


Figure 28b. Mean percent shrub cover by different species and overall mean shrub cover within non-cottonwood and disturbed cottonwood forests in segment 6. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments. DCW refers to disturbed cottonwood stands and NCW refers to non-cottonwood stands. Data for DCW 25-50 were based on a single stand.

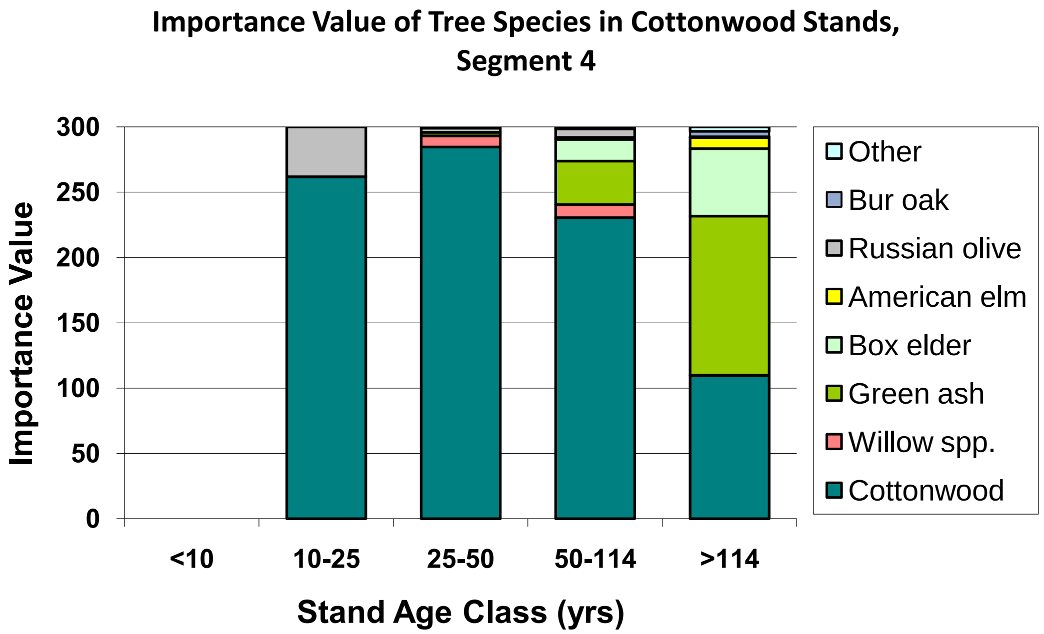


Figure 29a. Relative importance value (sum of relative frequency, density, and basal area) of different tree species by cottonwood forest age class in segment 4. Sampled cottonwood stands <10 years old did not have any trees (stems >10 cm dbh).

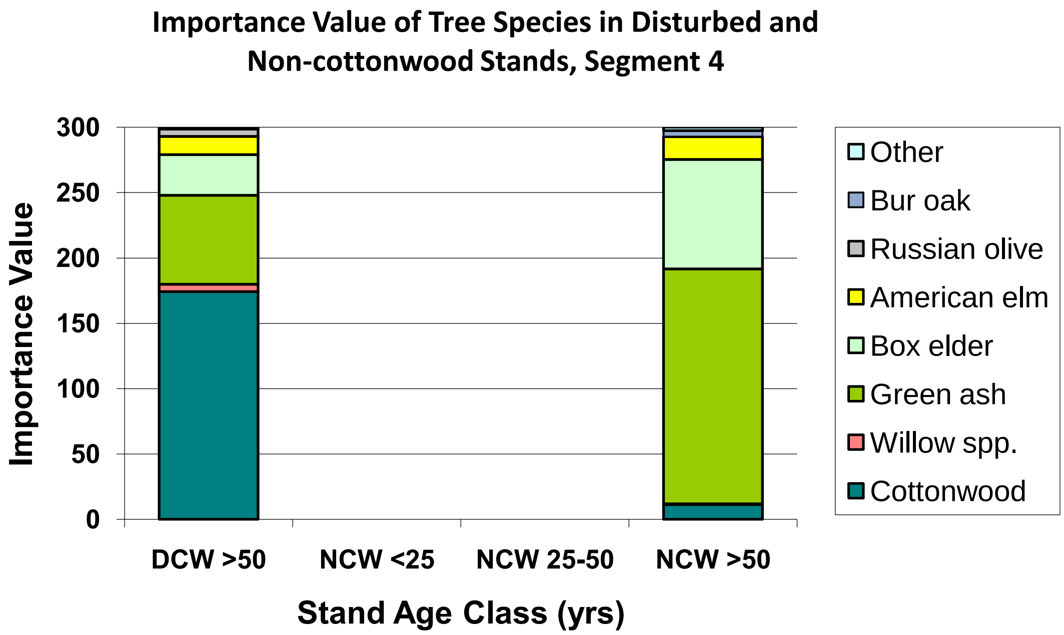


Figure 29b. Relative importance value (sum of relative frequency, density, and basal area) of different tree species within disturbed cottonwood and non-cottonwood forests in segment 4. DCW refers to disturbed cottonwood stands and NCW refers to non-cottonwood stands. Sampled NCW sites <25 and 25-50 years old did not have any trees (stems >10 cm dbh).

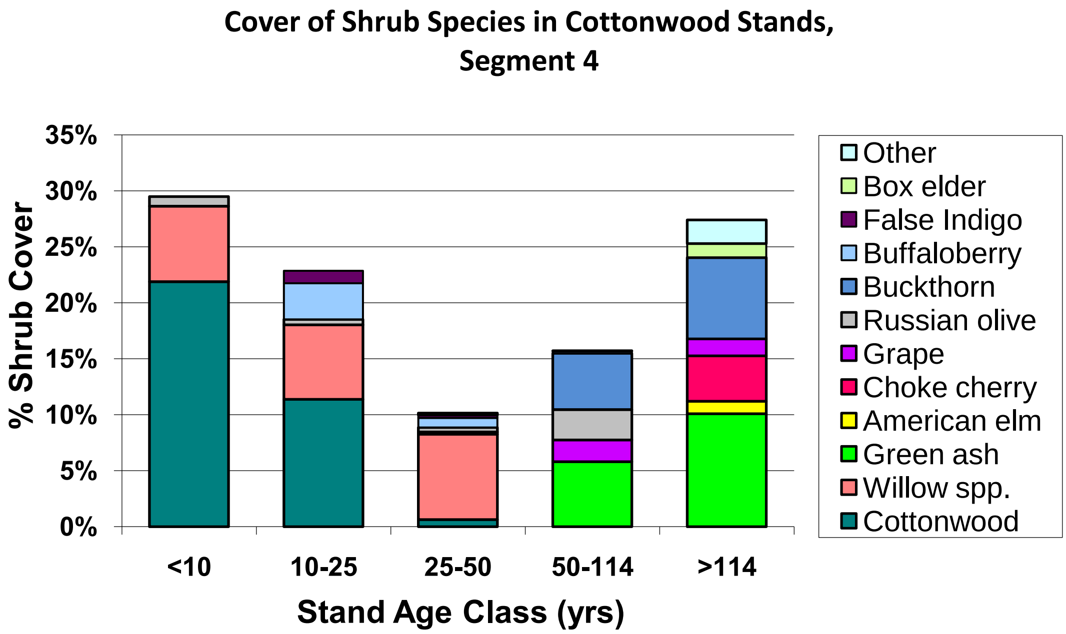


Figure 30a. Mean percent shrub cover by different species and overall mean shrub cover by cottonwood forest age class in segment 4. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

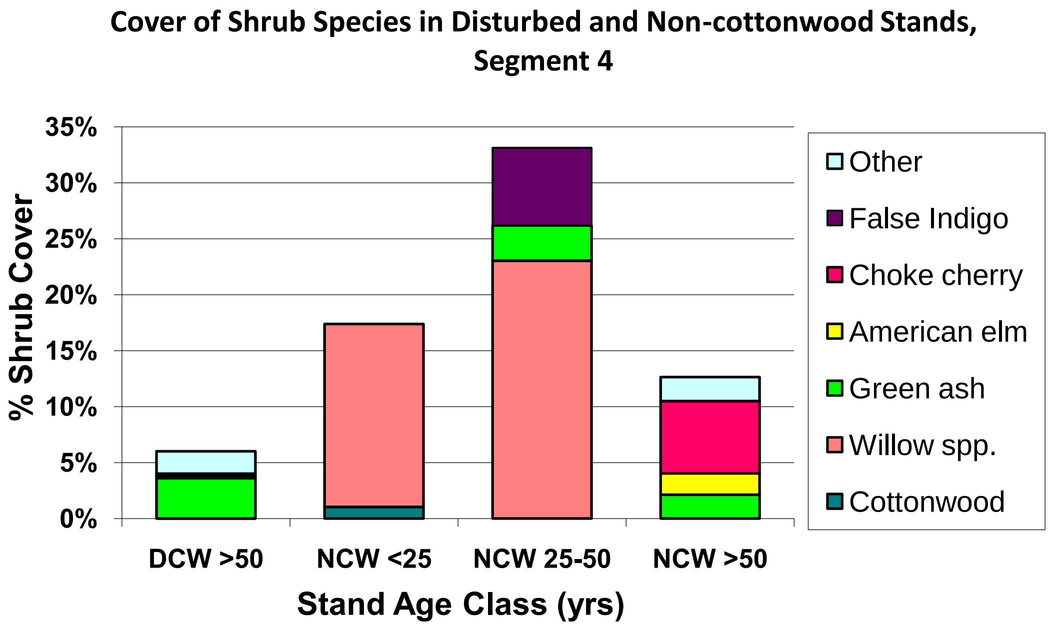


Figure 30b. Mean percent shrub cover by different species and overall mean shrub cover within non-cottonwood and disturbed cottonwood forests in segment 4. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments. DCW refers to disturbed cottonwood stands and NCW refers to non-cottonwood stands. Data for NCW 25-50 were based on a single stand.

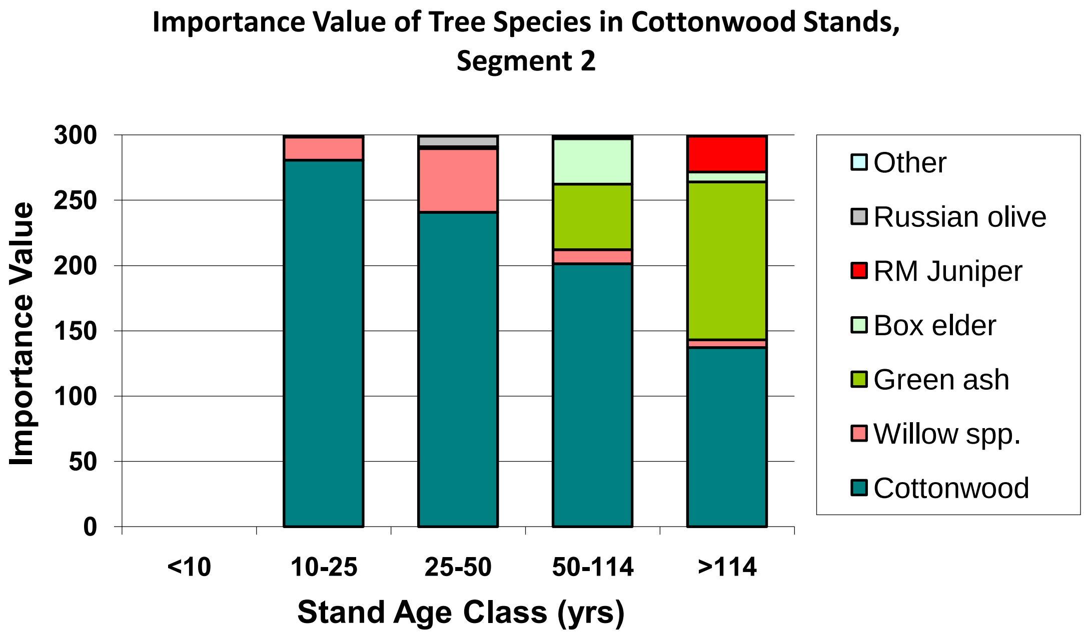


Figure 31. Relative importance value (sum of relative frequency, density, and basal area) of different tree species by cottonwood forest age class in segment 2. Sampled cottonwood stands <10 years old did not have any trees (stems >10 cm dbh).

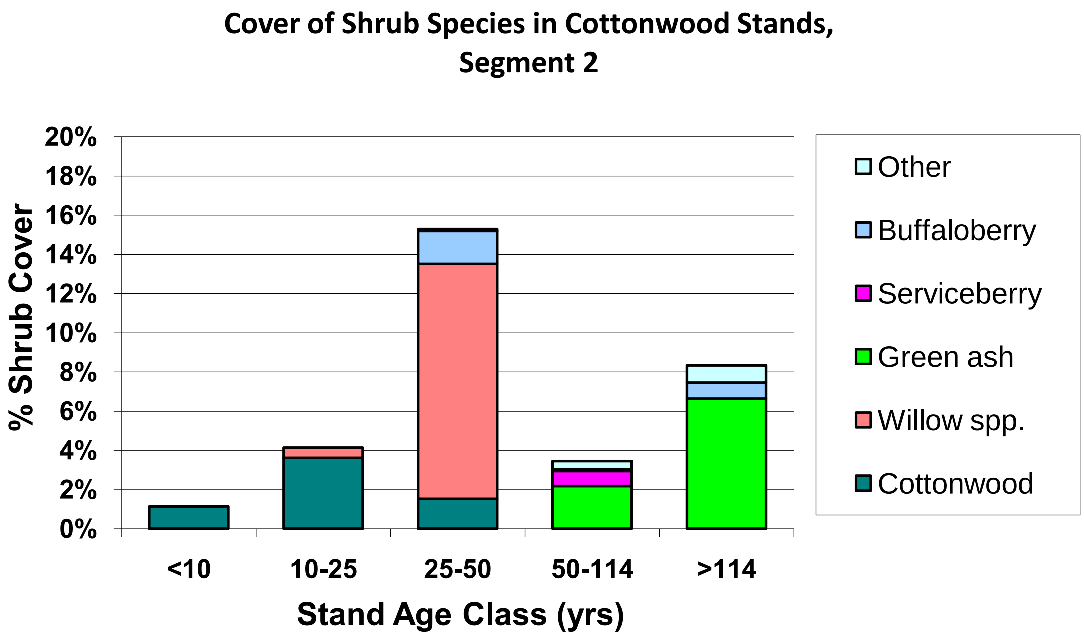


Figure 32. Mean percent shrub cover by different species and overall mean shrub cover by cottonwood forest age class in segment 2. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

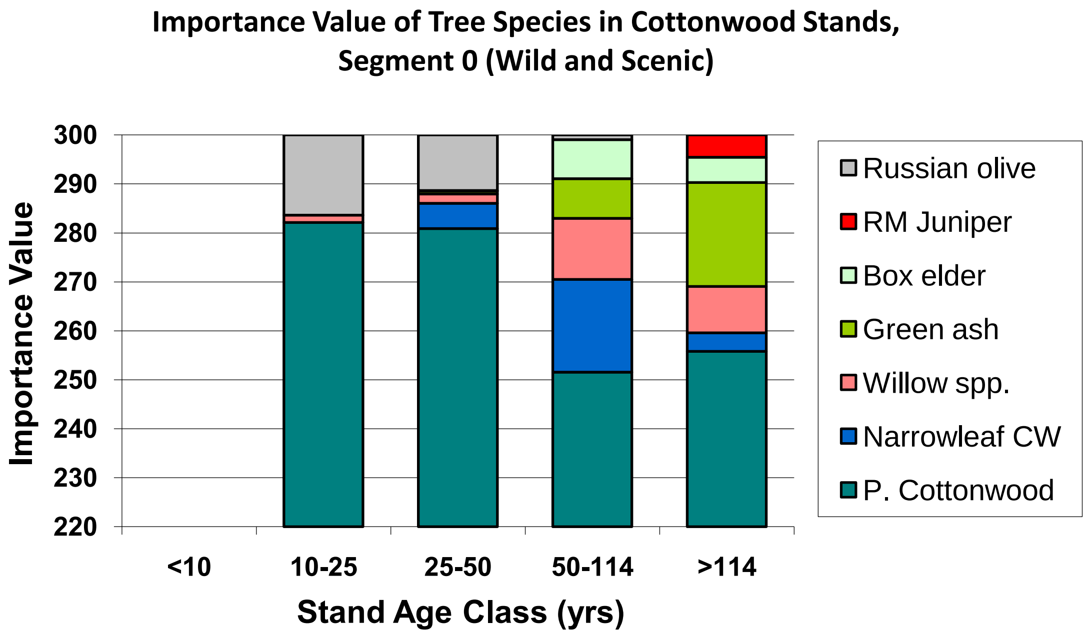


Figure 33. Relative importance value (sum of relative frequency, density, and basal area) of different tree species by cottonwood forest age class in segment 0. Sampled cottonwood stands <10 years old did not have any trees (stems >10 cm dbh).

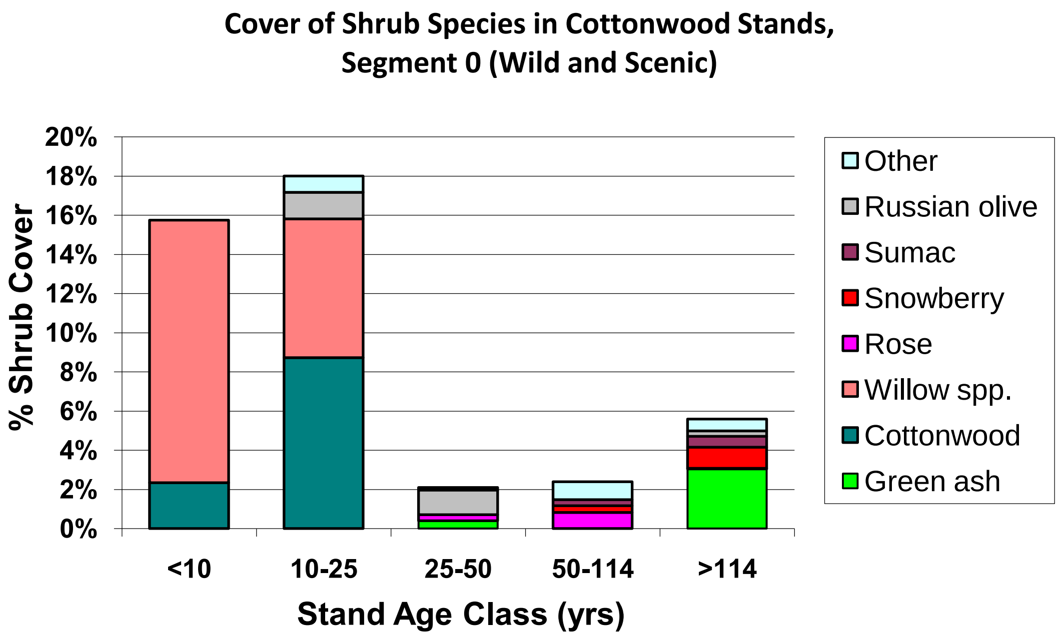


Figure 34. Mean percent shrub cover by different species and overall mean shrub cover by cottonwood forest age class in segment 0. Estimates of total shrub cover may be inflated because of overlapping cover of different species along the transect segments.

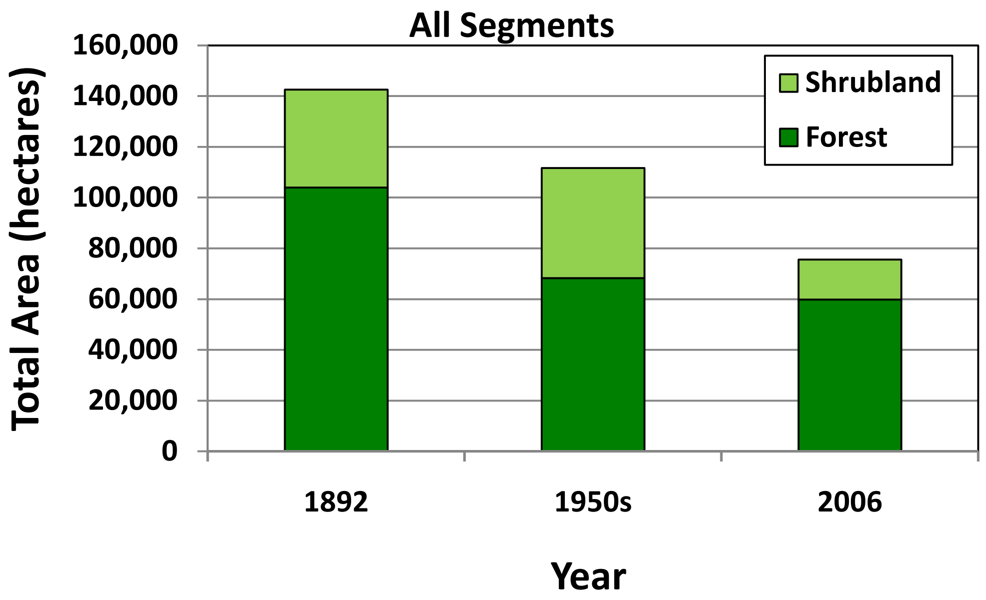


Figure 35. Composite changes in forest and shrubland area across all study segments from 1892 to the mid-1950s to 2006. Total area of natural woody vegetation declined 47% from 1892 to 2006, with a 42% decline in forest and a 59% decline in shrubland. Note that most forest loss occurred between 1892 and the 1950s, while most shrubland loss occurred between the 1950s and 2006.

APPENDIX A: GIS Maps of Study Segments

Figure Captions:

Figure A.1. Land cover maps for 1892, 1950s, and 2006, and forest age class map for segment 13, subreach 1 (RM 595-518). Pink in 1892 map indicates undefined land cover in 1892 Missouri River Commission maps. Segment 13 is the channelized segment between Plattsmouth, NE and Kansas City, MO.

Figure A.2. Land cover maps for 1892, 1950s, and 2006, and forest age class map for segment 13, subreach 2 (RM 518-440). Pink in 1892 map indicates undefined land cover in 1892 Missouri River Commission maps. Segment 13 is the channelized segment between Plattsmouth, NE and Kansas City, MO.

Figure A.3. Land cover maps for 1892, 1950s, and 2006, and forest age class map for segment 13, subreach 3 (RM 440-365). Pink in 1892 map indicates undefined land cover in 1892 Missouri River Commission maps. Segment 13 is the channelized segment between Plattsmouth, NE and Kansas City, MO.

Figure A.4. Land cover maps for 1892, 1955-56, 1983-85, and 2006, and forest age class map for segment 10, subreach 1 (RM 811-792). Segment 10 is part (59-mile reach) of the Missouri National Recreational River, running between Yankton, SD (Gavins Point Dam) and Ponca, NE.

Figure A.5. Land cover maps for 1892, 1955-56, 1983-85, and 2006, and forest age class map for segment 10, subreach 2 (RM 792-772). Segment 10 is part (59-mile reach) of the Missouri National Recreational River, running between Yankton, SD (Gavins Point Dam) and Ponca, NE.

Figure A.6. Land cover maps for 1892, 1955-56, 1983-85, and 2006, and forest age class map for segment 10, subreach 3 (RM 772-753). Segment 10 is part (59-mile reach) of the Missouri National Recreational River, running between Yankton, SD (Gavins Point Dam) and Ponca, NE.

Figure A.7. Land cover maps for 1892, 1950s, and 2006, and forest age class map for segment 8, subreach 1 (RM 880-867). Segment 8 is an inter-reservoir segment and is part (39-mile reach) of the Missouri National Recreational River, running between Pickstown, SD (Fort Randall Dam) and Niobrara, NE.

Figure A.8. Land cover maps for 1892, 1950s, and 2006, and forest age class map for segment 8, subreach 2 (RM 867-854). Segment 8 is an inter-reservoir segment and is part (39-mile reach) of the Missouri National Recreational River, running between Pickstown, SD (Fort Randall Dam) and Niobrara, NE.

Figure A.9. Land cover maps for 1892, 1950s, and 2006, and forest age class map for segment 8, subreach 3 (RM 854-841). Segment 8 is an inter-reservoir segment and is part (39-mile reach) of the Missouri National Recreational River, running between Pickstown, SD (Fort Randall Dam) and Niobrara, NE.

Figure A.10. Land cover maps for 1892, 1950s, and 2006, and forest age class map for segment 9 (RM 841-811). Segment 9 includes Lewis and Clark Reservoir and most of the delta that has formed in the lake downstream from the confluence with the Niobrara River.

Figure A.11. Land cover maps for 1892, 1950s, and 2006, and forest age class map for segment 6, subreaches 1 and 2 (RM 1072-1054). Segment 6 begins at Oahe Dam, near Pierre, SD, and continues to Big Bend Dam, near Fort Thompson, SD, including all of Lake Sharpe.

Figure A.12. Land cover maps for 1892, 1950s, and 2006 for segment 6, subreach 3 (RM 1054-987). Segment 6 begins at Oahe Dam, near Pierre, SD, and continues to Big Bend Dam, near Fort Thompson, SD, including all of Lake Sharpe. Subreach 3 is predominantly composed of Lake Sharpe.

Figure A.13. Forest age class map for segment 6, subreach 3 (RM 1054-987). Segment 6 begins at Oahe Dam, near Pierre, SD, and continues to Big Bend Dam, near Fort Thompson, SD, including all of Lake Sharpe. Subreach 3 is predominantly composed of Lake Sharpe.

Figure A.14. Land cover maps for 1892, 1950s, and 2006, and forest age class map for segment 4, subreach 1 (RM 1390-1360). Segment 4 is an inter-reservoir segment, beginning at Garrison Dam and extending to the headwaters of Lake Oahe, southeast of Bismarck, ND.

Figure A.15. Land cover maps for 1892, 1950s, and 2006, and forest age class map for segment 4, subreach 2 (RM 1360-1333). Segment 4 is an inter-reservoir segment, beginning at Garrison Dam and extending to the headwaters of Lake Oahe, southeast of Bismarck, ND.

Figure A.16. Land cover maps for 1892, 1950s, and 2006, and forest age class map for segment 4, subreach 3 (RM 1333-1304). Segment 4 is an inter-reservoir segment, beginning at Garrison Dam and extending to the headwaters of Lake Oahe, southeast of Bismarck, ND.

Figure A.17. Land cover maps for 1892, 1950s, and 2006, and forest age class map for segment 4, subreach 4 (RM 1304-1286). Segment 4 is an inter-reservoir segment, beginning at Garrison Dam and extending to the headwaters of Lake Oahe, southeast of Bismarck, ND.

Figure A.18. Land cover maps for 1892, 1950s, and 2006, and forest age class map for segment 2, subreach 1 (RM 1771-1698). Segment 2 is an inter-reservoir segment, beginning at Fort Peck Dam in Montana and extending to the headwaters of Lake Sakakawea, near Williston, ND.

Figure A.19. Land cover maps for 1892, 1950s, and 2006, and forest age class map for segment 2, subreach 2 (RM 1698-1626). Segment 2 is an inter-reservoir segment, beginning at Fort Peck Dam in Montana and extending to the headwaters of Lake Sakakawea, near Williston, ND.

Figure A.20. Land cover maps for 1892, 1950s, and 2006, and forest age class map for segment 2, subreaches 3 and 4 (RM 1626-1543). Segment 2 is an inter-reservoir segment, beginning at Fort Peck Dam in Montana and extending to the headwaters of Lake Sakakawea, near Williston, ND. The confluence with the Yellowstone River marks the boundary between subreaches 3 and 4.

Figure A.21. Land cover maps for 1892, 1950s, and 2006 for segment 0, subreach 1 (RM 2073-2027). Segment 0 extends from Fort Benton, MT to the headwaters of Fort Peck Lake, near the confluence with the Musselshell River. Much of the segment is designated a National Wild and Scenic River, within the Upper Missouri Breaks National Monument and Charles M. Russell National Wildlife Refuge.

Figure A.22. Forest age class map for segment 0, subreach 1 (RM 2073-2027). Segment 0 extends from Fort Benton, MT to the headwaters of Fort Peck Lake, near the confluence with the Musselshell River. Much of the segment is designated a National Wild and Scenic River, within the Upper Missouri Breaks National Monument and Charles M. Russell National Wildlife Refuge.

Figure A.23. Land cover maps for 1892, 1950s, and 2006, and forest age class map for segment 0, upper 1/3 of subreach 2 (RM 2027-2005). Segment 0 extends from Fort Benton, MT to the headwaters of Fort Peck Lake, near the confluence with the Musselshell River. Much of the segment is designated a National Wild and Scenic River, within the Upper Missouri Breaks National Monument and Charles M. Russell National Wildlife Refuge.

Figure A.24. Land cover maps for 1892, 1950s, and 2006, and forest age class map for segment 0, middle 1/3 of subreach 2 (RM 2005-1970). Segment 0 extends from Fort Benton, MT to the headwaters of Fort Peck Lake, near the confluence with the Musselshell River. Much of the segment is designated a National Wild and Scenic River, within the Upper Missouri Breaks National Monument and Charles M. Russell National Wildlife Refuge.

Figure A.25. Land cover maps for 1892, 1950s, and 2006, and forest age class map for segment 0, lower 1/3 of subreach 2 (RM 1970-1932). Segment 0 extends from Fort Benton, MT to the headwaters of Fort Peck Lake, near the confluence with the Musselshell River. Much of the segment is designated a National Wild and Scenic River, within the Upper Missouri Breaks National Monument and Charles M. Russell National Wildlife Refuge.

Figure A.26. Land cover maps for 1892, 1950s, and 2006 for segment 0, subreach 3 (RM 1932-1917). Segment 0 extends from Fort Benton, MT to the headwaters of Fort Peck Lake, near the confluence with the Musselshell River. Much of the segment is designated a National Wild and Scenic River, within the Upper Missouri Breaks National Monument and Charles M. Russell National Wildlife Refuge.

Figure A.27. Forest age class map for segment 0, subreach 3 (RM 1932-1917). Segment 0 extends from Fort Benton, MT to the headwaters of Fort Peck Lake, near the confluence with the Musselshell River. Much of the segment is designated a National Wild and Scenic River, within the Upper Missouri Breaks National Monument and Charles M. Russell National Wildlife Refuge.

