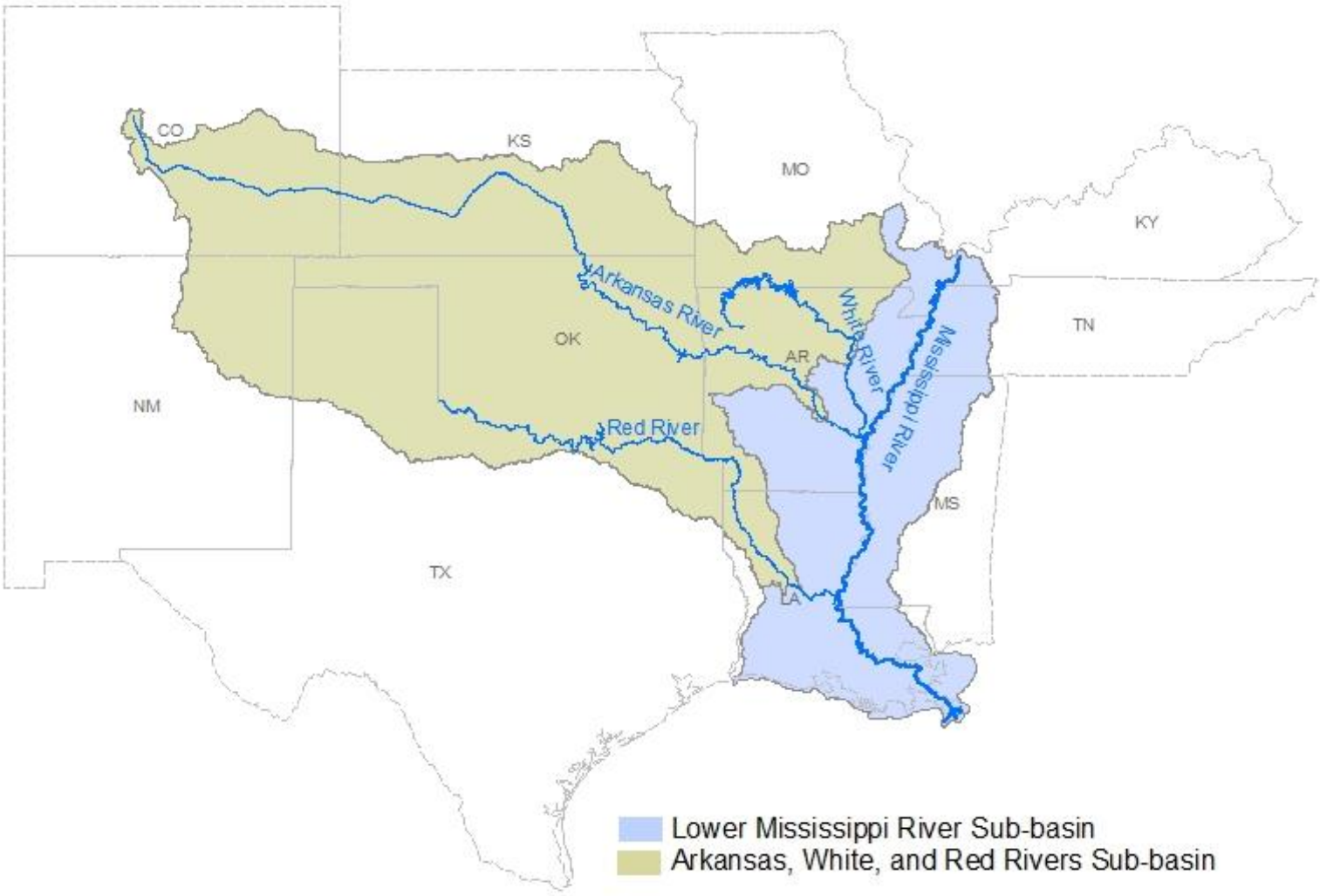
Lower Mississippi River Basin

Asian Carp Control Strategy Framework

August 2019



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Geographic Scope

For purposes of this document, the Lower Mississippi River Basin Asian Carp Control Strategy Framework (Framework) includes the entirety of the Lower Mississippi River basin, and also 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). According to USGS, the Lower Mississippi Region includes "the drainages of: (a) the Mississippi River below its confluence with the Ohio River, excluding the Arkansas, Red, and White River Basins above the points of highest backwater effect of the Mississippi River in those basins; and (b) coastal streams that ultimately discharge into the Gulf of Mexico from the Pearl River Basin boundary to the Sabine River and Sabine Lake drainage boundary. Includes parts of Arkansas, Kentucky, Louisiana, Mississippi, Missouri, and Tennessee." The Arkansas-White-Red Region includes "the drainage of the Arkansas, White, and Red River Basins above the points of highest backwater effect of the Mississippi River. Includes all of Oklahoma and parts of Arkansas, Colorado, Kansas, Louisiana, Missouri, New Mexico, and Texas." (USGS Hydrologic Unit Map)

Introduction

Asian Carp Threats in the United States

In North America, the expression "Asian carps" refers to a collection of four invasive species: Bighead Carp *Hypophthalmichthys nobilis*, Silver Carp *H. molitrix,* Black Carp *Mylopharyngodon piceus*, and Grass Carp *Ctenopharyngodon idella*. Asian carps were imported into the United States several decades ago primarily to be used in aquaculture and wastewater treatment plants for control of algae (Silver Carp and Bighead Carp) and grubs and snails (Black Carp), but subsequently escaped and are an increasing threat to the ecological, recreational and economic value of the Lower Mississippi (LMR), Arkansas, and Red Rivers and their tributaries (Kolar et al. 2005). The Aquatic Nuisance Species Task Force identified active control of Asian carps by natural resource agencies as a priority and developed the Management and Control Plan for Bighead Carp, Black Carp, Grass Carp, and Silver Carp in the United States (Conover et al. 2007) that identifies strategies to address Asian carps.

