RESTORING AMERICA'S GREATEST RIVER

A HABITAT RESTORATION PLAN FOR THE LOWER MISSISSIPPI RIVER

LOWER MISSISSIPPI RIVER CONSERVATION COMMITTEE

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Mission: Promote the protection, restoration, enhancement, understanding, awareness and wise use of the natural resources of the Lower Mississippi River, through coordinated and cooperative efforts involving research, planning, management, information sharing, public education and advocacy.

The cover photo, taken by Bruce Reid near Fitler, Mississippi, shows the Mississippi River main channel, a sandbar, a notched dike and the batture forest.

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Suggested citation: Lower Mississippi River Conservation Committee. 2015. Restoring America's Greatest River: A Habitat Restoration Plan for the Lower Mississippi River. Published electronically at http://lmrcc.org. Vicksburg, Mississippi.

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INTRODUCTION

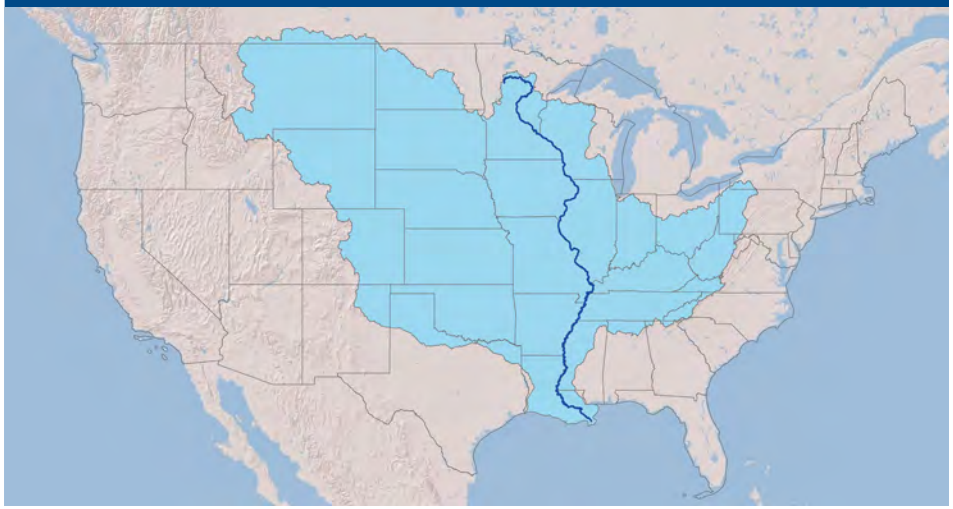
The Lower Mississippi River Conservation Committee (LMRCC) was founded in 1994 and is a coalition of 12 state natural resource conservation and environmental quality agencies from Arkansas, Kentucky, Louisiana, Mississippi, Missouri and Tennessee. The LMRCC Executive Committee has one member from each of the agencies. There are also five federal partners: U.S. Army Corps of Engineers (USACE), Natural Resources Conservation Service (NRCS), U.S. Environmental Protection Agency (EPA), U.S. Fish and Wildlife Service (USFWS) and U.S. Geological Survey (USGS). The USFWS provides a coordination office. LMRCC staff work out of the USFWS's Lower Mississippi River Fish and Wildlife Conservation Office in Jackson, Mississippi.

The LMRCC provides the only regional forum dedicated to conserving the natural resources of the Lower Mississippi River (LMR) and its floodplain. The focus of the LMRCC is habitat restoration, long-term conservation planning and nature-based economic development.

The purpose of this document is to synthesize the landscape-level planning efforts of the LMRCC. It begins with background information on the LMR system, including habitats and species, and concludes with planning efforts, accomplishments to date and recommendations for future direction.

The Mississippi River has a drainage basin of 1.225 million square miles and encompasses 41% of the contiguous United States and parts of two Canadian provinces (Baker et al. 1991). The river's main stem extends 2,348 miles from the headwaters at Lake Itasca in northern Minnesota to the most downstream portion at Head of Passes, Louisiana. The Upper Mississippi River is the portion above Cairo, Illinois, and is mostly impounded by 27 locks and dams. Between the mouths of the Missouri River at St. Louis and the Ohio River at Cairo, is a 200-mile, unimpounded reach often referred to as the Middle Mississippi River, although it is part of the upper river. The LMR begins at the Ohio River confluence at Cairo and flows 953.5 miles to the Gulf of Mexico (USACE 2013, USFWS 2013a).

MISSISSIPPI RIVER WATERSHED



The Lower Mississippi River Valley lies within the central Gulf Coastal Plain physiographic province (Baker et al. 1991, USACE 2013). The valley varies in width between 40 and 110 miles and includes parts of Missouri, Illinois, Kentucky, Tennessee, Arkansas, Mississippi and Louisiana. The size of the LMR leveed floodplain (i.e., batture) is unclear because estimates vary. For example, the National Land Cover Database (NLCD 2011) indicates that the batture is 2.1 million acres; Baker et al. (1991) lists nearly 1.5 million acres; and the USACE's 2011 post-flood report (MR&T 2012) has it at 2.8 million acres.

Regardless of this discrepancy, the floodplain has been reduced by 80% through the construction of the levee system (Baker et al. 1991).

RIVER MODIFICATIONS

After the 1927 flood, the Mississippi River and Tributaries (MR&T) Project was authorized by the Flood Risk Management Act of 1928, which has been modified several times. The MR&T Project includes a 2,216-mile levee system, three floodways to divert excess flows past critical reaches, and channel modifications and stabilization features. The Channel Improvement Program (CIP) of the MR&T Project provides for a low-water navigation channel from Cairo, Illinois, to Baton Rouge, Louisiana, that is at least 9 feet deep (authorized to 12 feet) and 300 feet wide (USACE 2013, USFWS 2013a).

Refugees of the 1927 flood took to higher ground in Vicksburg. Photo: National Weather Service

Another impact during the past 30 years has been a gradual but substantial loss of secondary channels and the area of seasonally flooded in-channel habitats. Approximately 23 secondary channels totaling nearly 10,000 acres have been lost in the LMR since the 1960s due to natural realignments and/or channel modifications, including closure dikes, as a result of the MR&T Project (Williams and Clouse 2003). Ninety-two LMR secondary channels remained in the 1990s.