Figure A.1 - Segment 13, Subreach 1 (RM 595 - 518)

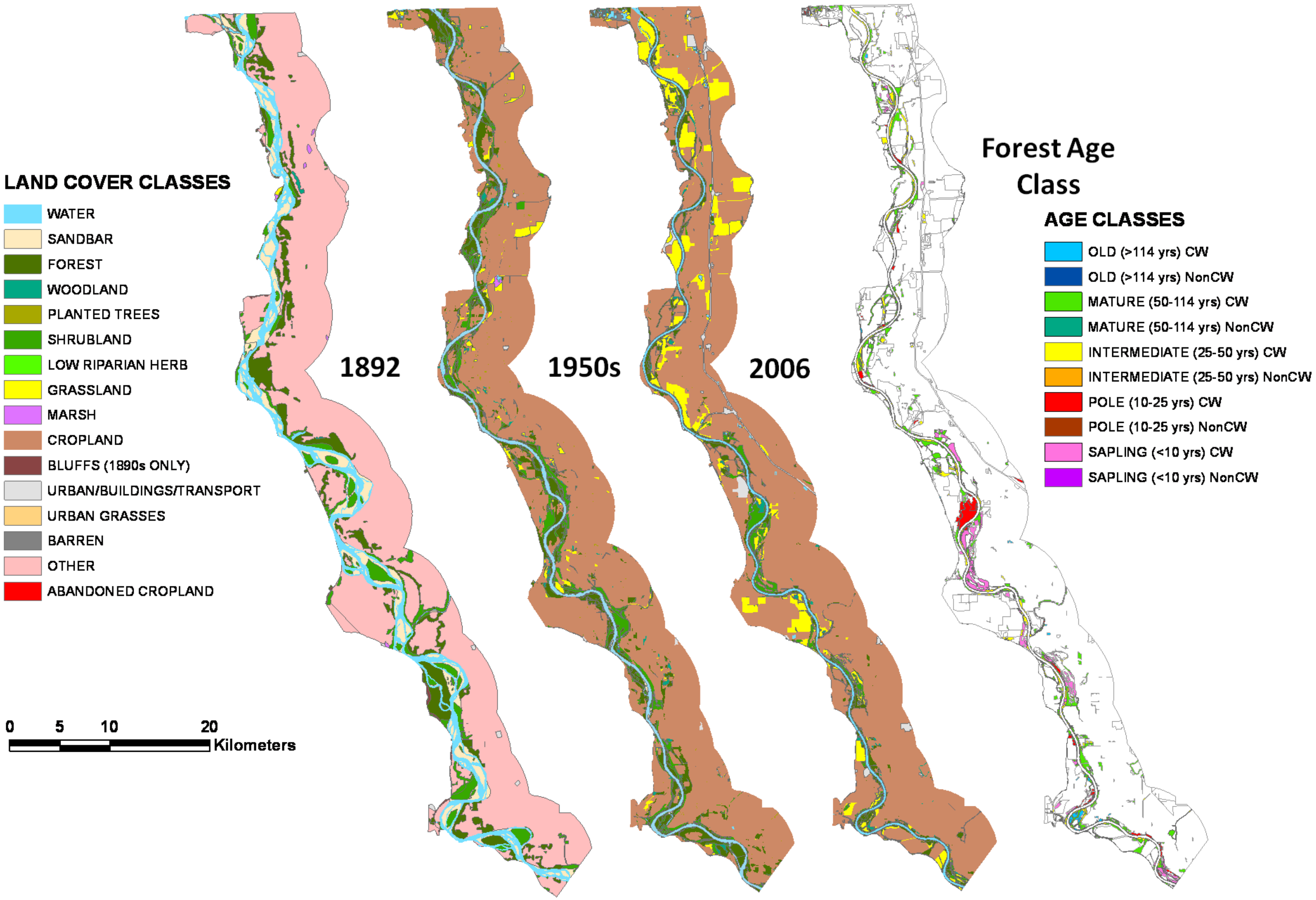


Figure A.2 - Segment 13, Subreach 2 (RM 518 - 440)

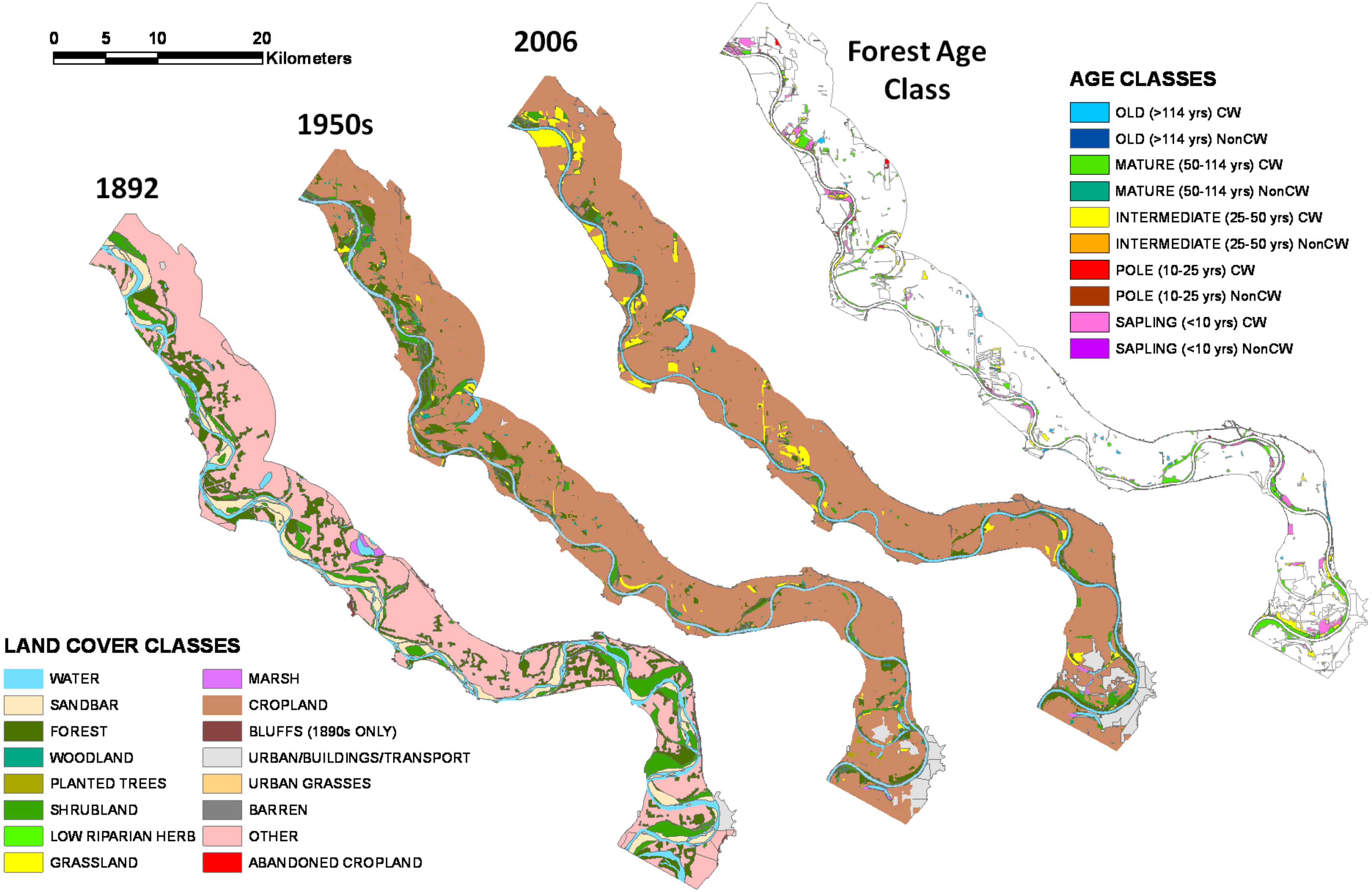


Figure A.3 - Segment 13, Subreach 3 (RM 440 - 365)

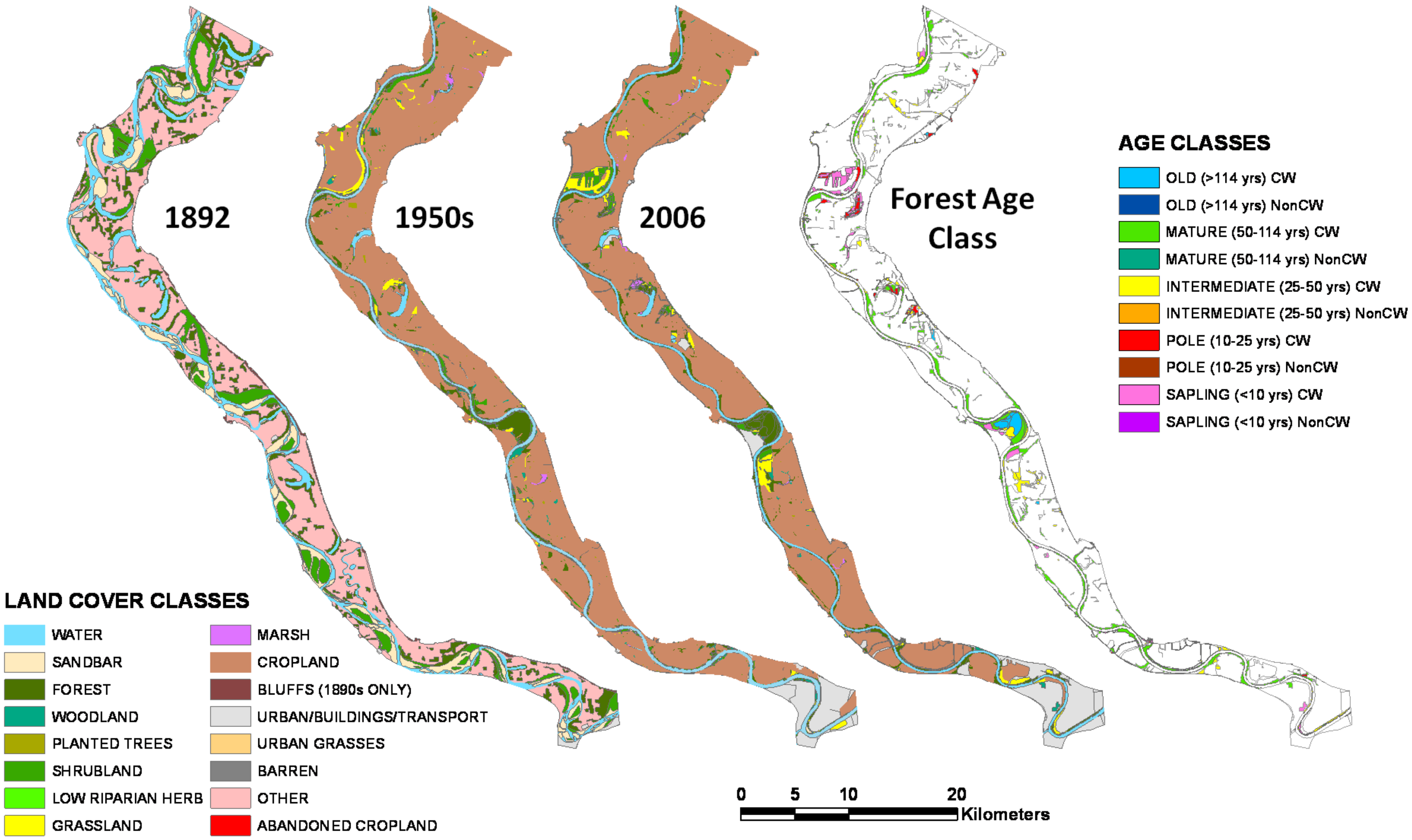


Figure A.4 - Segment 10, Subreach 1 (RM 811 - 792)

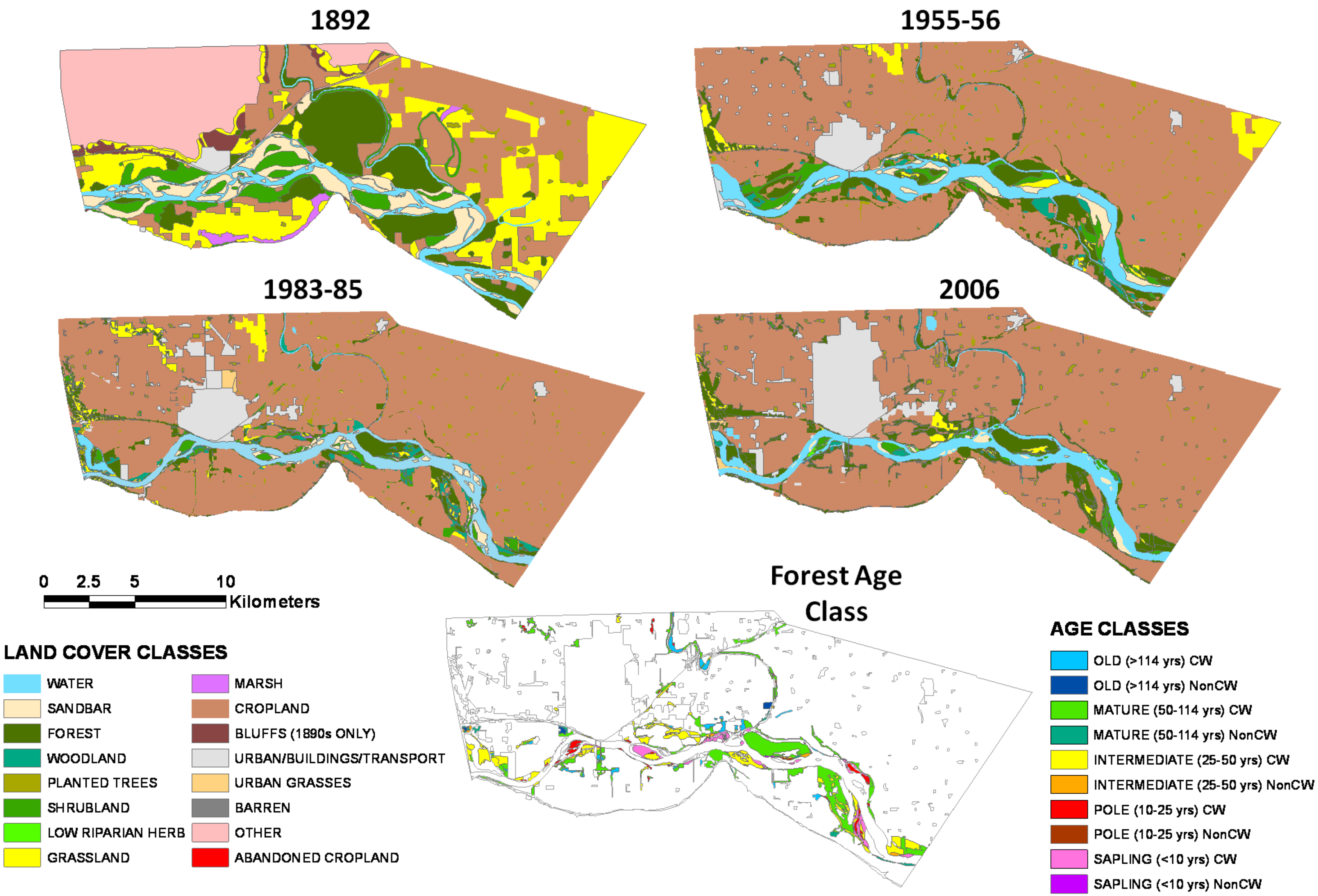


Figure A.5 - Segment 10, Subreach 2 (RM 792 - 772)

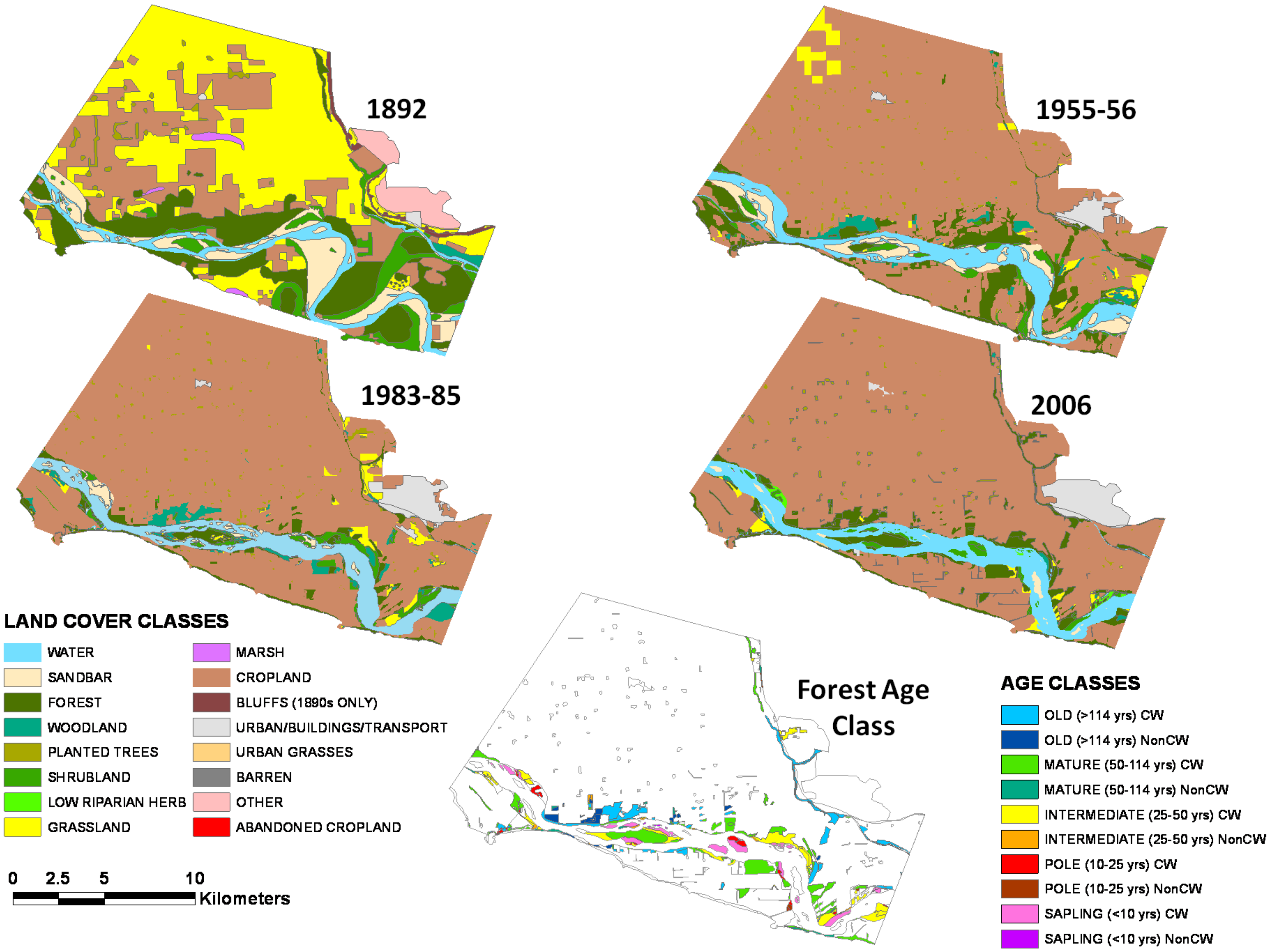


Figure A.6 - Segment 10, Subreach 3 (RM 772 - 753)

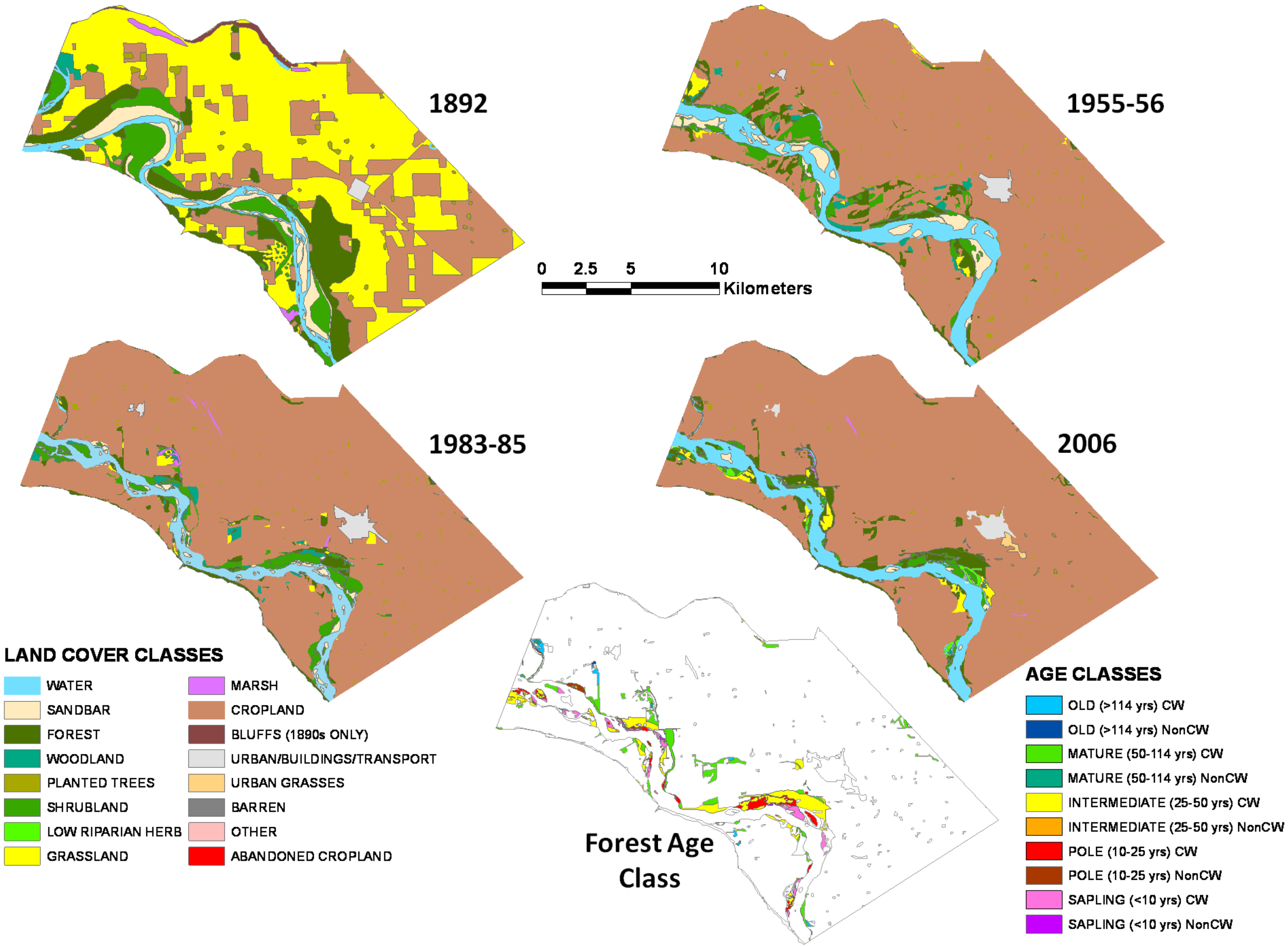


Figure A.7 - Segment 8, Subreach 1 (RM 880 - 867)

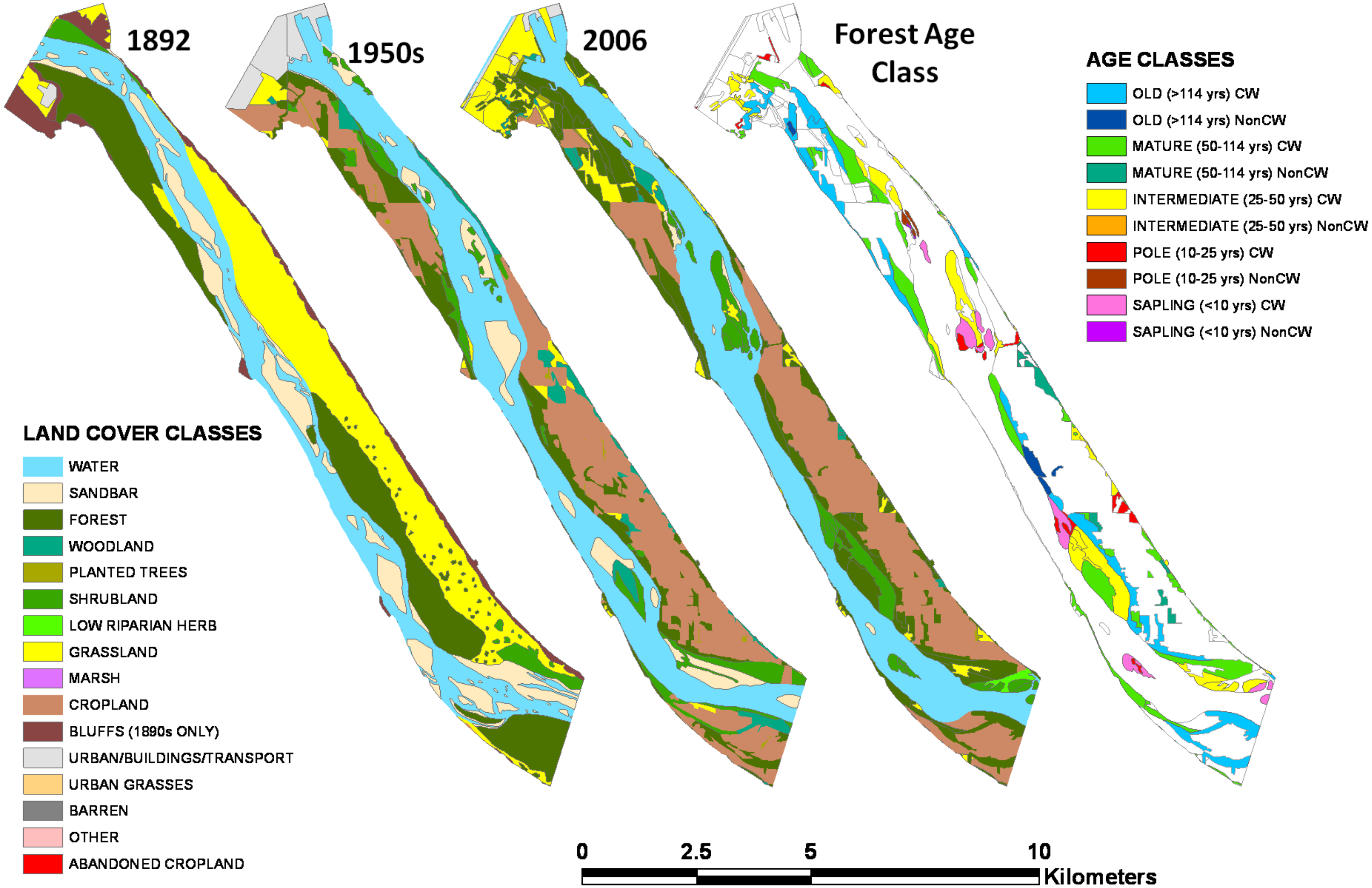


Figure A.8 - Segment 8, Subreach 2 (RM 867 - 854)

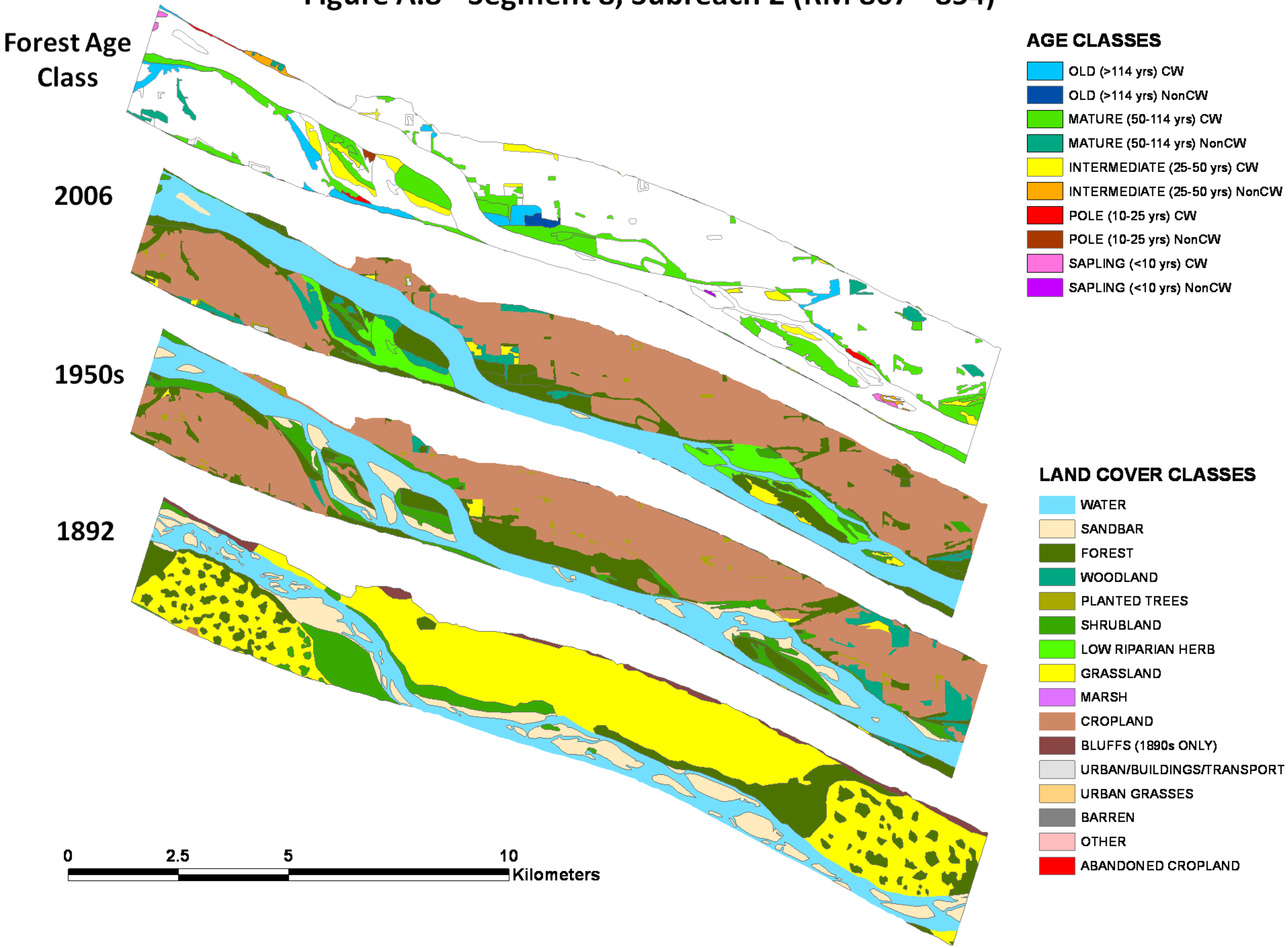


Figure A.9 - Segment 8, Subreach 3 (RM 854 - 841)

