Mississippi Valley Division,
Regional Planning and Environment Division South

Hatchie-Loosahatchie Mississippi River Ecosystem Restoration Study

Appendix 2b – Resource Significance

February 2023

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Section 1
Introduction and Existing Programs

1.1 INTRODUCTION

This appendix addresses resources of significance as related to the tentatively selected plan (TSP). It includes information on species and habitats of significance, in addition to existing and ongoing programs focused on the Lower Mississippi River to improve habitat quality and quantity. These existing programs are anticipated to continue and therefore can be used in conjunction with the restoration plan outlined within this report to provide cumulative benefits over the 39-mile project area and beyond in the Lower Mississippi River and its floodplain.

This section begins with an overview of a few of the existing organizations that focus on the Lower Mississippi River and its floodplain and their approach to conservation and restoration efforts. The TSP furthers the efforts of these entities and beyond and will be an asset to the resources of the Lower Mississippi River.

1.2 RESTORING AMERICA'S GREATEST RIVER (RAGR) AND THE LOWER MISSISSIPPI RIVER CONSERVATION COMMITTEE (LMRCC)

The LMRCC formed in 1994 to provide 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.

By 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.

Aquatic Resources Management Plan goals 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 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. “Restoring America’s Greatest River” (LMRCC 2015) (RAGR) is a landscape-level planning document for the Lower Mississippi River. It was originally compiled in 2004, with a revision in 2015 coinciding with the LMRRA. The goals listed in RAGR are focused around maintaining and improving aquatic and terrestrial habitats to enhance the aquatic, terrestrial and areal biologic communities of the LMR. Such restoration techniques can increase recreational opportunities which will improve public awareness and interest in the LMR. Secondary results would be increased economic opportunities of river-side communities and other users. The RAGR Plan describes restoration efforts that had occurred prior to 2015 and has recommendations for future work. Dike notching, reconnection of backwaters and meander scarps to the main stem of the river, restoration of bottomland hardwoods, and habitat development for species of concern are just a few restoration techniques in the report. Because there is no pre-existing, comprehensive habitat restoration management program in existence on the Lower Mississippi River, the LMRCC and its many partners have developed varied approaches to addressing needs for the river.

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. As mentioned in the Section 1.03, the USACE and USFWS launched work in 2006 to reconnect side channels to flowing portion of the river. Today this continuous

effort includes the reconnection of over 100 miles of side reconnected at 29 different locations plus the recognition that this work based on the findings of the Conservation Plan for three endangered on LMR under Section 7 (a) (1) of the Endangered Species Act.

With the desire to increase river restoration opportunities beyond side channel reconnection, LMRCC became a partner in the Lower Mississippi River Resource Assessment (LMRRA) in 2012. This was the region's first comprehensive natural resources study since the Lower Mississippi Region Comprehensive Study in 1974. *Restoring America's Greatest River:* A Habitat Restoration Plan for the Lower Mississippi River, became the reference for the location and restoration measures that should be pursued in the planning for the LMRRA.

The focus of RAGR 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. Each of the proposed projects has been placed into one of eight project focus categories.

Table A2b- 1. Current Project Focus Categories of Restoring America's Greatest River

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
Enhance main channel habitat diversity	1	14	32
Enhance terrestrial habitat	0	0	2
Improve recreational access	0	0	34

1.3 LOWER MISSISSIPPI VALLEY JOINT VENTURE FOREST BREEDING BIRD PRIORITY AREAS

The Lower Mississippi Valley Joint Venture (LMVJV) is a self-directed, non-regulatory private, state, and federal conservation partnership that exists for the purpose of sustaining bird populations and their habitats within the Lower Mississippi Valley and West Gulf Coastal Plain/Ouachitas regions through implementing and communicating the goals and objectives of relevant national and international bird conservation plans. The LMVJV completed its Breeding Bird Forest Protection Model in 2019, with details of the model published in the December 2019 article *Conservation–Protection of Forests for Wildlife in the Mississippi Alluvial Valley* in the open access journal mdpi.com/forests. Authors Blaine Elliott, Anne Mini, Keith McKnight, and Dan Twedt describe a refinement of priority forest patches for protection based on a variety of datasets as well as the Forest Breeding Bird Decision Support Model, which they used to identify potential forest patches of >2000 ha as well as dry forest patches, since bottomland forests with limited flooding tend to support more ground-nesting forest bird species.

The modelling effort revealed that 84% of MAV protected areas are forested. The model also found that just 109 large forest patches (of ≥2000 ha of core forest) held 1.5 million ha of the total 2 million ha of areas meriting additional conservation–protection. Within the 109 large patches, over 1.3 million ha lack current conservation protection.

Ironically, the model indicates that current MAV forests and even more so existing protected areas are biased towards locations that are less likely to face land conversion pressures, since they tend to have a greater flood frequency than non-forest land and are therefore less desirable for agriculture.

The model assigns priority for conservation–protection to core forest patches in the MAV, but these priorities should not be viewed as a directive or desire for increased public ownership of these forests. Private, voluntary conservation easements, such as those held by Ducks Unlimited, The Nature Conservancy, the Mississippi River Trust, and other conservation organizations can be equally effective at long-term conservation of these bottomland forests. It is hoped that the conservation–protection priorities prescribed by the Forest Protection Model fill an unmet need for land trusts and other conservation partners pursuing strategic forest protection in support of established bird conservation objectives because without protection, existing forests are subject to conversion to other uses.

The forest breeding bird protection model was utilized during plan formulation in support of identifying and siting forest restoration measures.

1.4 DUCKS UNLIMITED LAND PROTECTION MODEL

Ducks Unlimited has named the Mississippi Alluvial Valley (MAV) a priority I Conservation Area. They cite the historic floodplain of the valley is the most significant winter habitat for mallards in North America. The MAV was once a 24.7-million-acre

complex of forested wetlands interspersed with swamps, cypress-tupelo brakes, scrub-shrub wetlands and emergent wetlands. This vast complex of wetlands, through which nearly 40 percent of North America drains, provided wetland functions and wildlife values of incomparable worth. However, the landscape in the MAV has changed dramatically during the last 200 years, with the most rapid change occurring within the last 75 years. Today, only about 20 percent of the original forest remains in the MAV. The rest has been cleared for agricultural production, flood control or other land uses.

The LMR Feasibility Study footprint is well within this designation for Ducks Unlimited Priority 1 area. Special consultation and consideration with DU should be done for mallard, wood duck, gadwall, and green-winged teal during planning and implementation of restoration measures.

Ducks Unlimited protects land through its land holding subsidiary Wetlands America Trust and with willing landowners through several means including acquisitions, conservation easements and planned gifts. More information about the various land protection options Ducks Unlimited employs for its conservation work can be accessed here: Land Protection Options.

Ducks Unlimited also maintains a Habitat Revolving Fund accessible for target acquisitions and purchases of development rights within our Landscape Conservation Priority Areas.

Ducks Unlimited occasionally acquires land in key areas with the intent of long-term ownership and to address specific waterfowl conservation needs. More commonly, Ducks Unlimited acquires land to restore and/or enhance wetlands and other significant habitat and convey to a conservation partner as the permanent landowner.

1.5 MISSISSIPPI RIVER TRUST

The Mississippi River Trust (MRT), a charitable, nonprofit conservation organization established in 2002, focuses its work on habitat conservation, conservation education and conservation policy.

Habitat Conservation: MRT encourages landowners in the Lower Mississippi River region to donate land and interests in land for conservation purposes. MRT acquires and holds title to land and conservation interests to improve and protect water quality; to enhance and protect wildlife populations; and to improve local economies through nature-based recreation. The primary tool used for land conservation is a conservation easement. It is an alternative to selling land for development. A conservation easement allows a landowner to retain ownership of the land, protect important environmental or historical assets of the land from future development, and obtain certain tax advantages. Many of MRT's habitat conservation projects, including the Lower Mississippi River Batture Reforestation Project, focus on the active floodplain of the Lower Mississippi River, an area of 2 million acres of land and water from Cairo, Illinois, to Baton Rouge, Louisiana.

Conservation Education: MRT promotes a broader knowledge of conservation options and stewardship of the region's natural resources through landowner workshops, field days and Internet resources such as the Conservation Finance Center.

Conservation Policy: MRT works with government agencies and other private entities to address and solve the region's conservation challenges through legislation, federal appropriations and the development of innovative programs.

1.6 WOLF RIVER CONSERVANCY

The Wolf River Conservancy has focused on saving the 100 year floodplain from being developed or converted to non-natural and destructive land uses, such as sand and gravel mines. The Conservancy has protected approximately 18,000 acres. Through a 2013 Strategic Conservation Plan the land trust has defined their primary focus as the Hurricane Creek Sub-watershed as the area most vulnerable to urban development. This top-ranked focus area contains high value aquatic and terrestrial habitats of state significance with a large contiguous forest and thousands of acres of aquifer recharge areas.

The Wolf River Conservancy footprint includes areas within or flowing into the habitat complexes included in the Hatchie/Loosahatchie Conservation Reach. Involving this land trust with restoration efforts on the mainstem of the LMR will help ensure our ecological benefits mesh together to provide broader geographic reach and provide better knowledge and understanding of ecological restoration work occurring in conjunction with their regional conservation.

1.7 THE RIVERGATOR

The Rivergator supports canoeist, kayakers and others venture out on the big waters of the Lower Mississippi River. They provide outdoors enthusiasts with approximately 220 miles of travel information to conduct safe and enjoyable use of the river with human powered vessels. Included in these miles are routes from Shelby Forest Boat Ramp to Redman Point Bar, which align with most of the complexes of the LMR Feasibility Study. Ecological improvements of habitats within the conservation reach will certainly provide additional pleasure for people to interact with these areas especially where restoration provides more opportunity to interact with flora and fauna of the river floodplain.

1.8 LOWER MISSISSIPPI RIVER ECONOMIC PROFILE

In 2014, the Lower Mississippi River Economic Profile was released to document the $151.7 Billion in revenue and 585,423 jobs supported by the Lower Mississippi River. The study included 113 counties and parishes in the seven states along the LMR and focused on 10 sectors of the economy, Manufacturing, Agriculture, Mineral Extraction, Outdoor Recreation, Commercial Navigation, Natural Resource Harvesting, Tourism, Energy Production, Natural Resource Services, and Water Supply.

Economic sectors specifically connected with healthy ecological conditions on the Mississippi River include Outdoor Recreation, Natural Resource Harvesting, Tourism, and Water Supply (Natural Resources Services are not enumerated for this study). These sectors provide $17.75B and 258,600 jobs for the communities along the river. Implementing river restoration as a result the recommendations of the LMR Feasibility Study will entice more people to enjoy recreational activities and tourism events on the banks of the river, further securing these valuable economic sectors.

Section 2

Endangered Species Act (ESA) and the Lower Mississippi River

2.1 ENDANGERED SPECIES ACT (ESA)

Section 7 of the Endangered Species Act (Act) provides the Secretary (Departments of Interior or Commerce) the authority and tools necessary to conserve listed species. Two sections in the ESA provide the legal status to protect species in jeopardy from declining populations or possible extinction. In Section 7(a)(1) the Secretary (Secretary of the Interior/Secretary of Commerce) review other programs administered by them and utilize such programs to further the purposes of the Act. This section of the Act makes it clear that all Federal agencies should participate in the conservation and recovery of listed threatened and endangered species. Working in partnership with the agency that may cause jeopardy, USFWS/NOAA develop implementation plans that will minimize adverse impacts on species in the threatened and endangered categories.

Section 7 (a) (2) goes one step further to avoid adverse effects from Federal actions. Section 7(a)(2) states that each Federal agency shall, in consultation with the Secretary, insure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat.

2.1.1 Endangered Species restoration activities in the Lower Mississippi River

The USACE channel maintenance management practices include the use of channel structures to divert and concentrate flow in the main channel of the river to promote self-scour for the nine-foot navigation channel. In the early 1960s, the USACE determined they could decrease dredging and the cost of maintaining the navigation channel by diverting more flow from the side channels with closure structures, wing dikes and pile dikes. Overtime the reduced side channel flow and caused sedimentation in the side channels leading to partial or complete filling of these off channel areas. These actions degraded or eliminated critical habitat for endangered species as well as more common resident and migratory species.

Beginning in 2006, the USACE and USFWS acknowledged this issue and began working cooperatively to reconnect side channel habitat to restore this vital habitat in the LMR. USACE provides engineering plans to reconnect the side channels in a manner that will not jeopardize the nine-foot navigation channel and USFWS provides the funding to implement the notching or removal of channel structures to allow flow back into these side channel areas.

After almost a decade of informal collaboration on side channel reconnection the US Army Corps of Engineers, Mississippi Valley Division and US Fish and Wildlife Service, Southeast Region officially approved the *Conservation Plan 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. With this document, the two agencies agreed to use Section 7 (a) (1) to continue restoration using cost effective measures for side channel reconnection in the 954 miles of Lower Mississippi River (LMR). Through formal consultation the USACE agreed to use programmatic mechanisms from the Channel Maintenance Program of the Mississippi River and Tributaries project to maintain and improve habitat values for the recovery of endangered and other trust species inhabiting the river channel and protect migratory bird species occurring in the project area. To date this collaborative effort has led to the reconnection of more than 115 miles of side channel at 33 locations to the main flowing portion of the Mississippi River.

During the LMR Feasibility Study side channel reconnection was considered a valuable tool for restoration, but it was acknowledged that the current authorized program for side channel reconnection through Section 7 (a) (1) is delivering additional miles of reconnection annually. Therefore, natural resource managers are inclined to continue this restoration measure through the existing program, assuming the annual rate of reconnection continue at the 6-10 miles per year. When a new restoration program is authorized and appropriated for the LMR, the two program must be coordinate to assure syngenetic affects and maximize habitat outputs between the programs.

2.1.2 Ecological Benefits of Side Channel Reconnection

According to Crites, J. A. et al, 2012, restoring connectivity (i.e., increasing the duration of connection between the main channel and side channel) is an effective measure to maintain off-channel habitat and restore a temperature regime tolerable to most large river fishes (Stanford et al. 1996). Side channel reconnection also provides thermal and chemical mixing for favorable water quality conditions that support a broad range of invertebrates, fishes and other semi-aquatic species from herptiles to birds.

Side channels support all three endangered species during all or part of their life cycle. Fat Pocketbook mussels are expected to stay within a small range (60- 180M) throughout their life cycle so it is imperative that the species coexist with their known host fish, the Freshwater Drum. Drum are a common large river species that frequent side channel during most of year and should be present during the release of glochidia which is assumed to occur in the spring of the year. Large, exposed sandbars are a regular feature of reconnected side channels and provide critical habitat for nesting Interior Least Terns from May to September. Typically, side channels are flanked with isolated islands that include desirable nesting sandbars for ILTs, this combination provides additional protection from mainland predators (raccoons and fox for instance) because the predators have little to no to the islands. Pallid sturgeon thrive in these side channel areas during a majority of the year due to optimal flow, preferred water turbidity and submerged sand and gravel beds that provide optimum spawning habitat. For all of these endangered species, the lack of commercial navigation within side channels means less direct disturbance as the species spawn, feed, and rest during the crucial stages of their lives.

When considering the larger ecosystem attributes of a reconnected side channels, Dr Audrey B. Harrison, through the Mississippi River Geomorphology and Potamology Program, examined how invertebrate communities respond to immediate and prolonged disconnection of side channels from the main river channel. Her 2017 study found direct evidence that greater connectivity between the main and secondary channels results in higher species richness of the invertebrate fauna. Aquatic invertebrates provide multiple functions in these riverine systems including forage for fish and other aquatic organisms plus vital nutrient cycling to improve water quality in the LMR.

2.1.3 **Interior Least Tern (ILT)**

Least terns have evolved with the dynamic nature of rivers, so they are accustomed to highly variable nesting conditions when they return from wintering grounds. Life history includes longevity of up to 20 years, reproductive life starting at age 2 or 3 and continuing until death, their ability to re-nest after nest failure (which can increase recruitment following flooding and/or egg/chick predation), and a diet that can include a variety of fish species.

