LMRRA

Lower Mississippi River Resource Assessment

Assessment of Natural Resource Habitat Needs

Final Report
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Executive Summary

This report assesses the natural resource habitat needs for the Lower Mississippi River from its confluence with the Ohio River at Cairo, Illinois to the Head of Passes in Louisiana. The investigation was authorized in the Water Resources Development Act of 2000. The Nature Conservancy – Great Rivers Partnership is the lead study sponsor. This is the third report completed under the Lower Mississippi River Resource Assessment authority.

The Mississippi River and the land between the levees are a dynamic ecosystem that changes markedly in response to the river's annual hydrologic regime. The nearly 3 million-acre floodplain is interspersed with abandoned channels, meander scars, and large expanses of forested wetlands. These areas provide a diverse array of aquatic and terrestrial habitat types.

The Mississippi Flyway hosts the world's largest bird migration, connecting life from the Arctic to South America. Over 300 species of migrating birds and approximately 70% of the Nation's migratory waterfowl use the flyway. The river also supports over 90 freshwater fish species.

This assessment found nine areas of habitat needs on the Lower River and identifies several plans that have already been developed to answer some of these needs.

The Mississippi River receives water from 31 states. The water contains many contaminants and nutrients. Water quality is not a major limiting factor in the river ecosystem, but there is very little information about localized water quality effects, especially in backwaters, and side channels. There is a need to better understand water quality in secondary and tertiary habitats that are important for some life stages of fish and mussels.

The need to restore bottomland hardwood in the Lower Mississippi River Valley has long been recognized and is a priority for many entities, but other vegetation types have also declined. There is a need for research to examine current hydrology, soils and historic vegetation within the batture and develop tools to direct restoration species selection. This information would increase the success of restoration efforts. There is also a need to control or eliminate invasive plant species where they threaten restoration or preservation efforts.

There is a need to reconnect backwaters, side channels and floodplain lakes with the main channel at normal water levels. The Restoring America's Greatest River Initiative identifies specific opportunities for restoring some of this habitat. The federally listed interior least tern, pallid sturgeon, fat pocketbook mussel, and many other species in the Lower Mississippi River would benefit.

Most of the species native to the Lower Mississippi River are still present and their populations are viable, but the species abundance of many has declined. Habitat changes along the main stem and up the tributaries have caused most of the changes for mammals and birds, but the main factor driving aquatic population changes has been the introduction of exotic aquatic species such as carp and zebra mussel. There is a need for comprehensive studies of tributaries to understand their habitat value to the overall Lower Mississippi River system and there is also a need to control invasive species especially where they threaten native species.

Dynamic river forces form, enlarge, erode, move, and destroy sandbars and gravel bars. On established sandbars, high water removes existing vegetation and deposits new sand. Sandbars are the primary habitat component used for interior least tern nesting. Gravel bar habitats are important as spawning substrate for pallid sturgeon and other fish species. There is a need to protect and restore gravel and sand bars. The Conservation Plan for the Interior Least Tern, Pallid Sturgeon, and Fat Pocketbook Mussel addresses management and restoration of these features and the Restoring America's Greatest River initiative also identifies the need to conserve and restore them.

The Mississippi River floodplain is now 80% smaller than it was historically. The loss in area impacts water quality, habitat and species. The floodplains of tributary rivers may have become more important since the Mississippi River floodplain has been reduced. Cities, farms, highways, factories and other developments have moved into the historic floodplain. There is a need to assess tributary rivers to determine how their floodplains can be better managed to compensate for some of the loss of floodplain area. On the main stem Mississippi River, there is a need to restore the quality of habitat within the batture.

Many Mississippi River islands have been lost or altered. Islands offer important edge habitat. Since the islands are isolated from the bank, they afford many species safe places for sensitive life cycle events such as nesting. There is a need for an ecological inventory of islands in the LMR to determine their value for habitat and potential for restoration.

Preserving and rebuilding coastal wetlands is a recognized need and projects and programs are in place to address the problems. Louisiana's Comprehensive Master Plan for a Sustainable Coast sets forth a long term plan to address coastal needs.

Habitat in the Mississippi River main channel was once very diverse, and provided a variety of substrates and flow conditions. Habitat complexity in the main stem has been reduced. Fish species, such as pallid sturgeon, primarily use the main channel of the river and rely on the diverse habitats for their various life stages. There is a need to restore some of the diversity in the main channel of the Mississippi River in areas where it does not interfere with navigation.

The Mississippi River ecosystem is a dynamic system with interactions between the terrestrial and aquatic systems, main channel and side channel areas, mudflats, backwaters, tributaries and islands. There is a need to examine and manage the Mississippi River and batture at a manageable scale. There are some priority reaches of the river where there are opportunities to enhance a broad spectrum of features, i.e. restorable side channels, backwaters, and oxbows, a wide floodplain, large islands, populations of threatened and endangered species and sand bars. These areas should be examined holistically to develop plans for restoring all of the vital ecological elements.

Table of Contents

List of Figures

List of Appendices

I. INTRODUCTION

This is the third report completed for the Lower Mississippi River Resource Assessment authority. This assessment focuses on the natural resource habitat needs for the Lower Mississippi River (LMR). The Assessment of Information Needed for River-Related Management was completed in 2013 and found four areas of needed information: water quality, sediment, tributary watersheds, and data management. The Assessment of River-related Recreation and Access was completed in 2014. It identifies eight areas of need on the Lower River: boat ramps, bicycle trails, outfitter and guide services, lodging and dining, parks and vistas, interpretation, riverboat landings, and marketing.

The Mississippi River watershed drains all or parts of 31 states and 2 Canadian provinces. It is the third largest watershed in the world. According to the Mississippi River Cities and Towns Initiative, the River creates $105 billion worth of U.S. Gross Domestic Product; provides drinking water for more than 18 million people; transports 62 percent of our nation's agricultural output; and directly supports one million jobs.

The LMR begins at the confluence of the Mississippi and Ohio Rivers in southern Illinois and meanders southward 954 miles to Head of Passes, LA, where the channel subdivides into several distributaries to the Gulf of Mexico. The LMR has two distinct reaches. From the mouth of the Ohio River south to Baton Rouge, the river has well-defined point bars and forested floodplains adjacent to the river (Baker et al. 1991). The navigation channel is maintained at a minimum of 9 feet, but is authorized for 12 feet. Below Baton Rouge, the river flows through the Deltaic Plain to the Gulf. The channel is deeper to accommodate ocean-going traffic (45 feet), and there are few meander loops, sandbars, and little floodplain (Baker et al. 1991).

The active floodplain of the LMR is a dynamic freshwater ecosystem that changes with the river's annual hydrologic regime. The nearly 3 million-acre floodplain is interspersed with abandoned channels, meander scars, and forests. These areas provide a diverse array of aquatic habitats and are connected to the river at high water. However, over 80% of the floodplain is now disconnected from the river (Baker et al. 1991, USACE 2013).

The Mississippi Flyway hosts the world's largest bird migration, connecting life from the Arctic to South America. Over 300 species of migrating birds and approximately 70% of the Nation's migratory waterfowl (USACE 2012) use the flyway. The LMR also supports over 90 freshwater fish species, approximately 50 native mussel species, and several federally listed threatened or endangered species rely on the habitat in the Lower River and its tributaries.

Interest in the Mississippi River is increasing. Government agencies, industries, municipalities, and non-governmental organizations are joining forces to promote the river and highlight the opportunities and problems. In 2013, the Mississippi River Cities and Towns Initiative, signed a Memorandum of Common Purpose with the U.S. Army Corps of Engineers (USACE) with a goal to "perpetuate an era of cooperation and collaboration between the Mayors on the main stem Mississippi River and the U.S. Army Corps of Engineers, to protect, sustain and enhance the natural attributes and economic vitality of the Main Stem Mississippi River."

The Federal Mississippi River and Tributaries Project levees, floodwalls, backwaters, and floodways form the world's largest and most comprehensive flood risk management system. Navigation management began in the early 19th century and Mississippi River commercial shipping is a valuable national asset.

The Mississippi River Commission's 200-year working vision for the Mississippi River Watershed acknowledges its many uses and values.

Lead secure lives on the river or tributary

Enjoy fresh air and the surrounding fauna, flora, and forests while hunting, fishing, and recreating

Travel easily, safely, and affordably

Drink from and use the abundant waters of any river, stream, or aquifer

Choose from an abundance of affordable basic goods and essential supplies that are grown, manufactured, and transported along the river to local and world markets

This assessment of natural resource habitat needs and the two previous Lower Mississippi River Resource Assessment (LMRRA) reports, river-related recreation and access needs and information needed for river-related management, are providing some of the information necessary to move toward this vision. These three assessments touch on all five elements of the vision. A final assessment will combine the assessments and provide practical recommendations for projects and plans that leverage partnerships to answer the identified needs.

Figure 1. Bald Eagle on the Lower Mississippi River

Congressional Authority

The Lower Mississippi River Resource Assessment is authorized by Section 402 of the Water Resources Development Act of 2000, Public Law 106-541. It reads:

(a) ASSESSMENTS- The Secretary, in cooperation with the Secretary of the Interior and the States of Arkansas, Illinois, Kentucky, Louisiana, Mississippi, Missouri, and Tennessee, shall undertake for the Lower Mississippi River system--

> *(1) an assessment of information needed for river-related management;*
>
> *(2) an assessment of natural resource habitat needs; and*
>
> *(3) an assessment of the need for river-related recreation and access.*

(b) PERIOD- Each assessment referred to in subsection (a) shall be carried out for 2 years.

(c) REPORTS- Before the last day of the second year of an assessment under subsection (a), the Secretary, in cooperation with the Secretary of the Interior and the States of Arkansas, Illinois, Kentucky, Louisiana, Mississippi, Missouri, and Tennessee, shall transmit to Congress a report on the results of the assessment to Congress. The report shall contain recommendations for--

> *(1) the collection, availability, and use of information needed for river-related management;*
>
> *(2) the planning, construction, and evaluation of potential restoration, protection, and enhancement measures to meet identified habitat needs; and*
>
> *(3) potential projects to meet identified river access and recreation needs.*

(d) LOWER MISSISSIPPI RIVER SYSTEM DEFINED- In this section, the term `Lower Mississippi River system' means those river reaches and adjacent floodplains within the Lower Mississippi River alluvial valley having commercial navigation channels on the Mississippi mainstem and tributaries south of Cairo, Illinois, and the Atchafalaya Basin floodway system.

(e) AUTHORIZATION OF APPROPRIATIONS- There is authorized to be appropriated $1,750,000 to carry out this section.

Study Purpose

The purpose of the three LMR assessments is to develop a strategic approach to managing habitat restoration, recreational opportunities and the information needed to make river management decisions. Historically, the Lower River has been managed primarily for navigation and flood risk management. There is no comprehensive plan for the river's other uses. The LMR has important habitat and recreation resources that deserve focus.

The purpose of this assessment is to identify the natural resource habitat needs in the study area.

Goal

The goal of the Natural Resource Habitat Needs Assessment is to analyze the historic and existing habitats in the LMR, identify the needs for habitat restoration, protection, and enhancement; develop a comprehensive plan to meet those needs; and promote collaboration between the public and private sectors to leverage investments.

Problems

The Mississippi River Levee system has disconnected much of the floodplain from the river. Flood risk management and navigation projects have removed 152 miles of bends, and diverted flow from side channels (Baker et al. 1991). Extensive structural changes on the river's main-stem have disrupted the once dynamic ecosystem. There is less available habitat for federally listed threatened and endangered species including interior least tern, pallid sturgeon, and fat pocketbook mussels, and several other species. The problems vary in different reaches of the river. The specific habitat problems in the Lower Mississippi River are:

- Although water quality is generally good, localized problems occur and affect some listed species. High nutrient loads contribute to Gulf of Mexico hypoxia.
- Vegetative diversity and forested habitats have been reduced.
- Many side channels, backwaters, and oxbows are disconnected from the main channel.
- Native flora and fauna do not compete well against some invasive species.
- Some gravel bars and sandbars have been lost or degraded.
- The size of the floodplain and the associated habitat has been reduced.
- Mississippi River islands are a unique and limited habitat type, but their ecological importance is not fully understood.
- Coastal wetlands are declining.
- Habitat diversity in the main channel has decreased.

Opportunities

There is an opportunity to restore habitat and ecosystem function in the LMR to benefit a variety of species. The opportunities vary in different reaches of the river, and not all occur throughout the entire Lower River. Some of the specific opportunities are:

- Manage water quality in the river better.

- Restore vegetative diversity and forest habitats in the active floodplain.
- Re-connect side channels, backwaters, and floodplain lakes where feasible.
- Promote native species restoration in areas where invasive species have become common.
- Restore and protect sandbars and gravel bars.
- Improve the quality of floodplain habitats.
- Inventory islands to understand their ecological value and develop management plans.
- Restore some habitat diversity in the main channel.