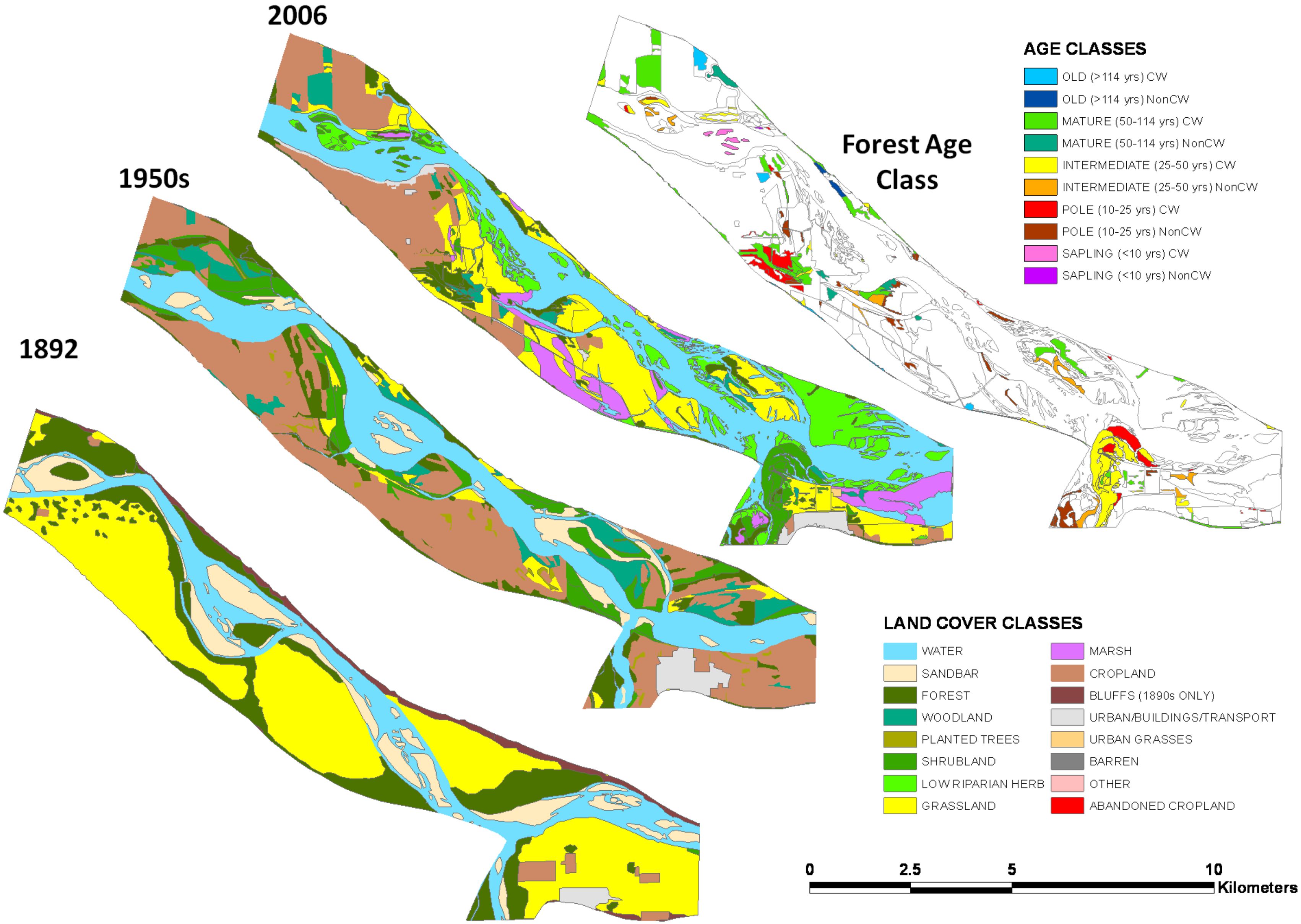


Figure A.10 - Segment 9 (RM 841 - 811)

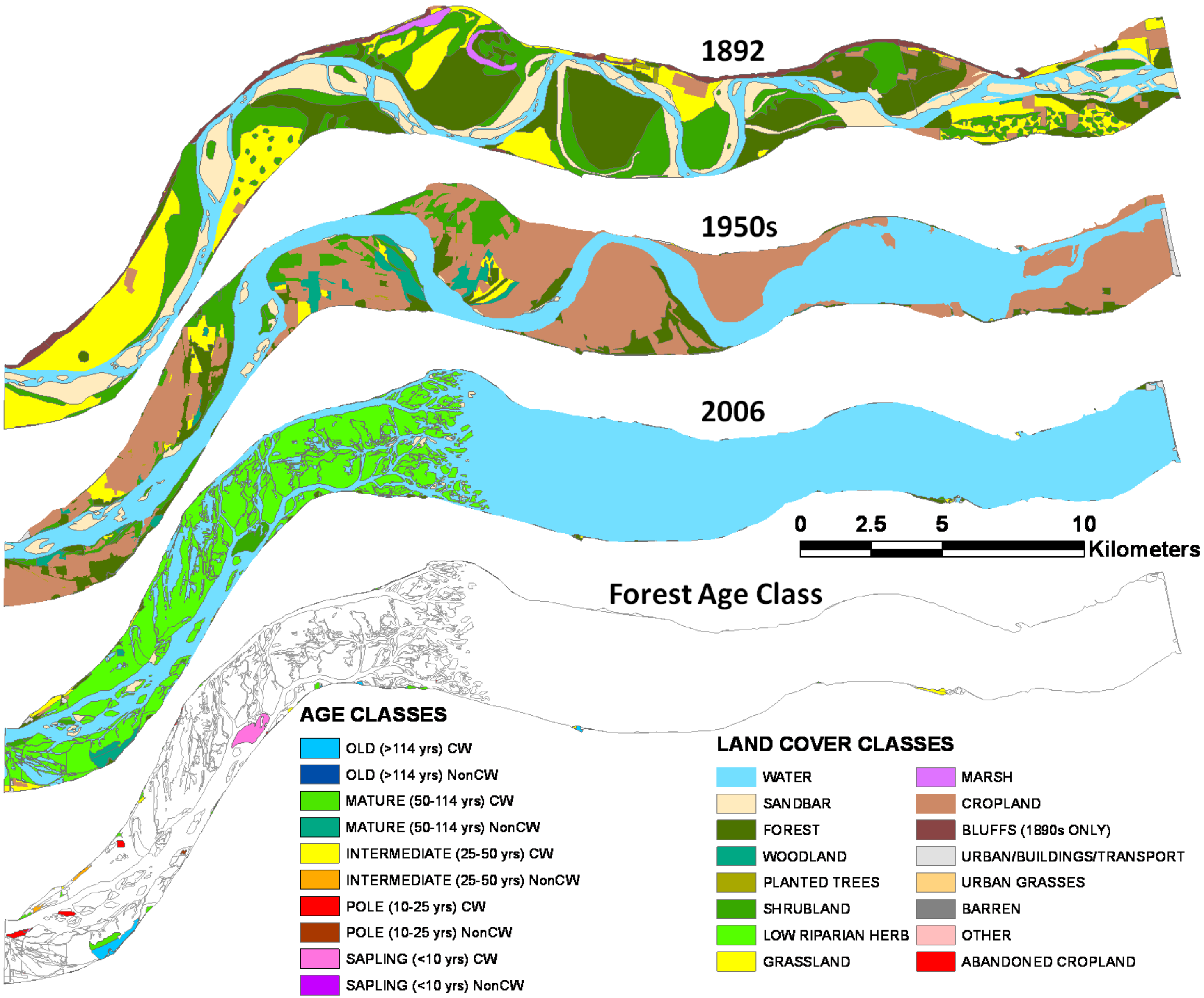


Figure A.11 - Segment 6, Subreaches 1 & 2 (RM 1072-1054)

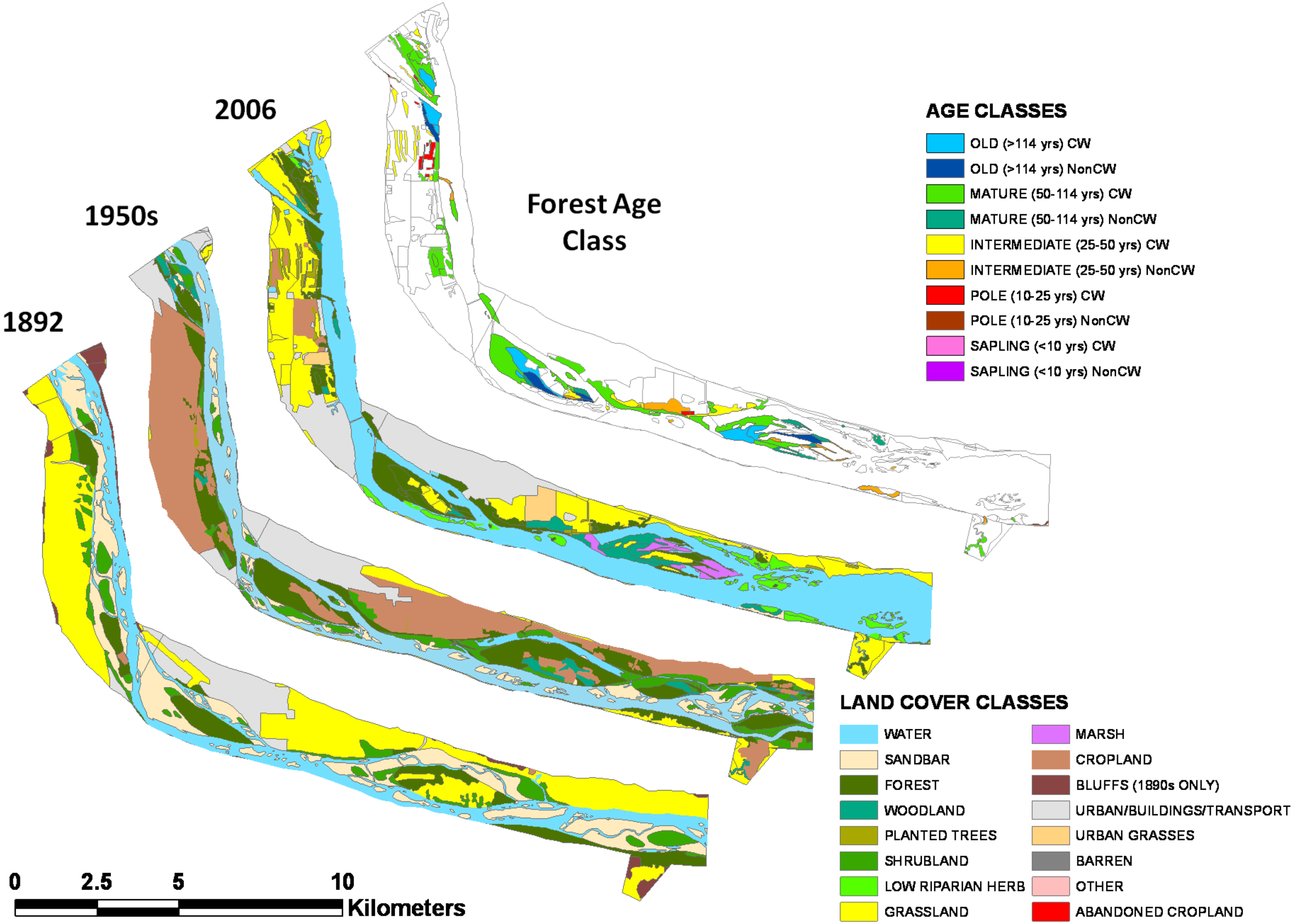


Figure A.12 - Segment 6, Subreach 3 (RM 1054 - 987)

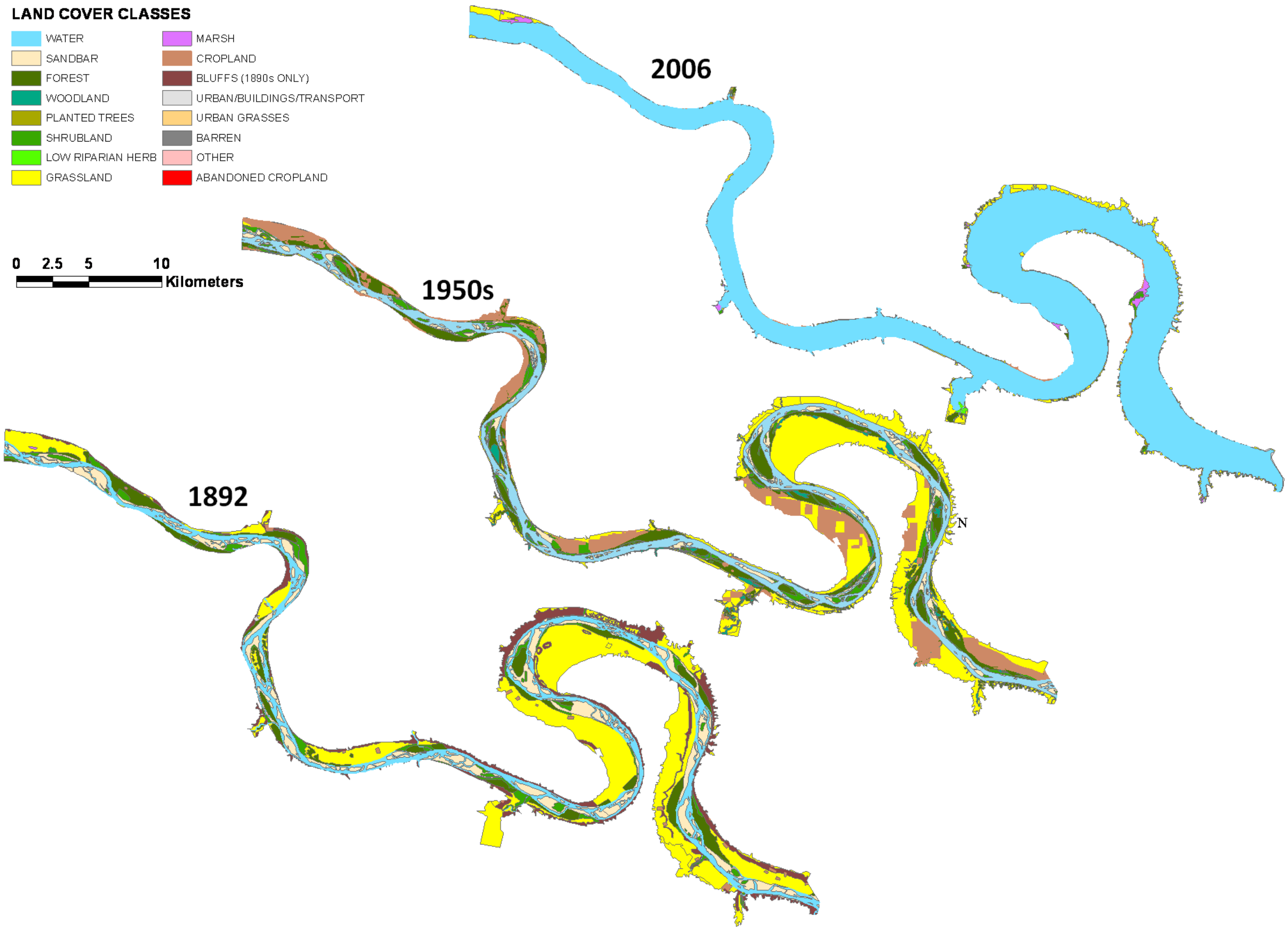


Figure A.13 - Segment 6, Subreach 3 (RM 1054 - 987)

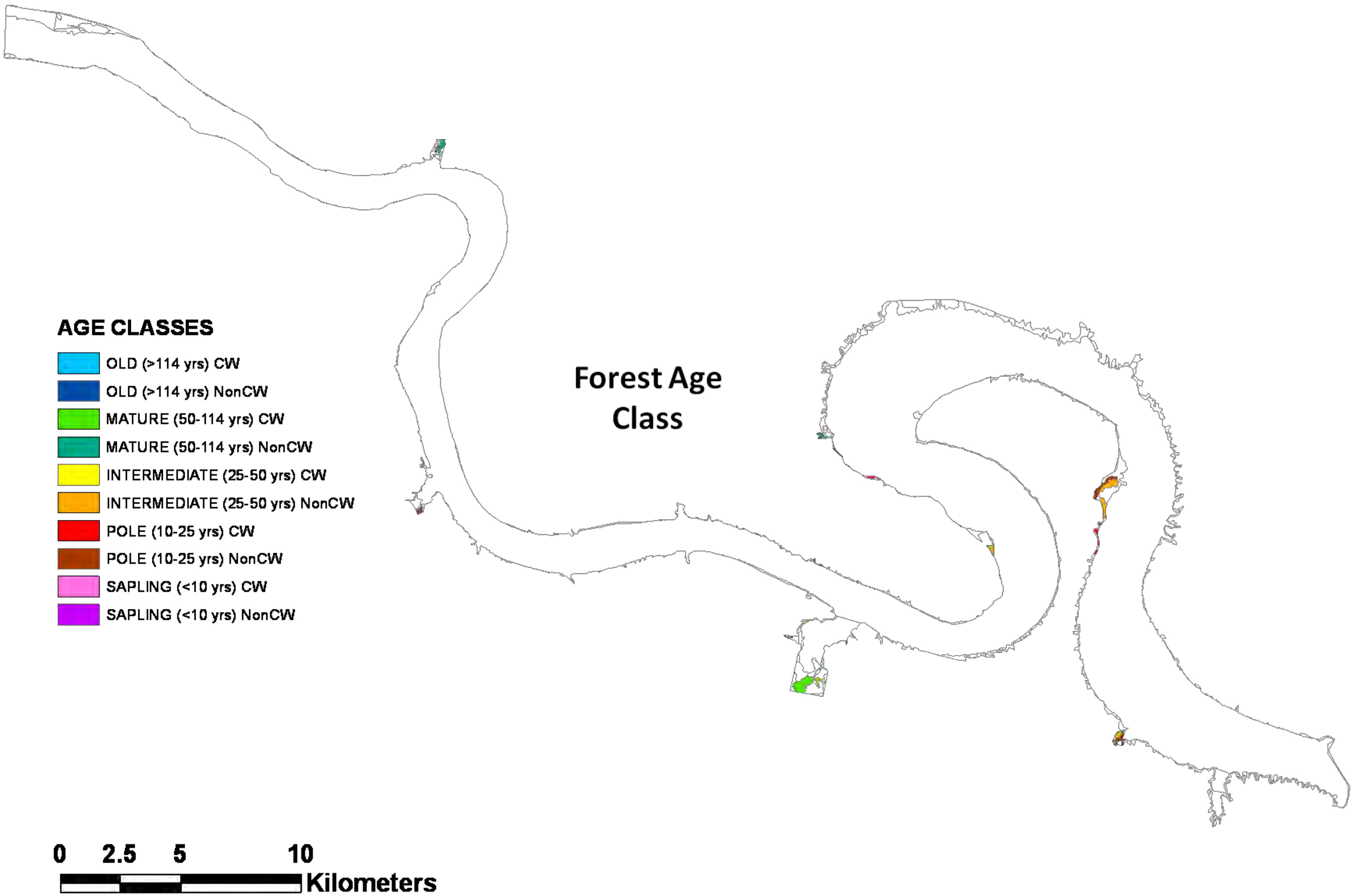


Figure A.14 - Segment 4, Subreach 1 (RM 1390 - 1360)

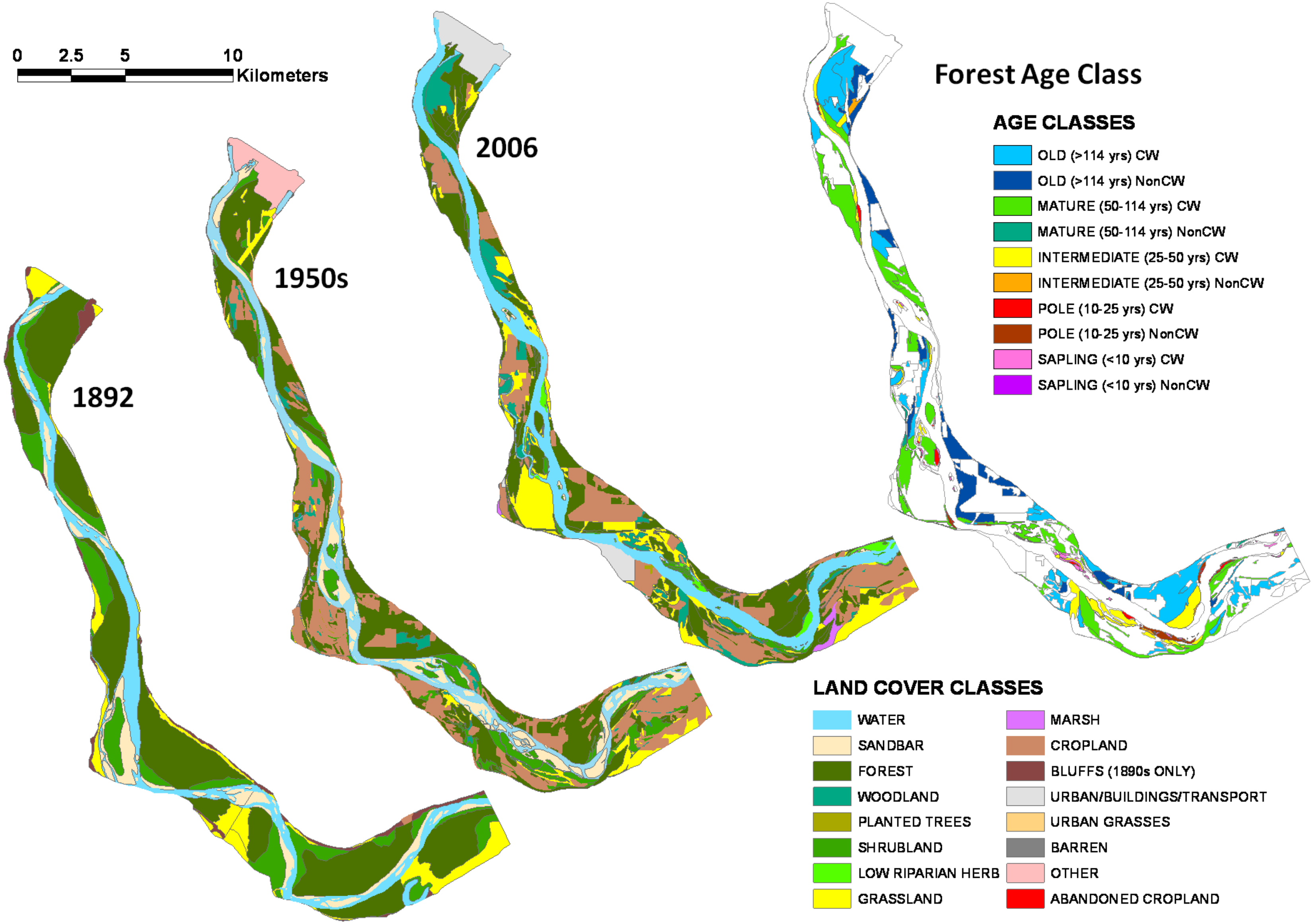


Figure A.15 - Segment 4, Subreach 2 (RM 1360 - 1333)

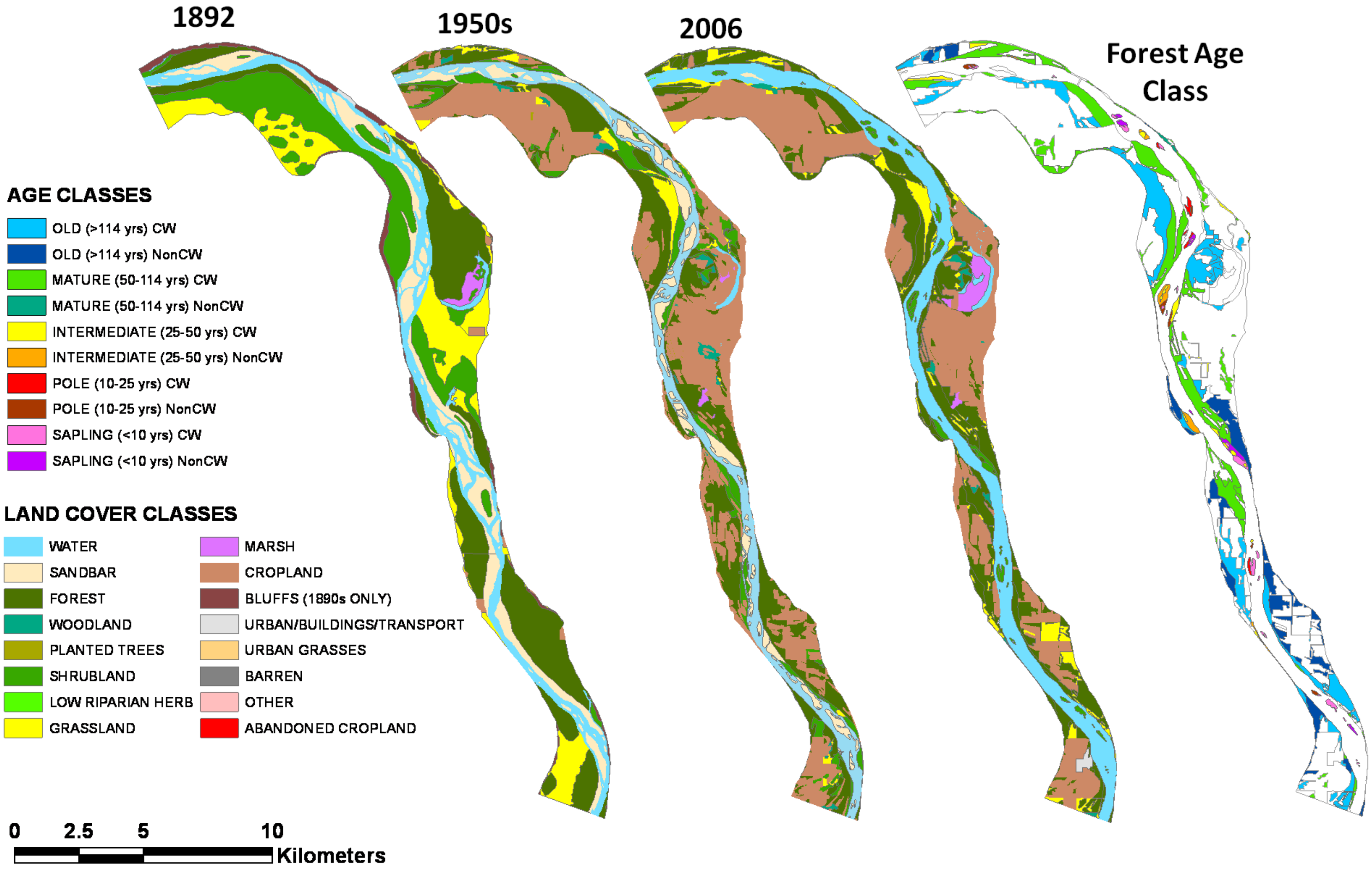


Figure A.16 - Segment 4, Subreach 3 (RM 1333 - 1304)

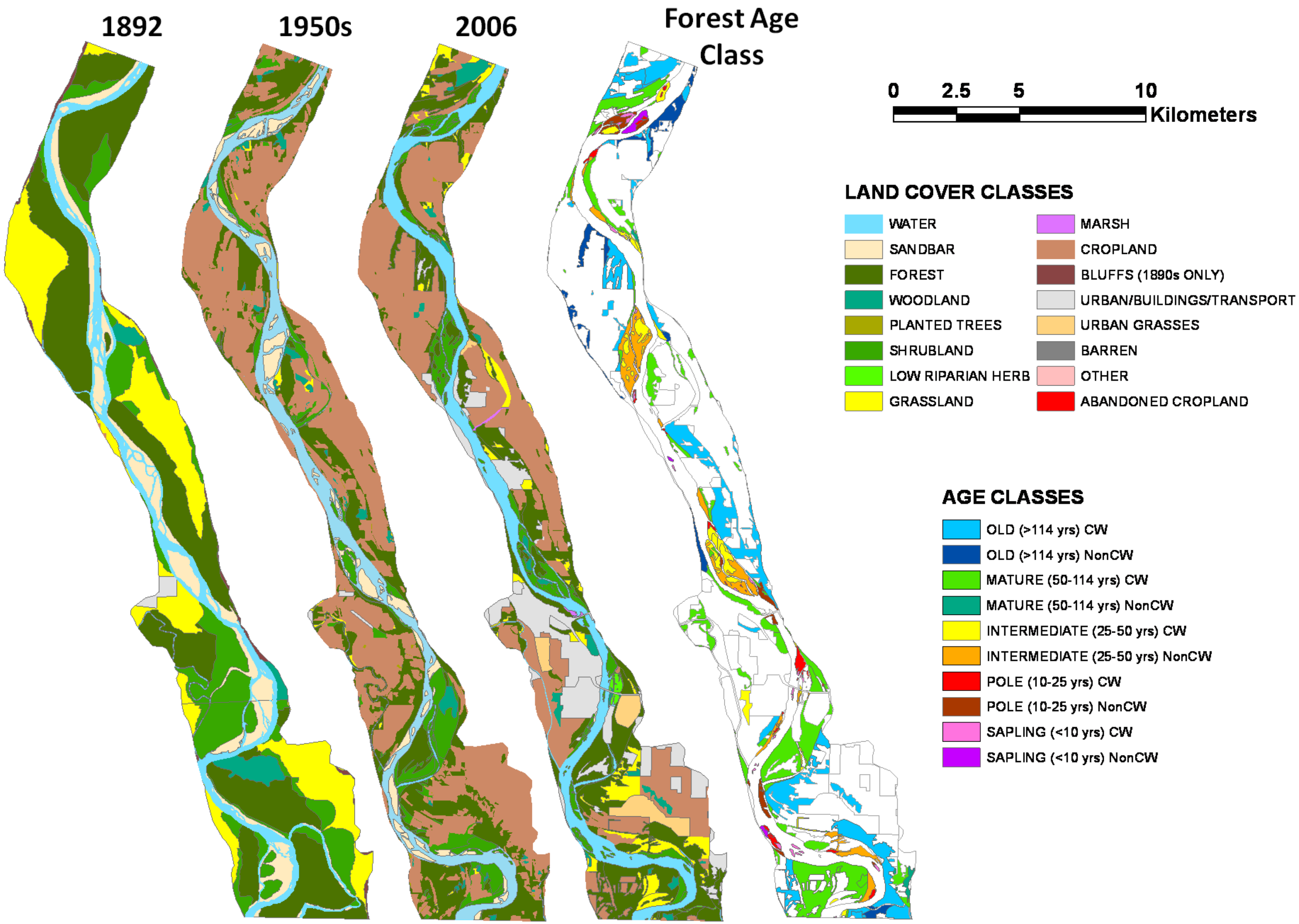


Figure A.17 - Segment 4, Subreach 4 (RM 1304 - 1286)