ILT require bare or ephemeral sandbar habitats which are formed with repetitive floods "cleaning" the sand and setting back successional stages of vegetation encroachment or newly depositing sand. During the summer nesting season with these areas occurring across the river floodplain, especially the secondary channels. Their diet requires an abundance of smaller fish for the species to have the energy to nest, lay eggs, hatch and raise fledglings, fed fledging and migrate substantial distances at the end of the breeding season. These are the critical pieces for ILT, and habitat complexity is essential to serve these needs during the nesting season and prepare adults and fledging for migration. Effective February 12, 2021, the U.S. Fish and Wildlife Service (USFWS) delisted the Interior Least Tern (ILT; Sternula antillarum) from the Endangered Species Act, (ESA) due to its population having met recovery goals.

2.1.4 **Pallid sturgeon (PS)**

The pallid sturgeon (*Scaphirhynchus albus*) is a riverine fish that occupies the Mississippi River Basin, including the Mississippi River, Missouri River, and their major tributaries (i.e., Platte and Yellowstone Rivers), and the Mississippi's major distributary, the Atchafalaya River (USFWS 1990b). They occupy the benthos of large, turbid rivers in North America, particularly the main channel (Kallemeyn 1983). Much of the natural habitat throughout the range of PS has been altered by humans, and this is thought to have had a negative impact on this species (USFWS 1993). PS are thought to occupy the sandy main channel in the Mississippi, Missouri, and Yellowstone Rivers most commonly, 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). Several studies have documented PS near islands and dikes, and these habitats are thought to provide a break in water velocity and an increased area of depositional substrates appropriate for foraging (Garvey et al. 2009; Koch et al. 2012).

It is thought that female Scaphirhynchus spp. do not reach sexual maturity until ages 6-17 and spawn every 2-3 years and that males do not reach sexual maturity until ages 4-9 (Keenlyne & Jenkins 1993; Colombo et al. 2007; Stahl 2008; Divers et al. 2009). Lower Mississippi River pallid and shovelnose sturgeons at lower latitudes may begin spawning at an earlier age than those in upper portions of the range because they are thought to have shorter lifespans and reach smaller sizes (George et al. 2012). LMR PS may be more highly fecund than those in northern portions of their range (George et al. 2012). It is thought that PS, like shovelnose sturgeon spawn over gravel substrates, but spawning has never been observed in this species (USFWS 1993; DeLonay et al. 2007; DeLonay et al. 2009).

PS move upstream for the annual spawn, triggered by increased water temperature and flows. Most movement occurs between March and June and some fish exhibit movement upstream for multiple years. Studies suggest that PS remain in one area after the spawn, this is likely done to conserve energy after and before the next spawning event. This behavior indicates habitat adjacent to spawning area is imperative for ichthyoplankton and juvenile but also adults of the species.

In 1990, the PS was listed as an endangered species under the Endangered Species Act of 1973 (USFWS 1990b). Its decline was attributed to several anthropogenic impacts, including habitat modification and commercial harvest of the fish (USFWS 1990b). A recovery plan, which listed recommendations and policy changes, was issued by the USFWS in 1993, and included a projected recovery date of 2040. The shovelnose sturgeon (S. platorynchus) is a sibling species to the PS and shares much of its range. To further protect the PS, the shovelnose sturgeon was listed as a threatened species under the Similarity-of-Appearance Provisions of the Endangered Species Act in 2010 (USFWS 2010b). This listing bans the commercial harvest of shovelnose sturgeon in areas where PS are known to occur (USFWS 2010b).

2.1.5 Fat Pocketbook Mussel (FPM)

The fat pocketbook mussel *Potamilus capax* is a freshwater pearly mussel native to the Ohio River system and Mississippi River drainage (Watters et al. 2009). This species is a relatively large species, with adults sometimes reaching over 5-inches in length (USFWS 1989). The FPM was listed as endangered throughout its range by the U.S. Fish and Wildlife Service in 1976, and a recovery plan was issued in 1989 (USFWS 1976; USFWS 1989). The decline of the FPM has been attributed to several anthropogenic impacts, including water contamination and loss of habitat, particularly to perturbations associated with river navigation and flood risk management (USFWS 1989). An updated 5-year review reported that the FPM species status is improving based on increases of site records throughout its range of animals that are 2-5 years old (USFWS 2012b).

FPM occupy depositional areas of large, slow moving rivers, and museum records suggest that this species requires flowing water and stable substrates (USFWS 1989; Watters et al. 2009). This species is typically found in sand and silt substrates, but has

also been collected in mud, clay, and fine gravel substrates in depths ranging from a few inches to ten feet in depth (Baker 1928; Parmalee 1967; Harris & Gordon 1987; USFWS 1989; Harris & Gordon 1990; USFWS 2012b). In the lower Mississippi River, FPM have been found in sand in secondary channels and in a mixture of sand, silt, and mud in side channels (USFWS 2012b). FPM movement is measured in yards so location where animals are found are vital to their existence.

Gravid FPM have been found between June and December and this species is likely spawn in the summer and release glochidia the following spring / summer timeframe (Baker 1928; Oesch 1984; USFWS 1989; Roe et al. Watters et al. 2009). The only known host species for FPM is freshwater drum Aplodinotus grunniens Rafinesque, but the method of glochidial attachment remains unknown (Watters et al. 2009; USFWS 2012b).

Section 3
Additional Species and Habitats of Significance

3.1 ALLIGATOR GAR

Alligator Gar stage and spawn from the end of April through May at St. Catherine Creek National Wildlife Refuge near Natchez, MS (Yvonne Allen pers. comm 31 March 2022). This behavior occurs when water temperature reaches 68-77° F. Because the project area is further north, staging would likely begin in May with spawning occurring approximately two weeks later. Alligator Gar prefer flooded herbaceous wetland for spawning where the shallow 1 – 4 ft deep waters warm from sunlight. A typical breeding season starts when river water reaches and submerges herbaceous floodplain habitat. It then takes a few days/weeks for the inundated floodplain to reach ideal temperature. During this time, the adult fish must find and travel to the site, congregate and spawn. The eggs attach to the flooded vegetation and hatch after another few days to weeks. Once hatched the young fry will typically stay in warm, protected backwaters for a few months.

Alligator Gar can probably utilize spawning sites which are inundated for only a month during the spring, but the survival rate of the recently spawned gar would be lower. A water control structure can be installed on sites that would normally drain. The structure would be opened during the spring flood pulse to let water and gar move onto the site. As the water drops and adult gar move out of the floodplain, the structure would be closed to hold water and rear the fry. When interior water levels fall to one foot or several months have passed, the structure would be opened to release the young gar.

3.1.1 Alligator Gar Habitat Suitability Index

The Alligator Gar *Atractosteus spatula* is a large, long-lived, physostomous fish that may be dependent on inundated floodplains or wetland vegetation for spawning and nursery habitats (Buckmeier et al. 2017). Historically, Alligator Gar were distributed throughout the central USA, ranging from Oklahoma southward to the Gulf of Mexico, but more recently abundances have declined (Poly 2001; O'Connell et al. 2007) and the species is now considered vulnerable to localized extirpation. Several authors have cited habitat alteration and overexploitation as the most important factors in the widespread decline in abundance (Robinson and Buchanan 1988; Simon and Wallus 1989; Etnier and Starnes 1993; Metee et al. 1996; Warren et al. 2000; Ferrara 2001; Jelks et al. 2008). Hydrologic alterations have disconnected much of the lower Mississippi River from floodplain and backwater spawning areas and have likely hindered Alligator Gar reproductive success (Simon and Wallus 1989; Etnier and Starnes 1993; Boschung and Mayden 2004).

Alligator Gar has therefore been identified by the American Fisheries Society, the U.S. Fish and Wildlife Service, and many state agencies as a species of concern in the lower Mississippi Alluvial Valley. The Alligator Gar Habitat Suitability Index (HSI) was developed to provide landscape-level spatial data to determine the extent and quality of floodplain habitat that may be available for Alligator Gar spawning. Multi-temporal analysis of remote sensing imagery was used to develop spatial data products that defined floodplain inundation extent, inundation frequency, and temperature. These products were combined with existing layers of physical habitat structure to define and quantify spawning habitat suitability throughout the entire area subject to direct inundation by the lower Mississippi River. Habitat suitability categories were defined based on meeting unique combinations of inundation, temperature, and physical structure so that the most suitable conservation measures can be applied to improve local conditions.

The Alligator Gar HSI data layer has been created for the Hatchie / Loosahatchie conservation reach. The HIS has been added to the H/L base map to provide comparison and consideration of the areas of significance for species of concern. This information was used as a planning tool by natural resource managers to evaluate priority measures for hydrologic/hydraulic restoration that would be run through one of the seven habitat suitability models. Models will generate “Best Buys” based economic and habitat output priorities to assist managers with measure selection. Final screening of “Best Buys” will include review of the Alligator Gar HSI tool, as well as other considerations of species and habitat significance to screen measures to determine the optimum priority for the TSP and eventual implementation in the H/L reach.

3.2 MEANDER SCARPS

Meander scarps are primarily flowing relatively narrow (less than ¼ the adjacent main channel’s width) forested channels that were historically occupied by the river’s main channel. There are 14 that maintain flow nearly year-round remaining in the LMR. There are only three flowing neck cutoff meander scarps in the entire LMR and likely the entire Mississippi River: Brandywine, Palmyra, Island 82. Of the remaining meander scarps formed by point bar cutoff, Island 35 and Sunrise/Sunrise Towhead are the longest. These channels range in length from 9 to 12.5 miles bringing main channel water to extensive amounts of floodplain creating a mosaic of aquatic connectivity and habitat, enhanced nutrient cycling, and flood storage. Consequently, hydrologic restoration of scarps is paramount in maintenance of biologic functions, structure and processes through all trophic levels and food chain support: nutrient cycling, decomposers (e.g., fungi, bacteria, protozoa, aquatic insects), producers (plants), and consumers (animals).

Meander scarps are rarely formed when an entire riverbend is cutoff as these neck cutoffs typically result in oxbow lakes. Still a rare occurrence, meander scarps are more

commonly formed by point bar (chute) cutoffs. After cutoff, the point bar becomes a mid-channel bar; this condition can persist for decades as with Fancy Point RM 257 and Profit Island RM 250. Over time, the main channel may move to the chute abandoning the longer more sinuous path around the historic point bar which then narrows to become a meander scarp. Winkley 1977 documented a chute cutoff rate of 0.09 per year or 9 every 100 years. With the channel maintenance program, meander scarps no longer form.

3.3 CYPRESS AND TUPELO SWAMPS

Cypress and tupelo swamps have been identified as uncommon within the LMR. Two cypress species may occur in the batture: *Taxodium distichum* (bald cypress) and T. ascendens (pond cypress). Three species of tupelo are common in the LMR: Nyssa sylvatica (black gum), N. aquatica (water tupelo), and N. biflora (swamp tupelo). Cypress and tupelo swamps have a diverse plant and animal community in part facilitated by the conditions created by the trees. Important hydrophytic plants associated with cypress/tupelo swamps include (but are not limited to) trees: slash pine, red maple, swamp white oak, swamp chestnut oak, black willow, and water hickory; shrubs: fetterbush, buttonbush, and wax myrtle; herbs: Virginia chain fern, bamboo brier, lizard's tail, sensitive fern, and St. John's wort. The diverse habitat supports aquatic macroinvertebrates such as isopods, damselflies, dragonflies, predatory beetles, midges and a rich assemblage of many other aquatic insects. Many still water species of fish are found there, such as mosquitofish and sunfish species. Herptiles include cottonmouth moccasins, banded water snakes, and many species of salamanders. Pruitt (1971) listed 17 mammals common to cypress/tupelo swamps. There are even more species that are wetland-dependent that visit cypress/tupelo swamps.

Cypress/tupelo swamps are uncommon in part due to logging, changing hydrology, and land use. In many places, ditches have been excavated across the floodplain increase runoff and reduce ponding duration (Stanturf et al. 2000, Gardiner et al. 2005). In addition, ditches drain the cypress/tupelo wetlands allowing colonization of upland species including invasive species. Cypress/tupelo swamps also provide valuable timber products and are thus targeted by loggers.

3.4 NATIVE CANE SPECIES

Three native species of *Arundinaria* are recognized in North America, *A. gigantea* (river or giant cane), *A. tecta* (switch cane), and *A. appalachiana* (hill cane) (hereinafter referred to as, cane). We assume *A. appalachiana* does not occur in the batture while both *A. gigantea* and *A. tecta* do. Dr. Bruce Pruitt mapped a large community, of what he believed as *A. tecta,* on the Meeman-Shelby Forest property. Groundwater wells have been installed on three different populations in the project reach to improve our understanding of the relationship between cane and groundwater hydrology. *Arundinaria* is the only genus of bamboo native to North America. Historically, its range was limited to the south-central and south-eastern United States where it was once

prevalent along open ridges in the LMR. Cane is a disturbance adapted species forming dense stands in areas cleared by fire, flood, tornadoes, or ice storms that persist for 10 – 25 years before being replaced by other species (LMVJV 2007). These dense stands of cane are referred to as cane breaks. Historically, native bamboos formed extensive cane brakes, often stretching for miles and so dense that early travelers and explorers would detour around them (Cirtain 2010). Apparently, cane can be found growing on a wide variety of soils which vary significantly in soil properties, nutrient levels, bulk density, particle size, pH, and hydraulic conductivity (Griffith et al. 2009). Cane is relatively inundation intolerant and can be inundated no more than ~ 14 days during the March – October growing season. Agricultural conversion and forest stand management has eliminated most stands reducing the prevalence of cane breaks by approximately 98% (Brantley and Platt 2001). Cane brakes provide high quality habitat for the Louisiana black bear and Swainson's warbler and several species of butterflies require river cane to complete their life cycle (Platt & Brantley 1997, Brantley & Platt 2001, Hendershott 2002, LMVJV 2007).

3.4.1 Rivercane Restoration Alliance and importance of River Cane to the ecology of the LMR and Tribes

The Rivercane Restoration Alliance is dedicated to combining Traditional Ecological Knowledge (TEK) and Traditional Western Ecological Knowledge to achieve successful rivercane recovery. The alliance is a collaboration between the USACE, with support from the USACE Sustainable Rivers Program (SRP), and The Nature Conservancy (TNC). The goals of this alliance are to identify partners, create a shared vision, facilitate technical workshops, develop a conceptual ecological model, identify existing data and knowledge gaps, and prepare recommendations for site specific USACE rivercane restoration studies and projects.

Rivercane (Arundinaria gigantea) is a species crucial to the continuity and culture of many Native American communities in the Southeastern United States, and it ranges from Florida to eastern Texas in the south, parts of the Midwest, and north to New York. The plant is used for almost every part of Native Americans life, sleeping mats, food prep area, flooring, roofing, walls, baskets, blow guns, and fishing creels.

Rivercane is a large grass native to the southeastern US and is technically a bamboo. It can grow to 20 feet in height and grows so dense that it shades out other plants to become the only species growing in an area, also known as a canebrake. In general, about one third of the plant density is contained in the root system and the other two thirds is above ground.

There are many environmental benefits from rivercane and the resultant canebrakes. Below the water, rhizomes form a dense mat that stabilizes shorelines from erosion during water level fluctuations. Research has shown that rivercane rhizomes are better at removing nitrogen, phosphorus, and sediment than a saturated buffer that includes multiple species and out-performs all other grasses for this valuable environmental service. Above ground, the extensive canebrakes slow velocity causing sediment to deposit from the water column plus alter flow patterns. The ground layer of canebrake provides habitat for insects, mice, shrews, moles, raccoons, and voles while the canopy

provides valuable habitat for many bird species including the Swainson's Warbler. It is often cited there was once over a million acres of canebrake in the lower Mississippi River Alluvial Valley. Today, this once abundant habitat is a critically endangered ecosystem with only a few thousand acres remaining.