Assessment Objectives

These objectives guide the assessment of the natural resource habitat needs within the LMR and lay the foundation for the Watershed Plan. The Watershed Plan will combine the results of this assessment with the completed Information Needs Assessment and the Recreation and Access Needs Assessment. These objectives will be further refined in the Watershed Plan. Only the first objective will be met in this assessment; the rest will be met in the Watershed Plan.

- Identify habitat needs along the LMR.
- Develop recommendations for projects to restore habitat in the LMR.
- Develop recommendations to foster collaborative habitat management.

Scoping

Public meetings were held in Dyersburg, TN, Helena, AR, and St. Francisville, LA; and The Nature Conservancy sponsored an online questionnaire at: greatriverspartnership.org/en-us/NorthAmerica/Mississippi/Pages/LMRRA.aspx. The public was eager to talk about birding, fishing and wildlife photography, but there were few specific comments about habitat. The comments received are included in Appendix A.

The non-governmental partners for this project are active in habitat restoration and hold public meetings when developing plans for habitat improvement. These organizations also maintain websites, many with message boards, Facebook and Twitter accounts. Team members reviewed the input from these and others including user groups, commercial enterprises, state agencies, and others. The team used these to scope the study and assess habitat needs.

Study Area

The study area for the project begins at RM (river mile) 953 of the main-stem Mississippi River at Cairo, IL, and extends downstream to RM 0, Head of Passes in Louisiana. It encompasses the main channel of the river and the area between the existing Mississippi River and Tributaries Project levees, including the mouths of all tributaries between the levees. It includes the rivers that have existing commercial navigation to the point of direct influence between each channel and the main stem River. An interactive online viewer of the area is available at: lmrgis.org/.

The Atchafalaya Basin Floodway System in Louisiana is also included within the authorized project area. There are ongoing state and Federal programs to manage and improve habitat within the Atchafalaya Basin. USACE has acquired over 350,000 acres in easements and 70,000 acres in fee land within the Atchafalaya Basin to preserve habitat and maintain public access. The State of Louisiana has developed an Atchafalaya Basin Program to oversee the Atchafalaya Basin Master Plan that brings together USACE, state agencies, and parishes to protect and enhance the natural resources of the Atchafalaya Basin. Sedimentation in backwater areas is the biggest threat to the conservation of aquatic habitat in the Atchafalaya Basin. As such, restoration activities have mainly focused on sediment management to improve habitat and alleviate poor water quality in backwater areas. This Habitat Assessment does not reexamine the habitat issues in the Atchafalaya Basin because state and Federal agencies are already giving the Basin and its issues appropriate attention.

Partnership

The Nature Conservancy (TNC) Great Rivers Partnership is the study cost-sharing sponsor. TNC signed agreements with a group of non-governmental organization partners who are providing work-in-kind study services. The study team includes staff from TNC North America Freshwater Program and TNC State Chapters in Tennessee, Louisiana and Mississippi, Lower Mississippi River Conservation Committee (LMRCC), National Audubon Society and Mississippi River Corridor-TN. All of these groups focus on sustainable river management and conservation and collectively they represent thousands of river users.

The LMRCC is a coalition of 12 state natural resources conservation and environmental quality agencies from Arkansas, Kentucky, Louisiana, Mississippi, Missouri and Tennessee. It provides the only regional forum dedicated to conserving the natural resources of the Lower Mississippi River floodplain. LMRCC focuses on habitat restoration, landscape level conservation planning, and natural resource-based economic development. The U.S. Fish and Wildlife Service (USFWS) leads the effort and provides a full time coordinator. The U.S. Geological Survey (USGS), USACE, U.S. Environmental Protection Agency (EPA), and U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) are cooperating agencies.

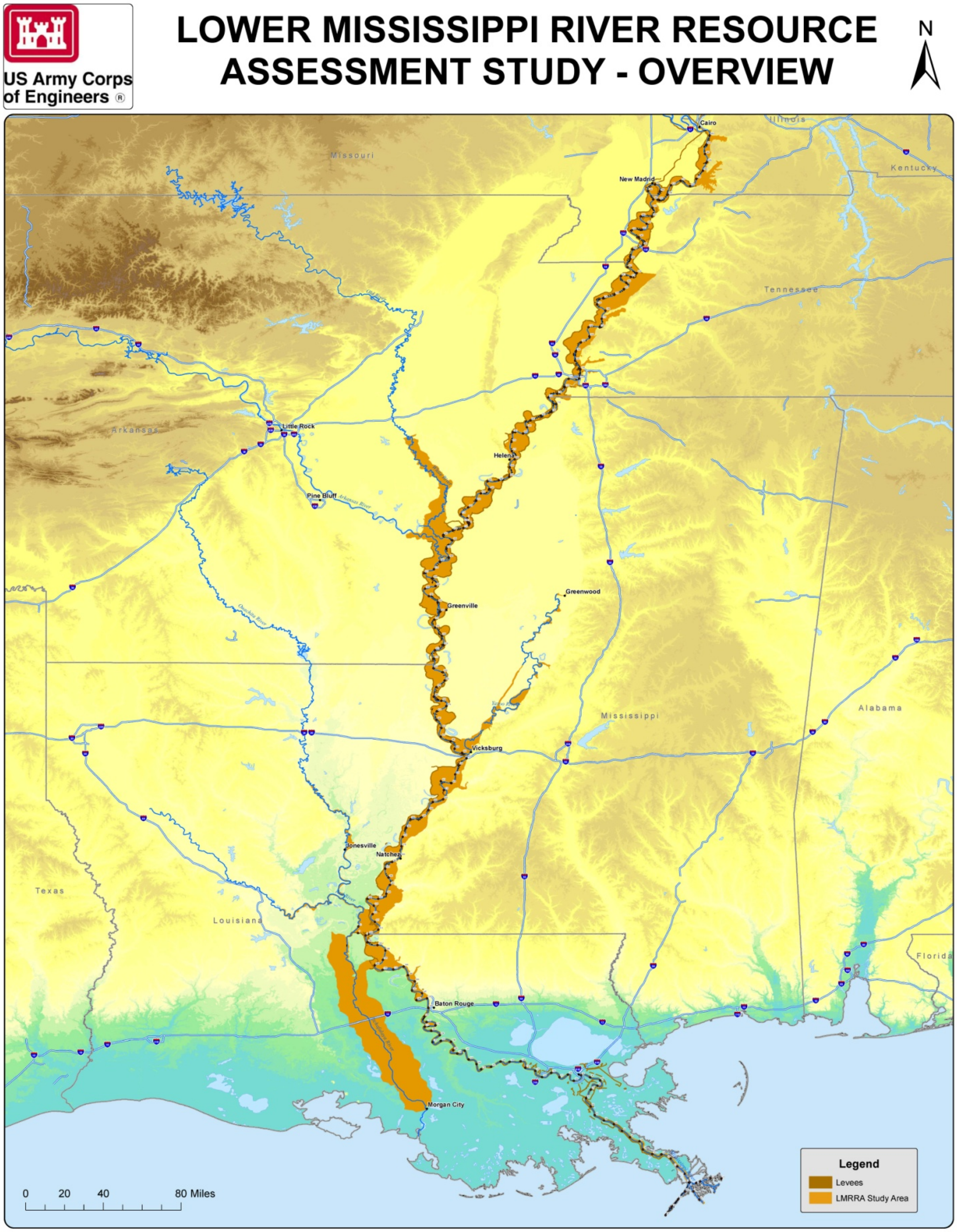


Figure 2. Map of the authorized study area.

II. LOWER MISSISSIPPI RIVER HABITAT

The study area for this project lies within a larger valley that covers around 25 million acres. Saucier (1994) describes the differences between the Lower Mississippi Valley, the Mississippi alluvial valley and the Mississippi alluvial plain and notes that these are sometimes used interchangeably. There are many studies of the Mississippi River that cite acreages for the floodplain and the valley, but the acreages vary. The merging tributary valleys, especially on the west side of the river, make it difficult to define what is part of the Mississippi River valley and what is part of the tributary valley; different studies divide the valleys differently. Geologically, Cape Girardeau is the upper end of the Lower Mississippi, but other studies set Cairo, IL as the upper end of the Lower River (Saucier 1994). For these reasons, this study does not present any analysis comparing acreage figures from one study to another. That level of analysis is also beyond the scope of this study.

Historically, bottomland hardwood forests, swamps, marshes, and oxbow wetlands covered most of the valley. The Mississippi River floodplain historically covered about two thirds of the valley; the 1927 flood inundated 16-17 million acres (USACE 2012). The LMR had a sinuous course with numerous meander loops, bends, and oxbow lakes (Baker et al. 1991) and shifted its channel frequently reworking parts of its alluvial meander belt (Saucier 1994, Amoros & Bornette 2002). These diverse habitats supported a rich biotic community including reptiles, amphibians, fish, freshwater mussels, birds, mammals, and plants.

Over the past 150-200 years, the alluvial valley, floodplain, and channel of the LMR have been altered (Baker et al. 1991). Forests have been cleared and drained for agricultural, municipal, residential, and industrial purposes. Levees reduce flooding in most of the valley and the channel has been realigned and constrained.

At least 90 freshwater fish species (Baker et al. 1991) and around 50 mussel species (Jones et al. 2005 & USACE records) are found in the LMR. The Mississippi Flyway is an important corridor for migratory waterfowl, shorebirds, and other birds that require feeding and resting habitat during spring and fall migrations. Over 300 species of birds use the Mississippi River corridor (Scott ed. 1983). The Lower River is home to 43 species of shorebirds (Elliott & McKnight 2000). Nearly 70% of all of the nation’s migratory waterfowl (USACE 2012), 45% of the continental mallard population (personal communication, Dr. Dale James Ducks Unlimited), and 60% of all bird species in the U.S. migrate through the valley (Scott ed. 1983).

There are a variety of Federally listed threatened and endangered species which are known or believed to occur in the LMR or its tributaries. They include mussels (Alabama heelsplitter, fat pocketbook, Louisiana pearlshell, scaleshell, rabbitsfoot), plants (decurrent false aster, Geocarpon minimum, pondberry), birds (interior least tern, red-cockaded woodpecker), mammals (Indiana bat, Louisiana black bear), and fish (pallid sturgeon, relict darter). The USFWS developed Recovery Plans detailing the life history, habitat needs, threats, and status for all of these species. The National Marine Fisheries Service manages listed marine species which occur just outside the study area (West Indian manatee, leatherback sea turtle, Kemp’s ridley sea turtle, hawksbill sea turtle, green sea turtle, loggerhead sea turtle, gulf sturgeon).

According to the *Conservation Plan for the Interior Least Tern, Pallid Sturgeon, and Fat Pocketbook Mussel in the Lower Mississippi River* (USACE 2013), despite river engineering activities over the past century, the LMR has not experienced any known extirpations or extinctions of channel species, such as have occurred in other large American rivers. Several reasons for this are given: 1) the LMR remains unimpounded, experiencing a natural flood cycle hydrograph; 2) although size and quantity of sediment input to the system has been significantly reduced through bank protection and construction of multiple impoundments of all major LMR tributaries, large quantities of stored sediment are available in its large channel that are continuously reworked during flood cycles; 3) implementation of the Clean Water Act throughout the drainage basin has significantly improved water quality in the LMR; and 4) the proactive nature of USACE, specifically Mississippi Valley Division, in carrying out its continuing responsibilities under the Endangered Species Act. These factors all contribute to the LMR channel remaining a highly functional and valuable fluvial ecosystem.

Conceptual Ecological Model for the Lower Mississippi River

The LMR ecosystem structures and functions are complex and intertwined. Conceptual Ecological Models (CEM) are non-quantitative planning tools used to identify major drivers and stressors on natural systems, and the ecological effects of these stressors. CEMs show general functional relationships among essential ecosystem components. They help resource managers understand and diagnose problems, isolate cause and effect, make qualitative predictions of ecosystem response, outline restoration, research and development, and develop metrics to measure success and adaptively manage projects.

A CEM (Figure 3, page 10) was developed to describe the LMR from the confluence with the Ohio River to the Head of Passes system as a whole. In reaches of the river certain drivers and stressors are more or less influential. For example, point sources may have a significant local effect, but farther away from the source the effect may be minor.

The following sections provide a brief overview of the Drivers and Stressors in the LMR. The extent and effects of these are well documented in published articles and agency reports. The section describing the Ecological Effects is more detailed, but these effects are also well documented in articles and reports.

DRIVERS

Drivers are the major external forces that have large-scale influences on natural systems. Drivers can be natural forces or anthropogenic. There are five major drivers in the LMR: flood risk management, channel improvements, climate, land use and tributary changes, and other anthropogenic effects including point sources. They are the top line of the model (Figure 3).