Conover et al. (2007) and Kolar et al. (2005) provide concise summaries of the history of introduction, biology, life history, use, and potential adverse effects of Asian carps. Bighead Carp and Silver Carp prefer areas of low velocity (<0.3 m/s) and off-channel areas without flow. Bighead Carp are strongly associated with dikes and backwaters, but not sandbars without dikes. Bighead Carp feed primarily on zooplankton, but will feed on phytoplankton if zooplankton density is low. Conversely, Silver Carp select phytoplankton over zooplankton, but will feed on both. There is concern that competition for plankton can impact native planktivores, such as Gizzard Shad *Dorosoma cepedianum,* Threadfin Shad *D. petenense*, Bigmouth Buffalo *Ictiobus cyprinellus,* Paddlefish *Polyodon spathula* and juveniles of many fish species. Sampson (2005) and Schrank et al. (2003) documented such competition. DeBoer et al. (2018) found compelling evidence of multiple trophic-level effects from the Silver Carp invasion with

quick and negative impacts to zooplankton populations and perhaps phytoplankton populations. Fish and birds that feed on prey fish species could ultimately be impacted, which could have negative effects on sportfishes that create recreational and economic implications.

Invasive Bighead Carp and Silver Carp are increasing in abundance and expanding their range in the LMR basin. Significant populations are established throughout many areas. Asian carps rapidly and densely colonize river reaches affecting the native food web in large river ecosystems (Freedman et al. 2012; Irons et al. 2007).

According to the Ohio River Asian Carp Control Strategy Framework (ORFMT 2014), multiple biological synopses and scientific risk assessments of the Asian carps (Kocovsky et al. 2012; Kolar et al. 2007; Kolar, et al. 2005; Nico et al. 2005; Cudmore and Mandrak 2004; Mandrak and Cudmore 2004) identify their potential for establishment and negative consequences to much of the aquatic resources of North America. Kolar et al. 2005 stated that the organism risk potential in the United States for both Bighead Carp and Silver Carp was high; an unacceptable risk. This classification means that both species are organisms of major concern for the United States, justifying mitigation to control negative effects.