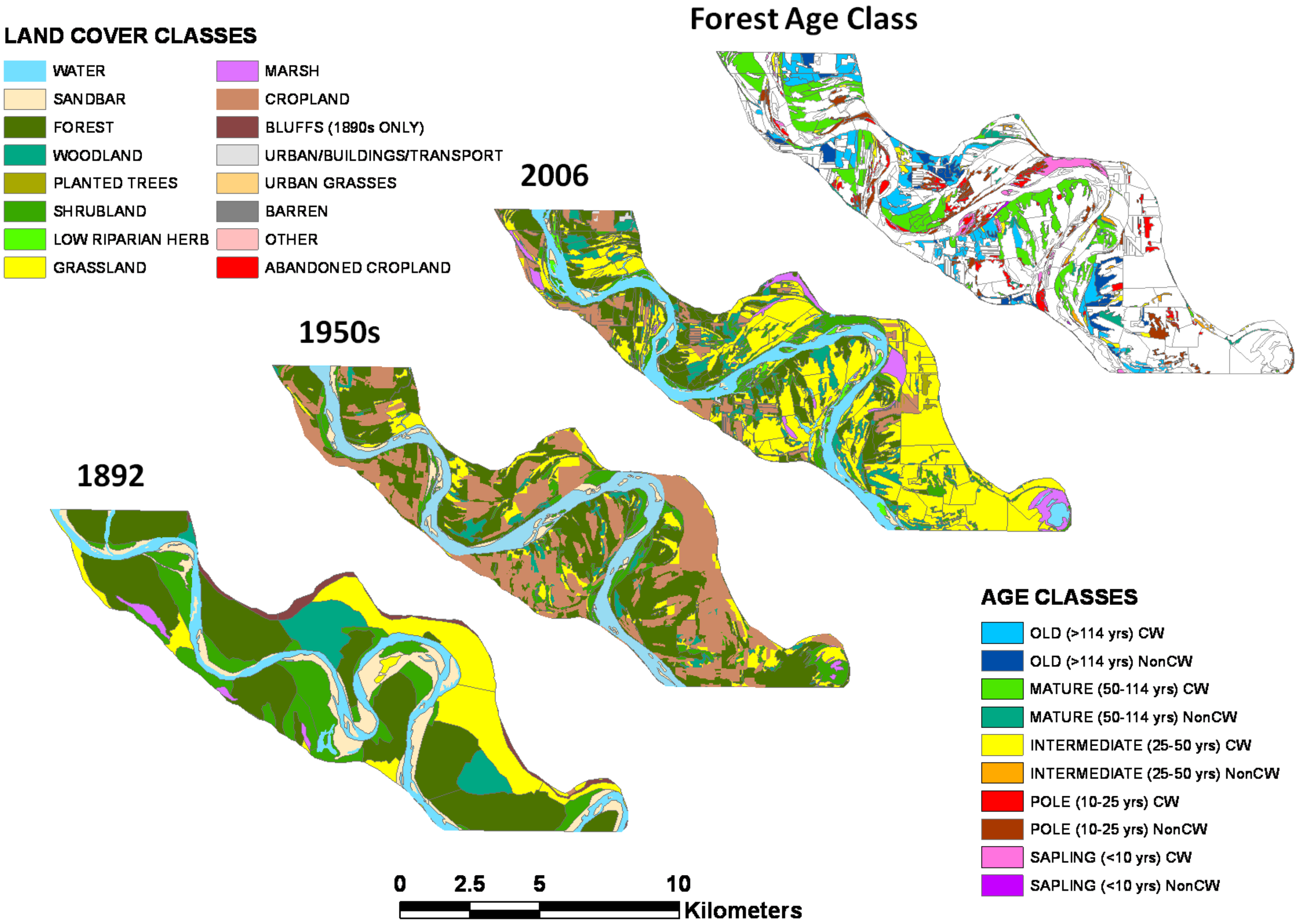


Figure A.18 - Segment 2, Subreach 1 (RM 1771 - 1698)

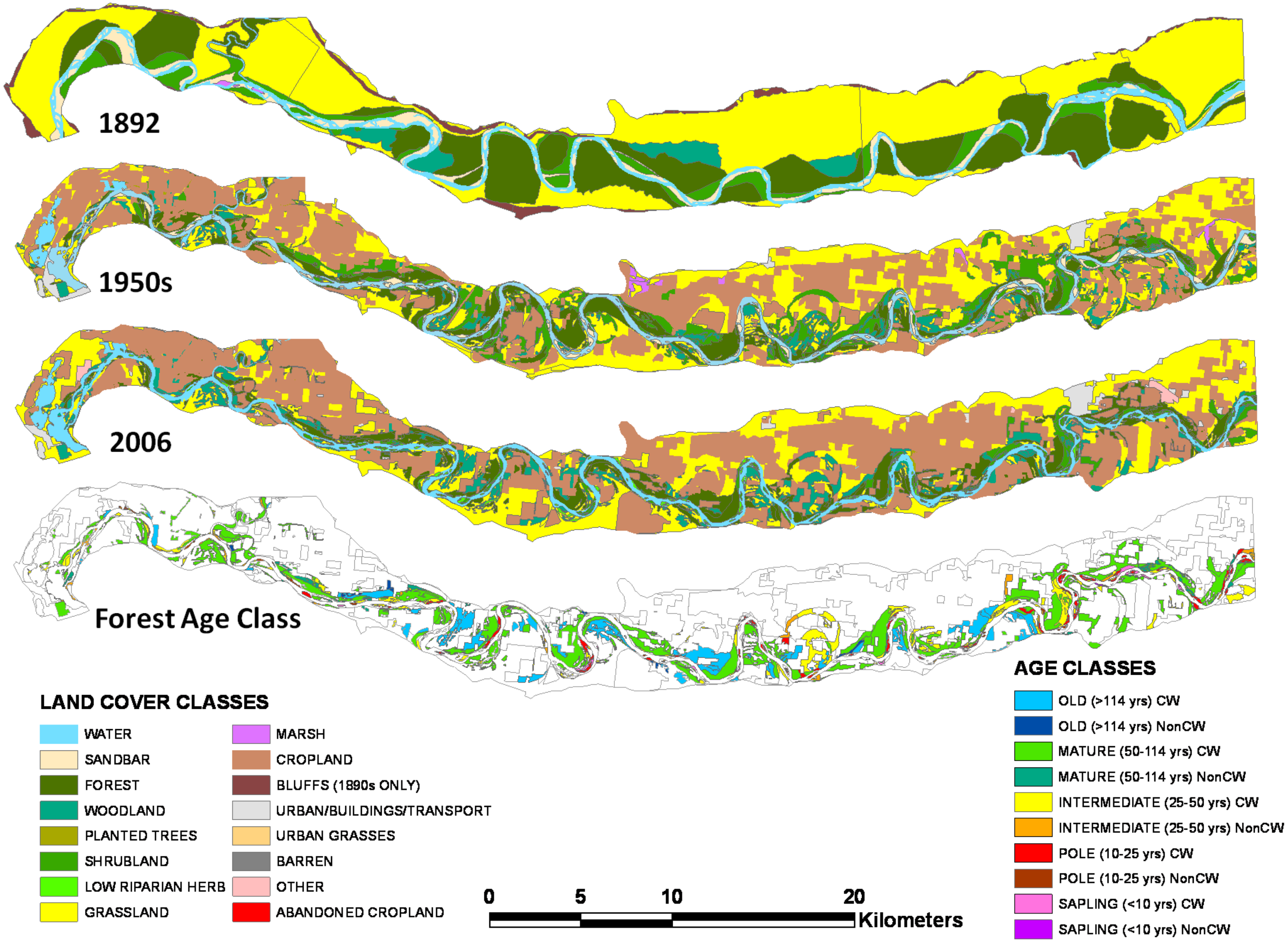


Figure A.19 - Segment 2, Subreach 2 (RM 1698 - 1626)

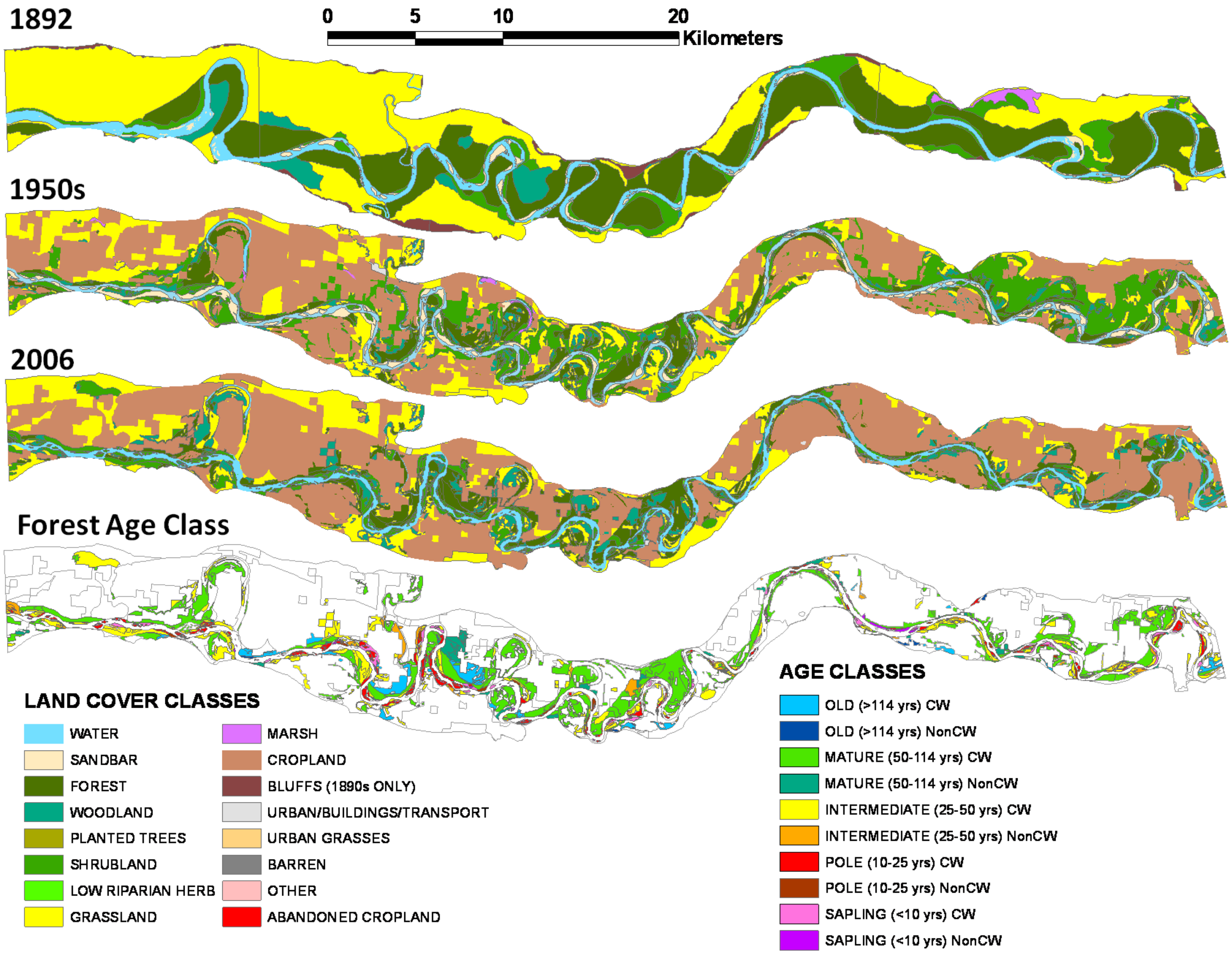


Figure A.20 - Segment 2, Subreaches 3 & 4 (RM 1626 – 1543)

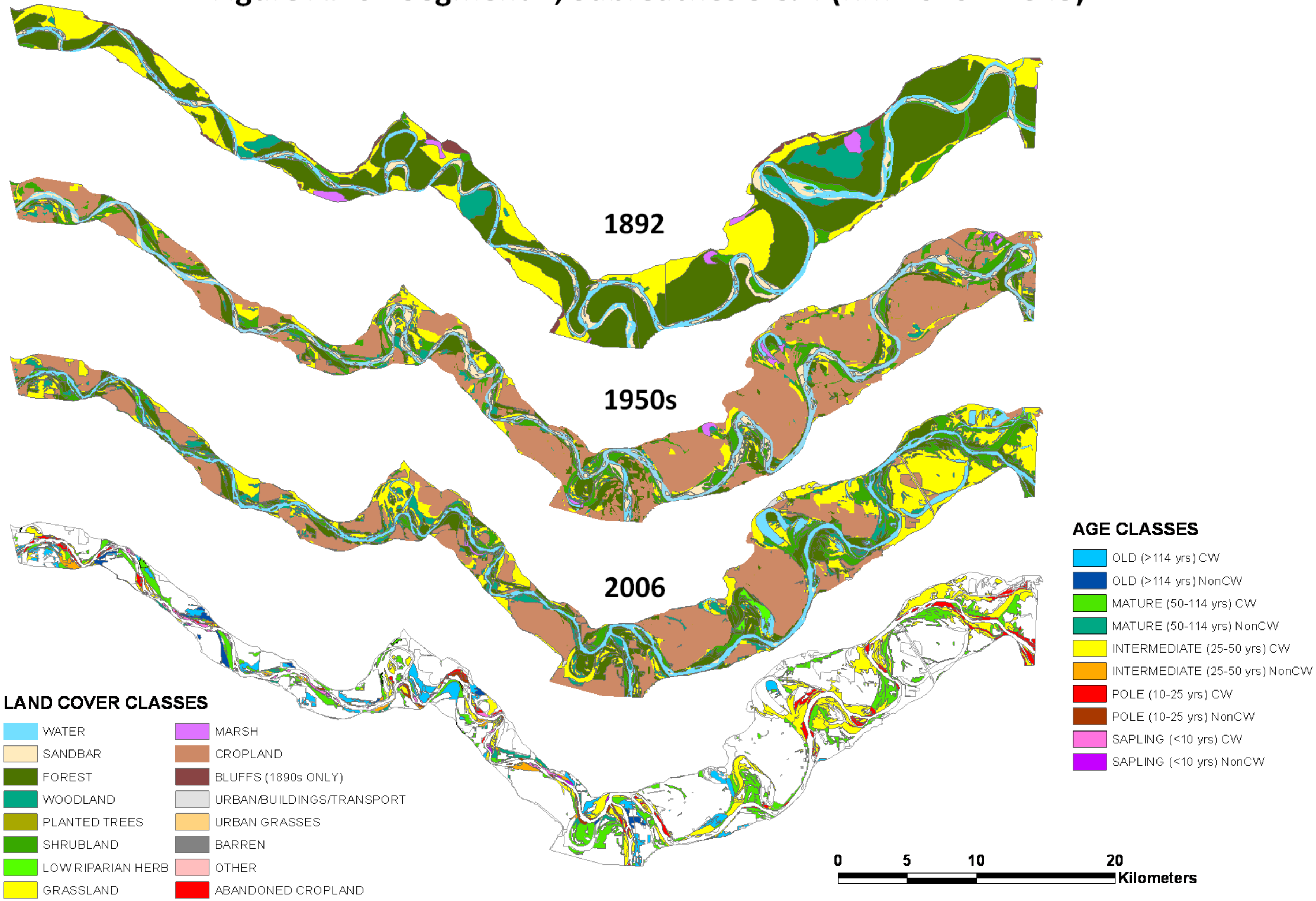


Figure A.21 - Segment 0, Subreach 1 (RM 2073 - 2027)

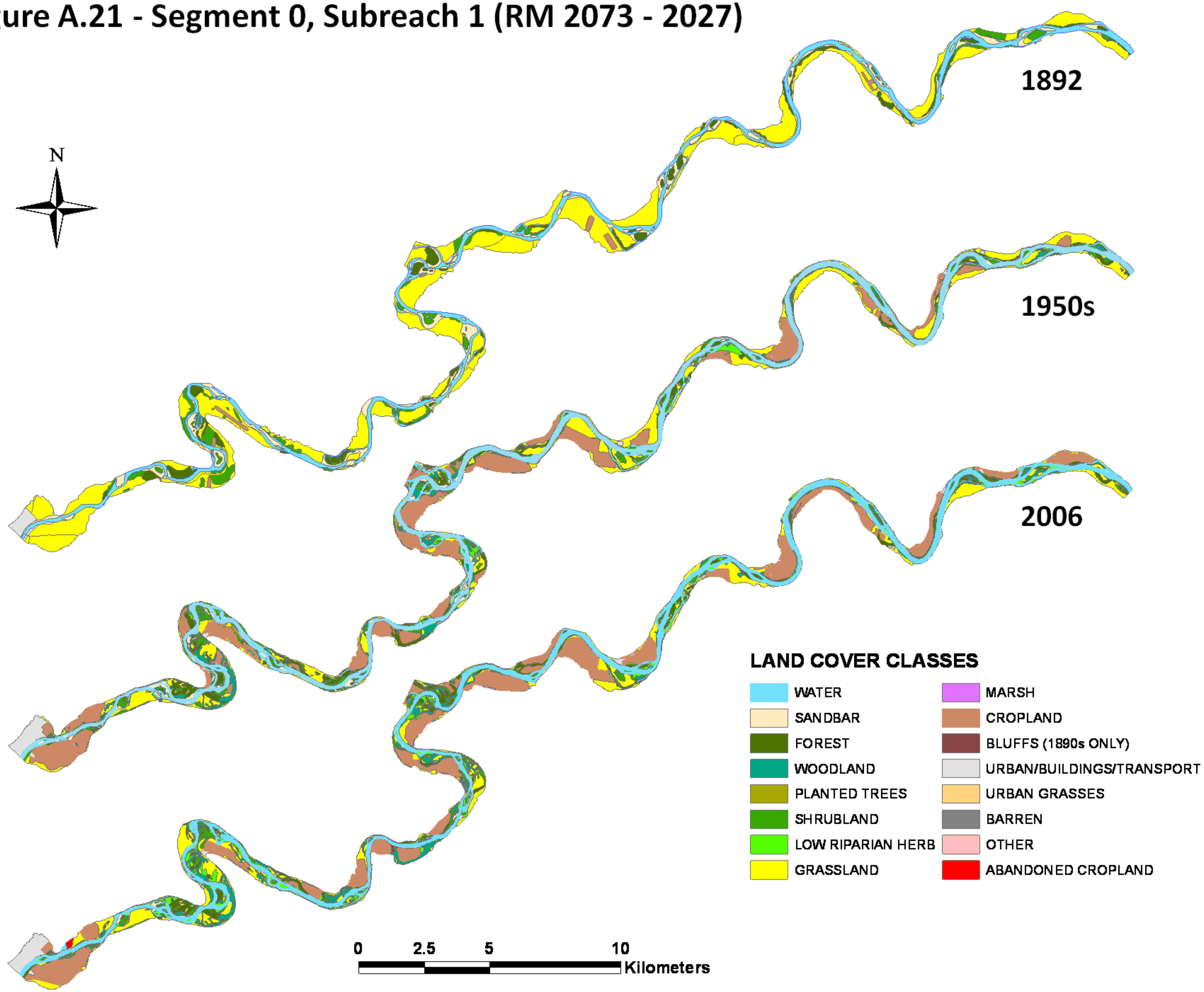


Figure A.22 - Segment 0, Subreach 1 (RM 2073 - 2027)

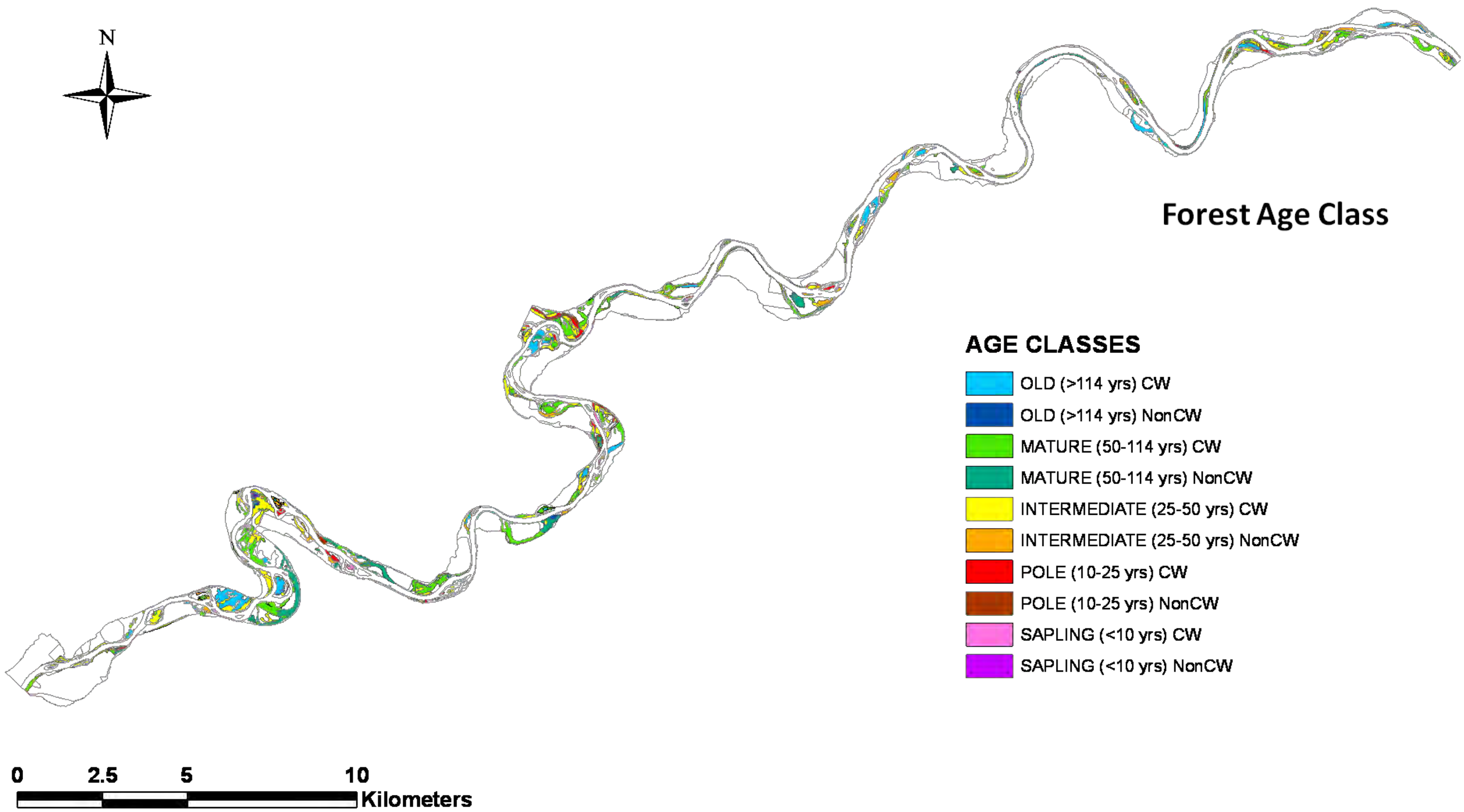


Figure A.23 - Segment 0, Subreach 2, upper 1/3 (RM 2027 - 2005)

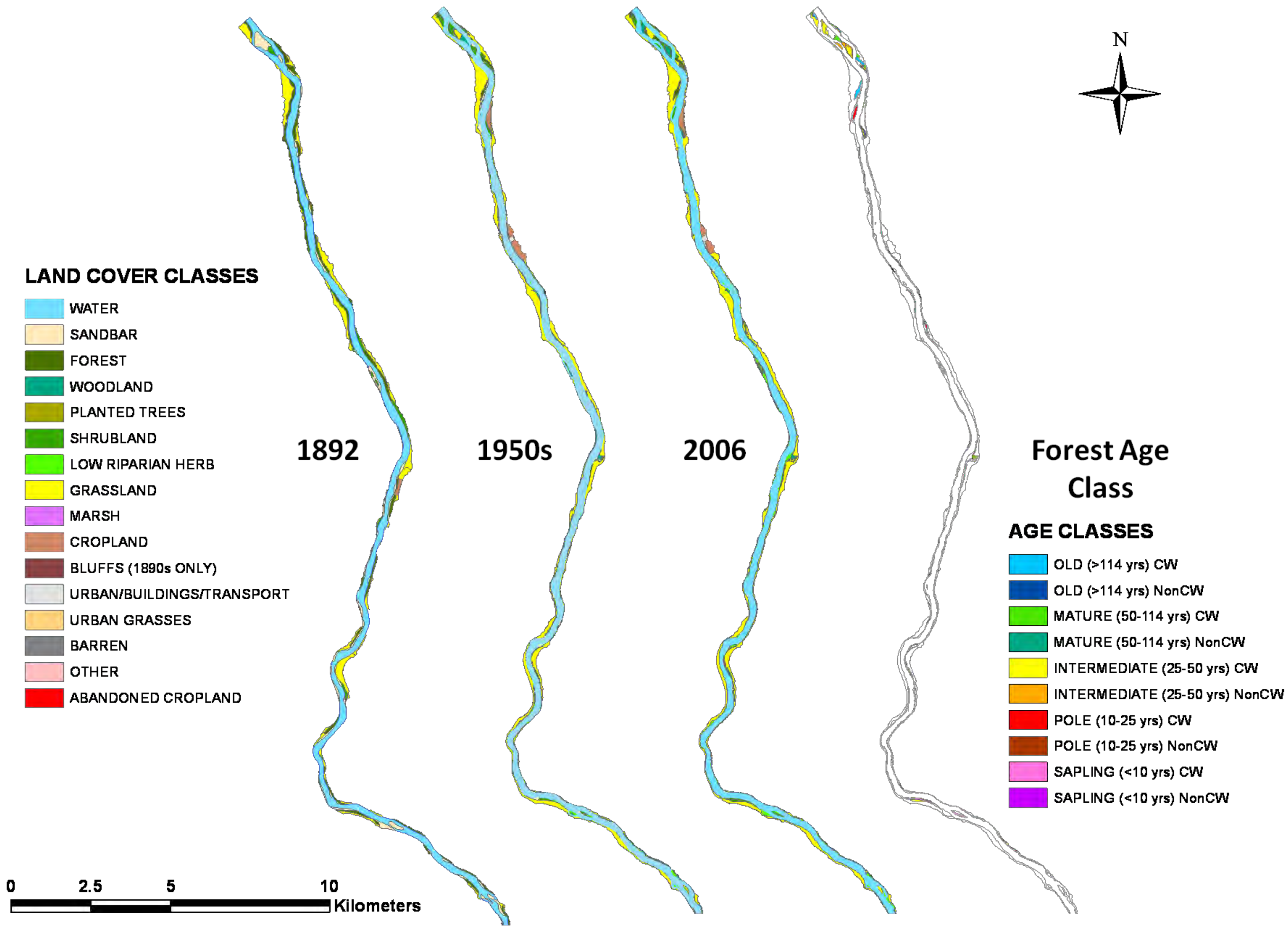


Figure A.24 - Segment 0, Subreach 2, middle 1/3 (RM 2005 - 1970)