The **flood risk management system** includes levees, floodwalls, and their operation. This system has disconnected over 80% of the historic river floodplain from the river (Baker et al. 1991). Nutrients and contaminants do not attenuate as much because the water does not spread over the wide floodplain. The area of flooding is reduced, but the depth of the floodwater and

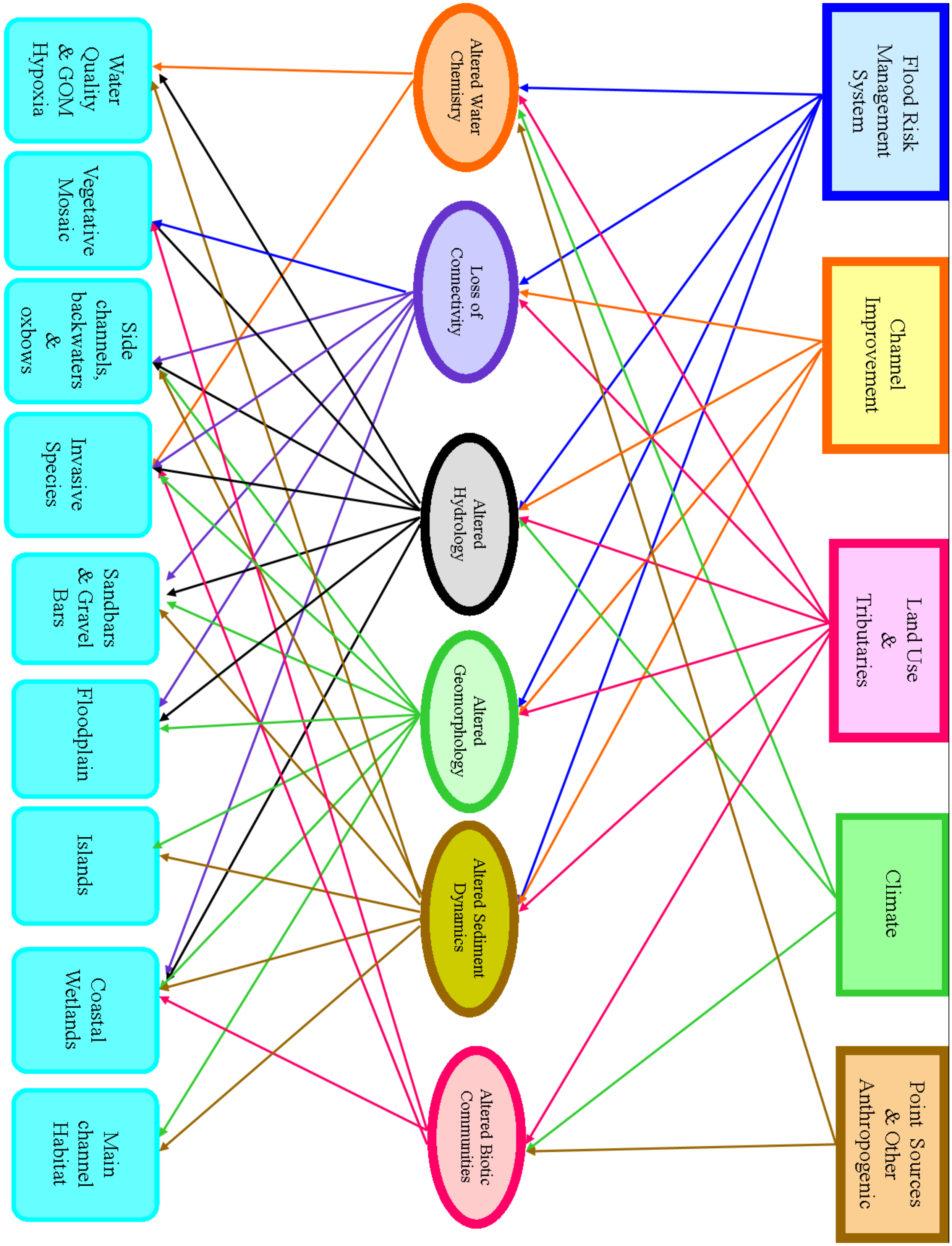


Figure 3. CEM for the Lower Mississippi River

the timing and duration of the flood events have changed. The levees have eliminated the river's geomorphic effect on areas outside the active floodplain, and change the effects within the batture. The levees reduce sediment input into coastal wetlands.

Channel improvements include dikes, articulated concrete mattress, bendway weirs, chevrons, and dredging. These have disconnected side channels, backwaters, and oxbow lakes from the river. In-channel structures and revetments limit the channel's ability to adjust and create new meanders and side channels. Dikes slow water velocity near shore causing sediment deposition, and increase velocity in the channel reducing sediment accumulation. Dikes do reduce the need for dredging that can cause localized disturbance to fish and other animals.

Climatic patterns drive the hydrologic regime and more frequent extreme events, including both floods and droughts, are expected. Climate change may drive water temperatures higher and affect the fate of nutrients and contaminants. Temperature changes may favor non-native plants and animals and could alter temperature dependent spawning cycles.

Land use in the watershed is now primarily agricultural and many of the **tributaries** have been altered to facilitate drainage. During storm events, rain is quickly drained from the floodplain and the timing and duration of flood pulses in the tributary rivers have changed (Baker et al. 2004). Nutrients have less opportunity to attenuate on the floodplain. Channelization in tributary rivers has altered the geomorphology of the landform and changed sediment dynamics within the systems. Conversion of forests to crop lands has disconnected forest patches and altered biotic community structure and function.

Point sources contribute contaminants to the river. **Humans** have introduced a variety of non-native plants and animals into the area. These include common carp, bighead carp, silver carp, grass carp, northern snakehead, zebra mussels, nutria, feral hogs, purple loosestrife, Eurasian water milfoil, water hyacinth, alligator weed, hydrilla, kudzu, Japanese honeysuckle, mimosa, and privet (USDA 2014).

STRESSORS

Stressors are physical or chemical changes that occur within natural systems in response to drivers. Stressors are directly responsible for significant changes in biological components, patterns, and relationships in natural systems. These are the second line in the model (Figure 3). The stressors also interact with each other to exacerbate their effects.

Water chemistry in the LMR has changed. Nutrient levels began to rise in the early 1900's, stabilized in the 1980's, and began to decrease in the 1990's (Turner et al. 2007, Broussard & Turner 2009, Murphy et al. 2013). Inputs, temperature, timing, and nutrient cycles all influence water quality. The biologic effect of these changes is not extensively documented. Changes in temperature may favor non-native species over natives. The Gulf of Mexico hypoxic zone and its relationship to changing water chemistry is well documented. (Smith et al. 1991, Pereira & Hostettler 1993, Antweiler et al. 1995, Gabarino et al. 1995, Moody & Battaglin 1995, Meade 1996, Coupe 1998, Coupe 2000, Sabo et al. 1999, Gonthier, 2000, Kleiss et al. 2000, Coupe 2001, Justus et al. 2001, Dowling et al. 2004, Mitsch & Day 2006, Alexander et al. 2008, Kresse

& Clark 2008, Sowa 2008, Schramm et al. 2009, Dalton et al. 2010, Rebich et al 2011, Saad et al. 2011).

Both terrestrial and aquatic systems in the LMR are **disconnected** with only isolated remnant patches remaining. Some of the remnant patches are not large enough to support all of the life stages of some species. Animals are less able to move between patches unless there are corridors of usable habitat. The losses of species and functions from particular areas, limits the ecosystem's ability to maintain and regenerate a functioning biotic community. Side channels, oxbows, and backwaters are often hydrologically disconnected from the main channel. (Baker et al. 1987, Baker et al. 1991, NBS USDI 1993, Ballweber 1999, Amoros & Bornette 2002, Wagner 2003, Williams & Clouse 2003, Winemiller 2003, Barko et al. 2006, USACE 2013).

The **hydrologic and hydraulic regimes** in the LMR have been altered. High water events are contained in a smaller area, and stages and velocity are higher in that area. Other areas no longer flood as often. At low water, side channels and other areas no longer receive flow. Levees also limit freshwater input into marshes and have allowed saltwater to intrude farther inland damaging coastal wetlands. (Humphreys & Abbot 1876, Winkley 1994, Biedenharn & Watson 1997, Schramm & Eggleton 2006, Hudson et al. 2008, Jemberie et al. 2008, Moore et al. 2011, Alexander et al. 2012, USACE 2013).

The **geomorphology** of the floodplain and the river are both altered. New side channels sometimes form in dike fields, but not in other areas. Aggradation and degradation in the river are managed to facilitate navigation. The river's influence on landform has been reduced. The river channel has been simplified and is less dynamic, the channel bed elevation is lower and the river is disconnected from 80% of the floodplain. A program begun around 1930, separated (cutoff) over 150 miles of meander s or bendways from the channel (Winkley 1977, Biedenharn & Watson 1997, USACE 2013). Channel improvement structures have reduced meandering and cutoffs have altered the energy in the system. Dikes restrict many of the secondary channels. Levees constrain the floodplain. However, the LMR still maintains some dynamic processes and is an open river system where minor morphologic adjustments can still occur, within the structural constraints. (Fisk 1944, Winkley 1977, Baker et al. 1991, Saucier 1994, Biedenharn & Watson 1997, Delaney & Craig 1997, Biedenharn et al. 2000, Hudson & Kesel 2000, Soar et al. 2005, Klimas et al. 2009).

Sediment dynamics are closely related to changes in geomorphology and the size, quantity, and timing of sediment in the river has changed. Prior to the 1930's, most of the sediment in the river came from caving banks and was stored mainly within the channel as channel bars, but also in overbank areas. Since that time, revetments have reduced bank caving decreasing sediment input, dikes trap much of the bedload and levees limit the overbank areas (Kesel 2003). Channel bars are now rarer and there is less sediment available to replenish coastal wetlands. The Mississippi River is a naturally turbid system and the native species are adapted to it. Lower levels of suspended sediments could favor non-native species. Deposition of finer sediments can cover spawning substrate making it unusable for some fish species, and it is less stable for mussels and other invertebrates. (Krinitzsky 1949, Harmar 2004, Harmer et al. 2005, Nittrouer et al. 2010, Allison et al. 2012).

The **biotic community** of the LMR is significantly altered. Conversion to agricultural lands has eliminated native vegetation in some areas. Invasive species in the river and on the floodplain are pushing out native species. Saltwater and physical disturbance have decreased freshwater marsh species which are important to the structure and function of coastal marshes. (USFWS 1954, Baker et al. 1987, Sigrest & Cobb 1987, Baker et al. 1988, Klimas 1988, Fremlin et al. 1989, Baker et al. 1991, Ouchley et al. 1992, Rutherford et al. 2001, Killgore & Hoover 1999, Driscoll et al. 2000, Lichtenberg 2001, LMVJV 2002, Twedt et al. 2002, Twedt et al. 2006, Middleton & Wu 2008, Norris et al. 2009, MICRA 2010, Crites et al. 2012).

Figure 4. Soybeans in the Mississippi River Batture

ECOLOGICAL EFFECTS

The effects of the drivers and stressors on the most significant ecological structures and functions are discussed below. They are the third line of the model (Figure 3).

Water Quality

Changes in water chemistry, hydrology, and sediment dynamics all have an effect on water quality, but there are few studies which show a clear linkage between water quality and biotic community health. Overall water quality in the Mississippi River is good and steadily improving, for example total nitrogen has decreased from its high in1990 (Turner et al. 2007). There are localized problems such as chemical spills or instances of low dissolved oxygen on backwaters or harbors that kill fish, but there is little documentation of these events. Nutrients and other water quality constituents enter the Mississippi River from both point and non-point sources including air deposition. There are storm sewer systems, industrial discharges, and agricultural runoff. The water coming into the river may contain nitrogen, phosphorus, cadmium, mercury, chlordane, atrazine, PCB, *E.coli*, and many other nutrients and contaminants. The river, side channels, and batture lands attenuate some of the nutrients that enter the river. Excess nutrients contribute to Gulf of Mexico hypoxia.

Changes in water quality could affect amphibians, birds, mammals, and even plants, but there is limited information on these effects. Some studies have shown effects on fisheries especially in side channels and backwaters. The degree of connectivity to the main channel, nutrient concentrations, the presence of macrophytes, and physical factors such as depth can affect water quality in side channels and back water areas. Baker et al. (1991) noted water quality (e.g., dissolved oxygen, turbidity, nutrients, and plankton densities) is one of several important aquatic habitat variables in the LMR. Low oxygen levels impact fish species richness and abundance in

Figure 5. River otter enjoying a catfish on the Mississippi River

river backwater areas, river channels, and lakes (Killgore & Hoover 2001). Pallid sturgeon are long-lived fish and contaminants can bioaccumulate in them even if the contaminant levels in the water are moderate to low. Recent studies point to this as one cause for sturgeon decline (Divers et al. 2009, USFWS 2009, Blevins 2011, Schrey et al. 2011). Ohio River shrimp once ranged through the entire Ohio and Mississippi River system, but their range and populations are greatly reduced. River modifications, pollution, commercial fishing and exotic predators have all likely played a role in the shrimp's decline (Bowles et al. 2000).