3.5 BOTTOMLAND HARDWOOD FOREST (BLH)

Historically the most common species in LMR forests included oak, hickory, pecan, tupelo, and bald cypress. Oak, hickory (pignut and mockernut), and pecan occur on the higher elevations within the floodplain (Twedt et al. 2006). Common oaks found in BLH systems include overcup oak, water oak, Nuttall oak, cherrybark oak, willow oak, and red oak. Other tree species include ironwood, bitter pecan, swamp dogwood, stiff dogwood, sugarberry, green ash, water elm, black willow, pond and bald cypress. Along the litter zone and backslope, river cane and switch cane can occur. Understory species include paw paw, box elder, red maple, silver maple, spicebush, ironwood, redbud, hawthorne, persimmon, swamp privet, and deciduous holly. Shrub and groundcover species include buttonbush, cross vine, bog hemp, Virginia creeper, sensitive fern, Virginia chain fern, cinnamon fern, royal fern, knotweed, lizard's tail, elderberry, muscadine, huckleberry, and green brier.

BLH systems were targeted for agriculture because of the reduced inundation frequency. Like Cypress/tupelo swamps, these trees have also been targeted by loggers, and river users often make note of, acquire, and log stands for secondary income. This has led to a decline in populations of songbirds that rely on BLH forest interior for shelter from weather, predators, and nest parasites (Twedt et al. 2006).

3.5.1 Batture Reforestation

In 2012, in partnership with the Mississippi River Trust, reforestation of frequently flooded cleared land within the LMR floodplain was initiated. Willing landowners enter their land in conservation easements and receive financial and technical assistance with restoring the land to bottomland hardwood forest. Reforestation efforts help to:

- Lessen the amount of nutrients entering the river and the Gulf of Mexico.
- Reduce flooding.
- Reduce federal crop insurance payments.
- Increase opportunities for outdoor recreation.
- Expand habitat for bears, migratory birds and other wildlife.
- Sequester harmful carbon dioxide from the atmosphere.

More than 32,000 acres have been replanted since the beginning of the project.

3.6 INVASIVE CARP

The Lower Mississippi River Basin Asian Carp Control Strategy Framework (Framework) includes the entirety of the Lower Mississippi River basin, and includes the following major tributaries and their watersheds: Arkansas River, Red River, White River, St. Francis River, Yazoo River, Obion River, Big Black River and Hatchie River. The area encompasses the U.S. Geological Survey (USGS) Hydrologic Units for Region 08 (Lower Mississippi Region) and Region 11 (Arkansas-White-Red Region).

For the six LMR states, the LMRCC provides a coordinating body for Asian carp control. Each state has a representative from their natural resource conservation (i.e., game and fish) agency and environmental quality agency to make up a 12- member Executive Committee. The LMRCC understands the magnitude of the Asian carp threat and the need for coordinated efforts to prevent the continued spread, explore strategies to reduce the abundance of established populations, and better understand the impacts of established populations. LMRCC's overlap between the Asian carps' control and the LMR Feasibility Study provides an important connection to ensure that feasibility study recommendations complement the work of the Asian Carp Control Strategy.

The Framework includes seven goals and associated potential strategies to collectively prevent further expansion, reduce populations, and better understand the impacts of Asian carps. Implementation is the responsibility of basin states, is voluntary, and is intended to minimize the social, ecological, and economic impacts of these invasive fishes. Goal 3 directly aligns with the study goals of the LMR Feasibility Study, which indicates the need to improve native fishes abundance and improve habitat through restoration of native fishes habitat.

Objectives 3.6 and 3.7 directly relate to the goals and objectives of the LMR feasibility study. For 3.6, indicates improving conditions for native fish species will increase the diversity and abundance of desirable species and based on native fishes life history timing should increase predation of ichthyoplankton and juvenile Asian Carps. This should cause natural suppression of invasive carps. Objective 3.7 indicates habitat improvements that increase velocity in off channel areas (reconnecting off channel areas) would adversely affect the feeding habits of Asian carps. Both objectives would be addressed in many of the measures outlined in the LMR Feasibility Study.

Goal 3 – Population Control and Agency Response: Reduce Asian carp densities with the goal of extirpation of Asian carps.

3.6 Implement management strategies to enhance populations of native piscivores that could prey upon both juvenile and adult Asian carps. (National Goal 3) Implementation of management strategies would benefit from research to determine if select native fish feed on Asian carp juveniles and adults, especially those that select for Bighead Carp, Silver Carp, and Black Carp over other prey species. Alligator Gar, Flathead Catfish, Blue Catfish, and Bowfin may feed on all life stages. Other predators (e.g., black basses, White Bass, crappies) may only be able to feed on juveniles for a short period because of the prolific growth of Asian carps.

3.7 Conduct habitat restoration projects that benefit native species and emphasize limiting factors for Asian carps (e.g., flow velocity, lack of plankton-rich water). As stated in the Introduction above, higher flow velocity and other habitat criteria can adversely affect the habitat distribution of Asian carps. (See 4.2.)

3.7 TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION (TDEC) EXCEPTIONAL TENNESSEE WATERS AND OUTSTANDING NATURAL RESOURCE WATERS

TDEC's Exceptional Tennessee Waters and Outstanding Natural Resource Waters, provides a look up table of exceptional water resources in the state of Tennessee. There are many records of note within the H/L Conservation Reach. Federally Endangered Pallid Sturgeon are documented in the area. Two Tennessee State Endangered Species are found within the area, the Hatchie burrowing crayfish and the Southern Hickory Mussel (G2, S1), which is extremely rare and imperiled in the world. Notable ecosystem areas include the Chickasaw National Wildlife Refuge, Hatchie State Scenic River, Hatchie and Lower Hatchie National Wildlife Refuges and Fort Pillow State Historic Park.

Table A2b- 2. Exceptional Tennessee Waters and Outstanding Natural Resource Waters – Mississippi River Matches

HUC	Watershed Name	Waterbody	County	Description	Basis for Inclusion
08010100	Mississippi	Middle Fork Forked Deer River	Lauderdale	From Mississippi River to Chisholm Lake.	Exceptional biological diversity. WPC ecoregion reference stream for 73a. Chickasaw NWR
08010100	Mississippi	Mississippi River	Dyer, Lake, Lauderdale, Shelby, Tipton	Portion in Tennessee	Federal endangered Pallid Sturgeon, state threatened Blue Sucker.
08010210	Wolf	Wolf River	Shelby	From Mississippi River to Fletcher Creek.	State threatened Blue Sucker
08010202	Obion	Obion River	Dyer	From Mississippi River to the ecoregion break near Lane.	Federal and state endangered Pallid Sturgeon.

08010208	Hatchie-Lower	Hatchie River including unnamed tributaries and associated wetlands	Lauderdale, Tipton, Haywood, Hardeman,	Portion in Tennessee (from confluence with Mississippi River to Mississippi State Line).	State threatened Blue Sucker. Designated a State Scenic River. Portions located in Hatchie and Lower Hatchie National Wildlife Refuges and Fort Pillow SHP. State Endangered Hatchie burrowing crayfish. Southern Hickorynut mussel (Obovaria jacksoniana) has a state ranking of 1 and a Global ranking of 2, which makes it "extremely rare and critically imperiled in the state" and "very rare and imperiled in the world

Table A2b- 3. Exceptional Tennessee Waters and Outstanding Natural Resource Waters – Meeman Shelby Matches

HUC	Watershed Name	Waterbody	County	Description	Basis for Inclusion
08010100	Mississippi	Barnishee Bayou	Shelby	Portion in Meeman Shelby Forest State Natural Area.	Meeman Shelby Forest State Natural Area
08010100	Mississippi	Big Cypress Slough	Shelby	Portion in Meeman Shelby Forest State Natural Area.	Meeman Shelby Forest State Natural Area
08010100	Mississippi	Dry Bayou	Shelby	Portion in Meeman Shelby Forest State Natural Area.	Meeman Shelby Forest State Natural Area.
08010100	Mississippi	Eagle Lake	Shelby	Portion in Meeman Shelby Forest State Natural Area.	Meeman Shelby Forest State Natural Area.

08010100	Mississippi	Grassy Lake	Shelby	Entire lake is in Meeman Shelby Forest State Natural Area.	Meeman Shelby Forest State Natural Area.
08010100	Mississippi	Gum Slough	Shelby	Portion in Meeman Shelby Forest State Natural Area.	Meeman Shelby Forest State Natural Area.
08010100	Mississippi	Little Cypress Slough	Shelby	Portion in Meeman Shelby Forest State Natural Area.	Meeman Shelby Forest State Natural Area.

3.8 ARKANSAS AND TENNESSEE STATE WILDLIFE ACTION PLANS

Statewide wildlife action plans have been developed for both Tennessee and Arkansas. These documents provide important considerations for essential habitats regarding populations of state special concern to endangered species. The information highlights what is known about a certain species and what is necessary to create conditions to maintain or increase population for these species of interest.

The state of Arkansas provides data on special consideration species with thorough descriptions, geographical regional maps and their species scoring system, but the information did not provide site specific species information from Arkansas. Culling through the Arkansas species was done by differentiating the geographic location of species and determining which species exist within the named ecoregions of the Mississippi Alluvial Plain and Mississippi Valley Loess Plain. From the initial list, further interpretation was conducted based on species habitat needs and whether these habitats are likely to include large rivers or tributary areas that connect with the Mississippi River during portions of their life history. The Arkansas SWAP list should be considered a broader range of species that exist or could potentially exist within Hatchie/Loosahatchie reach.

The Tennessee Chapter of The Nature Conservancy was able to provide species information specific for the TN boundaries of the Hatchie/Loosahatchie conservation reach based on Nature Serve GIS records. Therefore, the species identified are resident or migratory species within the H/L conservation reach. Difference between TN and AR SWAP could be interpreted to mean Tennessee's data is a more definitive list of special concern to endangered species while AR SWAP information that matches TN data further confirming of the species listing and may provide a broader list species that may be present if conditions are improved with habitat restoration.

The original list of species of concern from the states included 182 species but subsequent screening the list to include only the S1 or S2 species brought the list down to 105 species. Bird data indicates 83 species in some category of species concern with 43 of those species included in S1 or S2 levels of species concern. Following the same categorical reference as birds listed above (the broader level of species of concerns to the subset list of S1 and S2 levels species of concern), other categories include, Amphibians (7 (3), Birds (83) 43 Fish (27 (18)), Insects (13 (9)) , Mammals (10 (5)), Mussels (21 (9)), Plants (11 (10)), Reptiles (9 (4)) and “Other invertebrates” (1 (1)). These other categories were listed at considerably lower numbers than birds identified in the species of concern. This difference is likely attributed to the difficulty of monitoring and monitoring frequency in aquatic systems, especially the LMR, does not provide as accurate assessment of species of concern as terrestrial monitoring. This does not indicate that terrestrial species have higher level of concern but rather these species are easier to identify and enumerate than species in a freshwater system. Freshwater habitat is considered one of the most vulnerable ecosystems on the planet and freshwater mussels are considered the most endangered fauna among all freshwater species. Any significance calculations must include these underlying considerations in the scoring.

3.9 TECHNICAL SIGNIFICANCE OF STUDY AREA HABITATS

During the study, the study’s project delivery team and non-Federal Sponsor (LMRCC and partners) documented the technical significance of the habitat in the study area proposed for restoration using habitat scarcity and the importance of the habitat to special status species from Table A2b-4. To inform the determination of technical significance, the PDT evaluated and weighted the habitats in the study area based on their importance to populations of Federal and state endangered species, as documented in the Arkansas and Tennessee State Wildlife Action Plans provided by TNC along with the scarcity of the habitat documented by subject matter experts on the LMR Table A2b-5.

Table A2b- 4. High Priority Rankings (State listed S1 or S2) of species of conservation concern identified in State Wildlife Action Plans.

Order	Common Names	Scientific Name	Population status (AR SWAP	Scoring AR (out of 100)	Scoring TN (out of 100)	AR Extant/ Historic	AR Named Rank	Global and AR State Rank	TN Extant/ Historic	TN Named Rank	Global and TN State Rank	Federal Listing
Amphibians (3 species)												
	Southern Cricket Frog	*Acris gryllus*			12.90				Historic	NSS	G5, S2S3	
	Eastern Spadefoot	*Scaphiopus holbrookii*	Unknown	19.00			Imperiled	G5, S2			NL	
	Illinois Chorus frog	*Pseudacris illinoensis*	Decreasing	43.00			Critically Imperiled	G3, S1			NL	
Birds (43 species)												
	Great Egret	*Ardea alba*			19.50			NL		D	G5, S2BS3N	
	Upland Sandpiper	*Bartramia longicauda*			3.30				Extant	D	G5, SX?	
	Redknot	*Calidris canutus*			16.50			NL			G5, S2N	LT

Order	Common Names	Scientific Name	Population status (AR SWAP	Scoring AR (out of 100)	Scoring TN (out of 100)	AR Extant/ Historic	AR Named Rank	Global and AR State Rank	TN Extant/ Historic	TN Named Rank	Global and TN State Rank	Federal Listing
	Brown Creeper	*Certhia americana*			16.50				Extant	NSS	G5, S2	
	Piping Plover	*Charadrius melodus*	Decreasing	43	33.50		Critically Imperiled	G3, S2	Historic	NSS	G3, S2	(LE:LT)
	Little Blue Heron	Egretta caerulea			19.50				Extant	D	G5, S2	BCC
	Tricolored Heron	*Egretta tricolor*	Stable	19			Imperiled	G5, S2B			NL	
	Mississippi Kite	*Ictinia mississippiensis*			15.90				Extant	D	G5, S2S3	
	Least Bittern	*Ixobrychus exilis*	Unknown	19	19.50		Imperiled	G5, S2B	Extant	D	G5, S2	
	Swainson's Warbler	*Limnothlypis swainsonii*	Unknown	19	16.50		Vulnerable	G4, S3B	Extant	D	G4, S3	
	Painted Bunting	*Passerina ciris*			16.50			NL	Extant	NSS	G5, S2	
	Black-bellied Plover	*Pluvialis squatarola*	Decreasing	24			Imperiled	G5, S2N			NL	
	Yellow-bellied Sapsucker	*Sphyrapicus varius*			34.50			NL	Extant	D	G2T2Q, S2S3	

Order	Common Names	Scientific Name	Population status (AR SWAP	Scoring AR (out of 100)	Scoring TN (out of 100)	AR Extant/ Historic	AR Named Rank	Global and AR State Rank	TN Extant/ Historic	TN Named Rank	Global and TN State Rank	Federal Listing
	Interior Least Tern	Sternula antillarum athalassos	Increasing	31	50.40		Vulnerable	G4T2Q, S3B	Extant	E	G4T2Q, S2S3B	
	Northern Saw-whet Owl	*Aegolius acadicus*						NL	Historic	T	G5, S1	
	Henslow Sparrow	*Ammodramus henslowii*	Decreasing	33			Critically Imperiled	G4, S1B, S2N		NSS	G4, S1B	BCC
	Le Conte's Sparrow	*Ammodramus leconteii*	Decreasing	21	36.00		Vulnerable	G4, S3S2N	Extant	NSS	G4, S1N	
	Golden Eagle	Aquila chrysaetos			34.50			NL	Extant	D	G5, S1	BCC
	American Bittern	Botaurus lentiginosus	Stable	23	31.50		Imperiled	G4, S2N	Extant	NSS	G4, S1	
	Olive-sided Flycatcher	*Contopus cooperi*			39.00				Extant	D	G4, S1	
	Alder Flycatcher	*Empidonax alnorum*			31.50			NL	Extant	NSS	G5, S1	
	Peregrine Falcon	*Falco peregrinus*			46.00				Extant	E	G4, S1	No Status
	Common Gullinule	*Gallinula galeata*	Unknown	19	34.50		Imperiled	G5, S2B	Extant	D	G5, S1	No Status