There are federal and various state laws and regulations pertaining to the movement and sale of Asian Carps. Three species of Asian carp were added to the federal injurious species listing by the U.S. Fish and Wildlife Service (USFWS); Silver Carp in 2007 (USFWS 2007a), Black Carp in 2007 (USFWS 2007b), and Bighead Carp in 2011 (USFWS 2011) by notices in the Federal Register. The injurious wildlife listing (title 18) under the Lacey Act prohibits importation and transport of live Silver Carp, Bighead Carp, or Black Carp, including viable eggs or hybrids of the species, between the continental United States, the District of Columbia, Hawaii, the Commonwealth of Puerto Rico, and any possession of the United States, except by permit for zoological, education, medical, or scientific purposes. Under the Lacey Act, an injurious wildlife listing means the species has been demonstrated to be harmful to either the health and welfare of humans, interests of forestry, agriculture, or horticulture, or the welfare and survival of wildlife or the resources upon which they depend.

Since the 1960s the U.S. Fish and Wildlife Service (USFWS) has interpreted the shipment clause in the Lacey Act (18 U.S.C. § 42(a)(1)) as giving them the authority to prohibit live shipments between the 49 states in the continental United States of species federally designated as “injurious wildlife” in the Lacey Act(18 U.S.C. § 42(a)(1)). The United States Court of Appeals for the District of Columbia held on April 7, 2017 that 18 U.S.C. § 42(a)(1) does not prohibit transport of injurious wildlife between States within the continental United States. The D.C. Circuit Court found the shipment clause to be unambiguous and its interpretation consistent with the legislative history. Whereas, due to this ruling by the D.C. Circuit Court, any species of injurious wildlife can be legally shipped between states in the continental United States that do not have state laws or regulations prohibiting such shipment.

Lower Mississippi River

Worldwide, the Mississippi River is one of the largest rivers according to length, drainage area, and discharge (Baker et al. 1991). The LMR extends 953.5 miles from the confluence of the Ohio River at Cairo, Illinois, to the Head of Passes, Louisiana (USACE 2013) (Figure 1).

Baker et al. (1991) indicate at least 91 fish species reside in the LMR (e.g., reproducing populations), but they mention other studies list up to 121 species. This list does not include 'strays' from tributaries or recent additions of aquatic invasive species. Several federally listed species are contained within this list including Pallid Sturgeon *Scaphirhynchus albus* (endangered) and Shovelnose Sturgeon *S. platorynchus* (threatened based on similarity of appearance with Pallid Sturgeon to protect that species; it is only in effect where their ranges overlap and "take" only applies to commercial harvest). A few fish species of concern in the LMR as determined by state agencies include Lake Sturgeon *Acipenser fulvescens,* Gulf Sturgeon *Acipenser oxyrinchus desotoi*, Paddlefish *Polyodon spathula*, Alligator Gar *Atractosteus spatula*, Sturgeon Chub *Macrhybopsis gelida*, and Sicklefin Chub *M. meeki*. Some popular game species include Largemouth Bass *Micropterus salmoides*, Spotted Bass *M. punctulatus*, White Crappie *Pomoxis annularis*, Black Crappie *P. nigromaculatus*, Channel Catfish *Ictalurus punctatus*, Blue Catfish *I. furcatus*, Flathead Catfish *Pylodictis olivaris*, and White Bass *Morone chrysops*.