Water quality regulations were set forth in the Clean Water Act. The EPA delegates most of the responsibility for enforcing the Act to the individual states. Each state has broken the Mississippi River into segments and designated uses for each segment. Water quality standards have been established to protect the existing and designated uses. EPA is currently reassessing its water quality management program for the Mississippi River.

The hypoxic zone in the Gulf of Mexico is closely related to water quality in the river. The LMR collects and transports nutrients from the entire Mississippi River watershed directly into the Gulf of Mexico. The hypoxic zone forms in the northern Gulf of Mexico every summer. It has been as large as 5.5 million acres. Excess nutrients and seasonal stratification of Gulf waters cause the hypoxia. High concentrations of nutrients, especially phosphorous and nitrogen, promote excessive growth of algae. As the algae die and decompose, high levels of organic matter and the decomposing organisms deplete the water of available oxygen. Further, warm, fresh river water is less dense and remains above the colder, saline deep Gulf water. Stratification prevents the mixing of oxygen-rich surface water with oxygen-poor water on the bottom of the Gulf. Without mixing, oxygen in the bottom water is limited and the hypoxic condition remains. Hypoxic conditions stress and kill bottom-dwelling organisms and drive fish from the area. (EPA 2007, MRGOWNTF 2008, Bianchi et al. 2010, Kroger et al. 2012).

Vegetative Mosaic

Loss of connectivity, altered hydrology, altered geomorphology and changes in the biotic community all contributed to changes in the vegetative mosaic of the LMR. A variety of vegetative communities were interspersed throughout the floodplain before the levee system was complete and soybean prices rose in the 1950's. Between the 1950's and 1970's, nearly 300,000 acres were annually cleared and converted to agriculture (King et al. 2006). Soils and hydrologic regime influenced what species occurred in any given area. Bottomland hardwood forests (BLH) including oak, hickory, pecan, tupelo, bald and cypress were the most common species in the floodplain and are vital ecological resources. BLH are unique in structure and composition, and rich in wildlife and plant species. Softwoods such as cottonwood, elm, ash, and hackberry were also present. Forest types included cypress-tupelo, cottonwood-willow-sycamore, white oak-red-oak-hickory, hackberry-elm-ash, and many others (Klimas 1988). Channelization and levee construction separated much of floodplain from the river and changed these habitats (Stanturf et al. 2000, Gardiner et al. 2005).

Forest interior song birds are dependent upon large expanses of BLH forests. Their populations have declined (Twedt et al. 2002, Twedt et al. 2008). Fragmentation, human disturbances, and high edge to area ratios all contributed to the decline. Louisiana black bears depend on large, complex forest structure for forage, nesting or bedding sites, and successful reproduction (USFWS 1995). The flood prone forest species that now dominate the batture are less complex and not as suitable for black bear. Reptiles, amphibians, and many mammals, including the Indiana and gray bats, also depend on BLH forests for cover, food, and successful reproduction. Game species that depend on diversity of habitat include white-tailed deer, wild turkey, squirrel, rabbit, and many species of waterfowl (LMVJV 2007). Many species, like American woodcock, rely on the early successional stages of BLH (Kelley et al. 2008).

Figure 6. Bottomland Hardwood Forest in the Lower Mississippi River Batture

River cane or giant cane was once a significant habitat type. Dense beds of cane may grow to 15 to 20 feet in height along streambanks, riparian bottomlands, and wet forest edges (LMVJV 2007). Approximately 98% of this ecosystem has been lost throughout its range to agriculture, altered fire regimes, altered flood regimes, and grazing (Brantley & Platt 2001). Canebrakes are ephemeral and typically develop, grow, and regress during a period of 10-25 years. Fire, tornadoes, ice-storms, and other disturbances are important to the ecology of the plant, however, they are not tolerant of prolonged inundation (LMVJV 2007). These plants provided streambank stabilization, water infiltration, and increased soil porosity. Canebrakes are prime habitat for several species including the Louisiana black bear, Swainson's warbler, and several species of butterflies are cane obligates (Platt & Brantley 1997, Brantley & Platt 2001, Hendershott 2002, LMVJV 2007).

The floodplain of the LMR has emergent, floating, and submersed aquatic vegetation, but their occurrence and distribution is dependent on the flow regime and elevation relative to the main stem river. Littoral areas near the main channel are usually devoid of vegetation due to the scouring effect of moving water, except for duckweed that can become abundant after early isolation from the river. At higher elevations, sloughs and lakes can develop a variety of vegetation types if there is sufficient isolation during the growing season. Common emergent vegetation includes arrowhead, pickerelweed and alligator weed. Typical floating leaf plant communities are comprised of American lotus, spatterdock, and water hyacinth. Submersed aquatic vegetation occurs in waterbodies furthest removed from the mainstem river, such as borrow pits. Common species are coontail, fanwort and various species of pondweeds. Sedges, grasses, and rushes are also found along the periphery of larger waterbodies in the floodplain (personal communication, Dr. Jack Killgore, ERDC).

Invasive plant species include purple loosestrife, privet, kudzu, and many others. Purple loosestrife was introduced from Europe in the early 19th century and has spread across most of the United States. Loosestrife can invade wetlands and suppress native plant species and alter the structure and function of wetlands. There are over 50 species of privet native to Europe, Asia, and Africa. It was introduced to the United States in the mid-19th century as an ornamental shrub and has spread across the country. It has invaded many areas in the LMR that are now drier than they were historically. Privet crowds out native understory vegetation (Merriam & Feil 2002). Kudzu was first introduced to the U.S. in 1876, but it was the erosion control programs of the 1930's to 1950's that really caused its spread. It now covers 2 million acres of forest land in the southern United States. Kudzu is an aggressive, fast growing vine and is very heavy. It covers other plants blocking out sunlight, girdling stems, breaking branches and even uprooting trees (Forseth & Innis 2004, NPS 2010). Many other plant species are problems in localized areas. Most of the invasive species are unsuitable for food, cover, or nesting habitat.

Side Channels, Backwaters and Oxbows

Changes in hydrology, geomorphology, sediment dynamics and loss of connectivity all affect side channels, oxbows, and backwaters. Dense alluvial clays dominate in these backwater areas that historically supported extensive wetlands. Natural levees form along the banks of the LMR, and the riverbank can be 10 to 15 feet higher than the lowlands farther back from the river. Because of these natural levees, drainage within the floodplain, frequently flows away from the Mississippi River to lower elevations near the valley walls, except near tributary confluences (Kleiss et al. 2000). Slackwater areas, access to backwaters, structurally complex riverbanks, and other habitats are important for biotic integrity of aquatic communities (Killgore 2012, USACE 2013).

Historically, the Mississippi River moved across the alluvial floodplain forming meander loops and secondary channels. The secondary channels varied in size and complexity, but were always smaller than the main channel. Secondary channels were gained and lost as the river formed new courses to the Gulf of Mexico (Williams & Clouse 2003). Levees, revetment, and dikes have stabilized the river and floodplain and limit formation of new secondary channels. Secondary channels have become a finite resource. Sedimentation and loss of connectivity with the main channel continue to reduce the quality and quantity of side channels (Guntren et al. 2012, Kilgore 2012, USACE 2013). Secondary channels in the LMR depend on river stage; at higher stages, water moves laterally and reconnects many secondary and tertiary channels that are dry at lower stages.

Figure 7. Bend of the Lower Mississippi River with a side channel

Oxbow lakes were created when meander channels were isolated from the main channel (Biedenharn et al. 2000). Some of the lakes remain connected to the channel at high water and remain good habitat for fish and aquatic species (Dembkowski & Miranda 2011). Connected oxbow lakes support species like skipjack herring, river carpsucker, gars, and white bass. Oxbows with limited connection to the river support species such as largemouth bass, green sunfish, bluegill, and yellow bass (Miranda 2005). If the lakes do not flood frequently enough they succeed to wetlands, which provide habitat diversity for many species (Dembkowski and Miranda 2011). Miyazono et al. (2010) found that as forested wetlands around oxbow lakes increased, wetland-adapted species increased.

At low water, fish and other aquatic fauna may be confined to the main channel where deep water and high velocities can impair survival and growth. Secondary channels offer greater habitat diversity compared to the main channel (Killgore 2012, USACE 2013). Secondary channels function similarly to both main channel and floodplain habitats. There are areas of strong current with substrates of sand and gravel, and areas of slackwater with connections to backwaters and lakes. Flowing water supports fishes such as suckers, minnows, and darters that are relatively intolerant to habitat changes. Overall habitat heterogeneity in secondary channels supports a diverse assemblage of invertebrates and fishes and contributes to the overall health of the aquatic system (Baker et al. 1991, Simons et al. 2001). Many oxbow lakes are now outside of the levee system and turbidity, sedimentation, and land use have reduced their habitat quality (Miranda & Lucas 2004).

The endangered fat pocketbook mussel was probably common in oxbows and sloughs (Miller & Payne 2005). In the LMR, mussels have been found in sand in secondary channels and in a mixture of sand, silt, and mud in side channels (USFWS 2012). Backwaters provide nursery areas for both freshwater and estuarine mussels and their hosts (Parmalee 1967, Harris & Gordon 1987, USFWS 1989, Harris & Gordon 1990, Watters et al. 2009, USFWS 2012).

Invasive Species

Habitat changes have affected the relative abundance of native species in the LMR. Habitat changes alone have driven most of the population changes for birds and mammals as discussed in other sections. For aquatic species, the introduction of invasive species has also had a tremendous impact on species abundance. A variety of exotic aquatic species have been introduced into the LMR. Changes in water chemistry, hydrology, geomorphology, and connectivity have allowed some of these species to thrive and become invasive, disrupting native species assemblages. Predation or competition with exotic species jeopardizes almost half of the species listed as threatened or endangered in the U.S. (ANSTF 2012).

Figure 8. Silver Carp in the Lower Mississippi River

Common carp were introduced in the early 20th century and have become so well established that they are often overlooked in discussions of invasive species. The four recently introduced carp species (bighead, black, silver, and grass) garner most of the attention and management focus, but all of the carp species have had negative impacts on native fishes (Conover et al. 2007). Bighead carp are thought to adversely impact mussels, larval fish, and several adult fishes such as gizzard shad, bigmouth buffalo, and paddlefish. Grass carp prefer a diet of submerged plants with soft leaves, but will also consume detritus, insects, small fish, earthworms, and other invertebrates. Grass carp can damage native aquatic vegetation. Silver carp lack a true stomach which requires them to feed almost continuously and competition with native planktivores is a major concern (Conover et al. 2007, Fuller 2013c). Black carp could pose a serious threat to many of the remaining populations of federally listed threatened and endangered mussels, but they are not established in the wild (Conover et al. 2007).

Northern snakehead are established in several locations in the U.S., including the White River basin in Arkansas. This fish readily survives in waters with poor water quality because it can breathe air. If it expands its range to the LMR or other areas, it may threaten native fish populations because it is a voracious fish eater (Fuller 2013a).

Two species of mussels are a concern for the LMR. Both zebra and quagga mussels are thought to have entered North America in ballast water exchange from cargo ships in the Great Lakes. All the Great Lakes and large navigable rivers in the eastern U.S. have established populations of zebra mussels. Quagga mussels are established in all of the Great Lakes, and are likely to invade the LMR (MDC 2007, Fuller 2013b, Fuller 2013d).

Zebra mussels are very prolific and can reach high population densities (MDC 2007, Fuller 2013d). When present in large numbers, they can reduce the density of phytoplankton, which is food for many native fish and mussels. An estimated $200 million is spent annually to maintain intake pipes and screens that can become clogged with abundant zebra mussels (MDC 2007, Fuller 2013d). Quagga mussels have impacts similar to zebra mussels (Fuller 2013b), but they have wider habitat tolerances, are able to colonize the brackish water of estuaries, and reproduce successfully at colder temperatures than the zebra mussel. In the Great Lakes, the quagga appears to be displacing the zebra mussel on soft substrates in deep water.

Nutria, an invasive rodent, is a significant problem in coastal marshes. They were introduced from South America for the fur trade and were spread across the country for weed control. They are indiscriminant herbivores and destroy the native aquatic vegetation that is vital to the structure and function of coastal wetlands (USDA 2010).