Order	Common Names	Scientific Name	Population status (AR SWAP	Scoring AR (out of 100)	Scoring TN (out of 100)	AR Extant/ Historic	AR Named Rank	Global and AR State Rank	TN Extant/ Historic	TN Named Rank	Global and TN State Rank	Federal Listing
	Loggerhead Shrike	*Lanius ludovicianus*	Decreasing	24		39.00	Vulnerable	G4, S3	Extant	D	G4, S1	No Status
	Bachman's Sparrow	*Peucaea aestivalis*	Decreasing	33			Vulnerable	G3, S3B	Historic	E	G3, S1	
	King Rail	Rallus elegans	Decreasing	33			Critically Imperiled	G4, S1B	Historic	D	G4, S2	
	Virginia Rail	Rallus limicola			31.50				Historic	NSS	G5, S1	
	Purple Gallinule	*Porphyrio martinicus*	Stable	23	31.50		Critically Imperiled	G5, S1B	Historic	NSS	G5, S1	
	Bewick's Wren	*Thryomanes bewickii*			34.50				Historic	D	G5, S1	
	Bell's Vireo	Vireo bellii	Decreasing	19	31.50		Vulnerable	G5, S3B	Historic	NSS	G5, S1	No Status
	Ruddy Turnstone	*Arenaria interpres*	Decreasing	24			Imperiled	G5, S2N			NL	BCC
	Chimney Swift	*Chaetura pelagica*	Decreasing	19	2.00		Vulnerable	G5, S3B	Extant	NSS	G5, S5	BCC
	Prairie Warbler	*Dendroica discolor*										BCC

Order	Common Names	Scientific Name	Population status (AR SWAP	Scoring AR (out of 100)	Scoring TN (out of 100)	AR Extant/ Historic	AR Named Rank	Global and AR State Rank	TN Extant/ Historic	TN Named Rank	Global and TN State Rank	Federal Listing
	Swallow-tailed Kite	*Elanoides forficatus*	Decreasing	29			Critically Imperiled	G5, S1B				BCC
	American Kestral	*Falco sparverius paulus*										BCC
	Bald Eagle	*Haliaeetus leucocephalus*			12.00				Extant	NSS	G5, S3	Warrents Attention
	Wood Thrush	*Hylocichla mustelina*	Decreasing	19			Vulnerable	G5, S3B	Extant	NSS	G5, S4	BCC
	Eastern Black Rail	*Lateraluus jamaicensis ssp*										LT
	Short-billed Dowitcher	*Limnodromus griseus*	Decreasing	19			Vulnerable	G5, S3N				BCC
	Red-headed Woodpecker	*Melanerpes erythrocephalus*			5.10				Extant	NSS	G5, S4	
	American Golden-Plover	*Pluvialis dominica*	Unknown	15	9.00		Vulnerable	G5, S3N	Extant	NSS	G5, S3	BCC
	Pronthonotary Warbler	*Protonotaria citrea*			5.10			NL			G5, G4	BCC

Order	Common Names	Scientific Name	Population status (AR SWAP	Scoring AR (out of 100)	Scoring TN (out of 100)	AR Extant/ Historic	AR Named Rank	Global and AR State Rank	TN Extant/ Historic	TN Named Rank	Global and TN State Rank	Federal Listing
	Cerculean Warbler	*Setophaga or ? Dendroica ceruleacerulea*	Decreasing	24	16.50		Vulnerable	G4, S3B	Extant	D	G4, S3	
	Lesser Yellowlegs	*Tringa flavipes*										BCC
	Willet	*Tringa semipalmata*										BCC
Fishes (18 species)*												
	Brown bullhead	*Ameiurus nebulosus*	Unknown	19			Imperiled	G5, S2			N/A	
	Goldeneye	*Hiodon alosoides*	Unknown	19			Imperiled	G5, S2			N/A	
	Mooneye	*Hiodon tergisus*	Unknown	19			Imperiled	G5, S2			N/A	
	Pearlip Redhorse	*Moxostoma pisolabrum*	Unknown	19			Imperiled	G5, S2			NL	
	Striped Mullet	*Mugil cephalus*	Stable	19			Imperiled	G5, S2			NL	
	Sabine Shiners	*Notropis sabinae*	Unknown	23			Imperiled	G4, S2			NL	

Order	Common Names	Scientific Name	Population status (AR SWAP	Scoring AR (out of 100)	Scoring TN (out of 100)	AR Extant/ Historic	AR Named Rank	Global and AR State Rank	TN Extant/ Historic	TN Named Rank	Global and TN State Rank	Federal Listing
	Channel Shiner	*Notropis wickliffi*	Unknown	19			Imperiled	G5, S2			NL	
	Stargazing Darter	*Percina uranidea*	Decreasing	38			Imperiled	G3, S2			NL	
	Lake Sturgeon	*Acipenser fulvescens*	Unknown	27			Imperiled	G3G4, S2			G3G4, S1	
	Alabama Shad	*Alosa alabamae*	Decreasing	52			Critically Imperiled	G2G3, S1			N/A	
	Western Sand Darter	*Ammocrypta clara*	Decreasing	33			Vulnerable	G3, S3			G3. S1	
	Alligator Gar	*Atractosteus spatula*	Stable	27			Imperiled	G3G4, S2			G3G4, S1	
	Sicklefin Chub	*Macrhybopsis meeki*	Decreasing	43			Critically Imperiled	G3, S1			G3, S2	
	Silver Redhorse	*Moxostoma anisurum*	Decreasing	29			Critically Imperiled	G5, S1			NL	
	Stonecat	*Noturus flavus*	Decreasing	29			Critically Imperiled	G5, S1			NL	

Order	Common Names	Scientific Name	Population status (AR SWAP	Scoring AR (out of 100)	Scoring TN (out of 100)	AR Extant/ Historic	AR Named Rank	Global and AR State Rank	TN Extant/ Historic	TN Named Rank	Global and TN State Rank	Federal Listing
	Suckermouth Minnow	*Phenacobius mirabilis*	Unknown	23			Critically Imperiled	G5, S1?			NL	
	Flathead Chub	*Platygobio gracilis*	Unknown	23			Historic Record - Possibly extirpated in AR	G5, SH			NL	
	Pallid Sturgeon	*Scaphirhynchus albus*	Unknown	48			Critically Imperiled	G2, S1S2			G2, S1	LE
Insects (9 species)												
	Beach- Dune Tiger Beetle	*Cicindela hirticollis*	Unknown	17			Imperiled	G5, S2S3			NL	
	Tiger Beetle	*Cicindela lepida*	Unknown	25			Imperiled	G3G4, S2S3			NL	
	Woodland Tiger Beetle	*Cicindela unipunctata*	Unknown	21			Imperiled	G4G5, S2			NL	
	Monarch	*Danaus plexippus*	Unknown	15			Apparantly Secure in AR	G4, S4			NL	Candidate
	Six-banded Longhorn Beetle	*Dryobius sexnotatus*	Unknown	19			Imperiled	GNR, S2			NL	

Order	Common Names	Scientific Name	Population status (AR SWAP	Scoring AR (out of 100)	Scoring TN (out of 100)	AR Extant/ Historic	AR Named Rank	Global and AR State Rank	TN Extant/ Historic	TN Named Rank	Global and TN State Rank	Federal Listing
	Gray Comma	*Polygonia progne*	Unknown	19			Imperiled	G4G5, S2S3			NL	
	Lace-winged Roadside Skipper	*Amblyscirtes aesculapius*	Unknown	27			Critically Imperiled	G3G4, S1S3			NL	
	Duker's Skipper	*Euphyes dukesi*	Unknown	32			Critically Imperiled	G3, S1S2			NL	
	Yehl Skipper	*Poanes yehl*	Unknown	23			Critically Imperiled	G4, S1S3			NL	
Mammals (5 species)												
	Eastern Harvest Mouse	*Reithrodontomys humulis*	Unknown	19			Imperiled	G5, S2			NL	
	Southern Bog Lemming	*Synaptomys cooperi*	Unknown	19			Imperiled	G5, S2			G5, S4	
	Northern Long-eared Bat (Nothern Myotis - TN)	*Myotis septentrionalis*	Unknown	63			Critically imperiled	G1G2, S1S2		NC	G4, S4	LT
	Indiana Bat	Myotis sodalis	Decreasing	62			Critically imperiled	G2, S1		NC	G2, S1	LE

Order	Common Names	Scientific Name	Population status (AR SWAP	Scoring AR (out of 100)	Scoring TN (out of 100)	AR Extant/ Historic	AR Named Rank	Global and AR State Rank	TN Extant/ Historic	TN Named Rank	Global and TN State Rank	Federal Listing
	Golden Mouse	*Ochrotomys nuttalli*			3.30					NC	G5, SU	
Mussels (9 species)												
	Pink Mucket	*Lampsilis abrupta*	Unknown	46			Imperiled	G2, S2			G2, S2	LE
	Pyramid Pigtoe	*Pleurobema rubrum*	Stable	38			Imperiled	G2G3, S2			G2G3, S1S2	
	Fat Pocketbook	*Potamilus capax*	Stable	46			Imperiled	G2, S2			NL	LE
	Purple Lilliput	*Toxolasma lividum*	Decreasing	33			Vulnerable	G3Q, S3			G3Q, S2S3	
	Tapered Pondhorn	*Uniomerus declivis*	Unknown	19			Imperiled	G5Q, S2			G3Q, S2	
	Pondhorn	*Uniomerus tetralasmus*	Unknown	19			Imperiled	G5, S2			NL	
	Scaleshell	*Leptodea leptodon*	Decreasing	76			Imperiled	G1G2, S2			G1, SX	LE
	Pink Heelsplitter	*Potamilus alatus*	Unknown	23			Critically Imperiled	G5, S1			NL	

Order	Common Names	Scientific Name	Population status (AR SWAP	Scoring AR (out of 100)	Scoring TN (out of 100)	AR Extant/ Historic	AR Named Rank	Global and AR State Rank	TN Extant/ Historic	TN Named Rank	Global and TN State Rank	Federal Listing
	Salmander Mussel	*Simpsonaias ambigua*	Unknown	34			Critically imperiled	G3, S1			NL	
Plants (10 species)												
	Featherfoil	*Hottonia inflata*			24.00			NL	Extant	S	G4, S2	
	Copper Iris	*Iris fulva*			22.50			NL	Extant	T	G5, S2	
	Sweetbay Magnolia	*Magnolia virginiana*			22.50			NL	Extant	T	G5, S2	
	Red Starvine	*Schisandra glabra*			33.50			NL	Extant	T	G3, S2	
	Ovate Catchfly	*Silene ovata*			37.50				Historic	E	G3, S2	
	Willow Aster	*Symphyotrichum proealtum*			41.50				Historic	E	G5, S2	
	Tissue Sedge	*Carex hyalina*			39.00			NL	Historic	S	G4, S1	
	Multiflowered Mud-plantain	*Heteranthera multiflora*			39.00				Historic	S	G4, S1	
	Cedar Elm	*Ulmus crassifolia*			19.50			NL	Extant	S	G5, S1	

Order	Common Names	Scientific Name	Population status (AR SWAP	Scoring AR (out of 100)	Scoring TN (out of 100)	AR Extant/ Historic	AR Named Rank	Global and AR State Rank	TN Extant/ Historic	TN Named Rank	Global and TN State Rank	Federal Listing
	Pondberry	*Lindera melissifolia*										LE
Reptiles (4 species)												
	Common Wormsnake	*Carphophis amoenus*	Unknown	19			Imperiled	G5, S2			NL	
	Chicken Turtle	*Deirochelys reticularia*	Unknown	19			Imperiled	G5, S2			NL	
	Graham's Crayfish Snake	*Regina grahamii*	Unknown	19			Imperiled	G5, S2			NL	
	Rough Earth Snake	*Virginia striatula*			9.00				Historic	NSS	G5, S2S3?	
Other (1 species)												
	Striped Whitelip	*Webbhelix Multilineata*			16.50				Historic	NSS	G5, S2	

*subsequent analysis revealed Blue Sucker, *Cycleptus elongatus,* (S2) and Bigmouth Shiner, *Notropis dorsalis*, (S1) are also listed in the Tennessee State Rankings.

Table A2b- 5. Significance Rankings of habitats based off habitat scarcity and species of conservation concern identified in State Wildlife Action Plans.

Normalized Ranking		0.41	0.77	0.94	0.38	0.94	0.38	1	0.56	0.77	0.38	0.76	0.77
Average Weighting		0.27	0.51	0.62	0.25	0.62	0.25	0.66	0.37	0.51	0.25	0.50	0.51
Habitat Scarcity index (0-1) ***		0.25	0.75	1.00	0.25	1.00	0.25	1.00	0.50	0.75	0.25	0.75	0.75
Special Status Species -index (0-1) *		0.29	0.28	0.24	0.24	0.24	0.24	0.31	0.25	0.28	0.24	0.26	0.27
Species of Conservation Concern	Study Area Habitats:	**MC/Main Channel Border (lotic aquatic)	**Secondary Channels (lotic aquatic)	**Meander Scarp/ tertiary channels (lotic aquatic)	**Slough (lentic aquatic)	**Oxbow (lentic aquatic)	**Borrow Areas (lentic aquatic)	**Emergent Sand/ gravel bar (aquatic and floodplain)	**BLH (floodplain)	**Cypress-Tupelo floodplain)	**Riverfront Forest - Riparian buffers (floodplainl)	**Seasonally herbaceous wetland (aquatic & floodplain)	**Moist Soil (aquatic & floodplain)
Amphibians													
Southern Cricket Frog					1	1	1			1		1	1
Eastern Spadefoot												1	
Illinois Chorus frog												1	
Birds													
Great Egret				1	1	1	1		1	1	1	1	1
Upland Sandpiper								1				1	1
Redknot								1				1	1
Brown Creeper									1	1	1		
Piping Plover								1					
Little Blue Heron				1	1	1	1		1	1	1	1	1
Tricolored Heron				1	1	1	1		1	1	1	1	1
Mississippi Kite									1		1		
Least Bittern												1	1
Swainson's Warbler									1				
Painted Bunting													

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Black-bellied Plover								1				1	1
Yellow-bellied Sapsucker									1		1		
Interior Least Tern								1					
Northern Saw-whet Owl									1				
Henslow Sparrow													
Le Conte's Sparrow													
Golden Eagle													
American Bittern												1	1
Olive-sided Flycatcher													
Alder Flycatcher													
Peregrine Falcon												1	1
Common Gullinule					1	1	1					1	
Loggerhead Shrike													
Bachman's Sparrow													
King Rail												1	1
Virginia Rail												1	1
Purple Gallinule					1	1	1					1	
Bewick's Wren													
Bell's Vireo									1		1		
Ruddy Turnstone								1				1	1
Chimney Swift									1	1	1		
Prairie Warbler													
Swallow-tailed Kite									1		1	1	1
American Kestral													
Bald Eagle											1		
Wood Thrush									1		1		

Eastern Black Rail												1	1
Short-billed Dowitcher								1				1	1
Red-headed Woodpecker									1		1		
American Golden-Plover													
Pronthonotary Warbler													
Cerculean Warbler									1				
Lesser Yellowlegs								1				1	1
Willet								1				1	1
Fish													
Brown bullhead				1	1	1	1						
Goldeneye		1	1										
Mooneye		1	1										
Pearlip Redhorse		1	1					1					
Striped Mullet			1			1							
Sabine Shiners													
Channel Shiner		1	1					1					
Stargazing Darter													
Lake Sturgeon		1	1					1					
Alabama Shad		1	1					1					
Western Sand Darter		1	1					1					
Alligator Gar			1	1	1	1	1				1		
Sicklefin Chub		1	1					1					
Silver Redhorse		1	1					1					
Stonecat		1	1					1					
Suckermouth Minnow		1	1					1					

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Flathead Chub		1	1					1					
Pallid Sturgeon		1	1					1					
Insects													
Beach- Dune Tiger Beetle								1			1		
Tiger Beetle								1			1		
Woodland Tiger Beetle									1		1		
Monarch									1			1	
Six-banded Longhorn Beetle									1				
Gray Comma									1	1	1	1	1
Lace-winged Roadside Skipper									1		1		
Duker's Skipper										1	1	1	
Yehl Skipper											1		
Mammals													
Eastern Harvest Mouse												1	
Southern Bog Lemming												1	
Northern Long-eared Bat (Nothern Myotis - TN)									1	1	1		
Indiana Bat									1	1	1		
Golden Mouse									1		1		
Mussels													
Pink Mucket													
Pyramid Pigtoe													
Fat Pocketbook			1	1									
Purple Lilliput													
Tapered Pondhorn													

Pondhorn													
Scaleshell													
Pink Heelsplitter			1	1									
Salmander Mussel													
Plants													
Featherfoil					1	1	1						
Copper Iris									1	1		1	
Sweetbay Magnolia									1	1			
Red Starvine									1				
Ovate Catchfly													
Willow Aster												1	1
Tissue Sedge										1	1		
Multiflowered Mud-plantain					1	1	1					1	1
Cedar Elm									1				
Pondberry									1				
Reptiles													
Common Wormsnake									1	1			
Chicken Turtle												1	1
Graham's Crayfish Snake				1	1	1	1					1	1
Rough Earth Snake									1		1		
Other													
Striped Whitelip											1	1	

*Used average score across all species utilizing habitat from the highest state ranking in State Wildlife Action Plan. If no state ranking but Federally listed, used max score from that habitat.