Articulated concrete mattress (above) is used to stabilize banks along the Lower Mississippi River. Photo: Bruce Reid

Three main types of river training structures are used in the CIP: revetments (to prevent bank erosion, protect levees and maintain channel alignment), dikes (to promote a self-maintaining navigation channel) and bendway weirs (to widen narrow bends for navigation). Alternative structures are also used, including: hard points (functioning as revetment), roundpoints and chevron dikes ('U'-shaped structures constructed of riprap that function similar to dikes). A combination of these structures works synergistically to achieve navigation objectives.

For more than a century, revetments have been used on the Mississippi River to deter bank caving, protect levees and other structures, and to maintain an efficient channel alignment. As of 2012, there were 1,055 miles of revetment (e.g., articulated concrete mattress (ACM and riprap) along the banks of the LMR (USACE 2013).

Beginning in the 1960s, a comprehensive dike construction program was initiated to reduce dredging costs and enhance navigation

alignments. Stone dikes (e.g.,riprap) are constructed in the river channel to develop a self-maintaining (minimal maintenance dredging), low-water navigation channel (USFWS 2013a).

However, sediment can accrete downstream of dikes, creating sand bars and reducing the river's depth and width. Dikes can also disconnect secondary channels and the floodplain from the river, thus degrading the natural hydrology.

The USACE began a dike-notching program on the LMR in the late 1980s to reduce sedimentation in the dike fields. Notching closure dikes of secondary channels is effective in diversifying habitat by maintaining flows through secondary channels for extended periods, particularly during low-river stages. A total of 774 dikes have been constructed between river miles 212 and 953.5, and 29% of them have been notched to diversify habitat (USACE 2013, USFWS 2013a).

Bendway weirs are linear stone structures, similar to transverse stone dikes, except they are constructed from the concave bank across the main or navigation channel. A series of weirs are constructed in a bend. These structures typically have elevations 20 feet or more below the Low Water Reference Plane, allowing navigation traffic above the structures (USFWS 2013a).

Dredging is another tool used to maintain the navigation channel. Dredging primarily occurs at crossings (i.e., where the main current crosses from one bank to the other), of which there are approximately 200 between the mouth of the Ohio River and Baton Rouge, Louisiana (Baker et al. 1991). Over the past 10 years, nearly 431 million cubic yards of sediment have been dredged from the main channel of the Mississippi River, including the deep draft channel below Baton Rouge (USACE 2013).

Nearly 30% of the 774 rock dikes (above) along the Lower Mississippi River have been notched (below) to allow for more consistent water flows to secondary channels and to diversify aquatic habitat.

Photos: Bruce Reid and Angeline Rodgers

Meander cutoffs are an example of a historic modification used in the early to mid-1900s. In an effort to create a shorter and straighter river channel to increase discharge capacity and shorten navigation distance, engineers increased cutoff formation in the LMR (Baker et al. 1991). The meander cutoff program of the USACE in the 1930s and 1940s was initiated following the 1927 flood and potentially resulted in the greatest impact that altered reaches of the LMR from sinuous to straight (Schumm 2005).

Most of the 16 cutoffs that occurred in the LMR from 1929 to 1942 were constructed by the USACE and shortened the river by 152 miles (16%) (Baker et al. 1991). Schumm (2005) noted that the river was also shortened by 55 miles through chute development. Cutoffs made in a 340-mile reach of the LMR from near Memphis, Tennessee, to near Natchez, Mississippi, resulted in degradation upstream and deposition downstream (Schumm 2005). Cutoffs result in greater current velocity which results in bed and bank erosion (Baker et al. 1991). Schumm (2005) noted that flood peaks were reduced as designed, but channel stability decreased.

HABITATS AND LAND USE

Although the floodplain and backwater areas have been dramatically altered, the existing leveed floodplain, in many locations, continues to function as a dynamic freshwater ecosystem that can change in response to the river's annual hydrologic regime. The batture contains a diversity of habitats, including oxbow lakes, meander scars, borrow pits, wetlands and tributary mouths (Baker et al. 1991).

The 2.1 million-acre LMR floodplain comprises the following land uses:

Floodplain Land Use	Acreage
Woody wetlands	963,131
Open water	532,289
Farmland	419,160
Emergent herbaceous wetlands	53,598
Forest	44,466
Barren land	29,496
Grassland	8,065
Shrub/scrub	6,862
Developed land	56

Source: National Land Cover Database, 2011

There are also four backwater areas outside the batture that are hydrologically connected to the LMR: New Madrid Floodway, White River basin, Yazoo River basin, and Lower Red River basin, totaling 680,800 acres (MR&T 2012).

There have been several aquatic habitat classifications of the LMR. Nine macrohabitats were defined for the channel environment that can be easily

Forested wetlands cover large areas of the Lower Mississippi River floodplain and backwater areas. Photo: Bruce Reid

identified and include: 1) steep sandbar, 2) gentle sandbar, 3) island complex, 4) ACM/riprap, 5) natural bank, 6) flooded shoreline, 7) gravel bar, 8) channel and 9) dike (Miranda and Killgore 2011):

Steep sandbar: High sloping sandbar often associated with the downstream reach of an island or point bar where maximum current speeds begin to cross the channel, forming eddies, deep water and depositional areas along the bank.

Gentle sandbar: Low sloping sandbar with moderate to high current. They constitute the primary littoral habitat in the river and occur in association with point bars, islands, middle bars and dike systems.

Island complex: Usually include, from the bank outward, a secondary channel, island and main channel. Upper reach is shallow and swift while lower reaches become deeper and sluggish.

ACM/riprap: ACM is placed over eroding river banks with riprap along the top portion. Buckling and variation in bottom slopes create large interstitial spaces surrounded by hard substrates. Strong currents and deep water are usually associated with this habitat.

Natural bank: Usually occurs on the concave side of the river where consolidated silts and clays form the primary substrate. Banks are often steep and woody debris from fallen trees can accumulate.

Flooded shoreline: At high river stages, flooded sandbars and willow trees provide temporary habitats usually occurring along the convex side of the river. Detritus and terrestrial vegetation become available as relatively shallow, low-velocity refugia for a variety of fish species.

Gravel bar: Coarse sand and gravel are deposited in bendways, usually in the upper reaches of point bars or islands where water is shallow and swift. Gravel may extend from the shoreline to the channel border.

Channel: Includes the main channel and channel border. Water depth can exceed 82 feet. Currents are strong and substrate is usually sand.