The Mississippi River and Tributaries Project (MR&T) was initiated by the U.S. Army Corps of Engineers (USACE) subsequent to the 1927 flood (USACE 2013). Levees, revetments, flood storage reservoirs, and floodways were constructed to reduce flood risk, while dikes and other river training structures were constructed to facilitate navigation by towboats during low river stages (USACE 2013). Sixteen channel cutoffs were constructed during the 1930s and 1940s which reduced the main channel length by 152 miles (Baker et al. 1991). These activities have reduced the floodplain area by 80%, increased sedimentation which resulted in the subsequent loss of approximately 23 secondary channels, and reduced main channel complexity (Baker et al. 1991; Williams and Clouse 2003).

Hydrologic connectivity between the main channel and off-channel aquatic habitats is significant in determining fish assemblages in floodplain lakes (Dembkowski and Miranda 2011). This periodic connection enhances habitat heterogeneity, which is important for sustaining fish species richness and diversity in large-river floodplain lakes. Oxbow lakes with greater hydrological connectivity with the river support more species that require flow or flooding (e.g., Skipjack Herring *Alosa chrysochloris*, River Carpsucker *Carpiodes carpio*, gars (Lepisosteidae) and White Bass), whereas oxbow lakes with poor aquatic connection with the river support species that prefer low-flow conditions (e.g., sunfish *Lepomis* sp. (Centrarchidae), shad species (Clupeidae), and Yellow Bass *M. mississippiensis*) (Miranda 2005).

Habitat diversity is important for the LMR, and recent efforts by the USACE and the Lower Mississippi River Conservation Committee (LMRCC) to restore secondary channel habitat and main channel diversity have enhanced habitat complexity. Additionally, the LMRCC developed the Restoring America's Greatest River plan (RAGR), focusing on restoring aquatic habitat and, where conditions and landowners allow, the associated active floodplain (LMRCC 2015). The USACE and its partners also finalized the Lower

Mississippi River Resource Assessment (LMRRA), and that report was delivered to Congress in July 2016, which in part addresses restoring LMR habitat (USACE 2015).

River-related economic benefits are also considerable. An economic profile (Industrial Economics Inc. 2014) was conducted on 113 counties along the LMR in the states of Arkansas, Illinois, Kentucky, Louisiana, Mississippi, Missouri, and Tennessee. Ten economic sectors were evaluated, including: harvest of natural resources, outdoor recreation, tourism, water supply, agriculture and aquaculture, mineral resources, energy, navigation manufacturing, and ecosystem services (non-market). Combining economic benefits for all 10 sectors, 2011 revenues totaled $151.7 billion and more than 585,000 people were employed in these river dependent industries.

Arkansas River

The Arkansas River (AR) originates in Colorado and flows generally in an east-southeasterly direction through Kansas, Oklahoma, and Arkansas until it empties into the Mississippi River (Limbird 1993). It is the longest tributary in the Mississippi Missouri River systems (1,450 miles), and its drainage basin encompasses 159,988 mi^2 (Limbird 1993). The upper reaches in Kansas are shallow, but wide in places (up to one mile wide) because of land characteristics and water use. As the river flows through Kansas and northeastern Oklahoma, flow increases because of several tributaries (i.e., Little Arkansas, Canadian, Cimarron, Neosho-Grand and Verdigris Rivers). The Arkansas River enters the LMR at river mile 598.

Following the 1927 flood, Congress passed several acts directed towards flood control and navigation. Ultimately, the McClellan-Kerr Arkansas Navigation System (MKARNS) was constructed and managed by the Tulsa and Little Rock Districts of the USACE (Schramm et al. 2008; USACE 2003). Construction of 17 locks and dams in the AR was completed in 1971, along with other navigation projects (e.g., shorten navigation distance, rock dikes, closure dikes associated with secondary channels, and bank stabilization) to support navigation from its confluence with the LMR to Catoosa, Oklahoma (Schramm et al. 2008). In 2004, another lock and dam was constructed at the confluence with the Mississippi River. Nachtmann (2015) determined the MKARNS contributes economic benefits of $8.5 billion in sales, 55,872 jobs, and $289 million in taxes to the national economy. However, from 1973-1999 there was a 9% aquatic area decrease in the Arkansas River in Arkansas, with the greatest declines within diked secondary channels and backwaters (Schramm et al. 2008).