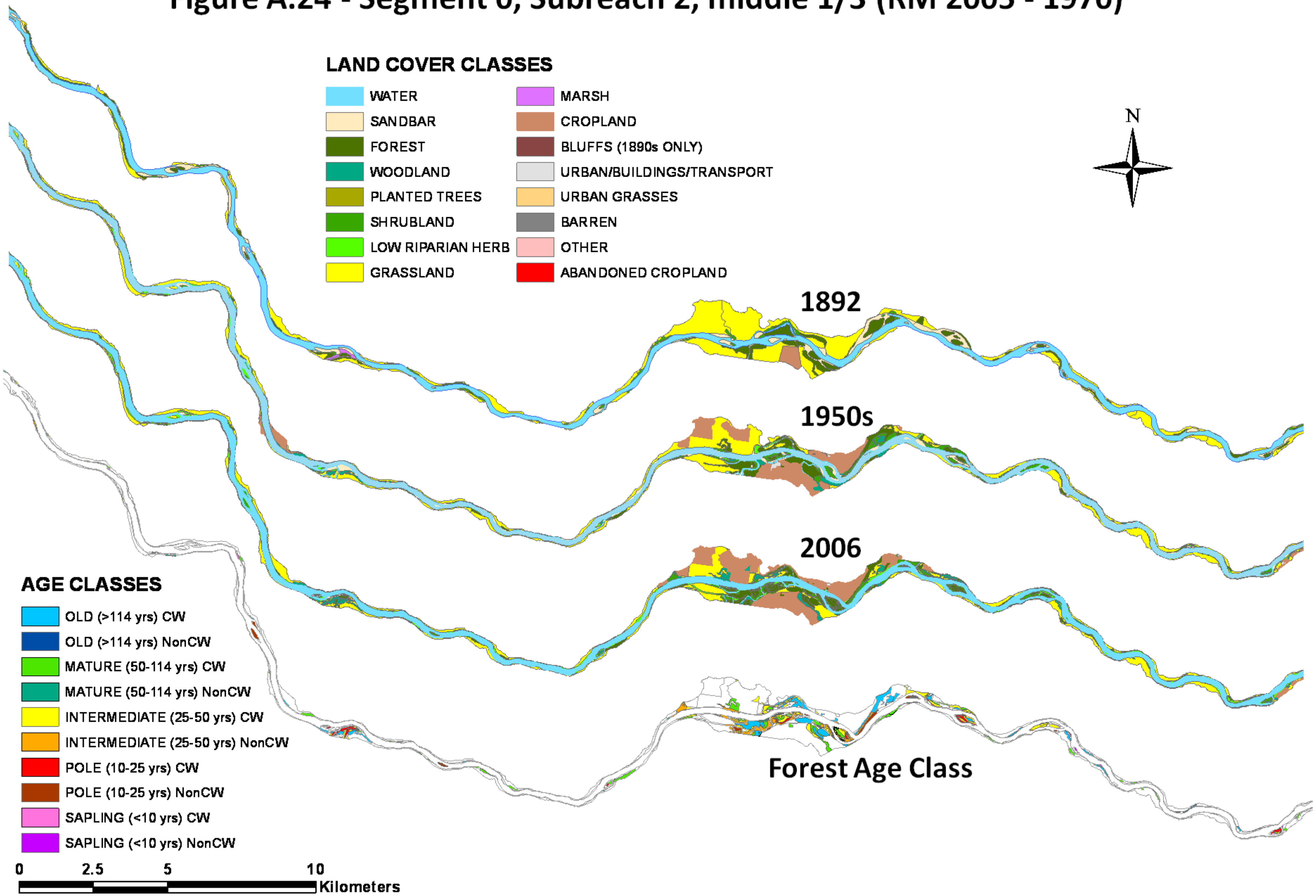


Figure A.25 - Segment 0, Subreach 2, lower 1/3 (RM 1970 - 1932)

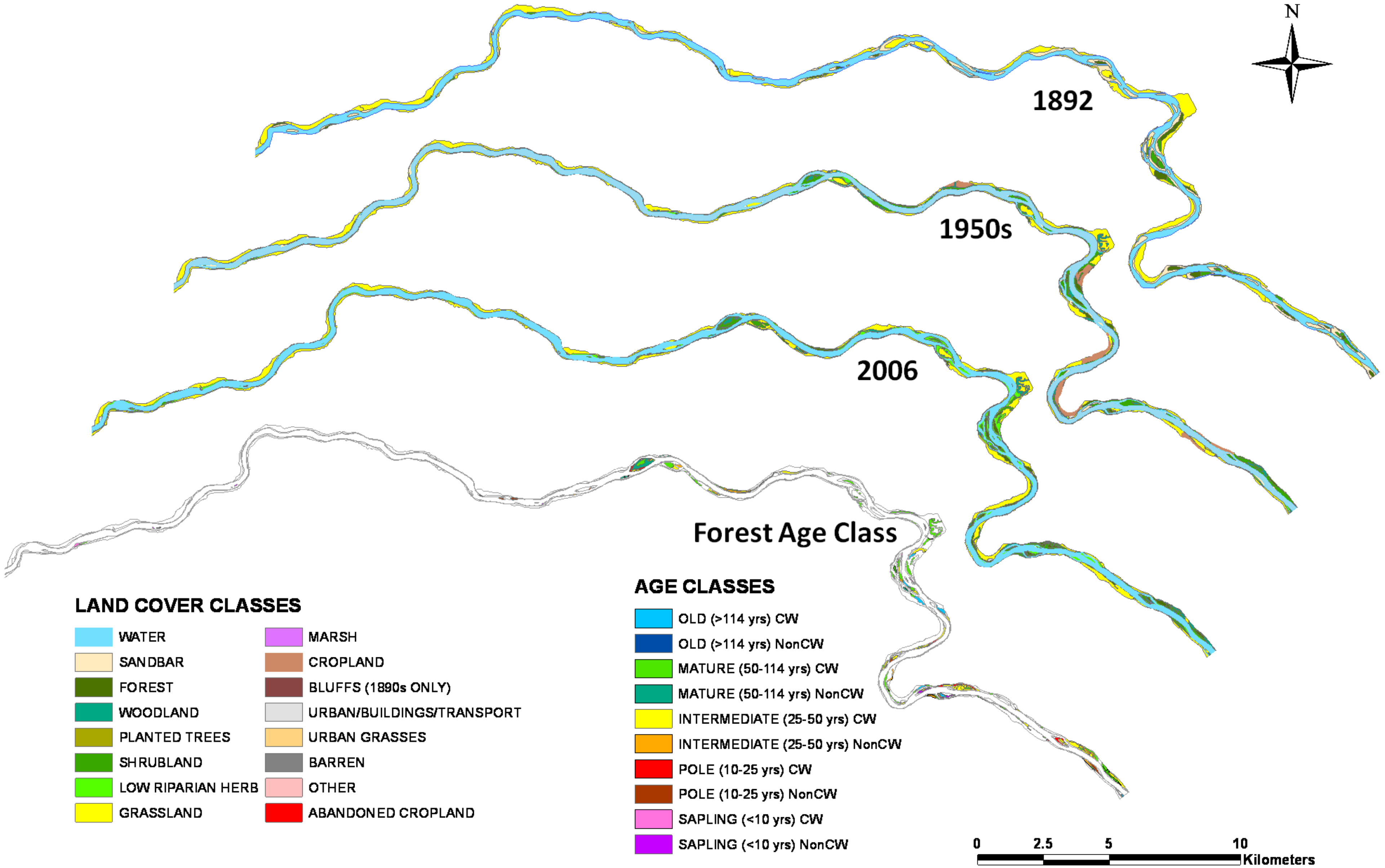


Figure A.26 - Segment 0, Subreach 3 (RM 1932 - 1917)

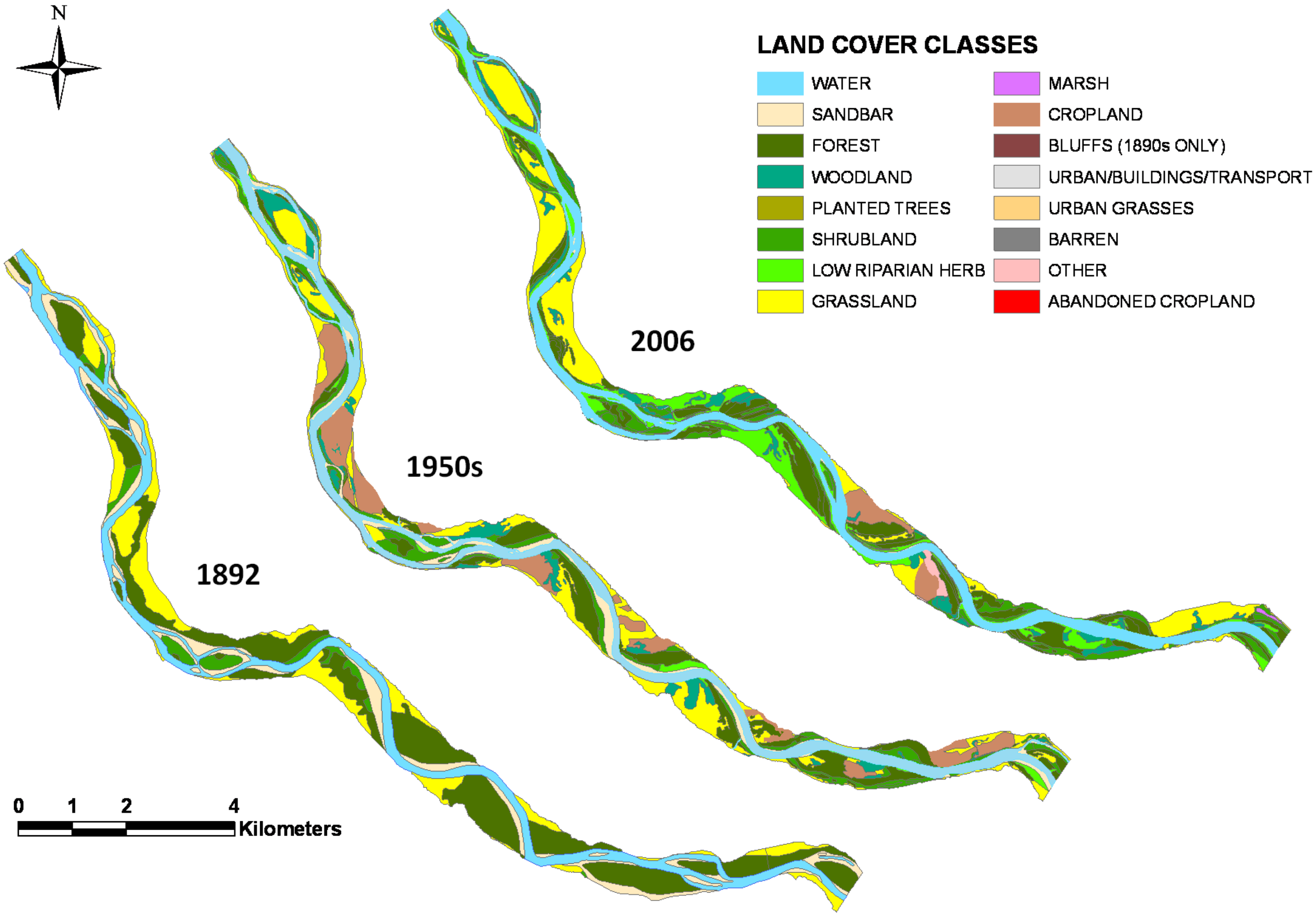
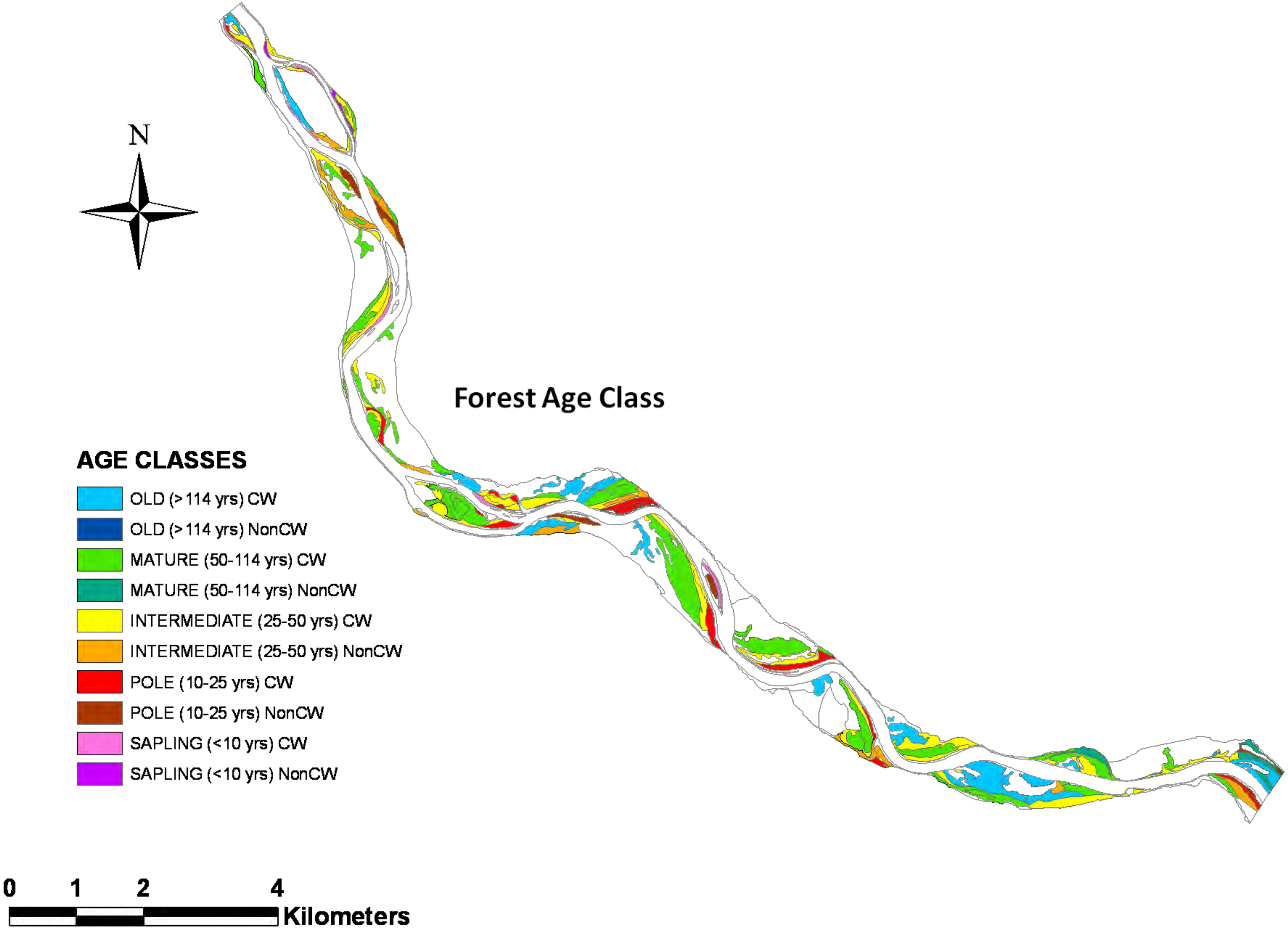


Figure A.27 - Segment 0, Subreach 3 (RM 1932 - 1917)



APPENDIX E
IMPLEMENTATION STRATEGIES AND SPECIFIC TECHNIQUES

LIST OF ACRONYMS

AMP	Adaptive Management Process
CCX	Chicago Climate Exchange
CRP	Conservation Reserve Program
CRS	Community Rating System
DWR	Division of Water Resources
EQIP	Environmental Quality Incentives Program
ESH	Emergent Sandbar Habitat
FEMA	Federal Emergency Management Agency
FLP	Forest Legacy Program
FMA	Flood Mitigation Assistance
HMGP	Hazard Mitigation Grant Program
IDNR	Iowa Department of Natural Resources
LWG	Local Work Groups
MDEQ	Montana Department of Environmental Quality
MNRR	Missouri National Recreation River
NFIP	National Flood Insurance Program
NRCS	Natural Resource Conservation Service
T&E	Threatened and Endangered
USDA	U.S. Department of Agriculture
USDOI	U.S. Department of the Interior
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
WHIP	Wildlife Habitat Incentives Program
WMP	Water Management Plan
WRDA	Water Resources Development Act
WREP	Wetland Reserve Enhancement Program
WRP	Wetland Reserve Program

Implementation Strategies	General Goal	Specific Technique	BOX Number	Associated Strategies
Protection of Existing Cottonwood Stands	Establish Land Conservation Measures	Discourage Development Near the River	1	2, 3, 4, 5
		Discourage Cottonwood Clearing Near the River	2	1, 3, 4, 5
	Purchase or Accept Lands Near the River	Purchase Lands or Create a Voluntary Property Buyout Program	3	6, 7, 8, 9, 10
		Pursue an Applicable Easement	4	1, 2, 7, 10
		Bequests for Conservation and Donations	5	7
	Use Funding Programs to Protect Cottonwoods	Use Short-Term Conservation Loan Funds	6	8
		Use Tax Incentives and State Programs	7	4, 5
		Use Existing Programs	8	4
		Use Forest Legacy Program Funds	9	8
		Use Conservation Cost-Sharing Programs	10	4, 8
	Prevent Competition to Existing Cottonwood Stands	Control and Prevent Domestic Livestock Grazing on Existing Cottonwoods	11	1, 26
		Control and Prevent Deer Grazing on Existing Cottonwoods	12	26
	Reduce Mortality to Existing Cottonwood Stands	Conservation of Surface Water and Alluvial Groundwater to Maintain Existing Cottonwoods	13	17, 27
Restoration of Hydrologic and Geomorphic Processes for Cottonwood Regeneration	Create Fluvial Processes Suitable for Cottonwood Establishment	Create Side Channels, Reconnect Old Oxbox Lakes and Establish Backwater Areas	14	1, 17
		Allow or Create In-Channel Sandbars to Naturally Revegetate with Cottonwoods	15	
	Floodplain Activities	Lower the Bench	16	4, 17, 22
		Eliminate Structural Limitations Along the River	17	
Artificial	Plant or Propagate	Harvest Cottonwood Seeds	18	19, 25

Implementation Strategies	General Goal	Specific Technique	BOX Number	Associated Strategies
Propagation of Cottonwoods	New Cottonwood Stands	Plant Cottonwood Seeds	19	19, 25
		Plant Rooted Cottonwood Seedlings (A) / Saplings (B)	20A / 20B	1, 21, 25
		Plant Small Unrooted Cottonwood Cuttings (Live Stakes)	21	20, 25
		Disk Land for Cottonwood Habitat	22	16
	Protect New Cottonwood Stands	Remove and Control Invasive Vegetation	23	25
		Control and Prevent Rodent and Ungulate Herbivory to Existing Cottonwoods	24	25
		Maintain Plantings through Short-Term and Long-Term Management	25	2
Modification to Management Policies to Protect/Restore Cottonwoods	Strategic Recommendations	Land Preservation Education and Information Exchange	26	1, 2
		Encourage Irrigation Water Management Plans to Benefit Cottonwood Stands	27	13
		Establish a Focus Group to Educate the Public about Carbon Credit Programs	28	26
		Collaborate with Established Conservation Trees Work Group	29	10
	Management Recommendations	Federal Use of Mitigation Projects to Require Cottonwood Plantings	30	19, 20, 21, 22
		State Use of Mitigation Projects to Require Cottonwood Plantings	31	19, 20, 21, 22

1.1 Protection of Existing Cottonwood Stands

The following options for Protection of Existing Cottonwood Stands are discussed in this Section:

- **1.1.1 Establish Land Conservation Measures:**
    - Discourage Development Near the River
    - Discourage Cottonwood Clearing Near the River

- **1.1.2 Purchase or Accept Lands Near the River:**
  - Purchase Lands or Create a Voluntary Property Buyout Program
  - Pursue an Applicable Easement
  - Bequests for Conservation and Donations
- **1.1.3 Use Funding Programs to Protect Cottonwoods:**
  - Use Short-Term Conservation Loan Funds
  - Use Tax Incentives and State Programs
  - Use Existing Programs
  - Use Forest Legacy Program Funds
  - Use Conservation Cost-Sharing Programs
- **1.1.4 Prevent Competition to Existing Cottonwood Stands:**
  - Control and Prevent Domestic Livestock Grazing on Existing Cottonwoods
  - Control and Prevent Deer Grazing on Existing Cottonwoods
- **1.1.5 Reduce Mortality to Existing Cottonwood Stands:**
  - Conservation of Surface Water and Alluvial Groundwater to Maintain Existing Cottonwoods

1.1.1 Establish Land Conservation Measures

BOX 1
Activity: Protection of Existing Cottonwood Stands
Goal: Establish Land Conservation Measures
Technique: **Discourage Development Near the River**

Discussion: Despite the hazards associated with the Missouri River's floodplains, the benefits of settling on them attracted settlers and resulted in increased occupancy and development. The Missouri River's historic floodplain is miles wide in many reaches and many farmsteads and towns currently exist in portions of the floodplain with little impact because of their distance from the river. Johnson et al. (1976) describes that the floodplain from Garrison Dam (forming Lake Sakakawea) south to the back-up waters of Oahe Reservoir as varying from approximately 1 mile to 7 miles wide. Additionally, the floodplain is very wide in Segment 10 while Segments 4, 6, and 8 have a more narrow floodplain, comparatively. Therefore, the phrase "along the river" is more appropriate than "floodplain" in this box and the following sections. Over the years, locations near the river have become the site of agriculture, homes, businesses, and infrastructure that supports many large and small communities. Discouraging and/or limiting development near the river is an important protection and conservation option that should be considered. However, waterway protections are severely limited by county and city boundaries unless these boundaries are part of a regional or statewide approach. Coordination of Land Use Plans, Floodplain Management Plans, local zoning laws, etc. between Counties and Cities is a necessity.

Utilization of river segment designations could be used to limit and/or restrict development near the river. For example, portions of the Missouri River (which includes Segments 8 and 10) is managed by the National Park Service, referred to as the Missouri National Recreational River (MNRR), and is part of the National Wild and Scenic Rivers System. A high priority of the National Park Service at the MNRR includes preventing the undesirable development of private lands along the river and keeping lands in current agricultural uses (NPS 2007). Additionally, the MNRR would like to establish a land protection program to help inform and educate the local public about the importance of keeping lands in current agricultural uses and developing sustainable practices that use Best Management Practices for farms and housing tracts. The General Management Plan/Final Environmental Impact Statement for the MNRR recommends that new development be either outside of the 100-year floodplain or flood-proofed to 1 foot above the 100-year floodplain to be consistent with the National Flood Insurance Program (NFIP).

The following suggestions could also be used to discourage and/or limit development near the Missouri River:

- Floodplain conservation districts can permit or exclude certain activities in the 100-year floodplain. The district could specify a minimum lot size in the floodplain as well as designating a "setback" from the median water line. Setbacks have the added benefit of providing protection to homeowners and others in areas that were improperly left out of floodplain mapping or from especially high floods. County development regulations can also be used to protect the floodplain areas by establishing construction setbacks.
- County zoning laws are a land use management tool that could be used to restrict development near the Missouri River, such as prohibiting all residential, commercial, and industrial structures within the

floodplains, with the exception of accessory agricultural structures. Other activities that could be restricted include the development in wetlands, construction on extreme slopes, and development in soils that are unsuitable for septic tanks. Any structure constructed within the floodplain could be mandated by county floodplain regulations to elevate the base floor above the 100-year flood elevation. Slopes in excess of a certain percent should generally be precluded from development. Soils in many areas of the county may not be conducive for septic tank installation.

- Writing zoning regulations for river setbacks and requiring a strip of natural, native, and undisturbed vegetation along the edge of the river could be implemented. Additionally, any construction occurring within a specified distance of the river could be required to complete a review process with the county.
- Counties could participate in the NFIP and would have the responsibility to control development within the 100-year floodplain under the Federal Emergency Management Agency (FEMA) program; failure to comply could result in losing the county's participation in the NFIP.
- Landowners and developers could be asked to accept permanent sloughing easements or flood easements (see BOX 4), although these programs would require funding.
- Increase public awareness of risks associated with building in a floodplain.
- Implement a County Flood Risk Mitigation Plan or a County Strategy for Floodplain Management.
- The county could designate watershed protection areas, wetland ordinance areas, river conservation zones, and/or write waterbody, wetland and riparian protection regulations.
- Development of a County Master Plan or Land Use Plan which could include limiting development in the floodplain as well as information on demographics, the local economy, community facilities and services, transportation, natural resources, land use, housing, and a future land use plan and/or thoroughfare plan.

Example documents: *St. Charles County, MO Master Plan*

Example programs: Montana Smart Growth Coalition

Source: NRC 2002; St. Charles County, MO 2008; NPS 2007; NPS 1999; MSGC 2008

POTENTIAL PROJECT LOCATIONS: ALL SEGMENTS

OTHER STRATEGIES TO CONSIDER: Discourage Cottonwood Clearing Near the River (BOX 2); Purchase Lands or Create a Voluntary Property Buyout Program (BOX 3); Pursue an Applicable Easement (BOX 4); Bequests for Conservation and Donations (BOX 5)

BOX 2

Activity: Protection of Existing Cottonwood Stands

Goal: Establish Land Conservation Measures

Technique: **Discourage Cottonwood Clearing Near the River**

Discussion: Rood and Mahoney (1990) have stated that agricultural clearing and direct harvesting of trees contribute to forest failure and that the clearing of river valley forests for crop cultivation has reduced the abundance of riparian forests. Agricultural clearing creates secondary problems as well, including exacerbating impacts from beaver herbivory and grazing by deer and cattle. To prevent existing cottonwoods from being cleared on the floodplain, agricultural clearing practices and forestry clearing practices should be discouraged. This could be accomplished through educational efforts involving local farmers and the requirement of a stream buffer program.

Each city or county could adopt a Stream Buffer Protection and Management Plan to regulate activities in the floodplain and educate landowners of approved activities within the floodplain. The city or county could adopt the plan that the U.S. Environmental Protection Agency (USEPA) has adopted, which includes a 3-zone buffer. The 3-zone buffer consists of a 100-foot buffer extending on both sides of a stream or 25 feet beyond the 100 yr floodplain, whichever is larger. The buffer is divided into the following zones: streamside zone (25 feet of undisturbed natural vegetation), the middle zone (50 feet of passive recreation with limited tree clearing, stormwater management facilities, and mature native vegetation), and the outer zone (25 feet with no permanent structures or impervious cover and the encouragement of native vegetation).

To additionally discourage clearing cottonwoods in the floodplain, each city or county could consider the cottonwood as a significant tree and specify the definition of a significant tree, which could include trees over 4 inches or more in diameter (as measured 4.5 feet above grade). Each city or county would not allow tree clearing in a sensitive area, sensitive area buffer, or shoreline zone. Additionally, tree protection measures could be established which meet or exceed best management practices and current standards of professional arboriculture, and which are sufficient to ensure the viability of protected trees and other vegetation identified for retention. During any necessary or approved clearing and/or construction activities, all protected vegetation could be surrounded by protective fencing which would prevent adverse impacts associated with clearing from intruding into areas of protected vegetation. If no other alternative exists, each city or county could require a Tree Clearing Permit for the removal of a significant cottonwood tree of a specified diameter at breast height within a specified distance from the river. Each existing significant tree removed could require replacement of a specified ratio and be replaced with new tree(s), based on the size of the existing tree, up to a maximum specified density. The following requirements could be implemented through state regulations and by a city or a county:

- Stream Buffer Protection and Management Plan
- Forest Management Plan
- Require a Tree Clearing Permit
- Require Tree Replacement Ratios and Mitigation/Reforestation
- Require a Landscape Plan for the property

Example programs: City of Tukwila, WA; City of Lincoln, NE

Source: City of Tukwila, WA 2007; City of Lincoln NE 2002

POTENTIAL PROJECT LOCATIONS: ALL SEGMENTS

OTHER STRATEGIES TO CONSIDER: Discourage Development Near the River (BOX 1); Purchase Lands or Create a Voluntary Property Buyout Program (BOX 3); Pursue an Applicable Easement (BOX 4); Bequests for Conservation and Donations (BOX 5)

1.1.2 Purchase or Accept Lands Near the River

BOX 3

Activity: Protection of Existing Cottonwood Stands

Goal: Purchase or Accept Lands Near the River

Technique: **Purchase Lands or Create a Voluntary Property Buyout Program**

Discussion: A voluntary floodplain buyout program could be implemented to remove development from the floodplain and/or to eliminate potential future development in the floodplain. This measure would be dependent upon a federal purchase or any fee-title purchase by states, tribes, or conservation organizations and would be limited to willing landowner sales. As part of the program, the public, government entity, or non-government organization would buy the property, acquire the title to it, and then clear the structures from it. The property must forever remain open space land such as park and/or wetland and cannot be sold to private individuals or developed. Additional benefits include: saving money, providing permanent protection, serving multiple objectives, enhancing natural flood protection, and protecting private property rights.

Federal funds can be acquired through the Hazard Mitigation Grant Program (HMGP) and the Flood Mitigation Assistance Program. A local entity (town or city) can sign an HMGP agreement with FEMA to allocate funding for mitigation projects, such as buyouts. FEMA has regulatory oversight of the HMGP. However, the states are responsible for administering the HMGP, and prioritizing and selecting project applications from communities. States then forward project applications to FEMA for final approval. It is important to stress that the HMGP funds must be used to acquire properties only from property owners who voluntarily agree to sell their properties, and that these funds will not use the power of eminent domain to acquire properties if a voluntary agreement is not reached. Any community implementing a property acquisition project using HMGP funds must dedicate and maintain the acquired property as open space, which could include wetland restoration, preservation, wildlife refuge, etc.

In addition to an HMGP, a Watershed Plan and Environmental Assessment could also be developed through the Natural Resource Conservation Service (NRCS) local Soil and Water Conservation District and a local city or town could be a partner. Also, if the HMGP application is not approved and the community is a participant in NFIP, the community could apply for funds under FEMA's Flood Mitigation Assistance (FMA) program. The FMA is a mitigation program that is not directly related to a disaster event, but provides funding to assist states and communities in implementing measures to reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insured under the NFIP. FEMA annually provides funds to the states to conduct FMA projects. The states then can offer two types of FMA grants to their communities, including project grants to implement mitigation measures such as property acquisition. Preparing a property acquisition plan and conducting hazard mitigation planning can help a community obtain a favorable entry under the Community Rating System (CRS) and possibly reduce flood insurance costs to citizens of the community.

Example projects: A Missouri watershed project was used to buy out more than 100 frequently flooded residences and businesses and created 50 acres of open spaces, including a park and hiking trail in the floodplain. Other environmental improvements associated with the project included planting more than 500 trees within the stream corridor as well as stabilizing and restoring 800 feet of streambank.