Dike: Constructed with large rocks (i.e., riprap) and extends perpendicularly from the bank to the channel border habitat. Some dikes can exceed 2,953 feet in length. Large eddies can form below dikes, and depth and velocity vary greatly along its longitudinal axis. Sand deposition is common below dikes.

Photo: Jan Hoover

Vegetated islands are valuable habitats within the Lower Mississippi River floodplain (Jack Killgore, pers. comm.). Because they are relatively stable, they provide shoreline habitats for littoral fishes and help maintain bathymetric complexity in secondary channels after floods. They also contribute woody debris to the aquatic system, which is used by a variety of organisms as feeding and spawning areas and as refugia from predators. Most major gravel bars occur at the upstream reaches of vegetated islands. At low river stages, the only available backwater habitat connected to the river is at the lower reach of the secondary channel of vegetated islands. The relatively high, steep sloping shorelines of vegetated islands maintain scour pools. These pools support large numbers of fish and other aquatic fauna attempting to escape faster flows in the main channel.

FLOODPLAINS

Floodplains are terrestrial areas adjacent to a river. They become inundated during high-water events and provide seasonal, unrestricted low-flow, backwater conditions. Natural fluvial processes such as lateral and vertical erosion and channel migration and abandonment create a variety of floodplain habitats (e.g., side channels, backwaters, isolated channels, oxbows, ponds, and marshes) (Amoros and Bornette 2002).

The extent, duration and timing of flooding provide a diversity of hydrologic connections that are vital for the ecosystem. Floods homogenize the floodplain and provide connectivity that allows fish movement between the river and floodplain, affecting fish assemblages (Miranda 2005). Dembkowski and Miranda (2011) noted that lateral connectivity is essential for providing fish life history needs and providing other lotic ecosystem services. Floodplain habitats are used by many river species for spawning and nursery areas (Baker et al. 1991) and for feeding and shelter (Miranda et al. 2013). Floodplain connectivity is also important for aquatic insects, mussels, turtles, birds and mammals (Winemiller 2003).

One of the most significant features affecting the natural resources is the loss of connectivity between the historic floodplain and the Mississippi River. Winemiller (2003) noted that levees eliminate connectivity between rivers and floodplains and prohibit the exchange of water, materials and organisms. This impairs nutrient cycling, productivity and biodiversity and diminishes habitats crucial for completion of many species' life cycles.

Virtually no new habitat is being created, while existing floodplain lakes and secondary channels are gradually being lost due to sedimentation (Williams and Clouse 2003). Modification of the flood pulse, channelization, dredging, levee construction and embankments all inhibit lateral erosion and other natural river dynamics (Amoros and Bornette 2002).

Habitat loss, a reduction in the flood-pulse and reduced connectivity may be contributing factors to poor recruitment by some fishes (Barko et al. 2006). Access between various habitats (e.g., to spawning and nursery areas) are critical for fish recruitment and sustainability of fish populations (Amoros and Bornette 2002). Enhancing floodplain connectivity will provide refugia for young fishes during floods and should be a high priority (Barko et al. 2006).

Alligator Gar (above) spawn in the Lower Mississippi River floodplain. Photo: U.S. Fish and Wildlife Service

The Lower Mississippi River floodplain provides important nesting and feeding habitat for Snowy Egrets (right) and other wading birds.

Photo: Bruce Reid

Some of the mysteries of the Lower Mississippi River floodplain are still being explored. U.S. Army Corps of Engineers biologist Jan Hoover has collected large numbers of invertebrates in borrow pits near Vicksburg, Mississippi (Jan Hoover, pers. comm.). Two species collected inhabit temporary pools and can remain dormant for years during dry periods. One species of Clam Shrimp, thought to be of the genus *Eulimnadia*, is still being identified with the help of a biologist at the University of Akron in Ohio. Hoover and students Tyler Strange and Heather Smith also found a species of Fairy Shrimp, *Streptocephalus seali*, that is widespread from Canada to Mexico.

U.S. Army Corps of Engineers biologist Jan Hoover (above) retrieves a trap used for collecting invertebrates such as the Fairy Shrimp (below left), *Streptocephalus seali,* and a Clam Shrimp (below right) thought to be of the genus *Eulimnadia*. Photos: U.S. Army Corps of Engineers

Populations of Black Bears, including the threatened subspecies Louisiana Black Bear, are expanding along the Lower Mississippi River. The heavily forested active floodplain provides important habitat. Photo: Brad Young

SPECIES OF CONCERN

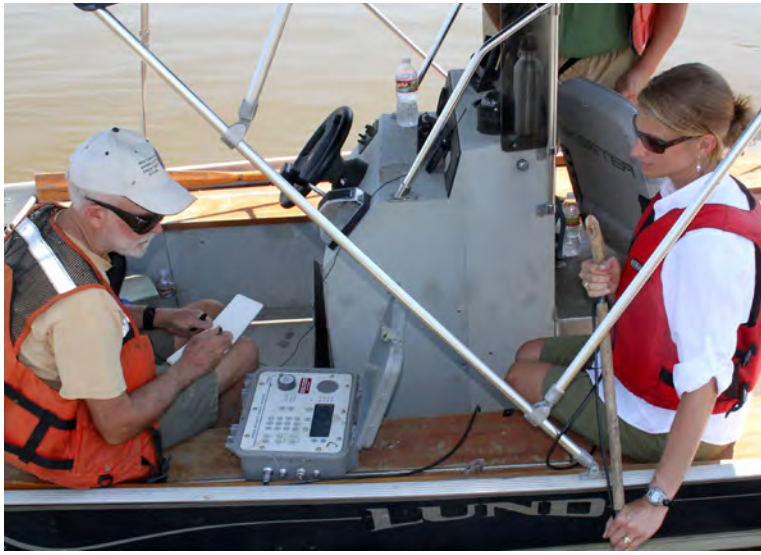
PALLID STURGEON, *Scaphirhynchus albus*

Since the USFWS listed the Pallid Sturgeon as endangered in 1990, the status of the species has improved and is considered stable. New information has allowed managers to gain a better understanding of the species in the Lower and Middle Mississippi River; however, rangewide data regarding recruitment, mortality, habitat use and abundance remain limited. (USFWS 2013c).