A total of 137 fish species have been reported in the mainstem Arkansas River. The Arkansas River Shiner *Notropis girardi* is endemic to the Arkansas River and its tributaries. This small schooling minnow has been extirpated from about 80% of its range likely due to habitat destruction and modification from stream dewatering or depletion due to diversion of surface water and groundwater pumping, construction of impoundments, and water quality degradation (USFWS 1998). The Arkansas River basin population of the Arkansas River Shiner was designated as federally threatened by the USFWS in December 1998 (USFWS 1998). In October 2005, USFWS designated 532 miles of rivers as critical habitat for the species, along with a 300-foot riparian area along each bank (USFWS 2005).

White River

Originating in Madison County, Arkansas, the White River flows northeast into Missouri, then turns southeast back into Arkansas, meandering to its confluence with the LMR at river mile 599 (Robison 2006). The White River is approximately 690 miles long (Hoover et al. 2009), while the White River basin encompasses a watershed of 27,765 square miles, of which 17,143 square miles are in Arkansas and 10,622 square miles are in Missouri (Lin 2010).

Hydrology of the White River has been altered by the construction of four dams/reservoirs on the upper White River (i.e., Beaver, Table Rock, Bull Shoals, and Norfork). Two additional dams/reservoirs were also constructed on tributaries, including Greers Ferry Lake on the Little Red River in Arkansas and Clearwater Lake on the upper Black River in Missouri (USFWS 2012).

Subsequent to the 1927 Mississippi River flood, levee construction occurred along the White River from about eight river miles upstream above its confluence with the Mississippi River for approximately 50 river miles (USFWS 2012). One of the projects included in the McClellan-Kerr Navigation Project was the excavation of a canal connecting the Arkansas and White rivers (river mile 10) to accommodate barge traffic (USFWS 2012).

The White River National Wildlife Refuge and Cache River National Wildlife Refuge are located in the lower White River, and combined with several state management areas, encompass one of the principal bottomland forests remaining in the lower Mississippi Valley (Lin 2010).

Both upland and lowland streams and lakes found within the White River basin provide a diversity of habitats that support rich and complex fish assemblages (Hoover et al. 2009). A total of 177 fish species have been identified from the White River basin (Robison, 2006). According to maps found in the USFWS' Environmental Conservation Online System, two federally listed fish species inhabit the White River basin, Yellowcheek Darter *Etheostoma moorei* (Endangered) and Ozark Cavefish *Amblyopsis rosae* (Threatened) (USFWS Environmental Conservation Online System).

Red River

The Red River originates in northwest New Mexico, flows across the Texas panhandle, and serves as the border of Texas and Oklahoma, as well as Texas and Arkansas border for a short distance, then flows through Arkansas and into Louisiana (Gulf of Mexico Foundation 2009, LSUS 2017). Historically the Red River emptied into the LMR. Upon completion of the Old River Control Structure, the Red River now joins the Black River which then flows into the Atchafalaya River (Gulf of Mexico Foundation 2009). The Red River is 1,360-miles long and has a drainage basin of 65,590 mi^2 (LSUS 2017).

The upper Red River basin is very arid resulting in intermittent flow in some locations. Natural saline conditions characterize the water quality of the upper river (Gulf of Mexico Foundation 2009). Although native aquatic species have adapted to these conditions, the USACE is implementing the Red River Chloride Control Project (RRCCP) to enhance agriculture and human consumption through diversion of saline inflows into evaporation ponds (Gulf of Mexico Foundation 2009). The lower reach in Louisiana is

vastly different as it flows through marshes and swamps exemplifying a wide range of hydrological conditions throughout the basin (USACE J Bennett Johnston Waterway).