**1 denotes habitat that provides significant contribution to a key life requisite of species)

***Scarcity Rankings from PDT: 1=rare scarcity (meander scarps, oxbow lakes, tributary mouths, crevasses, gravel); 0.75=Moderate scarcity =cypress tupelo, seasonal herbaceous wetlands, moist soil management, floodplain scour hole, creek, secondary channels); 0.5=moderate common scarcity (flooded BLH); 0.25=common scarcity (sloughs, borrow areas, floodplain forest/riparian buffers, main channel/main channel border)

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Section 4

Supplemental Information Provided by Arkansas Game and Fish Commission

4.1 INTRODUCTION

This information was prepared by various staff at the Arkansas Game and Fish Commission in support of the Hatchie-Loosahatchie Mississippi River Ecosystem Restoration Study, a U.S. Army Corps of Engineers (USACE) Ecosystem Restoration Study in partnership with the Non-federal Sponsor, the Lower Mississippi River Conservation Committee (LMRCC).

4.1.1 Non-federal Sponsor

Since 1994, the Lower Mississippi River Conservation Committee (LMRCC) has provided a regional forum dedicated to conserving the natural resources of the Mississippi's floodplain, focusing on habitat restoration, long-term conservation planning and nature-based economic development. We are a coalition of 12 state natural resource conservation and environmental quality agencies in Arkansas, Kentucky, Louisiana, Mississippi, Missouri and Tennessee, incorporated as a 501(c)(3) non-profit agency.

The LMRCC works in cooperation with numerous federal, state, and non-governmental organizations for continual improvements to the Lower Mississippi River (LMR), recognizing its value as a multi-purpose river. Through these partnerships, we promote holistic management of its numerous resources from navigation and flood risk management to conservation and restoration of ecosystems, to improvements for recreational opportunities. The LMR supports a diversity of aquatic and terrestrial species, including several of conservation concern: Pallid Sturgeon *(Scaphirhynchus albus),* Fat Pocketbook Mussel *(Potamilus capax),* and Interior Least Tern *(Sterna antillarum athalassos).* It contains incredibly rich bottom land hardwood forests and a variety of features to create habitat complexes, critical for the long term management of the LMR.

LMRCC worked in cooperation with the Memphis District, The Nature Conservancy and several other partners on the Lower Mississippi River Resource Assessment (LMRRA), which culminated in a final assessment with recommendations for information needs, natural resource and habitat needs, and recreation needs. To continue with that effort, the LMRCC was pleased for Water Resources Development Act 2018 authorizing language for a Lower Mississippi River Feasibility Study for Conservation Reaches identified in the LMRRA.

4.2 GENERAL SETTING

The Hatchie-Loosahatchie Study Reach occurs entirely within the Mississippi Alluvial Valley ecoregion beginning at the head of Sunrise Island (Island 34) near Mississippi River mile (RM) 778 and continuing downstream approximately 43 RM to the train trestle at Hopefield

Point near RM 735. The study area encompasses about 1.3 million acres within portions of Arkansas and Tennessee, including the lands and waters lying between the mainline MRL (and floodwalls), or bluffs where levees are absent, and lands and waters within the Loosahatchie-Wolf River Harbor Complex. Land cover is dominated by cropland (35 percent), bottomland hardwoods (35 percent), and open water (20 percent); no other land cover category is greater than 5 percent (Table A2b-6).

Public lands are limited within this reach. Meeman-Shelby State Forest in Tennessee is the largest at 9,434 acres, but Eagle Lake Refuge (3,497 acres) and a small portion of the Lower Hatchie National Wildlife Refuge (approx. 9,400 total acres) are also located within the batture. Significant tributaries of the Mississippi River in this area are the Hatchie, Loosahatchie, and Wolf rivers.

Shelby and Tipton Counties in Tennessee and Marion County, Arkansas flank the 43-mile reach. The Memphis, Tennessee metropolitan area (population 1,163,000; 2020 U.S. Census), one of the largest cities on the LMR, borders the study reach. Other population centers in the area include West Memphis, Osceola, and Marion, Arkansas.

The LMR supports 136 freshwater fish species, 325 migratory bird species, and approximately 50 mammal species, which includes eight federally threatened or endangered species and one candidate species, the Monarch Butterfly. Because of this diversity, hunting, fishing, and wildlife watching are popular recreational activities in this region.

Implementation of various ecosystem restoration measures are necessary to maintain the complexity and diversity of rare habitats that occur within this reach, such as river cane brakes, meander scarps, and alligator gar spawning grounds. Without intervention the ecosystem services of clean air and water, flood control, pollination, and recreation provided by these habitats will only continue to diminish through time with additional eutrophication and urban expansion.

Table A2b- 6. 2017 Study Area Land Cover.

Land Cover	2017 Acres	2017 % Composition
Cropland	44,591	35%
Bottomland Hardwood Forest	44,350	35%
Open Water	25,213	20%
Pasture, Oil Fields	5,442	4%
Scrub/Shrub	5,208	4%

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Sandbar	706	1%
Levee	666	1%
Urban	605	0%
Non-forested Wetland	517	0%
Marsh	174	0%
Bare soil	174	0%
Tree Plantation	65	0%
Total	**127,712**	

4.3 NATURAL ENVIRONMENT

Historically, a variety of vegetative communities were interspersed throughout the floodplain. The soil and hydrologic regime influenced what species occurred in any given area. Bottomland hardwoods (oak, hickory, pecan, tupelo, bald cypress, et al.) were the most common species in the floodplain, but softwoods (cottonwood, elm, ash, hackberry, et al.) were also present. Forest types included cypress-tupelo, cottonwood-willow-sycamore, white oak-red oak-hickory, hackberry-elm-ash, and many others (Klimas 1988, Stanturf et al. 2000, Gardiner et al. 2005). Drastic vegetation changes began after 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 cleared and converted to agriculture every year (King et al. 2006).

4.3.1 **Wetlands**

Dense alluvial clays dominate in LMR backwater areas that historically supported extensive wetlands. Natural levees form along the banks of the LMR. 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).

LMR floodplain including the Hatchie-Loosahatchie reach has emergent, floating, and submersed aquatic vegetation, but occurrence and distribution is dependent on the flow regime and elevation relative to the main stem river. Submersed aquatic vegetation occurs in waterbodies furthest removed from the main stem river, such as borrow pits (personal communication, Dr. Jack Killgore, ERDC).

Robust emergent wetlands, also referred to as herbaceous wetlands, are identified in the Arkansas Wildlife Action Plan for research and monitoring as a critical habitat. Emergent wetlands used by King Rails *Rallus elegans* (G4, S2 for AR and TN) and other marshbirds have few to no invading trees and shrubs, and native emergent wetland vegetation such as rushes, sedges and cattails are interspersed with shallow open water with a depth that varies from 4-8 inches during wintering, migrating and breeding periods and a depth that varies from exposed mudflats to no more than 6 inches deep during the brood rearing period. Open water areas are interspersed in the wetlands and ideally the habitats approach a ratio of 50% water to 50% emergent wetland vegetation. Return of these once abundant wetland areas, prior to levee construction and channelization of the main channel of the Lower Mississippi River, is a desired outcome of recovery and restoration measures for the LMR.

4.3.2 **Fish and Wildlife**

4.3.2.1 Bats

The Arkansas Wildlife Action Plan identifies five bat species that could occur in the Hatchie - Loosahatchie Reach. Only 2 of the 5 have been documented in the area, Rafineque's Big-Eared Bat and Southeastern Bat. According to the AWAP, marginal or suitable habitats are available for the Little Brown Bat, Northern Long-Eared Bat and Indiana Bat so they have the potential to occur in the area.

4.3.2.2 Birds

The AR and TN Wildlife Action Plans identify 83 bird species that could potentially exist in the Hatchie-Loosahatchie Reach. Of these bird species, 35 are S1 (State Critically Imperiled) or S2 (State Imperiled) for either or both states. Eighteen species are S1 in at least one state including Northern Saw-whet Owl, Henslow Sparrow, Le Conte's Sparrow, Golden Eagle, American Bittern, Sedge Wren, Olive-sided Flycatcher, Alder Flycatcher, Peregrine Falcon, Common Gallinule, Loggerhead Shrike, Eastern Black Rail, Bachman's Sparrow, Purple Gallinule, King Rail, Virginia Rail, Bewick's Wren, Bell's Vireo. Three bird species on the S2 list merit special attention as they are federally listed or under consideration for listing including Redknot, Piping Plover and Swainson's Warbler.

Nearly 40% of the Mississippi Flyway's waterfowl and 60% of all U.S. bird species migrate or winter in the MAV. The MAV is identified as the most important wintering location for Mallard (Anas platyrhyncos) and Wood Duck (Aix sponsa) populations. Additionally, the MAV winters significant numbers of Green-winged Teal (A. crecca), Northern Shoveler (A. clypeata), and Gadwall (A. strepera). Accordingly, the MAV was identified as a priority non-breeding site for waterfowl in the original North American Waterfowl Management Plan (1986) and became a part of one of the first established Joint Ventures (LMVJT).

The MAV is the continent's most important wintering habitat for mallards and wood ducks, but other species, such as gadwall and green-winged teal also are common. Following widespread land conversion, the region has become more significant to northern pintails, green-winged teal and northern shovelers, as well as snow and white-fronted geese. Eighty

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percent of bottomland hardwood forests have been converted to cropland or urban uses, which decreases vital habitat for all migratory waterfowl using the LMR flyway.

Table A2b- 7. List of bird Species of Greatest Conservation Need (SGCN) that likely occur in the Hatchie-Loosahatchie Conservation Reach of the Mississippi River from Arkansas and Tennessee state wildlife action plans.

Common Names	Scientific Name	Global Rank	AR Rank	TN Rank
Northern Saw-whet Owl	*Aegolius acadicus*	G5		S1
Henslow Sparrow	*Ammodramus henslowii*	G4	S1BS2N	S1B
Le Conte's Sparrow	*Ammodramus leconteii*	G4	S3S2N	S1N
Golden Eagle	*Aquila chrysaetos*	G5		S1
American Bittern	*Botaurus lentiginosus*	G4	S2N	S1
Sedge Wren	*Cistothorus platensis*	G5	S1S2, S4N	S3
Olive-sided Flycatcher	*Contopus cooperi*	G4		S1
Alder Flycatcher	*Empidonax alnorum*	G5		S1
Peregrine Falcon	*Falco peregrinus*	G4		S1
Common Gullinule	*Gallinula galeata*	G5	S2B	S1
Loggerhead Shrike	*Lanius ludovicianus*	G4	S3	S1
Eastern Black Rail	*Lateraluus jamaicensis ssp*			
Bachman's Sparrow	*Peucaea aestivalis*	G3	S3B	S1
Purple Gallinule	*Porphyrio martinicus*	G5	S1B	S1
King Rail	*Rallus elegans*	G4	S1B	S2
Virginia Rail	*Rallus limicola*	G5		S1
Bewick's Wren	*Thryomanes bewickii*	G5		S1
Bell's Vireo	*Vireo bellii*	G5	S3B	S1
Great Egret	*Ardea alba*	G5		S2B, S3N
Upland Sandpiper	*Bartramia longicauda*	G5		SX?
Great Egret	*Ardea alba*	G5		S2B, S3N
Upland Sandpiper	*Bartramia longicauda*	G5		SX?
Redknot	*Calidris canutus*	G5		S2N
Brown Creeper	*Certhia americana*	G5		G5, S2
Piping Plover	*Charadrius melodus*	G3	S2	G3, S2
Little Blue Heron	*Egretta caerulea*	G5		G5, S2
Tricolored Heron	*Egretta tricolor*	G5	S2B	NL
Mississippi Kite	*Ictinia mississippiensis*	G5		S2,S3
Least Bittern	*Ixobrychus exilis*	G5	S2B	S2
Swainson's Warbler	*Limnothlypis swainsonii*	G4	S3B	S3
Painted Bunting	*Passerina ciris*	G5		S2
Black-bellied Plover	*Pluvialis squatarola*	G5	S2N	
American Woodcock	*Scolopax minor*	G5	S2B, S3N	S4B
Yellow-bellied Sapsucker	*Sphyrapicus varius*	G2T2Q		S2, S3
Interior Least Tern	*Sternula antillarum athalassos*	G4T2Q	S3B	S2, S3B

4.3.2.3 Crayfish - Maxwell Hartman

Crayfishes of the Mississippi are of vital importance both economically and ecologically. The crayfish industry provides thousands of jobs annually and is estimated to bring in over $300 million annually to the states surrounding the Mississippi River. Red Swamp Crayfish (Procambarus clarkii) and White River Crayfish (P. acutus) are the most commonly harvested species, both from commercial ponds and wild-caught. Both of which are abundant throughout the Mississippi Alluvial Plain.

Species of greatest conservation need also occur within the Mississippi River mainstem. Ohio Shrimp (Macrobrachium ohione) is a large semi-translucent shrimp, originally known to be common in the Ohio River. However, likely due to the impact of dams and Ohio Shrimp's amphidromous life cycle the species has declined significantly in Arkansas and the upper parts of the Mississippi River. Today the species can still be found in tributaries and the mainstem of the Mississippi River congregating on sandbars and downstream of dikes, but few collection records exist.

Crayfish can also be nuisance species that can have a drastic impact on local fauna. Rusty Crayfish (Faxonius rusticus) native to the Ohio River drainage has been introduced, likely from bait bucket release, across much of the Northeast, including the Mississippi mainstem. Isolated records are as far west as Oregon and Nevada. This species outcompetes native crayfishes, displaces native fishes, and even preys on native species. If Rusty Crayfish invaded the lower reaches of the Mississippi River, it would be disastrous for local populations.

2.3.2.4 Fish - Jeff Quinn and Chelsea Gilliland

A total of 136 fish species are known to occur in the Lower Mississippi River, an estimate based on comprehensive fish species lists in the Mississippi have been published by Fremling et al. (1989) and Schramm et al. (2016). Of these 136 species, 86 species are considered residents, five are introduced species, three are strays, and the remainder are considered peripheral species usually associated with smaller systems. Baker et al. (1991) reported 91 species that potentially reproduce in the main river. Table A2b-8 documents the fish species likely to occur in the Hatchie-Loosahatchie reach (Baker et al. 1991, Schramm et al. 2015, Etnier and Starnes 1993; Robison and Buchanan 2000), which includes 93 species of fish.

Pallid Sturgeon are a federally-listed Endangered Species that occur in the Hatchie-Loosahatchie Reach. Although they are a common species, Shovelnose Sturgeon are federally-listed as threatened due to similarity of appearance with Pallid Sturgeon. Jordan et al. (2019) recently determined that field morphological identification is not reliable for separating the species, and the vast majority of field identified Pallid Sturgeon are likely hybrids.