The Coastal Plain Management Unit (CPMU) for the species consists of the entire LMR from the confluence of the Ohio River at Cairo, Illinois, to the Gulf of Mexico, and includes the Atchafalaya River distributary system in Louisiana (USFWS 2013c). When the Pallid Sturgeon was listed, only 28 historical records were documented from the CPMU. Since 2000, more than 1,100 Pallid Sturgeon have been captured in the CPMU (more than 500 from the LMR, and more than 600 from the Atchafalaya River) (Killgore et al. 2007, USFWS database 2013), exceeding wild Pallid Sturgeon capture numbers from all other management units combined.

Although Pallid Sturgeon population size in the LMR has not been quantified, available data suggest a substantial population when compared to fishing effort and fish species composition (USFWS 2013a). Killgore et al. (2007) found that Pallid Sturgeon comprised 2.2% of fish captured on winter-set trotlines, and ranked fifth in relative abundance out of 22 species collected. During two years of trotline sampling at Vicksburg and Tunica, Mississippi, Pallid Sturgeon comprised 2.4 and 2.5%, respectively, of fish collected at both locations, and ranked fourth in relative abundance out of 11 species collected (Aycock et al. 2012).

Telemetry studies have shown that larger Pallid Sturgeon consistently



Mississippi Department of Wildlife, Fisheries and Parks biologists with a tagged Pallid Sturgeon before release. Paul Hartfield (left) and Angeline Rodgers track tagged sturgeon.
Photos: Mississippi Department of Wildlife, Fisheries and Parks and Bruce Reid

use multiple channel habitats such as point bars, secondary channels, crossovers, island tips, natural banks, and river engineering structures such as dikes and reveted banks (Kroboth et al. 2013).

According to the Revised Recovery Plan (USFWS 2013c), the range-wide limiting factors for Pallid Sturgeon include: "1) activities which affect connectivity and the natural form, function and hydrologic processes of rivers; 2) illegal harvest; 3) impaired water quality and quantity; 4) entrainment in water diversion structures; and 5) life history attributes of the species (i.e., delayed sexual maturity, females not spawning every year, and larval drift requirements). "

Shovelnose Sturgeon appear similar to Pallid Sturgeon. Photo: Bruce Reid

Commercial harvest of sturgeon for caviar and smoked flesh has occurred to various degrees in the LMR since the 1800s. Harvest for Shovelnose Sturgeon has been closed for at least three decades in the Arkansas, Mississippi and Louisiana reaches of the LMR south of the Tennessee state line. However, harvest of Shovelnose Sturgeon for caviar had increased in reaches of Tennessee, Kentucky, Missouri and Illinois. Based on data that indicated significant numbers of mature female Pallid Sturgeon were being taken during harvest of Shovelnose Sturgeon in the Tennessee (Bettoli et al. 2009), and high mortality of pallids in reaches where commercial harvesting was still legal (Killgore et al. 2007), the USFWS listed the Shovelnose Sturgeon within the sympatric range of Pallid Sturgeon as threatened due to similarity of appearance (USFWS 2010a). This action, coupled with state regulations, has effectively eliminated commercial harvest of sturgeon in the LMR.

INTERIOR LEAST TERN, *Sterna antillarum*

The interior population of the Least Tern was listed as endangered by the USFWS in 1985. At the time the recovery plan was developed (USFWS 1990), there were an estimated 5,000 Interior Least Terns distributed throughout the Interior Basin. The recovery plan outlined recovery strategies to increase the population to approximately 7,000 birds (USFWS 1990).

Substantial new information now exists concerning the species' distribution, density, population dynamics, natural history, habitat quantity and quality, and threat levels. Data indicate the population has increased significantly throughout its range and reached the recovery criteria of 7,000 birds. Range-wide population counts were 722 in 1984, 8,859 in 1995 and 17,591 in 2006. Most of the increase has occurred on the LMR (USFWS 2013b).

Nesting colonies in the LMR have been monitored yearly since 1985. Terns are currently distributed along an 800-mile reach between the confluence of the Ohio River and Baton Rouge, Louisiana. The LMR population level has ranged from 8,000-18,000 birds over the past nine years, and the drainage basin recovery goal (2,500) has been exceeded for more than 20 years. Some proportion of the increase in adult tern numbers has been attributed to improved survey efforts and efficiency (Lott 2006). For example, changes in survey methods utilized in the LMR and extending survey reaches correspond to some degree with higher counts. However, the large numbers of terns within the LMR unimpounded navigation system has also been attributed to higher elevation sand and gravel bars associated with the construction of channel training dikes (Lott and Wiley 2012, Lott et al. 2013).

In the LMR, tern nesting colonies are typically located on an unattached (surrounded by water) sand and/or gravel bar usually associated with

a dike field and secondary channel. Those colonies that occur on sand or gravel bars connected with the bank are on very large, remote point bars, ½ to 1 mile wide and often 2 to 4 miles long (Jones 2012). USACE analyses indicate that habitat quantity has remained relatively stable and underutilized by nesting terns for the past two decades (USACE 2008, USACE 2013) and habitat quantity and quality does not appear to be a limiting factor for the species in the LMR. Based upon improvements in range-wide status and successful protection and management of its habitats, the USFWS has recommended delisting the Interior Least Tern due to recovery (USFWS 2013b).

Interior Least Tern nests (above) are shallow depressions in the sand.

Photo: U.S. Fish and Wildlife Service

FAT POCKETBOOK, *Potamilus capax*

Threats to endangered Fat Pocketbook mussel include habitat modification and loss, population fragmentation caused by dams, and channelization related to navigation and flood control. Fragmentation of suitable habitat and range make local populations susceptible to threats such as droughts, point- and non-point source pollution, and land-use changes in their respective watersheds. Federal and state laws protecting the mussel have reduced threats to the species. Studies indicate that populations may be self-sustaining at low densities. Fat Pocketbook mussels have recently been found in the LMR (USFWS 2009).

There are no historical records of the species from, or adjacent to, the LMR channel. Most recent LMR collection records are from secondary channels along the river (USFWS 2012), and the expansion of the species' range into the LMR appears to be related to more stable habitat conditions created within USACE dike fields associated with secondary channels. Live and fresh-dead specimens have been collected from secondary channels between River Miles 410 and 800 that are stabilized by dike fields and maintain hydrologic connectivity with the main channel. A single young individual has been collected in a trawl sample below a chevron dike, in Bolivar County, Mississippi (W.T. Slack, USACE-ERDC pers. comm.). Recent collections from the LMR indicate a widespread population, but more sampling is needed to assess abundance and trends.