Gravel bars and Sandbars

Altered hydrology, geomorphology, and sediment dynamics all impact gravel bars and sandbars. Sandbars generally are dynamic features of the natural river landscape. Dynamic river forces form, enlarge, erode, move, and destroy sandbars. On established sandbars, high water removes existing vegetation and deposits new sand. Properly deposited dredged material can also create sandbars (USACE 2013).

Figure 9. Interior Least Tern Nesting on a Sandbar

Sandbars are the primary nesting habitat for endangered interior least terns. Terns will not nest on fully vegetated sandbars (Thompson et al. 1997). Flooding can scour some vegetation from sandbars and convert them back to suitable nesting habitat. If perennial woody vegetation becomes well-established and high flows can no longer remove vegetation, sandbars succeed to forest and permanently lose nesting value (Sidle et al. 1992, Friedman et al. 1998, Johnson 2000, Leslie et al. 2000, Wiley & Lott 2012). Terns do not nest in proximity to tall vegetation (i.e., riparian forest) or other high features (USACE 2011), or where channels become narrow (Jorgensen et al. 2012). Gravel bar habitats are important spawning substrate for pallid sturgeon as well as other fish species.

Floodplain

The LMR floodplain provides habitat for birds, mammals, insects, amphibians, reptiles, resident floodplain fish, river fish, and freshwater mussels. Floodplains contain terrestrial and aquatic habitats including forests, canebrakes, side channels, floodplain lakes, natural levees, backwaters, abandoned channels, ridges and swales, manmade water bodies, and tributaries (Baker et al. 1991). Floodplain connectivity is important for not only fish, but also aquatic insects, mussels, turtles, birds, and mammals (Winemiller 2003). The Mississippi River levee system altered natural patterns of surface water drainage within the region and reduced the floodplain area over 80% from its historic size (Baker et al. 1991). Fish and other aquatic species no longer have access to millions of acres of foraging, spawning, and nursery habitat. Water no longer spreads out over the historic floodplain. There is less opportunity for nutrients to attenuate and for water to percolate through the soil (Winemiller 2003). Wetland quantity and quality has been reduced in the region.

The remaining floodplain and backwater areas are a dynamic freshwater ecosystem. The nearly 3 million-acre floodplain is interspersed with abandoned channels (e.g., oxbow lakes), meander scars (e.g., sloughs), levee borrow pits, large expanses of forested wetlands, and tributary mouths (Baker et al. 1991). These areas provide a diverse array of aquatic habitat types and are connected to the river at high water. The LMR floodplain varies in width from 1 to 15 miles. Flooding is necessary about once every two years to maintain populations of some fish and lack of flooding may result in successive reproductive failures (Barko et al. 2006). Changes in timing and extent of flooded acreage affect migratory waterfowl and shorebirds. The floodplain, at high water, provides nutrition, secure roosting, cover in inclement weather, loafing sites, protection from predators, and isolation for pair formation (USACE 2012).

Islands

River islands only occur in large rivers like the Mississippi, Snake, and Columbia and often harbor unique biological communities and habitats (Rosenberg 1990, Walters & Williams 1999, Gurnell et al. 2000, Zoellick et al. 2004). There are over 100 island complexes in the LMR. They each have a secondary channel and a main channel border (Williams & Clouse 2003). There are 199 chutes, which include both vegetated and non-vegetated islands associated with a point bar (Williams & Clouse 2003, Guntren et al. 2012).

Figure 10. Mississippi River Island

Pallid sturgeon have been documented near islands and dikes and prefer island tips and natural banks (Herrala et. al 2014). These habitats provide a break in water velocity and an increased area of depositional substrates appropriate for foraging (Garvey et al. 2009, Koch et al. 2012). Increased use of side channel and main channel islands has been noted in spring. These habitats may be used as refugia during periods of increased flow (Garvey et al. 2009, Koch et al. 2012).

Levees have limited the floodplain and altered forest conditions in the LMR (Peck & Smart 1986, Johnson 1992, Nelson 1997, Knutson & Klaas 1998, Scott & Udouj 1999). Large islands along the LMR contain remnants of the original forests and may be important reservoirs of biotic diversity (Greulich et al. 2007).

Coastal Wetlands

The State of Louisiana contains three million acres of coastal wetlands. However, wetland loss, subsidence, climate change, sea level rise, storms and storm surge, drought, repeated flooding, hypoxia, and saltwater intrusion all threaten the Gulf coast. Historically, the Mississippi River discharged fresh water and sediments into southeastern Louisiana estuaries like Breton Sound and the Barataria Basin. Over time, these alluvial deposits created vast subdeltas and diverse coastal wetlands habitats.

Figure 11. Louisiana Coastal Wetland

Human activities and natural forces have reshaped coastal Louisiana over the past three hundred years. Since the 1930s, over 880 square miles of Louisiana coastal wetlands have eroded. Storms, subsidence, sea level rise, development, energy exploration and production, navigation channels, and flood works have all contributed to the decline.

Today, the LMR carries less sediment than in the past and levee systems prevent most of the available sediment from entering the estuaries. Freshwater and sediment management are important for ecosystem restoration in the coastal marshes (Denslow & Battaglia 2002, Shirley & Battaglia 2006, Battaglia et al. 2007, Day et al. 2007, Shirley & Battaglia 2008, Battaglia et al. 2009, Syvitski et al. 2009, Middleton 2009, Batker et al. 2010, Brown et al. 2011, Couvillion et al. 2011, Piazza 2011, Visser et al. 2012).

Main Channel Habitat

Habitat in the main stem of the Mississippi River has been altered. Channel cut-offs reduced the number of bendways, which shortened the river causing a major loss in channel habitat including pointbars and gravel bars. Dike fields and the associated sediment accretion between dikes reduce aquatic surface area. However, dikes associated with outside bends often scour sediments and increase pool habitat. Revetment construction has reduced naturally steep banks (Baker et al. 1991). However, channel habitat and transitional areas between the thalweg and shoreline (i.e., channel borders) have persisted over time and continue to provide habitat diversity in the mainstem LMR.

Figure 12. Main channel of the Mississippi River at Catfish Point

Pallid sturgeon occupy the deep water of large, turbid rivers, particularly the main channel (Kallemeyn 1983). They mostly occupy the sandy main channel, but they are also collected over gravel substrates (USFWS 1993, Bramblett & White 2001, Hurley et al. 2004, Garvey et al. 2009, Koch et al. 2012).

Much of the natural habitat throughout the range of pallid sturgeon has been altered and this is thought to have had a negative impact on this species (USFWS 1993). Habitats were once very diverse, and provided a variety of substrates and flow conditions (Baker et al. 1991, USFWS 1993). Extensive modification of the Mississippi River over the last 100 years has drastically changed the form and function of the river (Baker et al. 1991, Prato 2003). Today, habitats are reduced and fragmented and much of the Mississippi River basin has been channelized to aid in navigation and flood risk management (Baker et al. 1991). The impact of habitat alteration on pallid sturgeon throughout its range is unknown, but recent studies have shown suitable habitat is available (USFWS 2007).

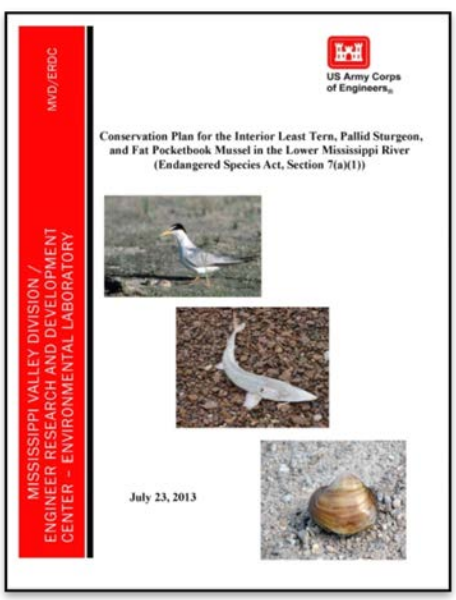
III. HABITAT PLANS

USACE, USFWS, the LMRCC, Lower Mississippi Valley Joint Venture, and others have recognized some of the ecological needs of the LMR and have developed plans to address them. These plans provide a solid foundation for habitat work and partnerships on the LMR. The plans below are comprehensive plans that address all or most of the Lower Mississippi River region. All of the entities above, the states, and Non-Governmental Organizations have also done site specific projects to address some of the needs.

Restoring America's Greatest River

The LMRCC developed and continues to update the Restoring America's Greatest River (RAGR) initiative. RAGR is a plan to implement aquatic habitat restoration and river-access improvement projects within the river's active floodplain from Cairo to the Gulf of Mexico. LMRCC and its partners have identified projects to address side channels, backwaters and oxbows, sand and gravel bars, islands, and main channel habitat. LMRCC has implemented 14 projects since 2006 with cooperation from USACE, USFWS, state agencies, and the Mississippi River Trust. These projects have restored flow to 56 miles and thousands of acres of side channel habitat. These projects are valuable to pallid sturgeon, fat pocketbook mussels, and interior least terns.

Conservation Plan for the Interior Least Tern, Pallid Sturgeon, and Fat Pocketbook Mussel in the Lower Mississippi River (Endangered Species Act, Section 7(a)(1))


MISSISSIPPI VALLEY DIVISION / ENGINEER RESEARCH AND DEVELOPMENT CENTER – ENVIRONMENTAL LABORATORY

MVD/ERDC

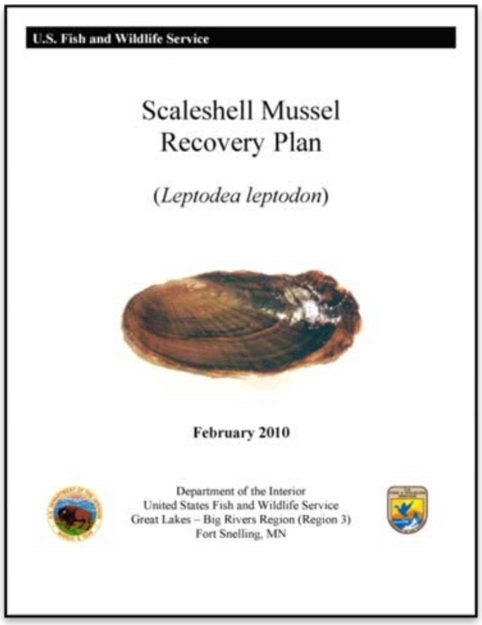
US Army Corps of Engineers

Conservation Plan for the Interior Least Tern, Pallid Sturgeon, and Fat Pocketbook Mussel in the Lower Mississippi River (Endangered Species Act, Section 7(a)(1))

July 23, 2013

USACE and USFWS worked together to develop a conservation plan for the three LMR listed species that depend on the main channel of the river. The Endangered Species Act requires Federal agencies to use their authorities as appropriate to carry out programs for the conservation and recovery of endangered and threatened species. USACE, USFWS, and state conservation agencies identified issues associated with USACE flood risk management and navigation projects on the LMR. These projects have caused the most significant impacts to the river, but offer the best, most cost-effective tools to address these issues. USACE will incorporate ecological engineering concepts in the design of channel improvement and channel maintenance projects. This should provide localized improvements in habitat function and value, with little to no effect on flood risk management, navigation, or project cost. USACE will continue to partner with other agencies to implement cost-effective secondary channel restoration where possible. These actions have already benefitted endangered species habitat in the channel. This plan describes the programmatic mechanisms USACE can use to implement recovery and conservation measures in the Channel Improvement Program of the Mississippi River and Tributaries project.

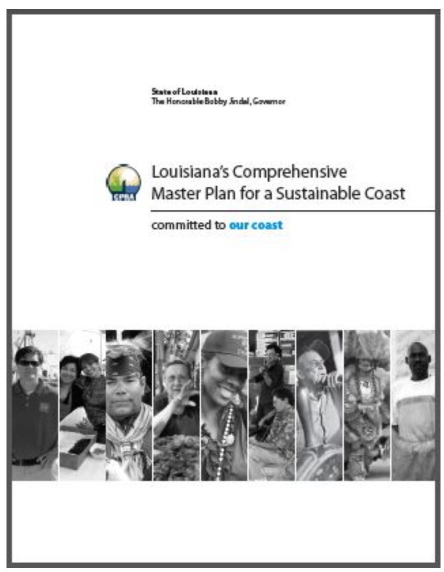
Recovery Plans



The interior least tern, pallid sturgeon, and fat pocketbook mussel are the three federally listed species which range throughout most of the Lower Mississippi River. There are several other listed species whose ranges include part of the LMR. The relict darter's range is limited to Bayou du Chein, KY and the Louisiana pearlshell mussel is only known to occur in Bayou Boeuf, LA. Other species like the Indiana bat and the Louisiana black bear are more widely distributed.