The U.S. Fish and Wildlife Service has been petitioned to list Lake Sturgeon, Sicklefin Chub, and Sturgeon Chub under the Endangered Species Act, and the Service is currently preparing species status assessments for these petitioned candidate species. Although Lake Sturgeon are often reported from the LMR as adults, there is little evidence that they naturally reproduce in the Mississippi River due to a lack of juvenile records. Commercial

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harvest of Lake Sturgeon, Pallid Sturgeon and Shovelnose Sturgeon is prohibited in the Hatchie-Loosahatchie reach in Arkansas and Tennessee.

Eight fish species are listed as Species of Greatest Conservation Need in the Hatchie-Loosahatchie reach by both Arkansas and Tennessee, including Lake Sturgeon, Pallid Sturgeon, Paddlefish, Alligator Gar, American Eel, Highfin Carpsucker, Sturgeon Chub, and Sicklefin Chub. The Species of Greatest Conservation Need list for Arkansas includes a total of 18 species from the Hatchie-Loosahatchie conservation reach and 11 species not recognized by Tennessee. Many of the additional species listed by Arkansas may be uncommon, but at least two (Channel Shiner and Shoal Chub) are likely common to abundant in the H-L reach. Tennessee recognizes one SGCN taxa not recognized by Arkansas, the Piebald Madtom, which may be a peripheral tributary species that does not occur west of the Mississippi River. Two highly-migratory native diadromous species occur in the LMR, including American Eel and Alabama Shad. The Flathead Chub *Platygobio gracili*s is considered a historical extirpated species.

Both Arkansas and Tennessee have open commercial fishing seasons, but the Tennessee portion of the Hatchie-Loosahatchie Conservation Reach has an area closure due to contaminants issues. The primary groups of commercially targeted species include catfishes (Ictaluridae), buffaloes (Catostomidae), carps (Cyprinidae), suckers (Catostomidae), and drum (Scianenidae), paddlefish (Polyodontidae), bowfin (Amiidae), and gars (Lepisostidae). In the LMR, estimates of commercial harvest in the LMR are scarce (Schramm and Ickes 2016) however, other reaches have experienced dramatic declines in harvest, attributed to lack of market demand and decreased profitability, rather than overfishing. Although, Kentucky reported moderate harvest rebounds from the Mississippi River due to increased take of bigheaded carps, mainly Silver Carp *Hypophthalmichthys molitrix (Schramm and Ickes 2016).* This trend is anecdotally supported in the LMR.

Paddlefish are a commercially fished species in both states, and they are also listed as SGCN due to their susceptibility to overfishing. Contingent on several assumptions concerning selectivity and natural mortality, Wilberg (2019) estimated Paddlefish fishing mortality rate at 0.34/year, and he suggested that a 36-inch minimum length limit was needed to achieve fecundity of 30%. Similarly, Risley et al. (2018) indicated that minimum length limits of 35-36 inches were needed to ensure sustainability of the lower Mississippi River Paddlefish fishery.

Table A2b- 8. List of fish species that likely occur in the Hatchie-Loosahatchie Conservation Reach of the Mississippi River, their relative abundance in the LMR from Schramm et al. (2016), and if they are an Arkansas or Tennessee Species of Greatest Conservation Need (SGCN). Relative abundance codes include (R= rare, U = uncommon, C = common, O = occasional, A = abundant, I = introduced).

Species	**Abundance**	**AR SGCN**	**TN SGCN**
Chestnut Lamprey *Ichthyomyzon castaneus*	R	No	No

Lake Sturgeon *Acipenser fulvescens*	R	Yes	Yes
Pallid Sturgeon *Scaphirhynchus albus*	R	Yes	Yes
Shovelnose Sturgeon *Scaphirhynchus platorynchus*	C	No	No
Paddlefish *Polyodon spathula*	C	Yes	Yes
Alligator Gar *Atractosteus spatula*	R	Yes	Yes
Spotted Gar *Lepisosteus oculatus*	U	No	No
Longnose Gar *Lepisosteus osseus*	C	No	No
Shortnose Gar *Lepisosteus platostomus*	C	No	No
Bowfin *Amia calva*	O	No	No
Goldeye *Hiodon alosoides*	O	Yes	No
Mooneye *Hiodon tergisus*	U	Yes	No
American Eel *Anguilla rostrata*	O	Yes	Yes
Alabama Shad *Alosa alabamae*	R	Yes	No
Skipjack Herring *Alosa chrysochloris*	C	No	No
Gizzard Shad *Dorosoma cepedianum*	A	No	No
Threadfin Shad *Dorosoma petenense*	O	No	No
Grass Carp *Ctenopharyngodon idella*	I	No	No
Red Shiner *Cyprinella lutrensis*	R	No	No
Blacktail Shiner *Cyprinella venusta*	O	No	No
Common Carp *Cyprinus carpio*	I	No	No
Cypress Minnow *Hybognathus hayi*	R	No	No
Mississippi Silvery Minnow *Hybognathus nuchalis*	C	No	No

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Pallid Shiner, *Hybopsis amnis*	R	No	No
Silver Carp *Hypophthalmichthys molitrix*	I	No	No
Bighead Carp *Hypophthalmichthys nobilis*	I	No	No
Sturgeon Chub *Macrhybopsis gelida*	R	Yes	Yes
Shoal Chub *Macrhybopsis hyostoma*	C	Yes	No
Sicklefin Chub *Macrhybopsis meeki*	R	Yes	Yes
Silver Chub *Macrhybopsis storeriana*	O	No	No
Golden Shiner *Notemigonus crysoleucas*	U	No	No
Emerald Shiner *Notropis atherinoides*	A	No	No
River Shiner *Notropis blennius*	C	No	No
Ghost Shiner *Notropis buchanani*	U	No	No
Taillight Shiner *Notropis maculatus*	R	No	No
Silverband Shiner *Notropis shumardi*	C	No	No
Weed Shiner *Notropis texanus*	U	No	No
Mimic Shiner *Notropis volucellus*	O	No	No
Channel Shiner *Notropis wickliffi*	A	Yes	No
Pugnose Minnow *Opsopoeodus emiliae*	O	No	No
Bluntnose Minnow *Pimephales notatus*	O	No	No
Bullhead Minnow *Pimephales vigilax*	U	No	No
River Carpsucker *Carpiodes carpio*	A	No	No
Quillback *Carpiodes cyprinus*	U	No	No
Highfin Carpsucker *Carpiodes velifer*	R	Yes	Yes

Blue Sucker *Cycleptus elongatus*	O	Yes	No
Smallmouth Buffalo *Ictiobus bubalus*	A	No	No
Bigmouth Buffalo *Ictiobus cyprinellus*	C	No	No
Black Buffalo *Ictiobus niger*	U	No	No
Black Bullhead *Ameiurus melas*	U	No	No
Yellow Bullhead *Ameiurus natalis*	U	No	No
Blue Catfish *Ictalurus furcatus*	A	No	No
Channel Catfish *Ictalurus punctulatus*	C	No	No
Piebald Madtom *Noturus gladiator*	R	No	Yes
Stonecat *Noturus flavus*	U	Yes	No
Tadpole Madtom *Noturus gyrinus*	R	No	No
Freckled Madtom *Noturus nocturnus*	U	No	No
Flathead Catfish *Pylodictis olivaris*	A	No	No
Pirate Perch *Aphredoderus sayanus*	R	No	No
Striped Mullet *Mugil cephalus*	U	Yes	No
Hardy Silverside *Labidesthes vanhyningi*	O	No	No
Mississippi Silverside *Menidia audens*	C	No	No
Golden Topminnow *Fundulus chrysotus*	U	No	No
Blackstripe Topminnow *Fundulus notatus*	R	No	No
Blackspotted Topminnow *Fundulus olivaceus*	R	No	No
Western Mosquitofish *Gambusia affinis*	O	No	No
Northern Snakehead *Chana argus*	I	No	No

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White Bass *Morone chrysops*	C	No	No
Yellow Bass *Morone mississippiensis*	O	No	No
Striped Bass *Morone saxatilis*	I	No	No
Flier *Centrarchus macropterus*	U	No	No
Green Sunfish *Lepomis cyanellus*	U	No	No
Warmouth *Lepomis gulosus*	O	No	No
Orangespotted Sunfish *Lepomis humilis*	O	No	No
Bluegill *Lepomis macrochirus*	C	No	No
Dollar Sunfish *Lepomis marginatus*	R	No	No
Longear Sunfish *Lepomis megalotis*	U	No	No
Redear Sunfish *Lepomis microlophus*	U	No	No
Redspotted Sunfish *Lepomis miniatus*	U	No	No
Bantam Sunfish *Lepomis symmetricus*	U	No	No
Spotted Bass *Micropterus punctulatus*	R	No	No
Largemouth Bass *Micropterus salmoides*	C	No	No
White Crappie *Pomoxis annularis*	C	No	No
Black Crappie *Pomoxis nigromaculatus*	U	No	No
Mud Darter *Etheostoma asprigene*	R	No	No
Bluntnose Darter *Etheostoma chlorosoma*	U	No	No
Swamp darter *Etheostoma fusiforme*	U	Yes	No
Slough Darter *Etheostoma gracile*	U	No	No
Harlequin Darter *Etheostoma histrio*	R	No	No

Logperch *Percina caprodes*	U	No	No
River Darter *Percina shumardi*	O	No	No
Sauger *Sander canadensis*	O	No	No
Freshwater Drum *Aplodinotus grunniens*	A	No	No
Banded Pygmy Sunfish *Elassoma zonatum*	R	No	No

4.3.2.5 Herpetofauna - Kelly Irwin

The herpetofaunal community in the lower Mississippi River is predominantly composed of wide ranging, generalist species. There are no federally listed species of herpetofauna that occur within the study area. While the main channel of the river has been significantly altered to optimize navigation, the peripheral backwater or side channel habitat that remains could harbor a variety of aquatic and semi-aquatic reptiles and amphibians. Water depth and velocity, and the presence of snags and logjams strongly influence whether these species will be present. Similarly, riparian areas composed of structurally diverse areas like floodplain forest, canebrakes, or other vegetative cover will provide optimal conditions for the presence of herpetofauna species.

In appropriate habitats you may find frogs along the banks, in riparian forests, or floodplain wetlands such as: Fowler's Toads *Anaxyrus fowleri*; Cricket Frogs *Acris blanchardi*; Bullfrogs *Lithobates catesbeianus*; Southern Leopard Frogs *Lithobates sphenocephalus*; and Gray Treefrog *Dryophytes chrysoscelis*. Several species of watersnakes inhabit backwater and side channel areas with woody debris and where water flow is minimal. This includes the Banded Watersnake *Nerodia fasciata*, Diamondback Watersnake *N. rhombifer*, and Plainbelly Watersnake *N. erythrogaster*.

The most readily visible species are the aquatic turtles. These species reside in areas with slack water and snags. Snags and rootwad debris provide optimal sites for basking turtles such as the Ouachita Map Turtle *Graptemys ouachitensis*, Mississippi Map Turtle *G. kohni*, Redear Slider *Trachemys scripta*, and River Cooter *Pseudemys concinna*. These habitats are also home to the Alligator Snapping Turtle *Macrochelys temminckii*, Snapping Turtle *Chelydra serpentina*, and Musk Turtle *Sternotherus odoratus*, which are not readily observed since they do not bask very often. The two species of softshell turtles, Smooth Softshell *Apalone mutica* and Spiny Softshell *A. spinifera*, can be very abundant, where they can be seen basking in numbers on sand or silt bars in or adjacent to moderate current. Spiny Softshells can also be found in snaggy backwater habitats as a generalist species.

Lizard species will be restricted to riparian forests or canebrakes and limited in diversity. One could potentially observe Five-lined Skinks *Plestiodon fasciatus*, Broadhead Skinks *P. laticeps*, and possibly Fence Lizards *Sceloporus consobrinus*. Intact swampy or marshy wetlands that persist in riparian areas could provide the necessary habitat for the eel-like Three-toed Amphiuma *Amphiuma tridactylum*, Lesser Siren *Siren intermedia*, and the

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Mudsnake *Farancia abacura* that feeds on them. While this section of the Mississippi River is within the range of the American Alligator *Alligator mississippiensis* observations in the main stem of the river are unlikely. Observations of this species are likely to increase in backwaters or floodplain swamps and marshes where flows are decreased.

4.3.2.6 Mussels - Kendall Moles

The once diverse mussel fauna of the Mississippi River has drastically changed in the last 100 years due to large-scale navigation and flood control projects. These projects greatly reduced and, in some instances eliminated the gravel shoal areas that are the preferred habitat of many riverine mussel species. As a result of these habitat alterations freshwater mussels are restricted to off channel habitats, such as backwater areas that contain sand, silt, and clay or side channels with a courser substrate of a gravel and sand mixture, that offer the flow refugia and substrate stability required for maintaining mussel populations at the local scale.

These habitat alterations have resulted in a shift in the mussel community. With the loss of the riffle/shoal dwelling species, the mussel fauna is comprised mostly of habitat generalists such as: the Bleufer *Potamilus purpuratus*; Threeridge *Amblema plicata*; Mapleleaf *Quadrula quadrula*; Butterfly *Ellipsaria lineolata*; Washboard *Megalonaias nervosa*; Yellow Sandshell *Lampsilis teres*; Fragile Papershell *Leptodea fragilis*; Threehorn Wartyback *Obliquaria reflexa*; Bankclimber *Plectomerus dombeyanus*; Pink Papershell *Potamilus ohiensis*; Wartyback *Quadrula nodulata*; Ebonyshell *Reginaia ebenus*; and Deertoe *Truncilla donaciformis*. This section of the Mississippi River contains at least three mussel species that are Species of Greatest Conservation Need in Arkansas. The Pink Heelsplitter *Potamilus alatus* has a state conservation rank of S1 and is considered Critically Imperiled in Arkansas. The Texas Lilliput *Toxolasma texasiense* and Hickorynut *Obovaria olivaria* have a state conservation rank of S3 and are considered Vulnerable in Arkansas. The federally endangered Fat Pocketbook *Potamilus capax* is known to occur in this section of the Mississippi River. The Fat Pocketbook appears to be more tolerant than most mussel species to sedimentation, as it is often found in areas of mud, fine silt, and sand in eastern Arkansas.

4.3.3 **Aquatic Resources - Jeff Quinn and Chelsea Gilliland**

The Mississippi River is among the largest rivers in the world and its aquatic resources have been shaped by natural and anthropogenic processes acting at several spatial and temporal scales. The watershed comprises 43% of the contiguous states at 1.225 million square acres, and it drains portions of 33 states (Baker et al. 1991; LMRCC 2015). The aquatic resources of the Lower Mississippi River include riverine habitats and associated floodplain and wetlands habitats. General overviews documenting status of and loss of aquatic resources and habitats associated with barge navigation in the Lower Mississippi River are provided by Fremling et al. (1989), Baker et al. (1991), Alexander et al. (2012), USACE (2013), Killgore et al. (2014), LMRCC (2015), and Schramm (2017).

A goal of this ecosystem restoration planning study is to develop a National Ecosystem Restoration (NER) plan that increases the quantity and quality of desired ecosystem resources. Specific objectives of the NER plan include: (1) restore vegetated habitats and

maintain a diverse floodplain vegetative mosaic of habitats that includes rare habitat types (e.g., aquatic vegetation, rivercane); (2) improve quality and quantity of diverse large river habitats to support life history requirements of large river aquatic fauna; (3) increase aquatic connectivity to improve quality of floodplain waterbodies (e.g., secondary channels, chutes, sloughs, oxbows, borrow pits, tributary mouths) to support life history requirements of large river aquatic fauna; (4) improve recreational opportunities and access. To support these goals and objectives, this aquatic resources chapter will provide a historical overview of aquatic resource management, describe aquatic and terrestrial floodplain habitats of the HL conservation area, and then provide a brief description of the proposed aquatic habitat complexes.