LOUISIANA BLACK BEAR, *Ursus americanus luteolus*

The range of the Louisiana Black Bear, a subspecies listed as threatened by the USFWS, includes portions of the Lower Mississippi River floodplain in southern Mississippi and eastern Louisiana. The lower river's active floodplain, or batture, is considered a priority conservation area for the Louisiana Black Bear, as are portions of the Atchafalaya River basin, a major distributary. Reforestation of the batture will expand travel corridors and provide important links to national wildlife refuges and other public lands (USFWS 2014b).

The Louisiana Black Bear occurs at numerous national wildlife refuges throughout its range, including two within the batture: St. Catherine Creek National Wildlife Refuge near Natchez, Mississippi, and Cat Island National Wildlife Refuge near St. Francisville, Louisiana. Several studies suggest that Black Bears at White River National Wildlife Refuge in eastern Arkansas are genetically similar to Louisiana Black Bear populations to the south, but those studies have not led to the protection of the Arkansas population under the Endangered Species Act (USFWS 2014b).

Populations are thought to be growing in the Tensas and Atchafalaya river basins. Two new breeding populations are in east-central Louisiana and western Mississippi (USFWS 2014b).

NATIVE FISHES

Baker et al. (1991) noted that there were at least 91 species of freshwater fishes living in the Lower Mississippi River and that other studies suggested there were as many as 121 species.

Commercial species include Channel, Flathead, and Blue catfish; three species of buffalo; and Freshwater Drum. Primary sport fish species include crappies, black bass, White Bass, sunfish, temperate bass and catfish.

Because different fish species have specific habitat requirements for their various life stages, diversifying habitat will greatly benefit the fish community.

White Bass are popular sport fish.

Photo: Paul Ingram

Habitat alterations, decreased connectivity and diminished water quality have affected fish communities. Crites et al. (2012) hypothesized that low dissolved oxygen concentrations contributed to the presence of few predatory, sport or commercial fish species in an isolated chute of the Middle Mississippi River. Connectivity is significant in determining fish assemblages in floodplain lakes (Dembkowski and Miranda 2011). They hypothesized that the periodic connection and the associated habitat heterogeneity that it provides are important for maintaining fish species richness and diversity in large-river floodplain lakes. Miranda (2005) noted that oxbow lakes with greater connectivity supported more species that require flow or flooding (e.g., Skipjack Herring, River Carpsucker, gars and White Bass). Conversely, oxbows with limited or no hydrological connection with the river supported species that prefer low-flow conditions (e.g., sunfish, Yellow Bass and shad species). Miyazono et al. (2010) noted that species richness of periodic strategists (e.g., riverine species) was positively correlated with connectivity.

Periodic connection to the river (right) is important for maintaining fish species richness and diversity in floodplain lakes. A fly fisherman (below) takes advantage of swift currents through a notched dike.

Photos: Bruce Reid and Tommy Shropshire

CLIMATE ADAPTATION

Over the past 30 years, scientists and managers have documented reductions in local species abundance and richness likely attributable to climate change. Ecological studies and monitoring have documented changes in phenology, distribution, physiology, behavior, survival, reproduction, community composition and nutrient cycling. Meteorologists have documented increasing frequency and intensity of extreme weather events such as hurricanes, floods and droughts. These trends are expected to continue, if not to accelerate (IPCC 2013; The White House 2014; Stein et. al. 2014; USFWS 2014a; Marino et. al. 2014; Johnson 2014).

Climate change imposes unprecedented new challenges and management problems that cannot be solved without a fundamental change in the way we approach conservation. Adaptation strategies are adjustments in natural or human systems to minimize the harmful impact of climate change. The LMRCC has included adaptation strategies (Stein et. al. 2014) into existing planning and implemented actions that provide climate change benefits. For example, one of the main adaptive strategies is enhancing floodplain connectivity that leads to protection and restoration of refugia, another adaptive strategy (Stein et. al., 2014; Heller and Zavaleta 2009). Refugia may provide habitats that are well distributed, replicated and connected in order for their resident species to have enough time to adapt to the changing conditions.

Efforts to develop and fund monitoring programs for water quality and fish populations are also particularly important for adaptation. A crucial element of "climate smart conservation" (Stein et. al. 2014) is documenting climate-related changes to habitat quality and short- and long-term changes in the composition of native and non-native species. Understanding species' responses will inform management needs.

Given that understanding climate change is an ongoing process, cooperation with the scientific community is an adaptive strategy (Heller and Zavaleta, 2009). Numerous ongoing and planned projects provide information for establishing a baseline and a potential climate change vulnerability assessment (Johnson 2014).

The LMRCC's wetland and forest restoration efforts support climate adaptation.

The Lower Mississippi River Batture Reforestation Project provides adaptive benefits from ecosystem restoration (Stein et. al. 2014; Heller and Zavaleta 2009). Relatively intact systems tend to respond better to disturbances. The significance of restoration is especially apparent in the context of wetlands in the batture, because wetlands are adaptation mechanisms themselves, providing flood control and water purification. Climate change can also be addressed through other means (e.g., carbon capturing and sequestration and emission reduction from power plants, factories, and vehicles). One of the most cost-effective options is carbon sequestration through photosynthesis in terrestrial sinks (USFWS 2014a). Therefore, the LMRCC's wetland and forest restoration efforts support climate adaptation.

Engagement is a third component of the climate change framework (USFWS 2010b). Engagement refers to providing leadership through cooperation, or building partnerships across local, state and federal agencies and non-government organizations. The LMRCC's success depends on the cooperative efforts of its institutional members.

Lower Mississippi River Batture Reforestation Project

The NRCS has identified the Mississippi River basin as a top priority because of water quality concerns (i.e., nutrient loading), and implemented the Mississippi River Basin Healthy Watersheds Initiative (MRBI). As part of the MRBI, the Lower Mississippi River Batture Reforestation Project was initiated in 2012 to restore wetlands and forests within the lower river's active floodplain, or batture. The LMRCC, the nonprofit Mississippi River Trust and the NRCS work together to identify flood-prone cleared land that landowners desire to reforest through Wetland Reserve Easements. Funding is provided by the NRCS, along with the Walton Family Foundation and the U.S. Endowment for Forestry and Communities. By late 2014, 58 properties covering 12,059 acres had been enrolled in the program.

Reforestation of the batture will help:

- Lessen the amount of excess nutrients (i.e., nitrogen and phosphorus) and various pesticides entering the river and the Gulf of Mexico.
- Reduce flooding of farmland.
- Reduce financial demand for disaster assistance and crop insurance on lands with repeated losses.
- Increase opportunities for outdoor recreation such as hunting, fishing and wildlife viewing.
- Expand habitat for bears, waterfowl, other migratory birds and other wildlife.