Dams and other river modifications have altered the hydrology of the river basin. Benefits include water supply, flood control, hydropower, and navigation; however, these alterations have resulted in habitat fragmentation (Gulf of Mexico Foundation 2009).

The USACE completed the J Bennett Johnston Waterway on the Red River in December 1994. A navigable waterway (i.e., 9' deep, 200' wide navigation channel) was created from the confluence of Old and Red Rivers upstream 236 miles to the Shreveport-Bossier City area (USACE J Bennett Johnston Waterway). The project includes five navigation locks, bank realignment through dredging, cutoffs, and river training structures, and bank stabilization with revetments, dikes and other structures.

Denison Dam impounded the Red River in 1943 forming the 89,000-acre Lake Texoma. The reservoir supports a self-sustaining striped bass *Morone saxatilis* population and fishery, with reproduction occurring in the Red and Washita rivers that flow into the reservoir (Gulf of Mexico Foundation 2009).

Status and Spatial Distribution within States

Large numbers of Silver Carp and Bighead Carp are now found throughout the LMR basin. Black carp are also being collected more regularly. State maps depicting the distribution of Asian carps (Silver, Bighead, Black) are included in Appendix A. Grass carp are not included in the distribution maps due to the presence of Grass Carp in numerous waterbodies in the states, many of which are stocked for biological control. Additionally, because of their widespread distribution, they have not been reported consistently to the USGS database. The current status and distribution of Asian carps for each state is summarized in Appendix B, provided by each state's representative as noted in Appendix C.

Control Strategy Framework Coordination and Implementation

The coordinated strategies outlined in this document directly address many of the goals in the *Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States* (Conover et al. 2007) by carrying out activities designed to slow and eventually eliminate the threats posed by these species. Asian Carp Control Strategy Frameworks have been developed for other sub-basins (e.g., Upper Mississippi River (Jackson and Runstrom 2018), Ohio River (ORFMT 2014), and Missouri River (Pherigo 2017), and framework implementation progress varies.

This 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.

This Framework was developed by the 11 states in the basins represented. The Asian Carp Team (Team) consists of representatives from state and federal natural resource agencies, universities, and non-

governmental organizations (NGOs). The Team will use the Framework to guide determination of highest priorities, identify lead and cooperating agencies for project development, and submit project proposals to USFWS for funding consideration. The Team will coordinate with the Mississippi Interstate Cooperative Resource Association (MICRA) Asian Carp Advisory Committee to maintain coordination among other subbasins to inform and guide efforts across the entire Mississippi River Basin.

There are varying levels of coordination within the basins included in this Framework. For the six LMR states, the LMRCC provides a coordinating body. 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 USFWS provides coordination through the Lower Mississippi River Fish and Wildlife Conservation Office. 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. State natural resource agencies are responsible for protecting and managing fish and wildlife resources, but realize they cannot effectively address this complex problem individually or without additional assistance and support. There are no such coordinating bodies in the Arkansas, White, and Red River basins, hence the need to establish the Team to provide representation from each of the 11 states and allow for a multi-basin coordinated effort.

Control Strategy Framework Goals and Strategies

The Framework contains seven Goals and associated Strategies for:

1. **Prevention**
2. **Monitoring and Population Status**
3. **Population Control and Agency Response**
4. **Understanding Impacts and Research**
5. **Agency Communication**
6. **Public Outreach and Education**
7. **Funding and Financial Support**

Goal 1 – Prevention: Stop the introduction and population expansion into basin waters that do not contain Asian carps.

Preventing movement of Asian carps to new waters is the foremost management strategy to restrict their establishment in new areas. To stop the expansion of Asian carps throughout the LMR basin, measures are needed to prevent range expansion, new introductions, and dispersal whether natural or human mediated.