Historical overview

Major impacts to aquatic resources of the LMR include flood control projects, channel improvement projects, and water quality alterations. Flood control includes construction of major flood control dams in the Missouri river systems and installation of levees that constrict the floodplain. Channel improvement projects include bank stabilization (rip rap or ACM), bendway cutoffs that shorted the channel, and channel training structures such as dikes and revetments that prevent lateral channel migration and help maintain a minimum depth of 9-ft for barges. A major impact of the river engineering has been a 60% reduction of overall sediment yield from the influence of dams and channel training structures that prevent lateral channel migration (Alexander et al. 2012). The reduction of sediment is a factor that likely has led to declines in species adapted to high-turbidity large river environments, including Sturgeon Chub *Macrhybopsis gelida* and Sicklefin Chub *Macrhybopsis meeki* (Pflieger 1997). River engineering impacts to the LMR channel that is the physical template of aquatic habitat were succinctly described by Alexander et al. (2012) as:

“The primary alterations to channel morphology by dams and other engineering projects have been (1) channel simplification; (2) lowering of channel-bed elevation; and (3) disconnection of the river channel from the flood plain, except during extreme flood events.”

The Lower Mississippi River drains one of the most productive agricultural regions in the world, and excessive nutrients and agricultural chemicals can alter water quality. Alexander et al. (2012) reported most of the nitrogen and phosphorus loads are from agricultural sources. An estimated 90% of the nitrogen load reaching the Gulf of Mexico is from nonpoint sources. Of that load, about 60% was estimated to come from fertilizer and soil. An estimated 37% of phosphorus comes from animal manure and 25% from row crop agriculture. Nutrient enrichment has been associated with a large dead zone in the Gulf of Mexico.

Floodplain area estimates range widely between 1.5 and 2.8 million acres for the LMR within the levees (LMRCC 2015). Human alterations of the river to improve navigation have resulted in 80% of the floodplain being eliminated by levees, loss of 23 secondary channels, and loss of 16 bends that were cut off that shortened the river by 143 miles and increase the gradient of the river (Baker et al. 1991).

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Bendway cutoffs constructed between 1929 and 1960 have shortened the LMR by >150 miles, and the cutoffs were mostly located downstream of Helena, Arkansas. Benway cutoffs have had major geomorphic effects that strongly influenced river-floodplain habitats and their connectivity (Killgore et al. 2014). The bendway cutoffs had almost an immediate effect (< 5 year) of reducing stages by up to 14 ft. (4.8 meters) at Arkansas City. The cutoff program continues to impact the river by headcutting. Biedenhauer et al. (2017) documented a modern dramatic lowering of stage levels (i.e., headcutting) at a given discharge for Osceola-Memphis gages (i.e., in the Hatchie-Loosahatchie reach), and the decline of stage at a given flow was more dramatic for lower flows than high flows. A decline in stages had the biological impact of lowering connectivity of the river to off channel habitats, side channels, and wetlands.

The head cutting caused by the channel cutoff program of the 1930-1940's has the potential to continue to lower stages as hard points formed by clay plugs of abandoned channels erode (Biedenharn et al. 2018). The clay bed materials near the City of Helena appeared resistant to stage lowering despite large changes in bed gradient until the 1970s. After the 1970s the bed appeared to degrade substantially once a thin erosion resistant layer had been eroded. A similar erosion resistant layer near Hickman, Kentucky, may have provided grade control up until the 2000-2012 time frame. The locations of natural geological grade controls is not well understood but is critical for understanding future connectivity of off-channel habitats.

In response to the habitat losses, the LMRCC developed a comprehensive Aquatic Resources Management Plan during 2000, with goals to restore habitat, implement clean water act strategies, and develop a sustainable economy (USACE, MVD Planning Decision Document Review Plan). This plan had aquatic habitat objectives of (1) restoring 50% of the degraded secondary channels, (2) restoring 60% of the lakes between the levees, and (3) restoring hydrology in 4 major backwater areas. The plan had clean water act implementation objectives of (1) restoring hydrology on 80,000 acres of wetlands, and (2) reforesting 130,000 acres of cleared wetlands. The LMRCC also developed the Recovering America's Greatest River plan during 2006, which identified 239 potential habitat restoration projects.

The USACE developed an annual interagency review of channel improvement program (CIP) activities and developed a program to notch dikes in response to endangered species issues. The USACE has over a 25-year history of notching dikes to improve habitat diversity and reduce habitat loss from sedimentation. This program was formalized in the 2013 Section 7(1)a Conservation Plan for Interior Least Tern, Pallid Sturgeon, and Fat Pocketbook Mussel (USACE 2013). This plan documented that 29% of existing dikes had been notched in the LMR. The effects of dike notching in the LMR is considered to have site-specific effects that are difficult to predict because sediment loads can vary by an order of magnitude for a given stage.

The Lower Mississippi River Resource Assessment (LMRRA) was developed by the USACE during 2015 after authorization by Section 402 of the Water Resources Development Act of 2000. This document presents a comprehensive strategic framework for habitat restoration, data science and communication, and recreation. Habitat Restoration was proposed to be

examined on a finer scale through eight Conservation Reach Studies at an estimated cost of $3 million each. A total of 125 habitat restoration projects were identified (0.2-15 million each), and $18 million of floodplain restoration was identified. The Water Resources Development Act of 2018 (P.L. 115-270; Section 1202/Investigations) provided Congressional authorization for the 8 LMR Conservation Reach Studies. These are feasibility studies for the restoration of aquatic and floodplain habitat that is compatible with flood control and navigation priorities. The stated value of the 8 Conservation Reach Studies was to "restore aquatic habitats (side channel, oxbow, main channel, islands and sandbars) and terrestrial habitats (wetlands, bottomland hardwoods, and floodplain) for native species and especially federally-listed species."

Hatchie-Loosahatchie Conservation Reach

The Hatchie-Loosahatchie (HL) Conservation Reach is a 39-mile reach that extends from river mile 736 to 775, including 17 LMRCC restoration sites (6 in Arkansas; 10 in Tennessee, and 1 shared). The reach extends from the Hatchie River mouth at the northern, upstream terminus south to the mouth of Wolf River Harbor at Memphis, Tennessee. The HL reach includes the river mouth of the Hatchie, Loosahatchie, and Wolf rivers. In Tennessee, the Meeman-Shelby and Fort Pillow State Parks, Lower Hatchie National Wildlife Refuge, and JM Tully Wildlife Management Area border the conservation reach. Potential restoration activities for the HL reach include side-channel restoration, reconnecting backwaters, restoration of canebrakes, bottomland hardwood and riverfront reforestation, enhancement of aquatic nursery areas, and improving islands for Interior Least Terns.

Secondary Channels

An estimated 198 secondary channels exist in the Lower Mississippi River (Guntren et al. 2016). Secondary channels are a major aquatic habitat resource in the LMR, and new secondary channel formation is largely prevented by river training structures that stabilize the alignment of the river. These secondary channels range from being hydrologically connected at all river stages (permanent secondary channels) to those only connected during high flows (temporary secondary channels). Most of these channels have one to several closing dikes that prevent flows from entering them at low to moderate flows. Closing dikes often result in siltation of the side channels and conversion of aquatic habitat to sandbar or terrestrial upland habitat. Side channels on outside bends tend to be smaller in width than those on inside bends. Secondary channels are frequently used habitats in the LMR by Pallid Sturgeon during the February - June time period when discharge is elevated (Herrala et al. 2014).

An estimated 13 secondary channels exist in the HL area between miles 778-738. Guntren et al. (2016) provided an overview of changes in side channel area and volume at several stages for reaches of the LMR. Unfortunately, their reaches do not align well with the HL conservation reach. Their reach E from miles 691-750 (Appendix E, page 177) includes four side channels in the HL reach (Chute of Loosahatchie bar dikes, Chute of Loosahatchie Bar, Chute of Hickman Bar Dikes, and Chute of Poker Point Dikes). Their study Reach D (miles 750-796.5) included 9 side channels in the HL reach, including Chute of Corona Bar Dikes (753.8R), Chute outside Densford Bar (755.6L), Chute of Dean Island (761.6R), Chute 1

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outside Dean island (761.6R), Chute Below Richardson Landing Dikes (761.1L), Chute of Lookout Dikes (772.2R), Chute Opposite Lookout Dikes (772.8L), Chute of Hatchie Island (775.1L), and Chute of Sunrise Towhead (777.5R).

Killgore et al. (2012) developed a multi-metric prioritization system to rank importance of sites for restoration that included (1) presence of gravel, (2) number of macro habitats, (3) percent forest riparian on the island side, (4) percent forested on the land side, and (5) distance to the levee or natural bluff. They found that secondary channels in the LMR averaged 3.1-miles long, 931-ft wide, and average area was 319 acres (range: 29-1,134 acres; N=53). They defined an optimum side channel as having a high abundance of gravel, greater than 4 habitats, > 50 and 75% riparian forest cover on island and mainland, and distance greater than 4 miles to levees or natural bluffs. Secondary channels had on average 4 closing dikes (range: 0-11). The priority index ranged from 0.1 (low habitat value; high cost due to numerous dikes) to 0.7 (high habitat value, less than 2 dikes) and averaged 0.34. They found there are numerous side channels with moderate quality and a high number of dikes. However, we are unaware of any attempts to correlate the priority index with quantitative empirical fisheries data.

Three secondary channels within the HL project area were rated by Killgore et al. (2012), including the Redman/Loosahatchie (mile 743; RDB, priority index = 0.24), Hickman Randolph (mile 749, LDB; priority index 0.24), Richardson Landing (mile 768, LDB; priority index = 0.28), and Lookout (mile 770, RDB, priority index = 0.07).

The LMRCC/USACE implemented side channel restoration at the Loosatchie Bar in 2008, and 11 notches were placed in 8 dikes to restore flows to 11.25 miles of side channel. Densford Bar side channel notches (~5) were completed during August 2022. Lower Cracraft bar dikes were notched during September 2022.

Islands

Islands are important habitats in the LMR and their importance is not fully understood. Island tip habitat of side channels is known to provide important winter refuge habitat for endangered Pallid Sturgeon. Herrala et al. (2014) found that federally endangered Pallid Sturgeon strongly selected island tip and natural bank habitats. Sand islands without vegetation may be important nesting sites for the Interior Least Tern.

Main Channel

The main channel at higher flows likely provides a challenging environment for aquatic biota to live due to high current velocities and high sand bedload. Baker et al. (1991) listed 25 species that are common to abundant in the main channel. The river's main channel likely provides an important migratory corridor and much of the available habitat for aquatic species is the main channel at low flows. The main channel has been strongly impacted by channel training. Main channel habitat has been subject to reduced frequency of dredging over time as more dikes and revetments have been constructed. Shallow main channel habitat has likely been eliminated to maintain the navigation channel. Turbidity in the main channel derived from the Missouri River inflows may be much lower than it was historically. Although main channel habitat is often non selected for by Pallid Sturgeon, most locations of

the species in telemetry studies often come from main channel because of its abundance (Herrella et al. 2014)

Bendway weirs are a series of rock dikes typically placed less than 20 ft. or more below the low water reference placed in the main channel where barges may go over them. Habitats provided by these bendway weirs for fishes are not well understood as sampling them may be problematic in the very deep waters with swift current. The total number of fields of bendway weirs is likely less than 15 (USACE 2013).

A major historical area of elevated dredging exists in the HL reach near the mouth of the Loosahatchie River from navigation miles 740-742. This is also an area of the river that widens at the upstream end of the Loosahatchie Bar side channel.

Cobb and Clark (1981) estimated that the main channel in a 40-mile reach (miles 480-530) was 45% of aquatic habitat at low flows but only 15% of habitat at high flows

Gravel bars

Gravel bars are thought to be an important aquatic resource in the LMR because they provide spawning substrate for many fish species. Endangered Pallid Sturgeon have been found to move to gravel bars during the spring (Koch et al. 2012) and during spawning (DeLonay et al. 2009). Sturgeon Chubs are known to use shallow gravel bar habitat, and they are a candidate species that is declining and the species is a known food source for endangered Pallid Sturgeon.

Using Red Hen video, a total of 76 gravel bars have been identified in the LMR. The Red Hen video GIS layer for 2012 indicates there are 10 polygons or bars with possible gravel present within the HL reach, and these areas total 7,394 acres. It is important to understand that quality of the bars may vary substantially because the depth of the gravel and percent gravel composition (i.e., vs sand) is not discernible from Red Hen video. The area of gravel coverage may change annually with floods and gravel tends to accumulate more towards the upstream ends of bars.

Channel Border habitats

Channel borders are the areas between the main channel and shoreline. Channel border habitats are often biologically productive habitats when they have natural banks with abundant coarse woody debris. Channel borders are often classified as having natural banks, revetted bank (e.g., articulated concrete mattresses, rip rap), or dike fields (e.g., Hann and Schramm 2017).

Dike Fields

Dikes are generally thought to cause the conversion of aquatic to terrestrial habitat when located at inside bend habitat and within secondary channels. Sheilds (1995) studied 26 groups of dikes and concluded that the aquatic value and area of low-velocity habitats was reduced by 38% and 17%. Side channels in outside bends may often be eroded and provide rare deep, slow velocity pool habitats.

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Approximately 30 dikes have been notched of 70 dikes constructed in the HL reach (42%), according to the 2011 Memphis District Master Plan. These dikes may be grouped into 16 dike fields within the HL reach.

During 2008, the LMRCC and Memphis District USACE implemented a series of dike notches to improve 11.25 miles of secondary channel in the Loosahatchie Bar (miles 741.5-737.0 AR-TN) across from Memphis. This project is one of the larger projects completed to date.

Revetted Bank

Revetted Banks include those with rip rap or articulate concrete mattress (ACM). USACE (2013) proposed to continue to use longitudinal grooves in the ACM to increase surface area, reduce surface current velocities, and increase attachment points for invertebrates. They also agreed to use hardpoints instead of ACM as an alternative where practical. ACM is generally laid from top bank to the edge of the channel in 48-in long, 18-inch wide, by 3-inch-thick blocks linked together to make 25 ft. by 4 ft. units. ACM tends to buckle over time that creates some substrate heterogeneity.

Killgore and George (2020) concluded from 30 years of research that, “The conversion of natural steep banks to ACM has ecological consequences.” A major impact of ACM installation is that bank lines are generally cleared of trees, which removes an important aquatic habitat of woody debris. They noted that ACM is known to shift aquatic invertebrate assemblages from burrowing mayflies to net spinning caddisflies. The impacts on fish communities is still largely unknown. Pennington et al. (1983) used hoop netting and electrofishing on revetted and natural banks and concluded that the fish populations were similar but there was greater variability at revetted banks.

Natural Bank

Natural Bank habitat within the Hatchie-Loosahatchie Reach needs quantification and a plan for keeping this rare habitat type from becoming endangered. Natural bank habitat is a declining habitat with increasing CIP activities (Baker et al. 1991; Shields 1995; Schramm 2017). Herrala et al. (2014) found natural bank habitat was strongly selected for by endangered Pallid Sturgeon. They concluded that maintaining natural bank habitat will benefit conservation of this federally-listed endangered species. Baker et al. (1991) suggested that hydroacoustics indicate that fish abundance may be greatly underestimated in this habitat with traditional sampling methods.

Sandbars

Sandbars can be categorized as steep and gentle based on morphology or lotic and lentic based on flow and position within the bend (Baker et al. 1991). Sand bars on the LMR are typically very large in the inside bendways. Baker et al. (1991) reported that at least 49 fish species use sandbars.

Least Terns nest in open sandy areas that are not vegetated (USACE 2013). Availability of small fish as forage during the breeding season is thought to influence chick survival. Large dikes that trap sand behind them have potentially a beneficial effect of providing nesting

habitat for Least Terns. However, river training structures generally lock the position of the channel and prevent dynamic formation of new sand bars.

Floodplain Habitats and Wetlands

The Lower Mississippi River seasonally floods and may vertically fluctuate 40 ft (12-13 m) in stage elevation, flooding surrounding floodplain habitats and wetlands. The LMR floodplain is approximately 2.25 million acres and its width ranges between 1 and 15 miles. Floodplain habitats are theorized to be important sources of biological production in large rivers (Junk et al. 1989). Up to 70 fish species may be found in larger, permanent floodplain habitats (Baker et al. 1991). Floodplain habitats are seasonally important nursery habitats for many fish species. About 23% of floodplain habitat is aquatic (Baker et al. 1991). Floodplain habitats include oxbow lakes, chutes, isolated secondary channels, ephemeral floodplain sloughs (meander scars), wetlands, and borrow-pit lakes (Miranda et al. 2013). Cobb and Clark (1981) estimated that the inundated floodplain was 0% of aquatic habitat at low flow but increased to 27% of aquatic habitat at high flow in a 40-mile reach from miles 480-530. Schramm (2017) noted that the impacts of dams and increased conveyance from the channel cutoff program have resulted in flooding that often occurs before water temperatures reach 22°C, a temperature where biological production has high benefits. He concluded that the thermal and hydrological cycles have largely been decoupled.