Workers (above) plant a 400-acre batture tract near Clarksdale, Mississippi. NRCS scientist Rachel Stout-Evans (right) tests soil to determine proper tree species for planting. The historic 2011 flood on the Lower Mississippi River caused widespread erosion of cleared land (below) in the batture. The flood also deposited large amounts of sand on some batture cropland.

Photos: Bruce Reid

PLANNING

In 2000, the LMRCC completed its Aquatic Resources Management Plan (LMRCC 2000). The plan outlines strategies for restoring aquatic resources within the river's active floodplain from the confluence of the Mississippi and Ohio rivers at Cairo, Illinois, to the Gulf of Mexico.

Goals of the plan are to:

- Maintain or improve aquatic habitat quantity, quality and diversity in the Lower Mississippi River ecosystem.
- Improve water quality in the Lower Mississippi River by implementing the Clean Water Act.
- Restore, conserve and manage the biological diversity of native fishes and invertebrates and provide for sustainable harvest of selected fish species in the Lower Mississippi River ecosystem.
- Improve economic opportunities in river-side communities through the sustainable use of environmental resources.
- Ensure coordinated management of the Lower Mississippi River ecosystem through involvement of management agencies, resource user groups and commercial interests in planning and implementing management activities.
- Increase public use and awareness of fisheries resources in the Lower Mississippi River ecosystem .

The Mississippi River Conservation Initiative was the implementation phase of the Aquatic Resources Management Plan. From 2001-2004, the LMRCC held meetings in the six member states to identify projects to improve aquatic habitat and enhance public access to the river environment. Through the meetings, 239 restoration projects were identified.

The restoration work of the LMRCC was coined "Restoring America's Greatest River" and is based on a unique partnership between the

Secondary channels with dike fields are priority restoration sites.

Photo: Bruce Reid

LMRCC, the USACE and the USFWS. The focus of these proposed projects is to enhance LMR habitats and restore floodplain hydrology and connectivity when landowners are interested and opportunities exist.

To better focus LMRCC restoration efforts, a ranking system for proposed secondary channel enhancement work was completed by the USACE Engineer Research and Development Center (ERDC). Scientists established a Habitat Quality Index and Economy of Restoration Index that were combined into a Priority Index (Killgore et al. 2012). Projects were ranked according to improvements to habitat quality and cost-effectiveness.

This ranking system is used to guide the selection of future restoration projects for secondary channels. The projects will benefit protected species such as the Pallid Sturgeon, Interior Least Tern and Fat Pocketbook mussel, in addition to other native species.

During the past several years, the LMRCC has been a partner in the Lower Mississippi River Resource Assessment (LMRRA), the region's first comprehensive natural resources study since the Lower Mississippi Region Comprehensive Study in 1974.

The LMRRA will identify information needed for river-related management, natural resource habitat needs, and river-related recreation and access needs. The project area includes the entire LMR, the Atchafalaya River and portions of some navigable tributaries. This project assesses available information and will make recommendations for improvement. A report will be delivered to Congress in 2015. Partners include the USACE districts in Memphis, Vicksburg and New Orleans; the LMRCC; The Nature Conservancy; National Audubon Society; Mississippi River Corridor-Tennessee; Wildlife Mississippi; Delta Wildlife; and Quapaw Canoe Company. The LMRRA incorporates habitat restoration needs identified by the LMRCC's planning efforts and was the impetus for the revised Restoring America's Greatest River plan.

Jason Dickard of the U.S. Army Corps of Engineers discusses the Lower Mississippi River Resource Assessment at the 2014 LMRCC annual meeting. Gretchen Benjamin (left) of The Nature Conservancy is a primary partner.

Photo: Bruce Reid

This plan, Restoring America's Greatest River: A Habitat Restoration Plan for the Lower Mississippi River, is not intended to replace the Aquatic Resources Management Plan (LMRCC 2000) but to build upon it. The new plan includes and combines information from the Aquatic Resources Management Plan, Mississippi River Conservation Initiative and the original 239 proposed projects into one document. The focus of this plan is habitat-driven, which will benefit native species that live in and along the LMR and the people who enjoy the river. Development and implementation of this plan are critical for the restoration of the LMR and its batture.

The former list of 239 proposed projects has been reviewed and updated. It now includes a list of 253 habitat restoration and access enhancement projects (Appendix A). Each of the proposed projects has been placed into one of eight project focus categories.

Current Project Focus Categories

- Create, rehabilitate and diversify secondary channels
- Restore and diversify floodplain water bodies
- Augment aquatic connectivity with the floodplain
- Tributary enhancement
- Create/rehabilitate wetlands
- Enhance main channel habitat diversity
- Enhance terrestrial habitat
- Improve recreational access

The USACE's Andy Simmerman and the LMRCC's Angeline Rodgers discuss a dike-notching project. Photo: LMRCC

ACCOMPLISHMENTS

Implementation of the Restoring America's Greatest River plan began in 2006. To date, the focus has been on rehabilitating secondary channels. Dikes and closure dikes are notched to provide more permanent flow between productive secondary channels and the main channel and to create new secondary channels through existing dike fields. Implementation of these projects has relied on a partnership among the USACE, LMRCC and USFWS, with assistance from Mississippi River Trust. The USACE provides engineering design and determines placement of notches to ensure dike integrity. The USACE also provides construction inspection. The LMRCC acquires all necessary permits, hires the construction contractor, and coordinates the project planning and implementation. The USFWS provides the construction funding through the National Fish Passage Program and staff. Mississippi River Trust also provides funding. To date, 14 projects have been completed, restoring more than 56 miles of channel habitat and thousands of surrounding acres.