Source: USDA-NRCS 2008a; FEMA 1998; Salvesen 2004

POTENTIAL PROJECT LOCATIONS: ALL SEGMENTS

OTHER STRATEGIES TO CONSIDER: Use Short-Term Conservation Loan Funds (BOX 6); Use Tax Incentives and State Programs (BOX 7); Use Existing Programs (BOX 8); Use Forest Legacy Program Funds (BOX 9); Use Conservation Cost-Sharing Programs (BOX 10)

BOX 4

Activity: Protection of Existing Cottonwood Stands

Goal: Purchase or Accept Lands Near the River

Technique: **Pursue an Applicable Easement**

Discussion: When a private landowner voluntarily gives up "developmental" rights and donates or sells this right to a government agency, it's called an easement. The landowner still owns and manages the land. If the land interest is being purchased by the agency, an appraiser estimates the value of the easement based on a portion of the fair market value. Landowners who donate their land may be eligible for a federal income tax deduction equal to the value of their property minus the developmental rights. The following types of easements may be applicable as measures in this plan:

The Corps has the approval to obtain the fee title to lands from willing private landowners. Sloughing easements are for lands that are forecasted to erode in the next 50 years. This easement allows for the owner to maintain title to the land; however the intent of the easement is to allow the lands to erode away. Bank erosion causes sediment to move downstream and form deposits of barren, mineral soil which are ideal for cottonwood seedbed locations. Sloughing easements are available through the Corps and there are other similar federal programs that have approval to enter into easements with willing sellers, including the U.S. Fish and Wildlife Service (USFWS) and the United States Department of Agriculture (USDA) NRCS.

Conservation easements are an effective way to permanently protect land from future development or use. Establishing conservation easements along the Missouri River would prevent the removal of cottonwoods, prevent development within the floodplain, and protect and maintain current stands of cottonwood trees and other native vegetation. Conservation easements are available through the National Park Service, Nebraska Land Trust, Northern Prairies Land Trust, and Corps, among others (see BOX 7 for a list of conservation trusts and organizations, some of which may offer conservation easements).

Wetland easements programs are offered in North and South Dakota through the USFWS. A wetland easement is an agreement between the USFWS and a private landowner, where the USFWS pays the landowner to permanently protect wetlands. The wetlands protected by the easement cannot be drained, filled, leveled, or burned (USFWS 2008b). Additionally, the USDA NRCS offers a Wetland Reserve Program (WRP) and a Wetland Reserve Enhancement Program (WREP). These programs are voluntary and provide technical and financial assistance to landowners to address wetland, wildlife habitat, soil, water, and related natural resource concerns. These programs allow participants to enter into a 10-year, 30-year, or perpetual easement. The participant controls access to the land and may lease land for hunting, fishing, or other recreational activities, given that the activities do not impact the preservation areas. Currently, enrolled lands are mostly agricultural lands located in flood prone areas which are restored to wetlands. The wetlands being restored varies from floodplain forest, prairie potholes, and coastal marshes (USDA NRCS 2007a).

Flowage easements provide landowners that do not want to establish a conservation easement an alternative to cooperate with the government on restoration projects. Flowage easements allow the government to temporarily or permanently flood an area of land. With the exception of access rights to and flooding of the flowage easement, no other rights to the land are purchased. Flooding could create bare, moist deposits outside of the channel bed for cottonwoods to become established.

Recreational river easements are a land protection option to compensate the landowner for keeping existing habitat undeveloped or for restoring habitat (MRF 2007). These easements are offered by the Corps.

Example Projects: The Buford-Trenton Land Acquisition project in Williston, North Dakota consisted of the acquisition of permanent flowage and saturation easements on approximately 11,750 acres from about 55 landowners. Due to the flooding, groundwater levels had increased making it impossible to grow sugar beets, a high dollar cash crop. The high groundwater was caused by sediment deposited in the headwaters of Lake Sakakawea (Garrison Dam) just west of Williston, ND (Remus 2008).

NRCS worked with a landowner on a Wetland Restoration Program site south of Plattsmouth, Nebraska on the Missouri River. The Corps was concurrently involved with stream back sloughing, shallow water habitat restoration, and notching of the dike along the river which allowed high flows from the river into the wetland. The wetlands held the water and slowly released it back into the river, which relieved flooding downstream (Ducey 2007).

Missouri River wetland during flooding

Source: USACE 2004; Ducey 2007 (text and photos); USFWS 2008b; Remus 2008; MRF 2007; USDA-NRCS 2007a

POTENTIAL PROJECT LOCATIONS: ALL SEGMENTS

OTHER STRATEGIES TO CONSIDER: Discourage Development Near the River (BOX 1); Discourage Cottonwood Clearing Near the River (BOX 2); Use Tax Incentives and State Programs (BOX 7); Use Conservation Cost-Sharing Programs (BOX 10)

BOX 5

Activity: Protection of Existing Cottonwood Stands

Goal: Purchase or Accept Lands Near the River

Technique: **Bequests for Conservation and Donations**

Discussion: A donation by bequest occurs when a gift of land is made at the time of death simply by writing the gift in a will. The advantage of this donation is that the landowner retains full use and control of the land until death. Bequests can be used to place conservation easements on land and come in several types, which can include specific bequests of a conservation or agricultural easement. The landowner has the ability to revise the will, allowing the landowner to change the gift as his or her personal situation changes. The landowner can reduce estate taxes by removing the land from the estate. The bequest can qualify as a charitable transfer which entitles the estate to a deduction equal to the value of the property. However, the landowner remains responsible for paying real estate taxes during their lifetime, and does not benefit from the income tax savings possible from other methods of land donation. If the landowner has specific restrictions or management plans they want the proposed recipient to follow, it is imperative that the landowner speaks with the recipient to ensure they are able to honor the landowner's wishes. It is essential that anyone considering his or her estate plan seek the advice of a competent attorney and/or estate tax expert before executing a will or living trust.

Land can also be donated in the present, but the landowner can continue to live on the land during their lifetime. This technique is called donating a remainder interest and retaining a reserved life estate or referred to as a gift of a remainder interest. Therefore, the landowner can reserve the right for themselves or any other persons they name to continue to live on the land or use it. When the named persons die or release their life interests, the full title and control of the land will be in the hands of the conservation organization or agency that the landowner has chosen. Donations of this kind may be eligible for an income tax deduction at the time the gift is made. The deduction is based on the fair market value of the donated property, minus the expected value of the reserved life estate. Reserving lifetime use by more than one person can significantly reduce the possible income tax deduction.

Organizations such as the Nature Conservancy accept bequests and/or donations with reserved or "retained" life estates as well as the Placer Land Trust, the Trust for Public Land, the Humane Society of the United States Wildlife Land Trust, the Natural Lands Trust, and many other charitable organizations.

Source: TNC 2008 (text)

POTENTIAL PROJECT LOCATIONS: ALL SEGMENTS

OTHER STRATEGIES TO CONSIDER: Use Tax Incentives and State Programs (BOX 7)

1.1.3 Use Funding Programs to Protect Cottonwoods

BOX 6
Activity: Protection of Existing Cottonwood Stands
Goal: Use Funding Programs to Protect Cottonwoods
Technique: **Use Short-Term Conservation Loan Funds**
Discussion: It is sometimes critical that public agencies such as the Corps respond quickly to land or conservation easement purchase opportunities with ready funding. Because the average wait for public funds or private fundraising campaigns is 18 to 24 months, bridge funding can be provided by nonprofit organizations. Therefore, short-term loans can be made to public agencies and nonprofit land trusts for the conservation of coastal and freshwater sites of high ecological significance. Funds are available for two primary types of transactions: direct loans to land trusts and advance purchase of land on behalf of public agencies and/or nonprofits. The Conservation Fund is an environmental nonprofit dedicated to protecting important landscapes and waterways for future generations that administers short-term loans in the form of Revolving Loan Funds across the Country. The Sierra Club also allocates short-term conservation funds to protect important land and resources. For example, the Mississippi River Revolving Fund administered by The Conservation Fund, provides loans to nonprofit organizations and government agencies to aid in the protection of land along the mainstem of the Mississippi River or along key tributaries, as well as greenways that are part of larger regional projects. These loans enable groups to quickly acquire or protect properties using direct loans to land trusts and/or other nonprofit organizations, and advance purchases of land in partnership with public agencies. With the repayment of loans, the revolving fund is then used again for conservation in a different location but throughout a specified region. On average, The Conservation Fund uses revolving funds three times every five years. With a lead grant, a Missouri River Revolving Fund could also be created to protect land along the mainstem as well as key tributaries. Once a revolving fund is created, interested parties should contact The Conservation Fund for an informal consultation to determine whether a formal loan application or, if it is a request on behalf of a public agency, a Letter of Intent should be submitted. After an in-depth review of the application or request, a representative from The Conservation Fund would visit the property and meet with the board and/or staff of the applicant or agency. The Conservation Fund's staff meets regularly to review proposed and pending advance purchase and loan transactions to analyze for each transaction the leverage of the deal and repayment plan. In the case of an advance purchase, a formal agreement would be prepared and, if it is approved, The Conservation Fund would proceed with the advance purchase and would then be reimbursed when public funding was available. For all loan applications, the committee would determine the amount and type of collateral needed for the loan, which could include pledged cash assets of the land trust, promissory notes, letters of credit from donors, a mortgage or appropriate securities. Finally, funds would be released as determined by the executed agreement. *Source: TCF 2008*
POTENTIAL PROJECT LOCATIONS: ALL SEGMENTS
OTHER STRATEGIES TO CONSIDER: Use Existing Programs (BOX 8)

BOX 7

Activity: Protection of Existing Cottonwood Stands

Goal: Use Funding Programs to Protect Cottonwoods

Technique: **Use Tax Incentives and State Programs**

Discussion: There are two main kinds of federal tax benefits available to conservation donors, which include federal income tax benefits and federal estate tax benefits. In addition to the federal tax benefits, some states have also enacted income tax deductions or credits for the donation of land or conservation easements, available through local land trusts and conservation associations. The following state tax incentives and programs may be applicable:

Conservation Tax Incentives **-** State Legislature can adopt a tax credit program for landowners per year for expenses related to such things as complying with a total maximum daily load or enhancing the habitat for endangered, threatened or candidate species. Some practices might include fencing riparian areas in spawning areas for fish. The State Soil Conservation Commission may administer these incentives.

Federal Income Tax Deductions – when a private landowner voluntarily gives up "developmental" rights and donates or sells this right to a government agency, it's called an easement. Landowners who donate their land as an easement may be eligible for a federal income tax deduction equal to the value of their property minus the developmental rights (see BOX 4 for details).

Property Tax Treatments **-** Rural landowners may opt for various land classifications that allow for lower taxes than if their lands were taxed at the *highest and best use*. For example, landowners who have lands with scattered trees and use that land for livestock grazing may opt for the dryland grazing tax category. As long as the land use does not change, the land is taxed at the lower rates offered by these options, despite the value of the land for some type of development.

Local land trusts may also provide tax incentives and tax breaks. In general, property tax reductions are available for landowners who grant land or a conservation easement. The exact results depend on the differing laws in each state. The landowner must file an application with the local tax assessor, who will then make the final decision on the amount of the reduction. The following are some examples of land trusts that may be available (by state) for this type of program. Note that the Headquarter locations of these associations may differ by the state list described below:

Land Trusts and Conservation Associations that currently exist in all 7 Missouri River Basin states:

American Forest Foundation **-** Washington, DC
National Wild Turkey Federation **-** Edgefield, SC
Project Learning Tree **-** Washington, DC
Watershed Land Trust **-** Overland Park
The Nature Conservancy - State Field Offices in Bismarck, ND; Rapid City, SD; Helena, MT; Omaha, NE; Des Moines, IA; St. Louis, MO; Topeka, KS

Land Trusts and Conservation Associations that currently exist in North Dakota:

North Country Trail Association - Lowell, MI
Rocky Mountain Elk Foundation **-** Missoula, MT
Watershed Land Trust **-** Overland Park, KS
North Dakota Natural Resources Trust – Bismarck, ND

Land Trusts and Conservation Associations that currently exist in South Dakota:

Northern Prairies Land Trust - Sioux Falls, SD
Rocky Mountain Elk Foundation - Missoula, MT
Spearfish Canyon Land Trust - Spearfish , SD

Land Trusts and Conservation Associations that currently exist in Montana:

Bitter Root Land Trust - Hamilton, MT
Five Valleys Land Trust - Missoula, MT
Flathead Land Trust - Kalispell, MT
Friends of Les Mason Park - Whitefish, MT
Gallatin Valley Land Trust - Bozeman, MT
Mid-Yellowstone Land Trust - Billings, MT
Montana Land Reliance - Helena, MT
Prickly Pear Land Trust - Helena, MT
Rocky Mountain Elk Foundation - Missoula, MT
Save Open Space, Inc. - Missoula, MT
The Trust for Land Restoration - Ridgway, CO
Trust for Public Land, Northwest Regional Office - Seattle, WA
Vital Ground Foundation - Missoula, MT

Land Trusts and Conservation Associations that currently exist in Nebraska:

Fontenelle Forest Association - Bellevue, NE
Nebraska Land Trust - Lincoln, NE
Platte River Whooping Crane Maintenance Trust - Wood River, NE
Prairie Plains Resource Institute - Aurora, NE

Land Trusts and Conservation Associations that currently exist in Iowa:

Dubuque County Conservation Society - Dubuque, IA
Four Mounds Foundation - Dubuque, IA
Indian Creek Nature Center - Cedar Rapids, IA
Iowa Natural Heritage Foundation - Des Moines, IA
Johnson County Heritage Trust - Iowa City, IA

Land Trusts and Conservation Associations that currently exist in Missouri:

American Wildlife Partnership - Osage Beach, MO
Civil War Preservation Trust - Washington, DC
Dancing Rabbit Land Trust - Rutledge, MO
Earth Rising - Kansas City, MO
Great Rivers Land Trust - Alton, IL
Greenway Network, Inc. - St. Peters, MO
L-A-D Foundation - Saint Louis, MO
Meramec Valley Community Land Trust - Saint Louis, MO
Missouri Caves & Karst Conservancy - Saint Louis, MO
Missouri Farmland Preservation Trust - Smithville, MO
Missouri Prairie Foundation - Columbia, MO
North American Land Trust - Chadds Ford, PA
Open Space Council of the St. Louis Region - Saint Louis, MO
Ozark Greenways, Inc. - Springfield, MO
Ozark Regional Land Trust - Carthage, MO

Platte Land Trust - Parkville, MO St. Charles County Land Trust, Inc. - Saint Charles, MO St. Louis Regional Open Space Foundation - Saint Louis, MO Trailnet, Inc. - Saint Louis, MO Trust for Public Land, Central Regional Office - Saint Paul, MN Land Trusts and Conservation Associations that currently exist in Kansas: Kansas Land Trust – Lawrence, KS Sunflower Land Trust – Wichita, KS Watershed Land Trust - Overland Park, KS Ranchland Trust of Kansas – Topeka, KS Ozark Regional Land Trust - Carthage, MO *Source: Levin 2008*
POTENTIAL PROJECT LOCATIONS: ALL SEGMENTS
OTHER STRATEGIES TO CONSIDER: Pursue an Applicable Easement (BOX 4); Bequests for Conservation and Donations (BOX 5)

BOX 8

Activity: Protection of Existing Cottonwood Stands

Goal: Use Funding Programs to Protect Cottonwoods

Technique: **Use Existing Programs**

Discussion: Funds authorized for the Corps under the Water Resources Development Act (WRDA) could be used for Missouri River restoration projects, including removing barriers to fish passage, restoring wetlands, securing higher instream flows for trout spawning tributaries, and purchasing ecologically critical riparian areas that might otherwise be developed. For example, WRDA of 2007 authorized $30M for ecological restoration projects aimed at repairing and protecting the Yellowstone River from further damage; this WRDA bill allows the Corps to plan projects on the Yellowstone River and its tributaries that have been identified through a multi-year cumulative effects study. Several other federally funded programs focus on conservation by purchasing lands and interests in lands and include the following:

- ***The Forest Legacy Act*** was established in the 1990 Farm Bill – state and federal partners implement the Forest Legacy Program together (see BOX 9).
- ***Land and Water Conservation Fund*** – established by Congress in 1964 (Public Law 88-578) – which provides funding for national forests, parks, and wildlife area easements and in holding acquisitions
- ***The North American Wetlands Conservation Act*** of 1989 – provides matching grants to private or public organizations or to individuals who have developed partnerships to carry out wetlands conservation projects in the United States
- ***The Farmland Reserve Protection Program*** of 1996 – administered by the USDA and provides matching grants to states, local and tribal and entities with existing farmland protection programs for the purchase of agricultural conservation easements to protect prime top soil.
- ***The Food, Conservation, and Energy Act*** *of 2008 (2008 Farm Bill)* – Broadens the Farmland Reserve Protection Program purpose of protecting topsoil to preserving the agricultural uses and conservation values of land.
- ***The Coastal and Estuarine Land Conservation Program*** – allows Congress to fund land acquisitions
- ***The Wetlands Reserve Enhancement Program (WREP)*** – is a voluntary program administered by the USDA that offers both financial and technical assistance to landowners and tribes wishing to restore wetlands and increase wildlife habitat in the Missouri River floodplain in Nebraska along the South Dakota/Nebraska state line and from Ponca, NE to Rulo, NE.
- ***Grassland Reserve Program*** – is a voluntary program offering landowners the opportunity to protect, restore, and enhance grasslands on their property, including shrubland that has the potential to serve as wildlife habitat of significant ecological value. The program is implemented by the USDA NRCS Farm Service Agency and the U.S. Forest Service (USFS).
- ***Forestry Provisions in New 2008 Farm Bill*** – the new 2008 bill enhances existing and establishes new forest preservation programs.
- ***The National Fish and Wildlife Foundation*** – is a non-profit organization that preserves and restores native wildlife species and habitat using public conservation dollars and matching those investments with private funds.
- ***The USEPA Targeted Watersheds Grant Program*** – is designed to encourage successful

community-based approaches and management techniques to protect and restore the nation's watersheds.

Source: USDA-NRCS 2007b; USEPA 2008

POTENTIAL PROJECT LOCATIONS: ALL SEGMENTS

OTHER STRATEGIES TO CONSIDER: Pursue an Applicable Easement (BOX 4)

BOX 9

Activity: Protection of Existing Cottonwood Stands

Goal: Use Funding Programs to Protect Cottonwoods

Technique: **Use Forest Legacy Program Funds**

Discussion: The Forest Legacy Program (FLP) is a federal program in partnership with participating states that protects forests that are environmentally sensitive or endangered. The program focuses on interests and issues that deal with privately owned forests. The FLP provides financial assistance for privately owned forest that is endangered due to anthropogenic development, or forest that has become fragmented due to previous practices. The Forest Legacy program provides alternatives for landowners located in these troubled forested areas and develops cooperative conservation plans that allow private landowners to retain land ownership without the need to negotiate property rights. This reduces the effort needed to maintain a sustainable management plan and ultimately increases the benefit to the forest. The Forest Legacy Program has two main goals: 1.) to support property acquisition and, 2.) to acquire donated conservation easements. Participation in the FLP program is limited to private landowners; the federal government funds up to 75% of the costs that are involved and the remaining 25% comes from the landowners as well as other local and state resources. The following states in the Missouri River Basin currently participate in the FLP:

- Montana http://www.fwp.state.mt.us/habitat/forestlegacy.asp
- Nebraska http://www.nfs.unl.edu/FLegacy.htm
- South Dakota http://www.state.sd.us/doa/forestry/index2.htm
- Missouri http://www.dnr.mo.gov/index.html

Source: USDA-USFS 2008

POTENTIAL PROJECT LOCATIONS: ALL SEGMENTS

OTHER STRATEGIES TO CONSIDER: Use Existing Programs (BOX 8)

BOX 10

Activity: Protection of Existing Cottonwood Stands

Goal: Use Funding Programs to Protect Cottonwoods

Technique: **Use Conservation Cost-Sharing Programs**

Discussion: There are numerous cost-sharing programs available to landowners interested in conserving, preserving, and improving their lands. These programs are discussed in more detail below.

Created at the federal level, the Natural Resources Conservation Service and Farm Service Agency administers the Conservation Reserve Program (CRP). The CRP is a voluntary program that offers annual rental payments, incentive payments for certain activities, and cost-share assistance to establish approved cover on eligible cropland. The program encourages farmers to plant long-term resource-conserving covers to improve soil, water, and wildlife resources. While this is primarily an agricultural land oriented program, it is not uncommon for the marginal cropland along significant drainages (riparian areas) enrolled in it to be planted in trees, thereby helping establish more forest lands in the state.

The Environmental Quality Incentives Program (EQIP) is designed to protect water quality and the Forestry Incentives Program, which provides cost-share assistance to landowners who plant trees and implement other forest management practices.

The Wildlife Habitat Incentives Program (WHIP) is a voluntary program for landowners who want to develop and improve wildlife habitat on private land. Through WHIP USDA's Natural Resources Conservation Service provides both technical assistance and up to 75 percent cost-share assistance to establish and improve fish and wildlife habitat.

Local Work Groups (LWGs) could evaluate and make recommendations to change current policies/procedures for applicable conservation incentives programs, such as CRP, EQIP, and WHIP and:

- Add “Forests/Forestry” as a resource concern in the EQIP ranking system,
- Include and/or increase the points awarded for tree/shrub planting in the ranking system of other resource concern categories, e.g. soils, water quality, grasslands, air quality, wildlife, etc.,
- Increase the cost-share rate for conservation tree planting practices to provide more incentive for landowners,
- Forward LWG recommendations to the appropriate state sub-committees, e.g. EQIP Subcommittee.

Source: USDA-NRCS 2008b

POTENTIAL PROJECT LOCATIONS: ALL SEGMENTS

OTHER STRATEGIES TO CONSIDER: Pursue an Applicable Easement (BOX 4); Use Existing Programs (BOX 8)

1.1.4 Prevent Competition to Existing Cottonwood Stands

BOX 11
Activity: Protection of Existing Cottonwood Stands
Goal: Prevent Competition to Existing Cottonwood Stands
Technique: **Control and Prevent Domestic Livestock Grazing on Existing Cottonwoods**
<u>Discussion</u>: Livestock grazing has impacted native tree growth, including the consumption of cottonwood seedlings along the river. Seedlings and young trees are browsed by rabbits, deer, and domestic stock. Cottonwood seedlings are preferred forage for cattle, which also trample young plants and compact the soil. Domestic livestock also use cottonwood communities for both forage and cover (they provide shade in summer and thermal cover in the winter). This grazing can inhibit native vegetation regeneration and some areas along the wild and scenic reach in Montana have been subject to excess grazing that has resulted in overbank side channels along range lines (due to cattle trampling). Scott et al. (1997) has observed many cottonwood seedlings that had been damaged by grazing and that recent reproduction of cottonwood is more abundant at sites where cattle have been excluded. It seems likely that grazing has decreased cottonwood establishment and survival. It has been suggested by Scott et al. (1997) that construction and long-term monitoring of livestock exclosures could quantify the impacts of grazing in a study reach. One solution considered includes excluding livestock from riparian areas, referred to as livestock exclosures as noted above. In some cases, such a drastic change may be the most appropriate way to begin recovery. However, total livestock exclusion is not necessary in all cases; Elmore and Beschta (2008) stated that livestock grazing and healthy riparian systems can coexist even during recovery. If managed properly, livestock grazing can actually increase the diversity of floodplain habitats by developing a series of successional vegetative stages. Appropriate grazing techniques and scheduling should be prepared for restoration sites if requested by landowners or land management agencies. As stated by Elmore and Beschta (2008), grazing management provides a major opportunity to improve riparian areas without large expenditures of money. A grazing strategy or grazing management plan for each site is necessary which takes into account both timing and management of cottonwood-dominated riparian areas. This strategy could allow for cottonwood vegetation to rest and regrow during the summer and during the growing season of other upland plants. Congress is currently considering raising livestock grazing fees. Federal and state livestock grazing permits generally are expressed in terms of animal units per area or total animal unit months (AUMs). One AUM is the amount of forage required by an animal unit (AU) for one month. With respect to riparian areas, however, the dollar value of an AUM should not be the issue, but according to Elmore and Beschta (2008), the focus should be on the management of the land. Their thought is that riparian management will not improve just because more is charged for using grazing lands. Members of the livestock industry should be involved in the management of riparian areas, because their buy-in will be required to support changes in grazing strategies and other uses in managed riparian areas. Dialogue should be established between federal and state agencies, ranchers, land managers, environmental groups, and the general public. *Source: SOBTF 2004; Mitchell et al. 2008 ; Bjugstad and Girard 1984; USDA-NRCS 2002; Rood, Braatne, and Hughes 2003; CSP 2005; Scott et al. 1997; Scott et al. 1996.*
POTENTIAL PROJECT LOCATIONS: SEGMENTS 4, 6, 8, 9, 10, and 13

OTHER STRATEGIES TO CONSIDER: Discourage Development Near the River (BOX 1); Land Preservation Education (BOX 26)

BOX 12

Activity: Protection of Existing Cottonwood Stands

Goal: Prevent Competition to Existing Cottonwood Stands

Technique: **Control and Prevent Deer Grazing on Existing Cottonwoods**

Discussion: Both white-tailed deer and mule deer browse on the twigs and foliage of cottonwoods. Anderson and Katz (1993) have demonstrated that deer-browsed forests may take up to 70 years to return to their former state, or may not recover at all. Studies have shown that tree age structures has lacked cottonwood recruitment for more than a century, beginning in the 1880s and continuing to the present, which can be attributable to high levels of browsing, initially by livestock and subsequently by wild ungulates (including deer, moose, and elk), in the absence of large carnivores. This phenomenon is referred to as a trophic cascade, and occurs when the presence of a top predator (carnivore) substantially affects consumer (herbivore) population size or habitat use and then alters producer (plant) abundance distribution. It has been confirmed that ungulate herbivory represents a disturbance regime capable of having major effects on plant communities, including cottonwoods, within the Great Plains. Results from Ripple and Beschta (2007) indicate that Great Plains ecosystems may have been profoundly altered by high levels of herbivory by wild or domestic ungulates after the removal of large carnivores. Therefore, deer exclosures or increased hunting efforts should be considered to control deer browsing on young cottonwoods. Anderson and Katz (1993) have also demonstrated encouraging results from deer exclosures; the control of deer herds by increased hunting efforts have also shown favorable results to forest vegetation.

Example Project: On portions of Segment 4 in North Dakota, deer browsing of woody seedlings and saplings in the forest understory appears to be substantial. At this location, deer exclosures appear to have been effective for facilitating green ash (*Fraxinus pennsylvanica*) recruitment within mature cottonwood forests at The Nature Conservancy's Cross Ranch (Dixon, Johnson, Scott, personal observation 2007). Additionally, it has been observed that the impact of deer on cottonwoods appears to be age-dependent and that cottonwoods less than 25 years old are targeted by browsing deer. It has also been observed that deer browsing is less of an issue on public lands.

Source: USDA-NRCS 2002; Anderson and Katz 1993; Gubanyi et al. 2008; Ripple and Beschta 2007

POTENTIAL PROJECT LOCATIONS: SEGMENTS 4, 6, 8, 9, 10, and 13

OTHER STRATEGIES TO CONSIDER: Land Preservation Education (BOX 26)

1.1.5 Reduce Mortality to Existing Cottonwood Stands

BOX 13

Activity: Protection of Existing Cottonwood Stands

Goal: Reduce Mortality to Existing Cottonwood Stands

Technique: **Conservation of Surface Water and Alluvial Groundwater to Maintain Existing Cottonwoods**

Discussion*:* Johnson et al. (1976) hypothesized that past flooding and a high water table have been jointly responsible for the development of extensive forest vegetation on the floodplain along the Missouri River in North Dakota. The additional soil moisture and nutrient-rich silt provided periodically from floods may have been essential for roots to grow and reach the capillary fringe of the water table. Although most of the larger trees probably obtain supplemental subsurface moisture, the present surface soil conditions are more xeric (dries) in the absence of flooding (during the post-reservoir period) and may contribute to higher cottonwood seedling-sapling mortality. The forested ecosystems on the floodplain have developed historically under the influence of floods; therefore, it is not surprising that structural and compositional changes follow the elimination of floods as a major environmental factor. Several observations have been made that suggest less subsurface moisture during the post-reservoir period. Flow has been reduced by high evaporative losses from the reservoir surface and the increasing use of local aquifers for pumped irrigation water may have directly contributed to a lowering of the saturated zone. Additionally, a higher saturated zone during the post-reservoir period is not expected.

Declines in cottonwood forest cover have been observed where severe drought or land and water management activities have decreased water availability by reducing surface flows or depleting alluvial groundwater aquifers. Human activities can directly or indirectly influence alluvial groundwater sources and include damming and diversion of rivers and streams, groundwater pumping, and channel incision resulting from altered flows of water and sediments, bank stabilization, and in-stream gravel mining. For example, some perennial streams have turned intermittent as a result of groundwater pumping in aquifers, flow depletion along the rivers has been associated with loss of riparian trees, and large areas of riparian forest have been lost to groundwater pumping and associated flow depletion in the southwestern United States (Stromberg 1993).

Therefore, depletions of surface and shallow alluvial groundwater have contributed to the loss, fragmentation, or severe ecological impairment of riparian corridors, including impacts to cottonwoods. Cottonwoods are the most abundant trees of riparian ecosystems throughout arid and semiarid regions of North America and cottonwood-dominated stands provide unique structural habitat and are vulnerable to reductions in surface and groundwater availability. Efforts to minimize the loss of riparian cottonwoods require an integrated understanding of the role of surface and groundwater dynamics in the maintenance of existing cottonwood stands. Developing quantitative information on the timing and extent of morphological responses and mortality of cottonwoods to the rate, depth, and duration of water table declines can assist in the design of management prescriptions to minimize impacts of alluvial groundwater depletion on existing riparian cottonwood forests.