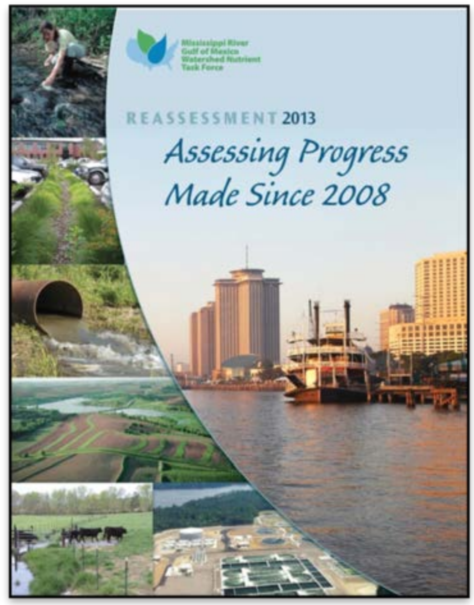
There are recovery plans in place for most listed species. These plans identify the causes of decline and the actions needed for recovery. For example, habitat fragmentation and overharvest are the major causes of decline of the Louisiana black bear. Three isolated breeding populations were known to exist in 1995 and the restoration effort focuses on restoring corridors between these populations. Most recovery plans recommend habitat conservation and management, additional research, and public education. These plans are useful when designing projects within the range of the listed species.

Louisiana's Comprehensive Master Plan for a Sustainable Coast



In 2012, Louisiana's Comprehensive Master Plan for a Sustainable Coast was approved. The plan outlines the state's coastal research, design, construction, and management strategy and is updated every five years. The USACE and the Louisiana Coastal Protection and Restoration Authority plan, construct, operate, and maintain diversion structures along the Mississippi River to divert some of the freshwater and sediment back into the estuaries. Efforts are underway, through the Louisiana Coastal Area Program's Mississippi River Hydrodynamic and Delta Management study, to collect river information and to use it in the development of science and engineering tools to support joint USACE-Louisiana coastal ecosystem restoration planning.

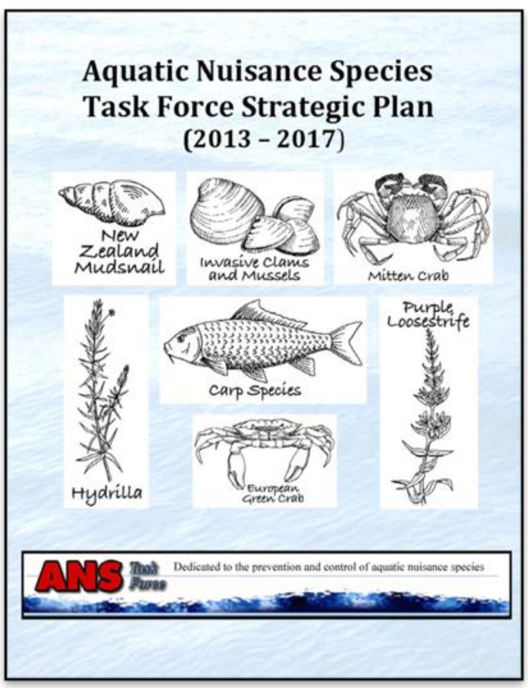
Mississippi River/Gulf of Mexico Watershed Nutrient Task Force



The Mississippi River/Gulf of Mexico Watershed Nutrient Task Force was established in 1997 to understand the causes and effects of eutrophication in the Gulf of Mexico; coordinate activities to reduce the size, severity, and duration of the hypoxia; and ameliorate its effects. The Task Force includes five Federal entities – USACE, USDA, Department of the Interior, EPA, and National Oceanic and Atmospheric Administration – twelve states, and the National Tribal Water Council. The primary priority of the Federal agencies is to provide broad support to the development and implementation of the state prepared nutrient reduction strategies.

The Task Force has identified five priorities: 1) monitoring to demonstrate water quality progress; 2) in-basin and Gulf modeling to demonstrate water quality progress; 3) regulatory program activities; 4) outreach, education, and initiatives; and 5) innovation to expand partnerships and technical assistance. A variety of programs and tools are being used and improved to accomplish these priorities.

Aquatic Nuisance Species Task Force



Congress passed the Nonindigenous Aquatic Nuisance Prevention and Control Act in 1990 to establish a broad national program to stop the introduction of nuisance species and control the spread of species already present. This legislation was reauthorized and expanded when the National Invasive Species Act was enacted in 1996 (ANSTF 2012). The task force (ANSTF) is comprised of 13 Federal agencies and 13 ex-officio representatives (i.e., Mississippi Interstate Cooperative Resources Association) devoted to preventing and controlling aquatic invasive species (ANSTF 2012). The ANSTF Strategic Plan 2013-2017 focuses on prevention, monitoring, and control of aquatic nuisance species, and increasing public awareness of aquatic invasive species and their impacts (ANSTF 2012). Controlling nuisance species is primarily achieved through prevention, early detection, and rapid response. Public education, awareness, and collaboration are vitally important to control aquatic nuisance species. Regional Panels (e.g. Mississippi River Basin Regional Panel) are responsible for implementing strategies that achieve the Strategic Plan's goals. States also play a vital role in preventing and controlling the spread of invasive species.

The USFWS and the ANSTF organized an Asian Carp Working Group to develop a comprehensive national Asian carp management and control plan.

The goals include:

1. Prevent accidental and deliberate unauthorized introductions of bighead, black, grass, and silver carps in the United States.
2. Contain and control the expansion of feral populations of bighead, black, grass, and silver carps in the United States
3. Extirpate, or reduce to levels of insignificant effect, feral populations of bighead, black, grass, and silver carps in the United States.
4. Minimize potential adverse effects of feral bighead, black, grass, and silver carps in the United States.
5. Provide information to the public, commercial entities, and government agencies to improve effective management and control of bighead, black, grass, and silver carps in the United States.
6. Conduct research to provide accurate and scientifically valid information necessary for the effective management and control of bighead, black, grass, and silver carps in the United States.
7. Effectively plan, implement, and evaluate management and control efforts for bighead, black, grass, and silver carps in the United States.

There are other plans for invasive species control:

- Management and control plan for bighead, black, grass, and silver carps in the United States (Conover et al. 2007)
- Asian Carp Marketing Summit (Charlebois et al. 2010)
- Aquatic Nuisance Species Management Plan 2007 (MDC 2007)

Joint Venture Plans

The Lower Mississippi Valley Joint Venture (LMVJV) is a self-directed, non-regulatory private, state, and federal conservation partnership. LMVJV's goal is sustaining bird populations and their habitats within the Lower Mississippi Valley and West Gulf Coastal Plain regions. They implement and communicate the goals and objectives of relevant national and international bird conservation plans (LMVJV 2013). The LMVJV partners work cooperatively to address deforestation and extensive alterations of wetland hydrology resulting from basin-wide flood control and drainage. Regional and national agencies and conservation groups have produced several plans to slow the loss of BLH forests and improve habitat conditions in the

Lower Mississippi Alluvial Valley. A similar Gulf Coast Joint Venture works to deliver habitat conservation to priority bird species along the coast from Texas to Alabama

The North American Waterfowl Management Plan recommends restoration of historic forested wetlands for wintering waterfowl and other wetland functions (NAWMP 2004, NAWMP). The waterfowl plan is updated regularly with adaptive management strategies based on advances in research and development. LMVJV partners have established objectives for maintenance and restoration of several wetland functions and values associated with forested floodplains.

The LMVJV's *Restoration, Management and Monitoring of Forest Resources in the Mississippi River Alluvial Valley: Recommendations for Enhancing Wildlife Habitat* (2007): 1) defines desired forest conditions that result from management of bottomland hardwood forests where the primary objective is the conservation of wildlife; 2) provides technical recommendations for the restoration of bottomland hardwood forest on areas that have been converted to non-forested land uses (e.g., agriculture) that reflect the cumulative knowledge and experiences of land managers and researchers from the past decades of active reforestation; and 3) recommends protocols and procedures for coordinated inventory and monitoring of forest resources on public lands managed for wildlife conservation such that restoration and management can be implemented in an adaptive manner.

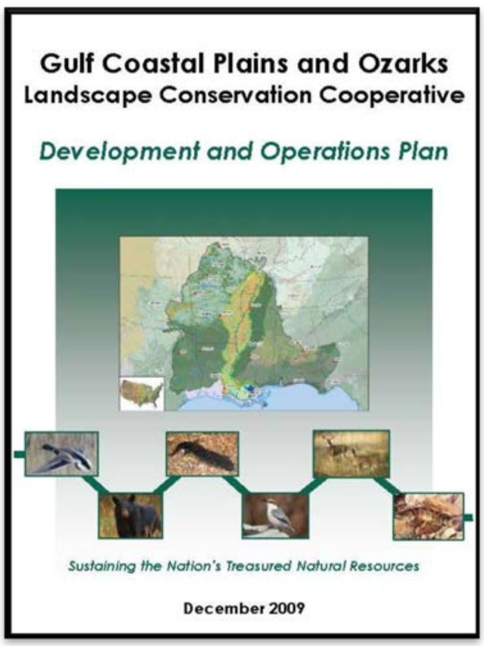
Partners in Flight produced the extensive Bird Conservation Plan for the Mississippi Alluvial Valley in 1999 (Rich et al. 2004, Twedt et al. 1998). This document includes conservation issues and opportunities, species prioritization, habitat objectives, and implementation recommendations. Although the Partners in Flight document establishes avian population goals, many species would benefit from the restoration recommendations, especially the objective to maintain or restore more than 3.7 million acres of predominately mature, forested wetlands in contiguous forests.

The Forest Breeding Bird Decision Support Model is a spatially explicit decision support model, based on a Partners in Flight plan for forest bird conservation, that prioritizes forest restoration to reduce forest fragmentation and increase the area of forest core (Twedt et al. 2006). The primary objectives were to increase the number of forest cores areas that are larger than 5000 acres, and to increase the number and area of forest core areas over 12,000 acres. Restoration within local (125 square miles) landscapes to achieve more than 60% forest cover was also targeted. Restoration of higher-elevation bottomland hardwood forests in areas where restoration would not increase forest fragmentation was also emphasized.

National Resource Conservation Service Programs

The NRCS provides technical and financial assistance to landowners for water quality and wetlands improvement projects. NRCS has established the Mississippi River Basin Healthy Watersheds Initiative to improve the health of the Mississippi River Basin. Through this Initiative, NRCS and its partners help producers in selected watersheds in the Mississippi River Basin voluntarily implement conservation practices that avoid, control, and trap nutrient runoff; improve wildlife habitat; and maintain agricultural productivity. They plan to restore over 11,000 acres of wetland habitat and prevent sediment and nutrients from entering waterways, decrease flooding, and improve bird and fish habitat. Approximately two thirds of the work is within the batture. The Wetlands Reserve Enhancement Program, part of the agency's Wetlands Reserve Program, provides the funding. Since 2010, the NRCS has formalized agreements with 47 landowners in the basin, investing $17.8 million in long-term conservation easements and wetland restoration projects.

Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative Programs



The Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative (GCPO LCC) is a voluntary network of partners working to address common landscape conservation goals (GCPO 2013). It includes members from seven Federal agencies, ten states, universities and many non-governmental organizations. The Cooperative's mission is to define, design and deliver landscapes capable of sustaining natural and cultural resources at desired levels now and into the future. They develop scientific protocols and decision support tools for habitat conservation. The Cooperative has developed an operations plan, a communications plan and is working on a Strategic Conservation Framework (GCPO 2013).

IV. CONCLUSIONS

An examination of the conceptual ecological model and the existing habitat conditions on the Lower Mississippi River has revealed several habitat needs. Some of these could be addressed with the plans that are already in place, while others have not yet been addressed.

Water Quality

Water quality in the Mississippi River is good and steadily improving, but there are problems with nutrients and contaminants. Bioaccumulation of contaminants is one probable cause for the decline of sturgeons. The Ohio River shrimp's range and populations are both greatly reduced and pollution is one of the identified causes (Bowles et al. 2000). There is little information on the effects of side channel and backwater disconnection on water quality, fish assemblages, and other biota (Crites et al. 2012).


Figure 13. Shovelnose sturgeon

There is a need for research focusing on the relationship between nutrients and hydrological connectivity (De Jager & Houser 2012). There is also a need to add biological monitoring, e.g. Ohio River shrimp, to ongoing water quality monitoring on the Mississippi River.

The LMRRA Information Needs Assessment concluded: The demand for good water quality in the lower Mississippi River far exceeds the capacity of any one agency or state to oversee and provide. A dedicated water quality monitoring and research program for the entire Lower Mississippi River would be valuable to develop more effective programs to manage water quality and protect the ecological resources of the LMR. The USGS, EPA, USACE, DOI, NOAA, LMRCC, twelve states, and the National Tribal Water Council are part of the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force. Continued and enhanced cooperation will produce benefits for fish and wildlife, coastal habitat, and Gulf of Mexico hypoxia reduction.