Completed Project	River Miles	State	USACE District	Year Built	Miles of Side Channel
Island 63	640.5 - 637.3	MS	MVM	2006	5.5
Loosahatchie Bar	741.5 - 737.0	AR-TN	MVM	2008	11.25
Kangaroo Point	649.5 - 645.3	AR	MVM	2008	1.5
Below Ludlow	624.0 - 621.0	AR	MVM	2008	1.5
Island 70	610.0 - 605.7	MS	MVK	2011	3.5
Island 15	853.7 - 849.0	MO	MVM	2010/2012	2.5
Caruthersville-Linwood	846.0 - 839.0	MO	MVM	2012	5
Island 18 Towhead	838.5 - 834.0	TN	MVM	2012	3
Island 20	833.2 - 828.0	MO	MVM	2012	4
Kentucky Point	887.0 - 885.0	KY	MVM	2013	4
Ashport-Golddust	796.0 - 792.0	AR	MVM	2013	4
Wrights Point	822.0 - 816.0	AR	MVM	2013	3
Below Prentiss	578.0 - 577.0	MS	MVK	2013	4
Catfish Point	570	MS	MVK	2013	4
TOTAL					**56.75**

USACE Districts have constructed 774 dikes between river miles 212 and 953.5 (up to 2012) and 225 (29%) of these structures have been notched (USACE 2013). These notches increase bathymetric diversity, and therefore habitat, below the dikes (USACE 2013). Notching structures has also been directed to enhance secondary channels.

In addition to completing secondary channel projects, the LMRCC has worked in the river floodplain. An example is a project to restore a weir at Lake Perry Martin in Mississippi. The project permanently raised lake water levels, improved water quality, increased fish access and created better public fishing opportunities.

Combining the habitat restoration accomplishments of the LMRCC, USACE and other agencies, 76 of the original projects (30%) are in some stage of completion. Challenges associated with determining the status of these projects are the dynamic nature of the river, redistribution of sediment with high water events and the scour needed to connect secondary channels between individual dikes. For projects listed as complete, further evaluation may identify additional project needs.

COMPLETED PROJECT LOCATIONS

Project Focus	Work Completed	Work Begun	Work Not Initiated
Create, rehabilitate, and diversify secondary channels	23	30	41
Restore and diversify floodplain water bodies	3	1	37
Augment aquatic connectivity with the floodplain	1	2	25
Tributary enhancement	0	1	4
Create/rehabilitate wetlands	0	0	2
Diversify main channel habitat	1	14	32
Enhance terrestrial habitat	0	0	2
Improve recreational access	0	0	34
TOTAL	**28**	**48**	**177**

Note: Table includes projects completed by USACE, LMRCC and other agencies.

If you are reading this on a computer or mobile device, click or tap on the buttons to the right to view project maps for each state. If you are reading a printed version, go to: http://lmrcc.org/maps.

AR KY LA

MO MS TN

Amanda Oliver (above), a U.S. Army Corps of Engineers contractor, holds a Pallid Sturgeon during a survey of a restored side channel at Island 63. Dike-notching projects help protect nesting colonies of the Interior Least Tern (below) from predators.

Photos: U.S. Army Corps of Engineers and Bill Stripling

Ron Nassar (above, right), retired LMRCC coordinator, confers with contractors at the Island 70 dike-notching project. The LMRCC has completed three projects to restore floodplain lakes, including at the 25-acre Lake Perry Martin (left) near Rosedale, Mississippi.

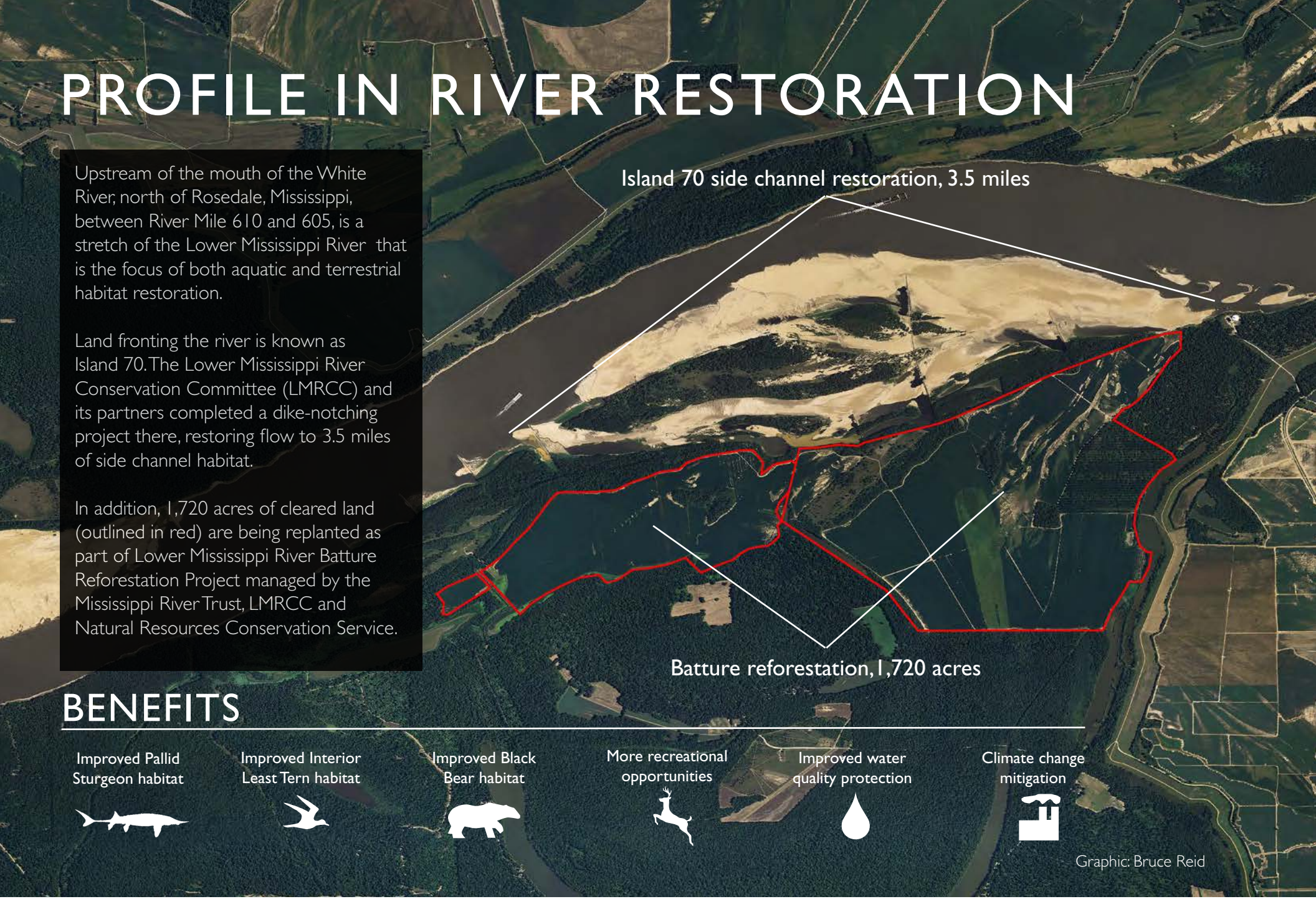
Photos: Lower Mississippi River Conservation Committee

PROFILE IN RIVER RESTORATION

Upstream of the mouth of the White River, north of Rosedale, Mississippi, between River Mile 610 and 605, is a stretch of the Lower Mississippi River that is the focus of both aquatic and terrestrial habitat restoration.