Source: Scott et al. 1999; Stromberg 1993; Johnson et al. 1976

POTENTIAL PROJECT LOCATIONS: Segments 4, 6, 8, 10, and 13

OTHER STRATEGIES TO CONSIDER: Eliminate Structural Limitations Along the River (BOX 17); Encourage Irrigation Water Management Plans to Benefit Cottonwood Stands (BOX 27)

2.1. Restoration of Hydrologic and Geomorphic Processes for Cottonwood Regeneration

The following Restoration of Hydrologic and Geomorphic Processes for Cottonwood Regeneration are discussed in this Section:

- **Section 2.1.1 Create Fluvial Processes Suitable for Cottonwood Establishment:**
  - Create Side Channels, Reconnect Old Oxbow Lakes and Establish Backwater Areas
  - Allow or Create In-Channel Sandbars to Naturally Revegetate with Cottonwoods
- **Section 2.1.2 Floodplain Activities:**
  - Lower the Bench
  - Eliminate Structural Limitations Along the River

2.1.1. Create Fluvial Processes Suitable for Cottonwood Establishment

BOX 14

Feature: Restoration of Hydrologic and Geomorphic Processes for Cottonwood Regeneration

Goal: Create Fluvial Processes Suitable for Cottonwood Establishment

Technique: **Create Side Channels, Reconnect Old Oxbow Lakes and Establish Backwater Areas**

Discussion: Degradation of the river channel disconnects the river channel from its floodplain. Channel degradation not only makes it more difficult for the river to overflow its banks, but it also affects the floodplain water table. When the water table is lowered, it effectively drains water from oxbow lakes, wetlands, and other important features and may cause stress to cottonwood trees through a declining water table. However, oxbows, old meander bends and old channel remnants could be reconnected to the river using high flow side channels, secondary channels, or pilot channels through river realignment. Reconnecting side channels, oxbow lakes, and backwater areas can be done more efficiently and effectively in places where the top-width of the river is being increased. The top-width of the river would be increased in locations where sloughing easements are appropriate as well as where the following structures would be altered as discussed in BOX 17, 1.) remove riprap and bank stabilization structures, 2.) set back levee, and 3.) create dike notches. Broadening the dimensions of the erosion zone, or the "top-width" increases floodwater storage capacity of the floodplain.

An oxbow lake is a crescent-shaped or u-shaped waterbody located adjacent to a stream or river that is formed when a wide meander from the mainstem of a river is cut off to create a lake. An oxbow lake is created over time as erosion and deposits of soil change the course of the river. These historic floodplain features are important wetlands or marsh areas for wildlife habitat and native vegetation regeneration. Side channels and backwater areas provide slower-moving waters critical for the reproduction, shelter, and feeding of fish species as well as the recruitment of cottonwood stands. Existing side channels and backwater areas of the Missouri River have been greatly reduced, thereby eliminating important habitat. The water, sediment, and nutrients previously spread across the floodplain by overbank flows and the meandering river are now primarily restricted to the main channel or contained in the system's reservoirs. Areas within the current trench of the Missouri River have opportunities for side channels, side chutes, backwater areas, and oxbow lakes to reinundate with water and regenerate cottonwoods. These secondary channels are companion channels to the main river channel. These channels would convey flow at less than bankfull discharge, but would not necessarily be wet at low flows. If reconnected as part of the existing channel system, these areas could be designed to provide slack water or slow velocity habitat for fisheries and cottonwood establishment. These features would lengthen the channel, increase sinuosity and create a more dynamic river with increased habitat diversity.

In order to enhance the hydrologic connectivity of the river and floodplain and to create processes suitable for cottonwood establishment, oxbow lakes could be reconnected, existing side channels could be enhanced or new overbank side channels could be created that would flood at high flows. The side channels could then flood backwater or wetland areas and provide low velocity flows through the floodplain at higher discharges. The channels could be limited in length and would only be flowing as the river approached bankfull discharge. The side channels could terminate in wetland areas and flooded bottomlands or they could be reconnected to the river downstream. The new backwater habitat would provide slower velocity areas for aquatic and terrestrial species and increase the potential for native species regeneration. Secondary channel construction may involve re-opening old channels, reconnecting old oxbow lakes, or abandoned meander bends or excavating a new channel across a floodplain terrace. The purpose of the secondary channel would be to create a wider channel and island complex. This measure could therefore include construction activities such as floodplain vegetation removal (non-cottonwood species) and side channel excavation through the bank. Disposal of the excess excavated material in the channel or in a location where it could be removed by the river may be preferred, but sediment transport studies are highly suggested. Excavated material could also be used to create or enhance point bars within the river. (BOX 15)

Example Project: Along the Missouri River, Jacobson (2006) has found that during periods of high-river flow, excavated side-channel chutes (designed to provide more shallow-water habitat in the Missouri River floodplains to promote the recovery of native and endangered aquatic species) can recharge ground water and enhance cottonwood growth. Cottonwood growth was found to be higher in plots closer to the river or side-channel chute. In the case of side-channel chute alignments, recognition of locations, sediment characteristics, and thickness of channel-fill allounits (a mapping measurement unit derived from allostratigraphic techniques) could provide useful information for alignments and channel dimensions. In order to implement this measure, Jacobson (2006) has suggested that surficial alluvium maps could help depict the spatial distribution of sediments with a wide range of potential for inundation, and for transmitting and retaining water. Recognition of the characteristics and spatial patterns of these sediment units could be useful in design of wetlands and alignments of side-channel chutes.

Source: SOBTF 2004; NRC 2002; Jacobson 2006

POTENTIAL PROJECT LOCATIONS: The Missouri River has been channelized downstream of Gavins Point Dam, from Sioux City, Iowa to its mouth. Historic chutes and side channels have been blocked and diverted, converting the once structurally-complex channels and in-stream islands into a single thread of deep, fast moving water.

OTHER STRATEGIES TO CONSIDER: Discourage Development Near the River (BOX 1); Eliminate Structural Limitations Along the River (BOX 17)

BOX 15

Feature: Restoration of Hydrologic and Geomorphic Processes for Cottonwood Regeneration

Goal: Create Fluvial Processes Suitable for Cottonwood Establishment

Technique: **Allow or Create In-Channel Sandbars to Naturally Revegetate with Cottonwoods**

Discussion: Cottonwoods are common in pure stands on stream bottomland habitat such as mid-channel island sandbars and sidebars. Allowing in-channel sandbars to naturally revegetate with cottonwoods or creating sandbar habitat to accelerate cottonwood establishment could occur as part of this technique. A component of the Missouri River Recovery Program being undertaken by the Corps is the Emergent Sandbar Habitat (ESH) Program, which builds sandbars for federally listed Threatened and Endangered (T&E) species such as the least tern and piping plover. These species prefer sparsely vegetated sandbar habitat versus sandbars populated by cottonwoods or other riparian species. Some piping plovers have been seen to nest among cottonwood saplings (McGowan et al 2007). The Corps is creating and maintaining sandbars by mechanically building new areas, by clearing existing sandbars of vegetation, or modifying river flows during the year. Over the past two years, the Corps have created more than 800 acres of emergent sandbar habitat, mostly by vegetation removal. Given the types of sites used by cottonwoods for recruitment, the ESH Program could be negatively affecting cottonwood regeneration on sandbar habitat. Therefore, the direct competition for resources among T&E species under the BiOp should be avoided. A specific avoidance buffer of 300-m (~984 ft) can be used to eliminate potential restoration sites along the river near the least tern and piping plover habitats can be employed, and sandbars in the river could be omitted entirely; restoration/preservation measures could be targeted along the banks outside of the avoidance zones. Adjacency to mainland, including sidebars, may be beneficial from a constructability standpoint and may not be useful to least terns and piping plover, who prefer more isolated mid-channel sandbar islands. Many mid-channel sandbars are also more highly dynamic and planting efforts may be lost more frequently. Coordination between the Cottonwood Management Team and the ESH Program should be initiated and maintained throughout the planning and implementation stages of both activities to reduce any negative effects, since both the Plan and the ESH Program are part of the larger Missouri River Recovery Program.

Source: Burns et al. 1990; USACE-Omaha 2007

POTENTIAL PROJECT LOCATIONS: Segment 4,6,8,9,10, and 13

OTHER STRATEGIES TO CONSIDER: None

2.1.2. Floodplain Activities

BOX 16
Feature: Restoration of Hydrologic and Geomorphic Processes for Cottonwood Regeneration
Goal: Floodplain Activities
Technique: **Lower the Bench**
<u>Discussion</u>: Pre-dam pioneer communities such as cottonwoods developed on relatively low river benches. Periodic floods deposited sediment on these benches, raising their elevation (referred to as aggradation). Thus, in the early stages of development these communities had a large proportion of facultative wetland plant species (plant species found in wetlands 67 to 99 percent of the time) in the young forest understory, which slowly declined as benches became elevated from the water table and were flooded less frequently. Currently, most sites potentially available for planting are on relatively high benches (Johnson 1992). Flooding has been eliminated on benches greater than 2 meters above mean river level, which has decreased the moisture available to floodplain ecosystems at the initial stages of the growing season as described by Johnson et al. (1982). The restoration activity proposed as part of this measure would expand the active floodplain by providing lower benches along the river. This could entail excavation of large areas of the floodplain with large construction equipment such as bulldozers and graders. To hydrologically reconnect streams and adjacent floodplains, gentle slopes would be created alongside streams or reservoirs. Cottonwoods would be planted in seedling safe sites, or natural recruitment would be allowed to occur on low, mineral-rich surfaces created by lowering the benches. Seedling safe sites are survivable locations with appropriate elevation relative to water, 0.6 to 2.8m (1.97 to 9.19ft) above base-stage, although specific elevation ranges will depend on the flow regime, sediment texture, and state-discharge relationships on the actual river segment and site location). The new growth would ultimately be able to absorb and then slowly release the flood waters to mimic the hydrology of an intact riparian ecosystem. This would also hold the soil in place. The lowered terraces would be inundated more frequently, increasing river-floodplain hydraulic connectivity, regenerating cottonwoods and other native vegetation, and improving slow velocity refuge for aquatic organisms at high discharges. Terrace lowering may require detailed analyses to ensure that flood control facilities are not compromised. This restoration activity could be accomplished in conjunction with other described techniques. *Source: SOBTF 2004; CSP 2005; Polzin and Rood 2006; Johnson et al. 1982; Johnson 1992*
POTENTIAL PROJECT LOCATIONS: ALL SEGMENTS
OTHER STRATEGIES TO CONSIDER: Pursue an Applicable Easement (BOX 4); Eliminate Structural Limitations Along the River (BOX 17); Disk Land for Cottonwood Habitat (BOX 22)

BOX 17

Feature: Restoration of Hydrologic and Geomorphic Processes for Cottonwood Regeneration

Goal: Floodplain Activities

Technique: **Eliminate Structural Limitations Along the River**

Discussion: Many changes in the Missouri River ecosystem jeopardize its fundamental natural processes, including the extensive bank stabilization and stream channelization that has occurred along the river (NRC 2002). Structural alterations, including the straightening of channels, bank stabilization, and construction of wing dams, were designed to constrict flows to the main channel and to prohibit channel meandering. Rock bank stabilization (referred to as riprap in some cases) has been applied selectively to reduce bank sloughing along the Missouri River. Additionally, levees have been constructed on both banks along much of the lower Missouri River to protect crops and settlements behind them; these levees constrain overbank flows to a narrow zone of the floodplain. The partial removal or elimination of structural limitations along the river is an important measure that should be considered to allow river meandering processes to occur and would increase the top-width of the river in select locations. Study results in Polzin and Rood (2006) have revealed that the flood-induced channel migration and abrupt avulsion (separation of a piece of land by a change in the course of the river) creates extensive barren nursery sites for cottonwood seedling establishment. If sufficient channel meandering is allowed through elimination of structural limitations (and flow pulses are allowed which emulate the natural hydrograph), cut-and-fill alluviation would occur as well; river meandering cannot occur without the cutting of one bank and the deposition, or fill of the opposite bank (referred to as cut-and fill alluviation). Restoring some degree of natural river-based processes, like flooding and cut-and-fill alluviation is essential to promote improved ecological conditions, including preserving existing floodplains and creating new floodplains for cottonwood establishment. In addition to flow, river meandering and sediment transport processes should be considered as well, since they are the key to understanding the spatial and temporal variability of cut-and-fill alluviation processes and sustain the ecological health of the river system. It is important to note that the measures described in this box should also be combined with sloughing easements, as described in BOX 4.

The following should be considered: 1.) remove riprap and bank stabilization along the river and prevent new riprap placed along the river, 2.) levee setbacks, and 3.) create dike notches. These suggestions are discussed in more detail in the paragraphs below.

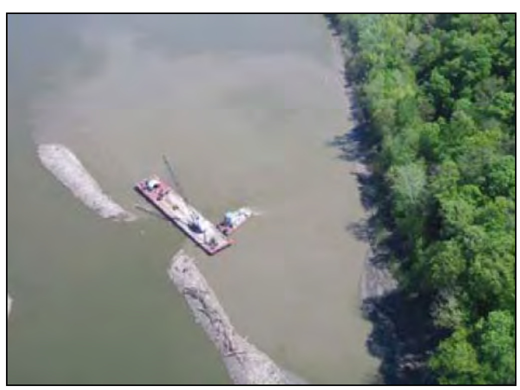
Bank stabilization structures such as riprap could be removed along portions of the river; following removal, some of these banks may require reshaping, such as creating flatter, less erosive slopes, and widening the radius-of-curvature or tightness of the meander bend to reduce the bank erosion and meander migration rates within an affected reach. Additionally, existing riprap located along the shoreline of the Missouri River could be removed and re-stabilized with bioengineering bank stabilization materials, such as installing live cottonwood stakes (i.e. unrooted cuttings). Therefore, it is anticipated that some reworking of the river banks could occur in specified reaches, but in some reaches, removing riprap to initiate bank erosion could be an effective method to create a more dynamic channel, and detailed bank shaping may not be necessary. The removal of structural limitations would create unconstrained corridors that provide room for the river to meander in an erosion zone that is integral to promoting cottonwood establishment. The placement of new riprap along the river should be discouraged to allow channel meandering. Meanders create point bars after moderate or higher peak flows and following flood deposition; river meandering is necessary to maintain extensive cottonwood and willow communities on the floodplain (Johnson 1992). The flood training of young cottonwoods is common on these point bars and allows for the establishment of mature trees often below current ground surface and near channel bed elevation.

Levees restrict the river to only a small portion of its total floodplain, except if the levees are breached during rare floods, as occurred in Iatan, MO during the summer of 2008. Overall, the levee system has reduced interaction between the river channel and its floodplain, resulting in the inability of the river to sustain its historic levels of biodiversity. However, it is possible that the land riverward of the federal levees could be available for seasonal flooding each year, or that the levees could be set back or notches could be constructed in flood-control levees to allow for some overbank flooding. Previous and current restoration in the lower Missouri River in Iowa, Kansas, Missouri and Nebraska, has aimed to restore some of the changes that were made to maintain navigation on the river. Restoration has included eliminating and moving some levees to open up shoreline for wetlands, river-bottom hardwood forests and prairies, as well as widening the river's channel by creating pilot channels, chutes, and notches into the riverbank and the levee.

To create a dike notch, a 50-foot cut (or similar size, depending on project needs), or partial opening is made in the dikes which are described as wood piling and/or rock structures that jut out into the water almost perpendicular to the river flow. This measure could also include creating pilot channels in bank revetments. Bank revetments are rock structures parallel to and at the river's edge that were originally constructed with open water landward of the revetment. However, subsequent sediment deposition filled in these areas. With this method, a small river channel is excavated landward of the revetment, which is then connected to the river by notches excavated in the revetments. The pilot channels could be up to 100 feet away from the river and 1,000 feet long. The result would include increased acres of aquatic habitat that are highly diverse and complex. Additionally, a chute would be created where conditions are favorable and a percentage of the flow can be captured without affecting the navigation channel. Chutes can be from a few hundred yards to a mile in length and would create an island on the riverside of the chute that could increase the amount and diversity of aquatic habitat available.

Example projects: A project located at the confluence of the Ohio and Mississippi Rivers (RM 951-953) involves notching a series of newly created dikes near their junction with the mainland. The purpose is to encourage erosion/scour of the accreted sand immediately below each notch. Over time, it is anticipated that the scour patterns would eventually connect, forming a secondary channel isolating the sandbar from the existing main bank.

Bank Notch



Dike Notch

Source: NRC 2002; CCM 2008; Remus 2008 (photos) ; Johnson 1992 ; ISG 1996 ; Gonser et al. 2006 ; Scott et al. 1997
POTENTIAL PROJECT LOCATIONS: ALL SEGMENTS
OTHER STRATEGIES TO CONSIDER: Pursue an Applicable Easement (BOX 4)

3.1 Artificial Propagation of Cottonwoods

Following is a description of the proposed Artificial Propagation of Cottonwoods, applicable practices that could be considered following planting techniques are described.

The following methods for Artificial Propagation of Cottonwoods are discussed in this Section:

- **Section 3.1.1 Plant or Propagate New Cottonwood Stands:**
  - Harvest Cottonwood Seeds
  - Plant Cottonwood Seeds
  - Plant Rooted Cottonwood Seedlings/Saplings
  - Plant Small Unrooted Cottonwood Cuttings (Live Stakes)
  - Disk Land for Cottonwood Habitat
- **Section 3.1.2 Protect New Cottonwood Stands:**
  - Remove and Control Invasive Vegetation
  - Control and Prevent Rodent and Ungulate Herbivory to Existing Cottonwoods
  - Maintain Plantings through Short-Term and Long-Term Management

3.1.1 Plant New Cottonwood Stands

BOX 18
Activity: Artificial Propagation of Cottonwoods
Goal: Plant or Propagate New Cottonwood Stands
Technique: **Harvest Cottonwood Seeds**
Discussion: Braatne et al. (1996) has found that cottonwood flowering and seed release is partially determined by photoperiod (the amount of hours in a day that cottonwoods are exposed to light and dark environments). Temperature patterns also influence the duration of seed drop, which usually occurs over a two-month period, although the bulk of seed dispersal normally occurs over a shorter period. Seed production normally begins when cottonwoods are 5 to 10 years old, increasing rapidly in amount as the trees become older and larger. Seed dispersal is characterized by considerable variation among trees as well as a lengthy dispersal period for some individual trees. Seed dispersal occurs from May through mid-July in the South and from June through mid-July in the North as the spring flood waters recede. It has been estimated by Kapusta (1972) that mature female cottonwoods can produce hundreds of thousands (or more) of seeds, although viability of the seeds has been determined by Braatne et al. (1996) as lasting from a 1 to 4 week period, but less if the seeds have been exposed to water. Seed release generally occurs after peak flows and during the falling limb of the hydrograph as demonstrated by Rood and Mahoney (1998). Therefore, the harvesting of cottonwood seeds for planting will occur during a small window in the spring-summer timeframe, depending on local and regional conditions. Cottonwood seeds can be collected using a variety of methods, which are dependent on site conditions. Because cottonwood and willow seeds are reported to be viable for only 1-5 weeks after maturity, depending on conditions (Stromberg 1993), seeds should be collected directly from the trees and not from ground litter. Where trees could be easily accessed, such as near roads, they can be collected using a dry-vacuum system equipped with an extended piece of PVC pipe to reach high branches and connected to a small gas generator. Seeds can be vacuumed into mesh or cotton laundry bags placed inside of the dry-vacuum bucket. If trees are not easily accessible, a long pruning pole can be used to cut small seed laden branches directly from the trees. Seeds and/or seed pods can then be either stripped from the branches, or small branches can be left intact with seeds still on them. All seeds and branches should be transported and stored (in cloth bags) either outdoors in the shade or indoors and placed on racks to allow air movement and prevent mold and mildew. Example project: A pilot habitat restoration program was conducted at Beale Lake in AZ using different types of cottonwood seeding techniques and the results are presented in U.S. Department of the Interior (USDOI) (2005); note that this project was located along the Lower Colorado River and that *Populus fremontii* was the study species in this location. *Source: USDOI 2005; Stromberg 1993; Braatne et al. 1996; Mahoney and Rood 1998; Kapustka 1972; Van Haverbeke 2008*
POTENTIAL PROJECT LOCATIONS: ALL SEGMENTS
OTHER STRATEGIES TO CONSIDER: Plant Cottonwood Seeds (BOX 19)

BOX 19

Activity: Artificial Propagation of Cottonwoods

Goal: Plant or Propagate New Cottonwood Stands

Technique: **Plant Cottonwood Seeds**

Discussion: Cottonwood seeds could be sown by hand, sprayed with a mixture and hydroseeded, or seed-laden branches could be placed on appropriate locations for cottonwood establishment. Cottonwood seeds require a very moist site to achieve good germination, normally achieved on sites that are flooded with germination taking place as the water recedes. The site could be flooded prior to planting, but irrigation is normally necessary as well as fencing following establishment. Seeds could also be collected from a site and then grown in a nursery prior to planting. These nursery grown seedlings have the potential to increase genetic diversity within the site and have generally shown a lower mortality rate than live staking. However, seedlings require longer periods of watering and care. Some studies conducted by the USDOI (2005) have shown that the highest number of cottonwood seedlings dispersed at a restoration site emerge from a [seed + mulch + fertilizer + tackifier] treatment and that the number of established seedlings decrease as distance from an irrigation valve increases. The [seed + mulch + fertilizer + tackifier] treatment included the following: water, mulch (pure wood fiber mulch (35 lb per 1000 gallons water), tackifier for adhesion (1 lb per 1000 gallons water), fertilizer (16 percent N, 20 percent Phosphate, 13 percent Sulfur; 5 lb per 1000 gallons water;) and seed which was sprayed onto a wet field that had been previously disked.

Seed-laden branches could also be cut and placed directly on a site with wet soil to allow for gradual wind dispersal of the seeds over the fields. Loose seed collected by stripping seed and pods from branches could also be dispersed by hand onto either wet soil or the water surface of flooded fields. Some tests conducted by USDOI (2005) have indicated that seeds stored while still on the branches until dispersed may have a longer *shelf-life* than seeds stripped from branches and then stored because this method allows the seeds to remain on the branch until they dry and disperse naturally. The drying of the soil surface could cause low survival and densities of seedlings and the storage conditions of seeds as well as the time of harvest are other important factors to consider. Seeds that are properly dried after collection have greater longevity and germination rates than those exposed to humid conditions during storage. In addition, keeping high numbers of seeds in place and evenly distributed well past germination should lead to high densities of seedlings and less infestation of weeds.

Example project: Beale Lake Habitat Restoration - results of pilot study of cottonwood plantings:

- Seed pods collected green but known to have opened prior to testing; no ripe pods observed on tree (56-58 percent germinated)
- Very green pods, unopened at the time of collection, may or may not have opened prior to testing (78 percent viable); no ripe pods observed on tree (78 percent germinated)
- Seed pods opened slightly and/or at least one pod open on the cluster when collected (98 percent viable and 58-98 percent germinated)
- Seeds collected either as "fluff"; pods completely opened and dispersing from tree (90 percent viable and 58-98 percent germinated).
- Seed pods collected were brown, pods shells dry, some fluffy seed still present (87 percent viable and 87 percent germinated).

Source: USDOI 2005; CSP 2005

POTENTIAL PROJECT LOCATIONS: ALL SEGMENTS
OTHER STRATEGIES TO CONSIDER: Harvest Cottonwood Seeds (BOX 18); Maintain Plantings through Short-Term and Long-Term Management (BOX 25)

BOX 20

Activity: Artificial Propagation of Cottonwoods

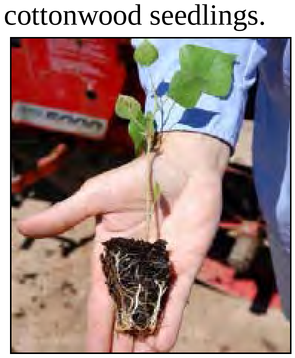
Goal: Plant or Propagate New Cottonwood Stands

Technique: **Plant Rooted Cottonwood Seedlings (A) / Saplings (B)**

Discussion: Rooted cottonwood seedlings or saplings could either be produced from seed or from cuttings (live stakes). Plant material consisting of small (<4-inch diameter) dormant poles would be collected. The cuttings would be soaked in a weak bleach solution to reduce the chances of disease. Then, cuttings would be reduced in size to approximately 3 inches in length, treated with a rooting hormone, and then placed in trays with individual cells filled with a soil medium. The trays/cells are designed to hold the cuttings and to increase their root growth until they are removed for planting in the field. The trays of cuttings would be placed in a greenhouse, and then eventually outdoors. Seedling size material (1-2 foot height) could likely remain in the trays, while sapling size material (2-5 foot height) would need to be transferred one or more times to large 1-2 gallon size containers. Prior to planting, the site would be disked and laser-leveled (if necessary). Cottonwoods in 1-gallon containers could be planted in appropriate locations using a two-seated tree planter pulled behind a tractor or a commercially available tomato planter, although the planter may need to be calibrated to handle larger cottonwood plantings. Larger containerized cottonwoods would need to be planted by hand. Another planting option includes using a small hand auger that is powered by a chainsaw motor and can be operated by a single person. Flood irrigation could be started immediately after planting to keep the root ball moist and then irrigated every 3 days for the first 4 weeks and then once a week. Based on documented studies, container plants grown in nurseries from cuttings started in December through January are typically ready for planting as seedling sized material beginning in mid-April, but can be later, depending on weather conditions. It may take 2 or more seasons of growing for trees to reach the sapling stage.

Example project: A pilot habitat restoration program was conducted at Beale Lake in AZ using different types of cottonwood seeding techniques and the results are presented in USDOI (2005); it is important to keep in mind that this project was located along the Lower Colorado River and that *Populus fremontii* was the study species in this location. This project noted that the level of plant dormancy during collection, climate control of plants in the greenhouse, level of field preparation, and temperature during the planting period significantly altered the survivability of transplanted cottonwood seedlings.





Source: USDOI 2007 (text and photos)

POTENTIAL PROJECT LOCATIONS: ALL SEGMENTS

OTHER STRATEGIES TO CONSIDER: Discourage Development Near the River (BOX 1); Plant Small Unrooted Cottonwood Cuttings (Live Stakes) (BOX 21); Maintain Plantings through Short-Term and

Long-Term Management (BOX 25)

BOX 21

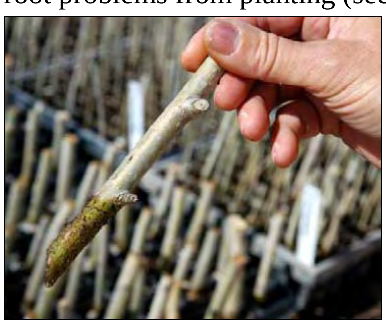
Activity: Artificial Propagation of Cottonwoods

Goal: Plant or Propagate New Cottonwood Stands

Technique: **Plant Small Unrooted Cottonwood Cuttings (Live Stakes)**

Discussion: Unrooted cottonwood cuttings (live stakes) could be used to plant new cottonwood stands and could be obtained either commercially, or from native stands at local sites. Propagation by planting clonal cuttings results in rapid initial growth, but may reduce genetic diversity in the stand if cuttings are taken from only one tree source. Assuming a good supply of cottonwood stakes can be found, this could be the most successful and the least expensive method available to grow cottonwoods. It is imperative to plan for appropriate irrigation, and if needed, fencing around the trees for protection to ensure survival of the stakes.

Dormant cuttings from cottonwood readily sprout if placed directly into wet soil or to the water table. Cuttings should be taken after the source trees become dormant and prior to leaf budding (estimated to be from March to April) from stems at least 2 years old (lower branches trimmed as needed) and should be at least ¾ inches in diameter, but diameters from 2 to 3 inches have the highest survival rates according to USDA-NRCS (1993). Cuttings from young recent sprouts should be avoided as hormones for proper root and leaf development may be lacking. The identification of the top of the cutting (versus the bottom) should be distinguished to ensure proper and upright planting of the cutting. Cut ends would be dipped into a fungicide and root stimulant (B vitamin) solution and then planted into 6" diameter 2 1/2-ft long sections of PVC pipe filled with sandy soil and vermiculite mixture. One or more internodes should be buried into the soil so that root formation can occur. Long sections of PVC pipe encourages vertical root formation. The bottom end of the pipes would be partially sealed with duct tape. These PVC containers would be placed in a sunny location and watered. If feasible, a trench could be dug for the cuttings, which would allow watering from the trench to encourage proper root formation. If irrigated, results with poles are typically equal to using rooted container plants. Cuttings should be well watered until root growth is observed at which time watering would decrease. Rooted cuttings could also be surrounded by fenced exclosures to protect cuttings from herbivory by wildlife. Plantings should be monitored and maintained as necessary. Until plants are fully established, maintenance could include weeding, watering, and fence repair. If unrooted cutting are planted in PVC pipes, the pipe should be removed at a future date. Plants with long roots will be hard to plant and care will be required to avoid root problems from planting (see photo below).



Source: USDA-NRCS 1993; Williams 1997; Rood and Mahoney 1990; USDOI 2007 (text and photo)

POTENTIAL PROJECT LOCATIONS: ALL SEGMENTS

OTHER STRATEGIES TO CONSIDER: Plant Rooted Cottonwood Seedlings/Saplings (BOX 20);

Maintain Plantings through Short-Term and Long-Term Management (BOX 25)

BOX 22

Activity: Artificial Propagation of Cottonwoods

Goal: Plant or Propagate New Cottonwood Stands

Technique: **Disk Land for Cottonwood Habitat**

Discussion: Prior to planting a site with cottonwoods, the land has to be prepared which may include disking the land and/or removing weeds at the site. The term disking generally refers to the mechanical breaking up or loosening of the surface of the soil. Land is normally disked prior to planting; in heavily compacted sites the soil is normally mechanically disked or raked to restore productivity. A tractor is used to pull the disk across the land. Disking land is an activity that can renew natural functions to benefit riparian and floodplain habitat. Disking land adjacent to existing cottonwood stands could be considered to create early, successional cottonwood habitat, if suitable moisture conditions occur there. Once an appropriate site is identified for disking, all existing vegetation would be eliminated (no cottonwood removal). The most cost effective method to remove vegetation is to use chemicals such as Roundup® to kill the existing vegetation prior to disking; Roundup® will not kill cottonwood as long as the chemical is not applied directly to the cottonwood tree. After the vegetation is removed, the land would be disked, and then either planted with cottonwood seedlings, or the site would be allowed to naturally recruit cottonwood seedlings. Disking land on lower benches adjacent to young, existing cottonwood forests would be most useful. On these sites, irrigation for seedlings may not be necessary because existing natural hydrology at the chosen site would be conducive for cottonwood growth. On higher beaches that do not flood and in other situations, irrigation would likely be required to enable seedling establishment and survival.

Example Project: At the Fort Peck Reservation, a site was prepared for cottonwood restoration. The site was removed of weeds with an application of Roundup and was irrigated during the period when local cottonwoods produced seed.