Vegetative Mosaic

The need to restore BLH in the Lower Mississippi River Valley has long been recognized and continues to be a priority, but other vegetation types have also declined. There is a need for research to examine current hydrology, soils, and historic vegetation within the batture and develop tools to direct restoration of BLH and other habitat types. This information would increase the success of restoration efforts. There is also a need to control or eliminate invasive plant species where they threaten restoration or preservation efforts.

Figure 14. Bald cypress and emergent vegetation

The Partners in Flight Bird Conservation Plan already includes recommendations for forest patch sizes. The NRCS Mississippi River Basin Initiative and the Wetlands Reserve Enhancement Program both provide assistance to landowners who are interested in reestablishing native vegetation on their lands.

Side Channels, Backwaters and Oxbows

Figure 15. Mississippi River side channel

Side channels, backwater, and oxbow lakes have been disconnected from the main river and many no longer provide suitable habitat for native species.

There is a need to reconnect and restore backwaters, side channels, and oxbow lakes. Borrow pits may offer opportunities to restore some lake habitat that has been permanently lost.

The Restoring America's Greatest River Plan and the Conservation Plan for the Interior Least Tern, Pallid Sturgeon, and Fat Pocketbook Mussel in the Lower Mississippi River both include opportunities for restoring some of this habitat.

Invasive Species

Many fish species depend on tributaries for at least part of their lifecycle. Although most of the species native to the LMR are still present and their populations are viable, the species abundance of many has declined. Habitat changes have caused most of the changes for mammals and birds, but the main factor driving aquatic population changes has been the introduction of exotic aquatic species such as carp and zebra mussel.

There is a need to control invasive species especially in areas where they threaten native species or interfere with restoration.

The Aquatic Nuisance Species Task Force is continually updating recommended measures to control invasive aquatic species.

Figure 16. Endangered Indiana bat

Gravel Bars and Sandbars

Gravel bars and sandbars are important habitats in the LMR. The number and quality of these bars has been reduced over the years.

Figure 17. Shipland Sandbar

There is a need to protect existing gravel bars and sandbars that are known to be important habitat and to restore those that are silted over or connected to the riverbank.

The Conservation Plan for the Interior Least Tern, Pallid Sturgeon, and Fat Pocketbook Mussel addresses management and restoration of gravel bars and sandbars for the benefit of federally listed species and the Restoring America's Greatest River initiative identifies some specific opportunities.

Floodplain

Figure 18. Mississippi River at high water in 2008

The Mississippi River floodplain is now 80% smaller than it was historically. The loss in area impacts water quality, habitat, and species. The floodplains of tributary rivers may have become more important since the Mississippi River floodplain has been reduced. Cities, farms, highways, factories, and other developments have moved into the historic floodplain. Opportunities to restore land to the floodplain will likely be rare and small scale.

There is a need to assess tributary rivers to determine how their floodplains can be better managed to compensate for some of the loss of floodplain area. On the main stem Mississippi River, restoration efforts should focus on restoring the quality of habitat within the batture. The preceding sections on Vegetative Mosaic and Side Channels, Backwaters and Oxbows identify the floodplain quality issues that need to be addressed.

Islands

Mississippi River islands are unique habitats. Islands afford many species safe places for sensitive life cycle events such as nesting.

There is a need for an ecological inventory of islands in the LMR to determine their value for habitat and potential for restoration. At least two Mississippi River islands have been offered for sale in the last two years. State, federal or non-governmental conservation organizations have shown some interest in acquiring these, but there is not enough information about their ecological value.

The Restoring America's Greatest River Plan includes some island conservation opportunities.

Figure 19. Mississippi River Island

Coastal Wetlands

Figure 20. Coastal Wetlands in Louisiana

Historically, the Mississippi River discharged fresh water and sediments into southeastern Louisiana estuaries and helped build and maintain them. Today, the LMR carries less sediment than in the past and levee systems prevent most of the available sediment from entering the estuaries.

Preserving and rebuilding coastal wetlands is a recognized need and projects and programs are in place to address the problems.

Louisiana's Comprehensive Master Plan for a Sustainable Coast sets forth a long term plan to address coastal needs.

Main Channel Habitat

Habitat in the Mississippi River main channel was once very diverse, and provided a variety of substrates and flow conditions. Habitat complexity in the main stem has been reduced.

Figure 21. Sunset over the main channel of the Mississippi River

There is a need to restore some of the diversity in the main channel of the Mississippi River in areas where it does not interfere with navigation.

The Restoring America's Greatest River Plan and the Conservation Plan for the Interior Least Tern, Pallid Sturgeon, and Fat Pocketbook Mussel in the Lower Mississippi River both include opportunities for restoring some of this habitat.

Cumulative Needs

The Mississippi River ecosystem is a dynamic system with interactions between the terrestrial and aquatic systems, main channel and side channel areas, mudflats, backwaters, tributaries, and islands. The previous sections discussed the needs for the individual ecological elements of the LMR, but these elements also interact with each other. The interactions are complex and on the scale of the entire 954 miles of the Lower Mississippi River are likely not describable.

There is a need to examine and manage the Mississippi River and batture and tributary watersheds at a manageable scale. There are some priority reaches of the river where there are opportunities to enhance a broad spectrum of features, i.e. restorable side channels, backwaters, and oxbows, a wide floodplain, large islands, populations of threatened and endangered species, and sand bars. These areas need comprehensive plans for restoring all of the vital ecological elements. Tributary river floodplain habitats are connected to the Mississippi River floodplain and are important for mammals, birds and other species. These rivers also provide important life stage habitat for fish and aquatic species in the river. Tributaries contribute sediment, nutrients and contaminants to the river. Tributaries should be assessed to identify opportunities to improve the overall Mississippi River ecosystem.

Most of the recovery plans noted a need for public education. Engaging and educating the public about natural resources in general and especially the Mississippi River could be valuable long into the future. Public awareness and appreciation of the Mississippi River's ecological value is necessary for implementation of restoration projects. The importance of public perceptions and knowledge was also noted in the LMRRA Assessment of Information Needed for River Related Management and the Assessment of Needs for River-Related Recreation and Access.

Figure 22. Driftwood on the bank of the Mississippi River

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Appendix A

Public Scoping

LMRRA Public Scoping Meetings

Recreation and Habitat Assessments

30 July 2013 Dyersburg, TN – Approximately 25 attendees. The Dyersburg State Gazette published articles before and after the meeting.

Boat Ramps – There is no Mississippi River Boat Ramp in Dyer County, TN. Fishing is a popular activity, but access is limited. There is a Blueway and a canoe/kayak ramp on the Forked Deer River that has spawned a lot of interest in canoeing and kayaking. The public would like to see ramps on the MS River every 10-20 miles that would at least accommodate paddlers.

Biking – Biking is a popular activity. There are new trails being developed. They would like to see more dedicated bike trails that connect the towns.

Bird watching – They have several good spots for birding and would like more.

We received specific suggestions for boat ramp locations and improvements, access improvements at wildlife refuges, habitat improvements at several small lakes, and a pavilion near the I-155 bridge.

1 August 2013 Helena, AR – Approximately 12 attendees.

Boat Ramps – Quapaw Canoe Company attended and provided numerous suggestions for boat ramps and paddling access throughout the lower river.

The American Queen docks in Helena and offers two premium excursions – paddling on the Mississippi and an historic/cultural tour of Helena and the Arkansas Delta. High water in 2011 and low water in 2012 prevented the American Queen from docking there on several of its trips. The Helena Boat Ramp is very steep and wheelchair access is problematic. The Phillips County Chamber of Commerce would like to see a better docking facility for the American Queen and other river boats in Helena.

Attendees suggested the opening of the Harahan Bridge in Memphis will create more opportunities for biking in AR. They would like to see more dedicated trails.

7 August 2013 St. Francisville, LA – Approximately 15 attendees

Attendees were interested in hunting and fishing. Some expressed concern about the condition of access roads.

Woodcock habitat on the lower river was mentioned and further information was provided via email.

Paddling and the lack of boat ramps were mentioned.

	Location
Projects like the Harahan Bridge will draw people to the river. Hopefully we can start to open the levee roads to bike traffic.	Dyersburg, TN
Water quality is a concern for the majority of people I tlak to about the river. Most people think that the Mississippi is polluted or that you can't even eat the fish out of it. "You can't eat the fish, you'll grow another toe!" Clearly this is untrue, but access to water quality reports are almost nowhere to be found. The upper Mississippi releases a State of the River report every year. I don't know of anything similarly comprehensive on the Lower Miss. Even before that, though, there should be an easily accessible place online where the public can find information on water quality.	Dyersburg, TN
Would like to see: dedicated bike trails, more boat ramps, more access for paddling, bike trails into towns Commented – seeing more coastal birds the last couple of years.	Dyersburg, TN
1. Scenic overlooks on the TN side of the Mississippi River close to traffic patterns where out of state tourists travel. 2. Boat ramp along the forked Deer/Obion River near the Mississippi River where Dyer and Lauderdale Co. border for small boats and canoes (to exit those rivers before going into the Mississippi). 3. Wildlife refuge that lends itself to bird watching and photography along the MS Rver. 4. Recreational/camping sites along the Mississippi River and its tributaries	Dyersburg, TN
Need a Mississippi River boat ramp in Dyer Co	Dyersburg, TN
Information about a 10 acre cypress swamp along the Forked Deer River just downstream of downtown Dyersburg that land owner would like to incorporate into a recreational plan for canoeing, etc . Possibly educational spot, picnic area as canoers travel towards Miss River and beyond. Canoe launching point currently exist in downtown Dyersburg.	Dyersburg, TN
Boat ramp at Forker Deer River (Lauderdale Cty) – Take rt 19 out of Ripley, 1 mile west of Arp. Turn west at last road before Walnut Grove Church, 2 miles past the bluff. Access to river is on the right.	Dyersburg, TN
Improve ramp at Tipton RM 765 – it is fast water, not good for smaller boats/canoes There are no ramps between Caruthersville and Ed Jones New ramp @ Cates Landing RM 900 New ramp @ RM 880 Randolph @ 770 needs access Need pamphlet on river access, history, safety for rec w/educ Dyersburg River Center on River w/ ramp – classes soon!	Dyersburg, TN
I paddle a sea kayak in the Mississippi River. Most of this is confined to doing laps between the casinos, because there is no public access to the river between St. Francisville and BR, a section of the river that is lightly trafficked and clean enough to swim in. There are canoeists,	St. Francisville, LA

SUP paddlers, and kayakers who would welcome such access. One serious obstacle to improving the recreational capability of the river is public opinion in Baton Rouge and places downstream. Baton Rougeans tend to dismiss the river as a toxic cesspool. (This is because BR <u>treats</u> the river as a toxic cesspool.) A better acquaintance with the wild and clean river just upstream would better inform these attitudes.	
Greater access to the MS R via boat launches, etc. Continuous effort to improve/increase connectivity of the MS R to backwater habitats Work to reduce headcutting on tributaries to the MS R example: Homochitto River- redirect down historic channel thru Lake Mary.	
Interested in Wilkinson County, MS area access on east side of Miss River Fort Adams, MS. Hwy 24 ends. No access to river. Jackson Point Road stays washed out. Can't get launched on river. Ramp not complete. Lake Mary road to Lake Mary stays washed out. Need road built up so can get to lake. Need Public launch at Mud Lake, Foster Lake on Lake Mary Road. Public lakes but no public launches. Ruled by few. Need more access to river in Wilkerson County, MS. More access in Adams County, but not Wilkerson County. Please look at this area Wilkerson County MS.	

Online questionnaire responses collected through December 2013 via GreatRiversPartnership.org

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#1-3. Full Name (optional), Email (optional), State of Residence

1. - Tennessee
2. - Arkansas
3. - Mississippi
4. - Tennessee
5. - Arkansas
6. - Louisiana
7. - Louisiana
8. - Louisiana
9. - Arkansas
10. - Mississippi
11. - New York (but my work includes the Louisiana and Lower Missouri Alluvial Valley)
12. *Anonymous A* - Alabama
13. - Arkansas
14. *Anonymous B* - Florida
15. - Tennessee
16. - Louisiana
17. *Anonymous C* - - Louisiana
18. *Anonymous D* - Mississippi
19. - Mississippi
20. - Upper Tennessee
21. - Tennesse

#4. Which of the following outdoor activities do you enjoy on the Lower Mississippi River?