Land fronting the river is known as Island 70. The Lower Mississippi River Conservation Committee (LMRCC) and its partners completed a dike-notching project there, restoring flow to 3.5 miles of side channel habitat.

In addition, 1,720 acres of cleared land (outlined in red) are being replanted as part of Lower Mississippi River Batture Reforestation Project managed by the Mississippi River Trust, LMRCC and Natural Resources Conservation Service.



BENEFITS

- Improved Pallid Sturgeon habitat
- Improved Interior Least Tern habitat
- Improved Black Bear habitat
- More recreational opportunities
- Improved water quality protection
- Climate change mitigation

Graphic: Bruce Reid

GOALS AND ACTIONS

Goals and actions have been developed to guide the process of habitat enhancement, rehabilitation and restoration of the Lower Mississippi River and its floodplain. Goals include:

HABITAT

Maintain or improve aquatic and terrestrial habitat quantity, quality and diversity, along with water quality, in the Lower Mississippi River ecosystem.

COORDINATION/COLLABORATION

Improve cooperation and collaboration among public agencies, navigation interests, NGOs, industries and municipalities to improve habitat or avoid, minimize or mitigate habitat losses.

PUBLIC USE AND ACCESS

Increase public use through enhanced access along the Lower Mississippi River.

HABITAT

1. LMRCC states will evaluate all proposed projects in their states and update as needed beginning in 2014.
2. Complete all proposed habitat restoration projects listed in Appendix A.
3. Quantify historical aquatic and terrestrial habitat conditions and subsequent losses.
4. Conduct pilot projects to better understand interaction between floodplain function and fish diversity and production.
5. Build large habitat complexes that include several different connected habitat types (e.g., islands, secondary channels, wetlands, batture reforestation and restoration of natural hydrology).
6. Restore natural hydrology within the batture through prevention or removal of unnatural barriers to flow.
7. Support levee setbacks, where appropriate, as an alternative to levee repair and to expand the existing floodplain.
8. Restore native terrestrial and wetland vegetation within the batture.
9. Work with willing landowners through easement or acquisition to accomplish priority projects.
10. Recommend measures to avoid, minimize and mitigate adverse impacts related to MR&T and CIP activities.
11. Work cooperatively to develop a mitigation bank for the LMR and its batture to compensate for impacts caused by flood control and navigation projects and commercial operations.
12. Design projects to benefit restoration of federally listed species as outlined in USFWS 1990, USFWS 2009, USFWS 2013a, and USFWS 2013c. Consider ways to benefit native species and deter exotic species during project design.

13. Utilize Hydraulic Sediment Response Models to design specific habitat restoration projects.
14. Support evaluations of river training structures (i.e., dikes, chevrons) and bank stabilization methods (i.e., ACM, riprap) as fish habitat and modify their design as needed and appropriate to the extent possible.
15. Identify beneficial uses for dredged material from the LMR during project design (e.g., wetland construction instead of main channel disposal).
16. Support pre- and post-project evaluations (e.g., hydrographic, biological and water quality) for select habitat restoration projects to determine benefits to the ecosystem.
17. Utilize the tool developed by ERDC to prioritize secondary channel restoration projects (Killgore et al. 2012).
18. Develop tools to prioritize the remainder of the projects in each of the other project focus categories (i.e., floodplain water bodies, wetlands, terrestrial).
19. Conduct at least one study to determine factors leading to gravel bar formation and stability.
20. Conduct at least one study each to determine sedimentation rates in secondary channels, floodplain water bodies and batture.
21. Design and construct projects that would help fulfill goals of the Clean Water Act.
22. Support legislation, programs and activities that reduce pollution and contaminants within the Mississippi River watershed.
23. Develop and fund a program to monitor water quality and fish populations in the LMR similar to the Upper Mississippi River Restoration Program's Long Term Resource Monitoring program.
24. Support efforts to develop and fund a spill contingency plan.

COORDINATION AND COLLABORATION

1. Finalize and implement the Lower Mississippi River Resource Assessment.
2. Invite partners to attend the annual LMRCC meetings, including the open session of the Executive Committee and its three technical sections (i.e., Habitat Restoration, Water Quality and Fisheries).
3. Work with the USGS and other agencies to develop and fund a long-term program to design, construct, maintain and evaluate habitat restoration projects (similar to the Upper Mississippi River Restoration Program).
4. Federal and state natural resource agencies should meet at least annually with each USACE District to discuss CIP and habitat restoration projects.
5. Encourage each USACE District to conduct annual on-board inspection trips along their reach of the LMR to view and discuss CIP and habitat restoration projects (e.g., similar to USACE St. Louis District).
6. Collaborate with the Mississippi Interstate Cooperative Resource Association, the Upper Mississippi River Conservation Committee, the Upper Mississippi River Basin Association and the Ohio River Fisheries Management Team in basin-wide goals and initiatives.
7. Maintain the LMRCC website.
8. Continue to utilize the Mississippi River Foundation to acquire needed funding to implement this plan.

PUBLIC USE AND ACCESS

1. Complete all proposed access enhancement projects.
2. Develop tools to prioritize access projects.
3. Enhance access and/or facilities on existing public lands to improve public use opportunities.
4. Identify additional public access needs.
5. Develop partnerships to implement access enhancement projects.
6. Maintain a GIS map of public land and access sites along the LMR and in the batture.

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ACKNOWLEGEMENTS

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Arkansas Department of Environmental Quality
Arkansas Game and Fish Commission
Kentucky Department for Environmental Protection
Kentucky Department of Fish and Wildlife Resources
Louisiana Department of Environmental Quality
Louisiana Department of Wildlife and Fisheries
Mississippi Department of Environmental Quality
Mississippi Department of Wildlife, Fisheries and Parks
Missouri Department of Conservation
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Restoring America's Greatest River plan

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