Source: Nemec 2009

POTENTIAL PROJECT LOCATIONS: ALL SEGMENTS

OTHER STRATEGIES TO CONSIDER: Lower the Bench (BOX 16); Maintain Plantings through Short-Term and Long-Term Management (BOX 25)

3.1.2 Protect New Cottonwood Stands

BOX 23
Activity: Artificial Propagation of Cottonwoods
Goal: Protect New Cottonwood Stands
Technique: **Remove and Control Invasive Vegetation**
Discussion: An invasive species is defined as a non-native or exotic species whose introduction does or is likely to cause economic or environmental harm or harm to human, animal, or plant health (NISC 2006). In this case, invasive species can affect the recruitment of cottonwood species, and have less of an impact on established cottonwood communities. Species such as Russian-olive and salt cedar have invaded many riparian woodlands across the Great Plains and southwestern United States dominated by cottonwoods and willows. From Bhattacharjee (2005), analyses of competition between cottonwood and salt cedar seedlings have revealed higher competitive abilities of cottonwoods over salt cedar. Competitive superiority of cottonwood seedlings over saltcedar suggests that while the two species recruit simultaneously, if conditions favorable for the growth and survival of cottonwood seedlings are provided in restoration areas, it will be possible to revegetate degraded areas with cottonwoods in a short period of time. As seedlings, cottonwoods are larger than saltcedar seedlings of the same age. This provides cottonwood seedlings with greater competitive advantage. Therefore, for successful restoration of cottonwoods in riparian areas, it is important to provide adequate soil moisture to the newly recruited seedlings. This can be achieved by using a slow water drawdown of 2 cm/day (0.8 inches/day). At this rate of water drawdown, cottonwood seedlings survive better and the density of seedlings recruited is optimum. Eastern red cedar, a native facultative upland species, has greatly increased in abundance in the understory of cottonwood forests along some reaches of the Missouri and other regulated rivers in the Midwest. Dominance by invasive plant species, and especially by species more characteristic of rarely flooded terraces or uplands or that are more drought tolerant and less flood tolerant than cottonwood, may be a symptom of hydrologic alterations (flood control, channel incision, flow stabilization) that better favor those species than cottonwood. Negative effects of invasive species on cottonwood forests may occur through the following mechanisms: (1) seedling/sapling competition on early successional natural or planted recruitment sites, particularly when streamflows or groundwater levels are marginal for cottonwood; (2) pre-emption (arriving and growing first) of open sandbar sites where cottonwoods could recruit naturally or be planted; (3) dense native or exotic undergrowth may provide fuel ladders for spread of crown fire on regulated river reaches where woody fuels accumulate in the floodplain; and (4) dense undergrowth of woody exotic/invasive species may reduce recruitment of native later successional tree and shrub species and reduce cover and diversity of native herbaceous species. Removal and control of invasive vegetation is likely to be most important during active planting programs to reestablish cottonwood forests, or to prepare overgrown, early successional sites for cottonwood planting or for natural recruitment via flooding. Removal of invasives within established cottonwood forests may also be useful to increase the diversity and cover of native understory herbaceous vegetation and shrubs, and to encourage recruitment of native later successional species, such as green ash and elm species. To increase the effectiveness, the removal of invasive species or other vegetation on low-lying accretion ground should be combined with cottonwood planting and/or timed with high flow events during the cottonwood seed dispersal period. Exotic vegetation control could occur with herbicide

treatments, ground crews, heavy equipment or a combination of these techniques, but each project site would require an individual evaluation to determine the most effective exotic vegetation control method(s). The following plant species have been listed as problem species for the natural or artificial propagation of cottonwoods along the Missouri River:

- Salt Cedar (*Tamarix* spp.)
- Eastern Red Cedar (*Juniperus virginiana*)
- Russian Olive (*Elaeagnus angustifolia*)
- Purple Loosestrife (*Lythrum salicaria*)
- Smooth Bromegrass (*Bromus inermis*)
- Canada Thistle (*Cirsium arvense*)
- Reed Canary Grass (*Phalaris arundinacea*)
- Common Reed Grass (*Phragmites australis*)
- Common Buckthorn (*Rhamnus cathartica*)
- White Mulberry (*Morus alba*)

Exotic and/or invasive plant species control is a very important aspect of the plan, as the individual projects may fail as invasive species tend to increase almost exponentially in disturbed areas and should be controlled before, during and after all riparian restoration projects have been implemented. Stromberg (2007) has noted that restoration efforts that emphasize plant species removal run two risks: 1.) because the 'target' species may be less well adapted to the current conditions than the introduced species, they may be less likely to sustain themselves over the long term and 2.) if the root causes of the riparian vegetation change are not addressed, restoration goals may not be met.

Source: CSP 2005; Mark Dixon Pers. Comm. 2007; NISC 2006; Stromberg 2007

POTENTIAL PROJECT LOCATIONS: Segments 4, 6, 8, 9, 10, and 13,where applicable

OTHER STRATEGIES TO CONSIDER: Maintain Plantings through Short-Term and Long-Term Management (BOX 25)

BOX 24
Activity: Artificial Propagation of Cottonwoods
Goal: Protect New Cottonwood Stands
Technique: **Control and Prevent Rodent and Ungulate Herbivory to Existing Cottonwoods**
Discussion: Herbivory from mice, voles, ungulates, and beavers can be an issue with sites that have been recently planted with cottonwoods. Beavers (*Castor canadensis*) prefer to consume willow, but cottonwoods are also preferentially selected. Beavers use the wood of the cottonwood for food and for buildings dams and lodges. Studies have found that beaver predation on cottonwoods is a major factor in declines on the Fort Peck Reservation (FPR 2001) and most likely in other locations along the Missouri River as well. It is probable that the historic operation of the Fort Peck Dam has influenced (and increased) beaver population densities, distribution, and effects on cottonwoods. It has been observed on the Fort Peck Reservation that higher densities of beavers are causing substantial mortality to cottonwoods along the Missouri River (FPR 2001). Lesica and Miles (1998) have found that high beaver populations on the Marias River in Montana greatly affected riparian ecology by destroying cottonwoods and allowing the proliferation of Russian olive. After cottonwoods are planted at identified restoration sites, individually trees could be loosely wrapped with wire fencing (beavers can chew through chicken wire), to allow the tree room to grow and reduce beaver herbivory. The wire should be checked every year to make sure the fencing is still loose and is not harming the tree. Two wraps around the tree with horse fence (12-14 gauge fence with a 2x4" grid) has been proven to work well against beaver and should be at least four feet tall. Groups of trees and shrubs identified for protection could also be surrounded with 3 to 4-foot high barriers made of galvanized, welded wire fencing or other sturdy material. The weight of a beaver can pull down chicken wire or similar lightweight materials. The barriers should be staked and flush to the ground (or include an 18-inch wide skirt on the beaver side of the fence) to prevent beavers from pushing them to the side or entering from underneath. These barriers will require annual checks to ensure that cottonwood seedlings are not being damaged by the barrier, and at some point, the barrier should be removed. Planting willows for beavers would provide a food source and could offer an alternative to consuming cottonwoods. The willows would require protection for a few years prior to maturation. Once willows are well-rooted, they will re-sprout if the beavers browse on them. In addition to fencing, the cottonwoods identified for protection could also be painted with a repellant, such as Big Game Repellent® or Plant-skydd® although these repellents need to be re-applied periodically. Also, the Internet Center for Wildlife Damage Management (ICWDM 2005) provides research-based information on how to responsibly handle wildlife damage problems, including beaver herbivory issues.

Source: WADFW 2008 (text and photos) ; Taylor 2001 ; FPR 2001; ICWDM 2005; Lesica and Miles 1998

POTENTIAL PROJECT LOCATIONS: Segments 4, 6, 8, 9, 10

OTHER STRATEGIES TO CONSIDER: Maintain Plantings through Short-Term and Long-Term Management (BOX 25)

BOX 25

Activity: Artificial Propagation of Cottonwoods

Goal: Protect New Cottonwood Stands

Technique: **Maintain Plantings through Short-Term and Long-Term Management**

Discussion: Each potential riparian restoration project varies in site physical and ecological characteristics, scale, scope, and objectives and therefore, goals and objectives may differ between restoration projects. Ideally, the preservation and long-term management of cottonwoods would revolve around the restoration of the natural regeneration processes of these species. Since cottonwood riparian forest decline can be primarily attributed to water management, it would be ideal to restore the natural hydrologic and geomorphic processes. However, the multiple uses of water in the Midwest likely precludes the prospect that dams and water diversions shall be managed primarily for riparian ecology rather than agriculture, power generation, navigation, and drinking water. Therefore, both short-term and long-term management would be required for a variety of cottonwood planting techniques. However, there may still be the opportunity for management that also enables river dynamism and cottonwood recruitment even within these constraints, by flow prescriptions in combination with other previously mentioned measures such as the recruitment box model.

The monitoring program and the Adaptive Management Process (AMP) will support the implementation and long-term maintenance of the restoration activities. However, management actions should be initiated that will maintain and improve the plantings as well as other important riparian vegetation. Proper management is necessary to maintain healthy, competitive plants that function for the intended objectives and meet the required goals. Both short-term and long-term management is as important as the planting itself to ensure long-term restoration of the riparian areas. Plantings should be monitored and maintained as necessary. Until plants are fully established, maintenance could include weeding, irrigation, and fence repair (if necessary). Cottonwoods planted by a variety of methods generally need supplemental irrigation (up to about 5 years) until the roots reach the ground water; the roots of mature cottonwoods generally do not extend beyond 5 meters (16.4ft) in length. Research analyses through the excavation of seedlings have indicated that only cottonwoods greater than 4 years old have rooted to the depth of the late summer groundwater table, although this is dependent upon

location. Most cottonwood seedling mortality in the first few years following planting has been attributable to either flood scouring or desiccation. For plantings in which a small square of fabric was placed around the seedlings as a weed barrier, the fabric would require maintenance because it could girdle trees in about 10 to 15 years. Therefore, the fabric should either be split or removed to avoid girdling. Weed control is normally required for planted trees and the herbicide Plantskid® has worked well for weed control at cottonwood restoration sites. The perpetuation of planted restored riparian forests may require a maintenance program involving periodic plantings. Visual inspections should include recording indications of drought and other environmental stressors. Primary indications of drought stress include reduced leaf size, premature leaf loss, and crown dieback. Prolonged periods of environmental stress such as drought may weaken the plantings and increase their susceptibility to disease and insect pathogens. Therefore, keeping the plantings disease-free and pest-fee would help maintain the vigor of the plantings, and this may include thinning cottonwood stands to keep them healthy. *Source: CSP 2005; Williams 2008; USDA-NRCS 1993; Cooper et al. 1999*
POTENTIAL PROJECT LOCATIONS: ALL SEGMENTS
OTHER STRATEGIES TO CONSIDER: Discourage Cottonwood Clearing Near the River (BOX 2)

3.4 Modification to Management Policies to Protect/Restore Cottonwoods

The following Modifications to Management Policies to Protect/Restore Cottonwoods are discussed in this Section:

- **Section 3.4.1 Strategic Recommendations:**
  - Land Preservation Education and Information Exchange
  - Encourage Irrigation Water Management Plans to Benefit Cottonwood Stands
  - Establish a Focus Group to Educate the Public about Carbon Credit Programs
  - Collaborate with Established Conservation Trees Work Group
- **Section 3.4.2 Management Recommendations:**
  - Federal Use of Mitigation Projects to Require Cottonwood Plantings
  - State Use of Mitigation Projects to Require Cottonwood Plantings

3.4.1 Strategic Recommendations

BOX 26

Activity: Modification to Management Policies to Protect/Restore Cottonwoods

Goal: Strategic Recommendations

Technique: **Land Preservation Education and Information Exchange**

Discussion: This strategy includes using education for land preservation and cottonwood preservation and management. Education of the existing regulatory and incentive-based approaches could be used to effectively preserve land. Educational efforts could be focused on agricultural preservation in applicable states and counties, rather than strict open space protection. In states such as Montana, agricultural lands often form the transition or buffer between public lands, such as National Parks, USFS lands, Bureau of Land Management lands, and more developed landscapes. Thus, educating owners of these private agricultural lands is critical as well as working with tribal organizations on land preservation and cottonwood planting techniques. Tribal organizations may be able to provide input on cottonwood restoration strategies that have been successful on tribal lands. Tribal organizations have also conducted other studies along the Missouri River and could provide results of these studies.

Example Project: Fort Peck Indian Reservation Project (BOX 22). Also, Sinte Gleska University completed a survey on Corps-owned lands along Lake Sharpe of plants, including cottonwoods, that are culturally important to tribal organizations (see list below). Incorporation of these species in a planting plan would recognize the cultural importance of these species to the tribes.

Bitterroot/sweet flag	*Acorus aromaticus*	Wild bergamot	*Monarda fistulosa*
Lead plant	*Amorpha canescens*	Cottonwood	*Populus deltoides*
Fringed sage	*Artemisia frigida*	Plum	*Prunus americana*
White sage	*Artemisia ludoviciana*	Choke cherries	*Prunus virginiana*
Ground plum	*Astragalus crassicarpus*	Wild turnip	*Psoralea esculenta*
Purple coneflower	*Brauneria angustifolia*	Fragrant sumac	*Rhus canadensis*
Indian paintbrush	*Castilleja sessiliflora*	Smooth sumac	*Rhus glabra*
Red willow	*Cornus stolonifera*	Black currants	*Ribes americanum*
Fetid marigold	*Dyssodia papposa*	Buffalo currants	*Ribes odoratum*
Wild licorice	*Glycyrrhiza lepidota*	Wild rose	*Rosa woodsii*
Curly top gumweed	*Grindelia squarrosa*	Compass plant	*Silphium laciniatum*
Broom snake weed	*Gutierrezia sarothrae*	Scarlet globe mallow	*Sphaeralcea coccinea*
Bush morning glory	*Ipomoea leptophylla*	Yucca	*Yucca glauca*
Wild mint/field mint	*Menthe arvensis*		

Source: Martinez and Wolfe 2008

POTENTIAL PROJECT LOCATIONS: ALL SEGMENTS

OTHER STRATEGIES TO CONSIDER: Discourage Development Near the River (BOX 1); Discourage Cottonwood Clearing Near the River (BOX 2)

BOX 27
Activity: Modification to Management Policies to Protect/Restore Cottonwoods
Goal: Strategic Recommendations
Technique: **Encourage Irrigation Water Management Plans to Benefit Cottonwood Stands**
Discussion: In addition to coordination with landowners, encouraging the use of Irrigation Water Management Plans (WMPs) may also be useful for applying water conservation measures in agriculture. These plans would promote or encourage more efficient uses of water (including both groundwater and surface water) in irrigation (air spraying vs. drip spraying) plans to conserve water for existing cottonwoods stands. An Irrigation WMP includes the use of water on the farm operation, including the methods of applying water, the type of conservation measures used to minimize water needed, the amount of water needed, timing and what water sources are currently or planned to be used. The USDA-NRCS provides sample Irrigation WMPs and associated worksheets. The worksheets summarize the management techniques that the landowner will be using to insure the most efficient use of irrigation water. *Source: USDA-NRCS 2008c*
POTENTIAL PROJECT LOCATIONS: ALL SEGMENTS that adjoin agricultural fields.
OTHER STRATEGIES TO CONSIDER: Conservation of Surface Water and Alluvial Groundwater to Maintain Existing Cottonwoods (BOX 13)

BOX 28

Activity: Modification to Management Policies to Protect/Restore Cottonwoods

Goal: Strategic Recommendations

Technique: **Establish a Focus Group to Educate the Public about Carbon Credit Programs**

Discussion: Forests are major contributors to the terrestrial carbon sink and its associated economic benefits. Carbon sequestration can be defined as the capture and secure storage of carbon that would otherwise be emitted to or remain in the atmosphere. Carbon credits encompass two ideas: 1.) prevention/reduction of carbon emissions produced by human activities from reaching the atmosphere by capturing and diverting them to secure storage and 2.) removal of carbon from the atmosphere by various means and securely storing it.

The carbon credit program is available through National Farmers Union; the North Dakota Farmers Union acts as the fiscal agent actually contracting and selling the carbon offsets on the Chicago Climate Exchange. The Chicago Climate Exchange (CCX) is an international rules-based greenhouse gas emission reduction, audit, registry and trading program based in the U.S. The CCX established a pilot 5-year carbon sequestration program for agriculture from 2005 to 2010. Carbon credits are available from the CCX for the following practices: no till, seeded grass, forage stands, prescribed grazing on native rangeland and forestry as well as for methane offsets. Forests, including cottonwood forests, are great at sequestering carbon. Larger plants absorb more carbon dioxide than no-till crops or grasses and therefore, forestry projects will earn more carbon credits than other offset projects. Afforestation projects (trees planted on land that was not forested or was degraded forest prior to that date) initiated on land that was degraded or bare as of January 1, 1990 and not required by law can earn CCX offsets. Afforestation projects that are implemented along with forest conservation can earn CCX offsets for both additional removal of greenhouse gases and the avoidance of deforestation. Trees that have been planted on CRP (Conservation Reserve Program) acres are eligible for the afforestation offset with a commitment to leaving trees for at least the 15 year contract. Thus, carbon credits could be earned in addition to government CRP payments. Older existing stands of trees are not eligible for this practice, but may be eligible for a *managed forestry* program.

The Corps could educate the public and landowners about the Carbon Credit Program. Landowners with the potential to qualify under the CCX for forestry carbon credits and/or the CRP, could be educated regarding the carbon credits and application process through the National Farmers Union. Informational seminars could be held or brochures describing the process could be mailed to landowners with the potential to qualify for the program. In addition, landowners can enroll in the program on-line at www.carboncredit.ndfu.org. The National Carbon Offset Coalition's (NCOC) was founded in 2001 to help farmers, ranchers, private forest owners, and tribal and state governments tap into the revenue stream of selling carbon credits derived from their land (www.ncoc.us)

Source: CCX 2007; Canadell 2008; NCOC 2008

POTENTIAL PROJECT LOCATIONS: ALL SEGMENTS

OTHER STRATEGIES TO CONSIDER: Land Preservation Education (BOX 26)

BOX 29

Activity: Modification to Management Policies to Protect/Restore Cottonwoods

Goal: Strategic Recommendations

Technique: **Collaborate with Established Conservation Trees Work Group**

Discussion: In the Midwest, annual tree seedling sales for conservation purposes, such as crop, livestock, and farmstead windbreak protection, aquatic and terrestrial wildlife habitat protection and enhancement, watershed protection, soil erosion control, forest products, and water quality improvement, have declined. Some of the suspected reasons for the downward trends include new tree planting design specifications that require fewer trees and less emphasis on tree planting by Natural Resource Districts and NRCS due to other priorities. To counteract these trends, the Corps could collaborate with local work groups or established Conservation Trees Work Groups, in association with other federal and state agencies, to develop an action plan to increase conservation tree planting. The Conservation Trees Work Group could write a plan that could address the following issues:

- Increasing public awareness of the value and benefits of conservation tree planting through educational and promotional efforts,
- Increasing technical forestry assistance to landowners,
- Improving tree ordering procedures,
- Expanding cost-share opportunities for landowners, both locally and statewide.

Example programs: Nebraska has created a Conservation Trees Work Group with support from the Nebraska Forest Service, Natural Resources Conservation Service, Natural Resources Districts, Nebraska Association of Resources Districts, and the U.S. Forest Service. The goal of project is to plant 1.7 million conservation trees annually in Nebraska (1 tree for each Nebraska citizen).

Source: Miller and Adams 2008

POTENTIAL PROJECT LOCATIONS: ALL SEGMENTS

OTHER STRATEGIES TO CONSIDER: Use Conservation Cost-Sharing Programs (BOX 10)

3.4.2 Management Recommendations

BOX 30

Activity: Modification of Management Policies to Protect/Restore Cottonwoods

Goal: Management Recommendations

Technique: **Federal Use of Mitigation Projects to Require Cottonwood Plantings**

Discussion: Cottonwood is classified by the USDA-NRCS as a facultative plant, which is defined as equally likely to occur in wetlands or non-wetlands at an estimated probability of 34 to 66 percent. The cottonwood inhabits riverine forested wetlands on the floodplains of rivers and streams. These forested wetlands are important because they contain a number of diverse habitats and support high numbers of plant and animal species, yet forested wetlands experienced the greatest decline of all wetland types according to the USFWS (2000).

Cottonwoods can therefore occur in both federally-defined and state-defined wetland areas and may require wetland mitigation for impacts to these wetland areas. Wetland mitigation is generally defined as avoiding or minimizing wetland impacts, but can also include the following: rectifying the impact by repairing, rehabilitating, or restoring the impacted environment, reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; or compensating for the impact by replacing or providing substitute resources or environments. Compensation is normally determined through a mitigation ratio, which is defined as the ratios of values gained per unit area to values lost per unit area; the mitigation ratio is generally expressed in terms of area (e.g., a ratio of 5 to 1 equals five mitigation acres for each acre impacted through development). The USEPA and the Corps issue federal regulations governing compensatory mitigation for authorized impacts to wetlands, streams, and other waters of the U.S. under Section 404 of the Clean Water Act in a 2008 rule entitled *Compensatory Mitigation for Losses of Aquatic Resources*.

The Corps, through the Joint Permit Application Process for impacts to wetlands, could require the planting of cottonwoods in appropriate locations as mitigation requirements for wetland impacts at specified ratios. Or, the Corps could allow for the natural establishment of cottonwoods at appropriate mitigation project locations. The Corps is already undertaking mitigation projects along many rivers, including the Missouri River and these projects could include cottonwood planting requirements. Specifically, the Missouri River Mitigation Project and the Missouri River Ecosystem Restoration Project performed by the Corps and other agencies could be used to require cottonwood plantings. Mitigation guidelines could be created or required to comply with the following authorities:

- Clean Water Act (33 USC 1251 et seq.)
- National Environmental Policy Act (42 USC 4321 et seq.)
- Executive Order 11990 *Protection of Wetlands*
- State Clean Water Law or State Water Quality Act

Additionally, the incorporation of cottonwood plantings and/or other habitat manipulation or stream engineering practices on Corps-run lakes could be used for cottonwood establishment if opportunities exist and appropriate locations are available.

Example projects: In Lake Sharpe, SD, the Corps is proposing a shoreline protection and cottonwood habitat enhancement project that includes a 1-mile long, 20-acre breakwater dike with peninsulas and an island. Over 12,000 riparian trees (including cottonwoods), shrubs, and vines will be planted on the dike and peninsulas. It is assumed that wetlands will eventually develop between the dike and the shoreline in

the shallow water areas. To date, the Lower Brule Sioux Tribe has successfully used willow wattles to establish willows, cottonwoods, and other native riparian vegetation along the shoreline of Lake Sharpe. Cottonwoods can be bundled into long bundles called wattles, which are staked into shoreline areas. This method can be low-cost and effective where wave and ice action are not so extreme as to scour out the wattles and their resulting plants. The method does not require much technical expertise and can be done with a small crew. For example, in the spring of 2005, the Lower Brule Sioux Tribe wildlife department planted 6-8 foot long cottonwood and willow wattles about 10 inches in diameter along the shoreline. Department employees covered the wattles with soil after installing them. It took less than a week for five to ten people to lay 237 feet of willows. Additionally, at the Jandreau Site along the south shore of Lake Sharpe in SD the construction of a structure was completed to both protect the cultural resources site from erosion and restore floodplain habitat that was lost when the area was flooded to fill Lake Sharpe. The project included a 3.7-acre terrace constructed on the landward side of a breakwater upon which several different species of floodplain trees and shrubs, including cottonwood, were planted. *Source: USDA-NRCS 2008d; USACE 2007; USFWS 2000b*
POTENTIAL PROJECT LOCATIONS: Segments 4, 6, 8, 9, and 10
OTHER STRATEGIES TO CONSIDER: Plant Cottonwood Seeds (BOX 19); Plant Rooted Cottonwood Seedlings/Saplings (BOX 20); Plant Small Unrooted Cottonwood Cuttings (Live Stakes) (BOX 21); Disk Land for Cottonwood Habitat (BOX 22)

BOX 31

Activity: Modification of Management Policies to Protect/Restore Cottonwoods

Goal: Management Recommendations

Technique: **State Use of Mitigation Projects to Require Cottonwood Plantings**

Discussion: In addition to the federal government, the states could also take a lead role in requiring cottonwood plantings for mitigation projects. Impacts to wetlands or streams could be mitigated through state requirements to plant cottonwoods in appropriate locations. With grants from the USEPA, some states have created Wetland Boards or Wetland Councils which act as forums for stakeholders to participate in wetland conservation issues and activities. These Boards or Councils are at the forefront of both conservation and mitigation requirements and include a multitude of state agencies. The Corps could work with these Boards and Councils to establish requirements for planting cottonwoods as mitigation measures.

The creation of wetland banks by private companies as mitigation requirements could also be used to require cottonwood plantings if the bank is located at an appropriate location for cottonwood establishment. The bank could provide a mechanism by which permit applicants can satisfy wetland replacement/mitigation requirements, including agricultural-related wetland mitigation. A bank could also provide environmentally sound mitigation at an affordable price for producers, thereby resulting in *no net loss* of wetland area or function. Operations of wetland banks could be monitored for compliance by state agencies. After a bank is set up, individual farmers and/or public entities (levee/drainage districts) could then purchase from the bank owner the amount of parcels equivalent to or at ratios to the type of wetland designated land they are impacting. Payments for bank parcels go to the bank owner at a specifically listed price. If wetland banks are located near agency-operated wildlife areas, this would increase the overall size and operating efficiency of the existing wildlife facility and create a more contiguous wetland area. The following list by state describes current wetland regulations and the establishment of any important Wetland Boards or Wetland Councils:

- Montana – Montana Department of Environmental Quality (MDEQ) coordinates and provides leadership to wetland conservation activities state-wide. One activity includes providing leadership to the Montana Wetland Council, which is a forum for all stakeholders to participate in wetland issues. With USEPA grants and MDEQ leadership, the Council developed a draft Conservation Strategy for Montana's Wetland and Situation Assessment, which guides the Council in pursuing wetland conservation activities.
- North Dakota – The state regulates activities in state waters and drainage of some wetlands pursuant to its wetland statute. The state has adopted an overall no net loss goal and a mitigation bank. However, ND does not have a state Wetland Conservation Plan or a No Net Loss/Net Gain Goal. The North Dakota Game and Fish Department is currently building support for a more effective wetlands protection program, development of a Wetlands Protection Program. There is an informal 1:1 wetland mitigation policy in North Dakota.
- South Dakota – South Dakota Department of Environment and Natural Resources provides environmental and natural resource assessment and regulation that provides protection of natural resources and preservation of the environment. South Dakota Department of Game, Fish and Parks promotes conservation, restoration, and where appropriate, creation of wetland habitat as part of its public-and private-land wildlife habitat programs. The *Wetland Conservation and Management*

Guidelines for South Dakota State Agencies was developed through a USEPA grant to develop a state wetland policy by South Dakota Interagency Wetlands Working Group, which included many state agencies and is designed to provide state natural resource agencies with an overall view of wetland issues for their use in providing financially and environmentally viable wetland conservation and management programs.

- Iowa – The state passed a Protected Wetlands Act in 1990 that covers some types of wetlands, but this Act has not been implemented from a regulatory standpoint. Iowa does not have a state Wetland Conservation Plan or a No Net Loss/Net Gain Goal. Permits are required from the Iowa Department of Natural Resources (IDNR) floodplains section for development in floodplains and for activities on meandered streams and lakes to the high water marks as well as for activities on IDNR-owned property. An informal wetland mitigation policy has been adopted as guidance and two known mitigation banks exist in Iowa.
- Nebraska – The state does not explicitly regulate wetlands under a wetland protection statute but enforces wetland actions pursuant to a Section 401 Water Quality Certification Program. No explicit official wetland goal for the state exists, however, antidegradation language of Surface Water Quality Standards implies *no net loss* and mitigation is required as part of Section 401 certification. The Nebraska Department of Environmental Quality is authorized to administer all provisions of the federal Clean Water Act by the Nebraska Environmental Protection Act (Section 81-1501 to 81-1533). Mitigation policy includes the re-creation of wetlands, on-site and off-site mitigation, and habitat enhancement are required pursuant to Section 401 certification.
- Missouri – The state has not adopted a wetland protection statute although some measure of protection is being provided through the Missouri clean water law and the Section 401 certification program. There exists a Missouri Wetland Advisory Council to achieve *no overall net loss* of the state's remaining wetland resources. Missouri regulation of wetlands rests solely with 401 certifications and the state's general water quality standards. At present, the state has no established use designations. The state has Aquatic Resource Mitigation Guidelines which establish the hierarchy of avoidance, minimization, and mitigation, as well as mitigation ratios for wetland impacts. There are at least six wetland banks that are currently in operation in Missouri.
- Kansas – The state's wetland regulatory efforts include 401 water quality certifications through the Kansas Department of Health and the Environment for any actions requiring a federal permit, license, or approval that result in a discharge into waters of the state, including §404 dredge and fill permits and Nationwide Permits. In addition, the Kansas Department of Agriculture's Division of Water Resources (DWR) issues permits for any type of fill, one or more feet high, placed in floodplains; stream obstructions; dams; and modifications to stream channels. Although wetlands are not explicitly included in the state's Levee Law that regulates the permitting in floodplains, the DWR will issue permits for fill in wetlands in floodplains. The state has not adopted mitigation requirements for 401 certifications and is currently developing stream mitigation guidelines for use by the state and the Corps. Kansas has not developed WQS or an anti-degradation policy specific to wetlands; however, the standards and policy refer to all surface waters of the state, which encompass wetlands.

Source: MDNR 1998; SDIWWG 2001; Waters undated; ASWM 2005

POTENTIAL PROJECT LOCATIONS: Segments 4, 6, 8, 9, and 10

OTHER STRATEGIES TO CONSIDER: Plant Cottonwood Seeds (BOX 19); Plant Rooted Cottonwood Seedlings/Saplings (BOX 20); Plant Small Unrooted Cottonwood Cuttings (Live Stakes) (BOX 21); Disk Land for Cottonwood Habitat (BOX 22)