1 – paddling, hiking, photography

2 - Paddling; Cycling; Hiking; Fishing; Birding/Wildlife Viewing; Photography; meditating

3 – Paddling; Hiking; Fishing; Birding/Wildlife Viewing; Photography

4 – Paddling; Hiking; Fishing; Birding/Wildlife Viewing; Photography; botanical exploration

5 – Birding/Wildlife Viewing; Photography

6 – Cycling; Birding/Wildlife Viewing; Photography

7 – hiking

8 – cycling

9 – Paddling; Hiking; Fishing; Birding/Wildlife Viewing; Camping

10 – Paddling; Hunting; Fishing; Birding/Wildlife Viewing; Photography

11 – hunting

Anonymous A – Hiking; Birding/Wildlife Viewing; Photography; historical tourism, ancestor research

13 – Paddling; Cycling; Hiking; Hunting; Fishing; Birding/Wildlife Viewing

Anonymous B – Hiking; Fishing; Birding/Wildlife Viewing; Photography

15 – Paddling; Cycling; Fishing; Birding/Wildlife Viewing

16 – Cycling; Hiking; Fishing; Birding/Wildlife Viewing

Anonymous C – Paddling; Hiking; Birding/Wildlife Viewing; Photography

Anonymous D – Birding/Wildlife Viewing; Sitting and looking at the river, watching boats pass

19 – Fishing

20 – Hiking; Birding/Wildlife Viewing; Photography

21 – Cycling; Hiking

#5. What improvements could be made along the Mississippi River to enhance your experience?

1 – Water quality. I live in the Memphis suburbs near Collierville and used to paddle quite a bit downtown. There have always been signs posted at the boat ramp at the mouth of the Wolf River and under the Auction Street bridge which caution people not to eat the fish that swim in the Mississippi and Wolf. I get terrible headaches after I paddle in the river, so I no longer go downtown to paddle.

2 – bicycling -- no vehicles allowed, guided tours to explore parts I can't get to by myself, wildlife sanctuaries, parks for picnicing and camping, ammenities that encourage people to hike the river just like people hike the Appalachian Trail, a boat ramp in Mississippi County, AR at the end of Highway 18

3 – Better boat ramps, more facilities at public lands (visitor centers, trails, viewing platforms), and more public access to places where you can see the river.

4 – more watershed protection measures such as natural buffers

5 – easier access to Buck Island

6 – Multi--use path from Natchez, Miss. continguous through to New Orleans. Building of IBMA--spec multi--use trails (not hunting ATV trails and not super--steep amateur hack hiking trails) in the North and South Tracts of the unique and gorgeous Tunica Hills Wildlife Management area.

7 – Expansion of the bike trails on the levee. They could be wider and longer for expanded use.

8 – None that I can think of...it would be great if there were safer access points with respect to crossing the busy street to get on the levee but that is not your issue :)

9 – Pave roads in state forest (St. Francis north of Helena). Provide more recreational access for human--powered boats.

10 – Public access. I use Shipland WMA as it is the only public access area to the channel side.

11 – Improve habitat for American woodcock and ensure access for recreational activities, especially for huntingl.

Anonymous A – no answer

13 – Turn the bature into a national park

Anonymous B – no answer

15 – no answer

16 – More land. More trees. More wetlands.

Anonymous C – Levee access

Anonymous D -- Walking paths along the river.

19 – Public access is greatley needed for bank fishing. A reservoir built would be even better. Installing more dams on the lower Mississippi to control the current and make it easier to navigate like on the Upper MS river

20 – Better trails, closer to river with more places to view birds/wildlife

21 – More walkable trails

#6. Are you interested in the history and culture of the Mississippi River? If so, please explain why and which aspects are most compelling to you.

1 – *no answer*

2 -- This is the greatest river in the world! It has so much rich history and culture associated with it but we're ignorant about a lot of it. Not enough people know about the Sultana, for instance. Not enough people know how important the barge industry is to our economy or the role the river has played in our country's history. People need to know where the stories and the music about the river come from.

3 -- I am interested in the natural history of the river as well as music and local food.

4 – yes. the history of alluvial deposits

5 – As an employee of the Delta Cultural Center in Helena, I am very interested in the history and culture of the River. As a native of Helena, I know that it helped shape and define our region. Specific topins of interest: changes in the

course of the River over time; transportation along the River; opportunities for nature-based tourism

6 – Yes. Researched the plight and history of the Tunica Indians and their Supreme Court case to recover the "Tunica Treasure" that later funded their relocation and business in Minden.

7 – *no answer*

8 – I don't think most people realize just how critical the river is to our economy relative to the transport of agricultural exports, raw materials, and imports. I personally am very interested in the social, political, and cultural influences of the river, especially the delta.

9 – Plantation life; foods

10 – Yes, the book Rising Tide by John Barry was a revelation to the history and tied the Delta, the marshes and history together for me.

11 – We are very interested in the culture and history of the region in regards to hunting, fishing, trapping, and land use history, particularly forestry.

Anonymous A - Yes, I have grown up hearing stories from my father's family in southeast Arkansas about life in that area. My grandfather was born at Arkansas Post and was extremely proud of that fact. My grandparents (as well as two sets of great grandparents) lived through the 1927 flood. Granddaddy (1905-2000) worked with local preservation groups in Desha Co., AR, and wrote about his history. All my relatives go duck hunting and depend on that "industry" and its tourism for their livelihoods. All my life I have heard about the rich history of the Stuttgart area and the famous people who used to (and still do) duck hunt (Pulitzer, Hemingway, etc). I love the folkways, the music and the history generally. There is so much.

13 – the pre-history as well as the colonial history is most fascinating... I like the early pre-WWII 20th Century history too.

Anonymous B – no answer

15 – no answer

16 – I know the history of the Mississippi. The taming of the river by man is the most compelling aspect of the river to me. And the fact that if man had left the river alone Louisiana would actually be bigger than it was 30 yrs ago instead of washing away. Oil companies should be held accountable.

Anonymous C - Yes. Historic transportstion settlement trends woukd be interesting

Anonymous D -- Live in Vicksburg -- just like the river.

19 – Not really

20 – This river was here long before the Corps of Engineers began to "tame" it. The culture of Tennessee, Mississippi and Louisiana are tied to this River. We should preserve it as much as possible so that as it flows by Memphis.... one mile wide, still majestic...it takes our breath away.

21 – Yes because it has served so many civilizations and provided them resources

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#7. Where would you take a visitor who had never seen the river before? And why would you choose this location?

1 – Beale Street Landing. Beale Street is a must--see for tourists and the views are very nice there.

2 -- I would take them to the end of Highway 18 in Mississippi County, AR and the dirt road that parallels the river. It has huge, beautiful live oaks and is a lovely, peaceful spot. Another place would be Helena, AR. I would also love to stand in the middle of the Harrahan Bridge and look north and south.

3 -- Any place where you can get a good view of the main channel. There are not enough easily accessible overlooks in many places. If possible, I would take visitors in a motorized boat to see the main channel, sandbars, oxbows and backwater areas. Pedestrian access on old Mississippi River bridges (Harahan Bridge in Memphis and the old U.S. 80 bridge at Vicksburg should be developed for pedestrian access (cyclists and walkers).

4 – Vicksburg because of the dramatic bluffs

5 – Helena RiverPark -- best view of river and barge traffic -- can sit and relax

6 – Tunica Hills Wildlife Management area

7 – *no answer*

8 – "The Fly" at Audubon Park. It is the only real place to see a sunset on the horizon in New Orleans. It's also a great place to see large ships pass.

9 – Helena/St. Francis National Forest/West Memphis to Memphis Bridge/Memphis

10 – Shipland WMA. It is public access, the area is beautiful, the quiet water on the channel side is navigable by kayaks and now that the dikes are notched you can pass through as well as the notches have improved fishery habitat.

11 – bottomland hardwood sites within the floodplain, in search of American woodcock (during winter months). Lower Mississippi floodplain is very important winter range for the American Woodcock.

Anonymous A – no answer

13 – Helena Arkansas River Park "Helena Occupies the Greatest Situation on the Mississippi" Mark Twain, "Life on the Mississippi"

Anonymous B – no answer

15 – The river front in New Orleans.The look on their faces when they see the height of the river,and then look down at the city.

16 – I'd go to the Butterfly which is between Audubon Zoo in New Orleans and the river. I've been going there all my life. Great view of the river there and so close. Great place to bird. Lots of open sky over the river and the batture has overgrowth that attracts birds.

Anonymous C – The Fly. The Batture. The levee in Baton Rouge at the shaw center I don't have a boat so those locations are scenic and easy accesd.

Anonymous D – Vicksburg because it is the key to the south. It has hills and the delta. It has it all.

19 – Some of the dykes to fish

20 – Tom Handy Park. It gives you a view of the River like no other in Memphis

21 – Tom lee park because it is a nice open space and view of the river

#8. What do you believe are the major issues threatening Mississippi River habitats that impact, fish, birds, mammals, reptiles, amphibians and other river life?

1 – Water quality and air quality. For water quality, see my other responses. There is a hazardous waste burning facility north of Mud Island. There is an oil refinery at the south end of Memphis. There is no getting away from the terrible air quality in downtown Memphis. When I worked at the AutoZone headquarters (1998‐2001), many people fell ill with pneumonia or had terrible problems with allergies.

2– pollution, invasive species, destruction of wetlands, short‐sighted projects that make unwise use of tax payers' dollars

3 – Fish need more floodplain and side channel access where possible. Forests along the river and in the alluvial valley are often fragmented and too small to support viable populations of songbirds. Certain tributaries have low flows during the year or are suffering from erosion caused by channel maintenance.

4. – urban and agricultural runoff

5 – pollution

6 – over‐population, pollution, litter

7 – *no answer*

8 – At the delta, the loss of coastline and the marshes that separate the barrier islands and shore is troubling.

9 – Overuse of water resources; agriculutral practices; shipping ? I don't know about these impacts, but can't believe they don't exist.

10 – Apathy, more people need to be able to experience to appreciate. Habitat improvment is a major issue. Notching the dikes is a great example of how simple adjustments make huge improvements for habitat.

11 – invasive species and policies that would prohibit or inhibit beneficial sustainable forest management practices.

Anonymous A – no answer

13 – development and the use of front yard herbicides across the deainage basin

Anonymous B – no answer

14 – Pollution.

15 – Man, dead zone, invasive species, oil, vanishing wetlands, habitat loss

Anonymous C -- Petroleum industry canals.

Anonymous D -- Pollution

19 – Not enough people care, and do not know the true wonders of the resource

20 – Pollution. It has to stop being the sewer for cities.

21 – Dumping waste

#9. How do you think the Mississippi River could be improved to benefit, fish, wildlife and people?

1 – Improve water quality and adjacent city air quality.

2 – Stricter pollution controls, enforce waste management regulations, increase the number of wildlife management areas (and their funding), improve national flood protection policies

3 – Consistent funding for habitat restoration is needed, along with funding for monitoring the success of restoration projects. We should examine options for managing water more holistically to benefit fish, wildlife and people. We should investigate ways of providing more floodplain storage of flood waters where possible. Safe public fishing opportunities should be increased.

4 – designate more flood zones and allow more flooding

5 – Leave as much of the land along the River as possible undeveloped, yet provide adequate access for people to participate in recreational activities without disturbing the natural aspects

6 – Continue to protect the Cat Island National Wildlife refuge, encourage eco--tourism in the place of hunting and fishing.

7 – *no answer*

8 – I suppose greater awareness and appreciation would come from greater recreational access along the river. Linear parks and bikeways are a great start. Although it's a strange comparison, I thnk what New York City has done on the Hudson greenway to connect people to the river is fantastic. The recreational and park spaces all along the westside of Manhattan are incredible.

9 – public outreach/education/advertising campaigns to connect land and water use practices with the DEAD ZONE drama. documentary films STEM education outreach to all Delta schools

10 – Managing the dikes and channels for wildlife and provide public access because more people using the river will provide more people that care about it.

11 – maintain diverse, healthy forests through forestry best management practices, and ensure access for full range of traditional outdoor recreation activities.

Anonymous A -- Preserve historical landmarks all along the river. Do more documentation and do more to attract tourists to those spots. (Just one example, Arkansas City has a historic courthouse with framed historic photos inside, many of the 1927 flood. That town has other sites that could be part of a driving tour with brochure and CD for narration as you drive.)

13 – take the batture and turn it into a park and then work up each of the major tributaries and implement a non--point source pollution program.

Anonymous B – no answer

15 – Not sure,it's just a complicated question.

16 – Allow diversions all along the lower Mississippi delta. Use the Morganza spillway to deposit sediment to help build land by letting it flood on a regular basis. Allow the river to build land like it was intended to do.

Anonymous C -- Let it flood and deposit silt to build up the coast.

Anonymous D -- More opportunities to get close to this huge river.

19 – a reservoir built of the river, using water from the river to fill and replenish fish would be an out resource

20 – Better access to the less inhabited area so you can hear mocking birds, the cardinals, etc instead of urban noises.

21 – Inform people of what animals are in the river and thrive in it