Small Floodplain Channels and Swales

Small channels that allow water flow from the main channel and floodplain habitats are vital migratory corridors for movement of floodplain dependent species like Alligator Gar. These channels are sometimes called tie-channels or perhaps tertiary channels. These small channels function similar to capillaries in a vascular system of an organism, as they function to allow flow of liquids and organic matter between areas of the floodplain. These channels may be blocked by inappropriately sized culverts or filled during road construction. These small channels are often largely overlooked in GIS analyses due to their small physical size and uncertainty about the water surface elevation when they are functioning.

Oxbow Lakes

Potential conservation measures to be evaluated include examining tie-channels to determine need for grade control due to lower impacts of head cutting and maintaining periodic connectivity with the river (e.g., dredging, weirs). Barriers within the tie channels may be removed or replaced to improve connectivity for floodplain-dependent fishes.

Borrow Pits

Borrow pits are artificially made lentic waters made from removal of soil for the construction of levees, and they are often located near or adjacent to the levee. They are relatively new lake features and they are subject to flooding. Miranda et al. (2013) found engineered morphologic features of borrow pits were associated with fish assemblages, and they found 65 species in eight borrow pit lakes in the floodplain.

Scarce Vegetative Communities

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Restoration activities should Scarce vegetative communities including wetlands, canebrakes, riverfront forests, and bottomland hardwood forests.

Scrub/shrub landcover is found at 5,208 acres in the HL area, and there is a large concentration at the Island 35 Dean Island habitat complex. Allen et al. (2020) noted that open canopy, low vegetation, broad relief floodplains appear to be preferred habitats for Alligator Gar spawning and egg deposition, and locations with woody wetland forest were considered poor habitat for spawning. They also found Alligator Gar also used a rare deepwater "bluehole" habitat that was situated up on the floodplain and it had temperatures warmer than the main channel.

Canebrakes

Canebrakes of River Cane or Giant Cane were once common habitats in the LMR but approximately 98% of this terrestrial habitat type has been lost (LMRAA 2015). Cane brakes provide suitable habitat for numerous reptile, mammal, bird, insect, and butterfly species (Brantley and Platt 2001; Platt et al. 2013). The margins of flooded canebrakes are often habitats fished by commercial fishers for sturgeons along White River, Arkansas.

Within the HL area, potential conservation measures include: (1) protecting existing rivercane stands at higher elevation near Brandywine Island, and (2) propagate or establish river cane at new higher elevation locations surrounding floodplain waters and at spoil piles from plug removals.

Floodplain Forests - Reforestation of Agricultural Lands

The White River National Ecosystem Restoration Plan developed the Habitat Evaluation Procedure (HEP) for the change in average annual habitat usings for fish rearing per acre of reforested agricultural lands. Flooded agricultural land only has a Habitat Suitablity Index of 0.2, whereas Bottomland Hardwoods have a value of 1.0.

Tributaries

Tributary mouths are aquatic resources of importance for large rivers including the Lower Mississippi River (Dunn et al. 2019), and up to 82 fish species may be found in tributary mouth habitat. Multiple endangered Pallid Sturgeon have been documented entering the lower Arkansas River during winter floods (Kuntz and Schramm 2012), likely because it provides refuge habitat.

The HL reach includes three sizable tributaries that all enter the river from the east side of the river. The Loosahatchie River and Wolf River may have legacy contamination issues. Groundwater inflows often occur in rivers at the mouth of a tributary, and tributaries may provide important sources of gravel substrate.

Groundwater

The Mississippi Alluvial Aquifer is the primary aquifer in the Mississippi Alluvial Valley. Interactions of the Mississippi River with its adjacent aquifer are not well understood and studied. We are unaware of studies that delineate groundwater upwelling zones within the

Mississippi River, but such areas could potentially provide thermal refuge habitat and explain variability in patterns of fish assemblages.

Contaminants

Serious contaminants issues within the HL reach are derived from the City of Memphis area. Contaminants are often elevated in samples taken from the vicinity of the Mississippi River near Memphis. Tennessee has a fish consumption advisory and commercial fishing closure in the Mississippi River due to chlordane, mercury, and other organics (https://www.tn.gov/content/dam/tn/environment/water/documents/water_fish-advisories.pdf, accessed 12/30/2022;). The closure is in a 30-mile reach from the Mississippi State line to Meeman-Shelby State Park. Schmitt (2002) noted elevated levels of dieldrin and cyclodiene insecticide and related chemicals) from a manufacturing source and a landfill known to leach pesticide manufacturing wastes near Memphis. Concentrations of endrin, among the most toxic organochlorine insecticides to fish, appear to be declining in the Memphis area (Schmitt 2002). Chlordane concentrations in fish were measured at 0.255-0.55 ug/g in carp and the Memphis area may also be a PCB concentration hotspot.

Several EPA superfund sites exist in Shelby County, Tennessee near Memphis (https://en.wikipedia.org/wiki/List_of_Superfund_sites_in_Tennessee, accessed 12/30/2002). Arlington Blending and Packaging leaked chlordane, heptachlor, endrin, PCP, and arsenic, and there was shallow groundwater contamination. This site is 25 miles northeast of Memphis and is 3000 ft from the Loosahatchie River (https://cumulis.epa.gov/supercpad/cursites/csitinfo.cfm?id=0403838, accessed 12/30/2022) This site was cleaned up and is now a park.

The Velsicol Chemical Plant was another superfund site that manufactured chlordane, heptachlor and endrin near Cypress Creek in the Wolf River basin in Memphis. This company apparently deposited chemicals in the North Hollywood Memphis landfill and in the 1960s this was associated with fish kills along the Mississippi River south of Memphis.

Habitat Complexes

The Hatchie-Loosahatchie Conservation Reach has been subdivided into eleven habitat complexes that span 8-10 miles of river on one bank.

- Hopefield Point-Big River Park
- Loosahatchie-Wolfe River Harbor
- Redman Point-Loosahatchie Bar
- Island 40-41
- Meeman Shelby Forest-Eagle Lake
- Brandywine Island Complex
- Densford Bar Complex
- Richardson-Cedar Point Complex
- Island 35-Dean Island
- Hatchie Towhead-Randolph Complex
- Sunrise Island 34 complex
- 2.3.4 Special Status Species

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4.3.4 **Special Status Species**

4.3.4.1 Monarch Butterfly - Allison Fowler

Monarch (Danaus plexippus)

In December of 2020, the US Fish and Wildlife Service determined that listing the monarch butterfly under the endangered species act was warranted but precluded by higher priority listing actions (85 FR 27523). With this decision, the monarch became a candidate species. The monarch butterfly is found throughout North America and is generally divided into 2 populations–the western and eastern populations which are separated by the Rocky Mountains. Eastern monarchs undertake a monumental migration from areas in the US and Canada to overwinter in central Mexico. Monarchs are present statewide in Arkansas from late March to early November. They are found in open habitats (grasslands, savannas, rights of way, urban areas) where they nectar on available forbes. Monarchs are obligates to milkweed plants, as females will only lay eggs on these species. Maintaining areas with a diverse composition of forbs including milkweed, particularly in the fall, is important to the conservation of this species.

2.3.4.2 Pondberry

Pondberry (Lindera melissifolia)

Pondberry was listed by the US Fish and Wildlife Service as endangered in 1986 (51 FR 27495). This species is known from Arkansas, Missouri, Mississippi, Alabama, Georgia, South Carolina, and North Carolina. Pondberry is a deciduous shrub that grows between 2-6 feet in height. This colony forming shrub is typically found in poorly drained, swampy depressions in bottomland hardwood forests. In Arkansas, it is known from Ashley, Clay, Craighead, Crittendon, Jackson, Lawrence, Poinsett and Woodruff Counties, where it grows in sandy sinks or potholes.

4.3.5 **Invasive Species**

Habitat changes have driven most of the population changes for birds and mammals, but the introduction (intentional or unintentional) of invasive species has caused significant impacts to native aquatic species. A variety of exotic aquatic species are established in the LMR. These species disrupt 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).

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 more recently introduced carp species (bighead, black, silver, and grass) garner most of the attention and management focus, but all the carp species have had negative impacts on native fishes (Conover et al. 2007). Bighead carp adversely impact mussels, larval fish, and several adult fishes such as gizzard shad, bigmouth buffalo, and paddlefish. Black carp pose a threat to many of the remaining populations of federally listed threatened and endangered mussels. Competition between black carp and native freshwater drum, the host for the endangered fat pocketbook mussel, is significant (Conover et al. 2007). 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 so they feed almost continuously and competition with native planktivores is a major concern (Conover et al. 2007, Fuller 2013a). Silver carp are also hazardous to boaters because they jump out of the water in response to boats.

Northern Snakehead *(Channa argus)* is a native fish of Eastern Asia that was unintentionally introduced by fish markets and the pet trade. Native species, like bowfin *(Amia calva)*, that thrive in slack water habitats like the Northern Snakehead do not compete well in the shared habitat of the LMR and tributaries. Northern Snakehead has been established in several tributaries of the Mississippi, White, and Arkansas rivers in Eastern Arkansas.

Zebra mussels were unintentionally introduced to US waters through ballast water exchange into the Great Lakes. There are several connections between the Great Lakes and the Mississippi River Basin. By 1991 they were found in the Illinois River and soon after were found throughout the Mississippi River Basin. Zebra mussels are prolific and can reach high population densities quickly (MDC 2007, Fuller 2013b). They can reduce the density of plankton (microzooplankton and phytoplankton), which is essential food for various life stages for many native fish and mussels. An estimated $200 million is spent annually to maintain intake pipes and screens that become clogged with zebra mussels (MDC 2007, Fuller 2013b). Quagga mussels have also recently been found throughout the Mississippi River drainage. Their origin and impact on the system is much the same as zebra mussels.

Numerous other non-native species have been introduced to US waters through the release of ballast water from Great Lakes freight ships. There are several connections between the Great Lakes and the Mississippi River Basin and there are at least 25 aquatic invasive species that have progressed into the Mississippi River Basin or are close to moving into the system since the 1970s. New invasive species are or will likely become part of the fauna of the LMR include spiny waterflea, Eurasian ruffe, round goby, plus many species from groups of algae, annelids, daphnia and copepods.

Invasive plant species pose a serious risk to native species. Kudzu was first introduced to the U.S. in 1876, and the erosion control programs of the 1930's to 1950's caused its spread. It now covers 2 million acres of forest land in the southern United States (Forseth & Innis 2004). 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). Privet was introduced to the U.S. in the mid-19th century as an ornamental shrub. It has invaded many areas in the LMR that are now drier than they were historically. It crowds out native understory vegetation (Merriam & Feil 2002). Neither of these plants provides suitable habitat for native species.

The U.S. 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 Aquatic Nuisance Species Task Force (ANSTF) comprised of 13 Federal agencies and 13 ex-officio representatives (i.e., Mississippi Interstate Cooperative Resources Association or MICRA) is devoted to preventing and controlling aquatic invasive species (ANSTF 2012).

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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.

4.3.6 **Recreation**

Recreation and tourism are important economic sectors in the LMR. Outdoor recreation in the region generates over $1.3 billion in direct revenues and employs nearly 55,000 people. Tourism in the area generates $15.5 billion in direct revenues and employs over 190,000 people. These statistics derived from the counties along the Lower Mississippi River, highlighting the intrinsic value of the river to people and natural resources of the region. (The Economic Profile of the Lower Mississippi River: Update by Industrial Economics, Inc. of Cambridge, Massachusetts.)

Focusing in on the H-L reach of the LMR, habitat restoration within the reach will provide improved conditions for multiple species of fish, wildlife and waterfowl. In turn, these improved conditions will provide more opportunities for successful outcomes while hunting and fishing plus improve conditions for off channel recreational pursuits such as kayaking, beaching and bird watching.

Getting to these areas will be a challenge. Recommendation RP 1 from the LMRRA study concludes that resource management agencies should, “Increase the number of boat ramps on the LMR. A boat ramp every 10 to 20 miles on the river would provide more opportunities for paddlers, fishermen and hunters and would increase the ability to conduct search and rescue operations. More ramps would be available to directly access backwaters and side channels. Ramps also provide locations for interpretive signs about the Mississippi River, environmental education and safety”. Within the Hatchie-Loosahatchie reach, there are six boat landings on the Tennessee side of the river and one on the Arkansas side of the river. Increasing water access/boat landings to a goal of 8 for the entire reach would be a positive outcome especially when paired with habitat restoration.

Within the boundaries of the H-L reach there are federal and state designated recreation areas from refuges to parks to historical areas.

<u>Lower Hatchie National Wildlife Refuge</u>

Lower Hatchie National Wildlife Refuge was established in 1980 and is located at the confluence of the Hatchie and Mississippi Rivers in Lauderdale and Tipton Counties in west Tennessee. The refuge encompasses the lower reaches of the Hatchie River and consists of bottomland hardwoods, moist-soil units, agricultural fields, and associated uplands. The large, forested tracts, open lands, and aquatic features found on the refuge provide an important ecological niche for fish, wildlife, and plant species.

<u>Meeman-Shelby Forest State Park</u>

Meeman-Shelby Forest State Park is a 12,539-acre hardwood bottomland area bordering the Mississippi River 13 miles north of Memphis. Special interests include mature Bald

Cypress and Tupelo swamp, Chickasaw Bluffs and bottomlands covered with large oaks, American beech, hickory and sweet gum. There are 10 state Champion Trees and two National Champion Trees as well as endangered and protected plants within the park. Visitors can visit for the day or stay in the vacation cabins or at one of the 49 well-equipped campsites.

Big River Crossing, Delta Regional River Park and Big River Trail

Big River Crossing, Delta Regional River Park and Big River Trail provides a recreational opportunity to walk or ride your bike across the Mississippi River from downtown Memphis, TN to West Memphis, AR. Those that want an additional challenge can follow the Big River Trail to Marianna, AR. some 70 miles from the start of the trail. Ducks Unlimited (DU) is partnering with Big River Park Conservancy (BRPC), and others to restore 1,500 acres of wetlands and to promote recreational and tourism opportunities in Downtown Memphis and nearby West Memphis, mostly in and around the Delta Regional River Park.

Mud Island River Park

Mud Island River Park is located on an island adjacent to Memphis, TN. Visitors to Mud Island River Park can see a hydraulic scale model that represents the lower Mississippi River from Cairo, IL to New Orleans, LA, take a paddle boat or kayak on the river or bike extensive trails using the Big River Crossing. The Mississippi River Museum is located on site with galleries and exhibits that cover human existence within the area for the last 10,000 years.

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List of Acronyms and Abbreviations

ANSTF	Aquatic Nuisance Species Task Force
BLH	Bottomland Hardwood Forest
ERDC	Engineer Research and Development Center
ESA	Endangered Species Act
FPM	Fat Pocketbook Mussel
H/L	Hatchie-Loosahatchie Reach
HSI	Habitat Suitability Index
ILT	Interior Least Tern
LMR	Lower Mississippi River
LMRRA	Lower Mississippi River Resources Assessment
LMRCC	Lower Mississippi River Conservation Committee
LMVJV	Lower Mississippi Valley Joint Venture
MAV	Mississippi Alluvial Valley
MRT	Mississippi River Trust
PDT	Project Delivery Team
RAGR	Restoring America's Greatest River
SRP	Sustainable Rivers Program
TEK	Traditional Ecological Knowledge
TNC	The Nature Conservancy
USACE	US Army Corps of Engineers
USFWS	US Fish and Wildlife Service

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