1.1 Identify and assess risk of human-mediated vectors for movement and introduction of Asian carps within the LMR basin and develop strategies to address these vectors. (National Goal 1)

Human-mediated vectors are a significant source of range expansions. The most likely vectors include: bait bucket discards, releases from aquaria, live-food fish markets, the sale of live wild-caught fishes to pay/fee fishing lakes, the production and transport of farm-raised Asian carps, accidental escapes from aquaculture facilities, and intentional stockings. An assessment of the potential pathways for introduction and their relative risk is needed to identify prevention strategies.

1.2 Prevent the introduction of Asian carps in locations where they do not exist, or the spread of existing populations, through legislation, regulation, and enforcement. Enforce the federal Lacey Act laws and state regulations pertaining to the sale, transport, possession, production, and use of live Bighead Carp, Silver Carp, and Black Carp. (National Goals 1 and 2)

Regulations on the movement and sale of live Asian carps vary among the states. Consistent regulations addressing risks and the capability to effectively enforce those regulations are needed. Effective, uniform state regulations are especially important now since the recent court ruling (United States Association of Reptile Keepers, Inc. v. Zinke, No .15-5199), which determined the Lacey Act language does not prohibit the interstate transport of injurious wildlife species between and among the states in the continental United States (USFWS 2017).

1.3 Identify all natural and anthropogenic barriers (e.g., locks, dams, pumping stations, grade control structures) that could be used to prevent, or at least deter, Asian carp population expansion within the tributary systems. Once key locations have been identified, it should be a high priority to fund, install, operate, and evaluate deterrent technologies at strategic sites. (National Goal 2)

After identification and mapping of barriers, evaluate the potential for Asian carps to transgress into areas not currently occupied. At key barrier locations, alternative technologies (sound, light, bubble curtains/screens, chemical, and electric barriers) offer potential solutions to slow passage. These technologies, alone or in combination, should be considered at strategic locations and at other potential sites, such as where flood control or water storage projects have confined the channel, or are planned for the future. It is important to consider whether potential deterrent technologies (or systems) would have negative impacts on native species.

1.4 Evaluate the potential of operational changes at locks and dams to deter passage of Asian carps. (National Goal 2)

The operation of low-usage lock and dam (L&D) gates should be evaluated for potential permanent closure or operational modification. Operational changes may limit the opportunity for Asian carp passage through lock chambers while long-term solutions to prevent fish from moving through the locks are being developed. For example, a recent study at L&D 8 (near Genoa, Wisconsin) on the Upper Mississippi River used velocity measures combined with Asian carp swimming speed data to model Asian carp passage through the dam. Based on the results of the model, changing the operation of gates at the dam could decrease passage by 40% (Dan Zielenski, personal communication). Further investigations are warranted to reduce the passage of Asian carps through locks and dams.

Goal 2 – Monitoring and Population Status: Determine the spatial extent of Asian carp populations and evaluate responses to control efforts.

Early detection of Asian carps is necessary to determine if a response effort can be effectively implemented to prevent establishment and continued spread in the basins. To date, detection within the basins has largely been the result of ongoing fisheries surveys, commercial harvest, and reported public sightings. Targeted surveillance efforts are needed to detect incipient populations and implement effective response measures.

The detection of an incipient population will provide an opportunity to evaluate and implement response actions. A response action could range from an intensive survey for rapid assessment to attempted eradication, or involve simple reporting and communication depending upon the finding.

2.1 Develop and implement standardized sampling protocols and methods for Asian carps. (National Goal 2)

Establishing standardized sampling protocols and methods and best management practices will enable agencies to better compare data between and among basins. Because sampling methods that target Asian carps are often different than those used in established fisheries surveys, efforts should be made to implement Asian carp specific sampling protocols where possible. Determination of effective sampling gears and methods is also critical to improve the effectiveness of commercial fishing harvests.

2.2 Continue existing fisheries monitoring programs in the LMR basin, including mainstem rivers, tributaries, oxbow lakes, floodplain lakes, and other backwaters within the batture as a means of surveillance. (National Goal 2)

State natural resource agencies, with varying degrees of frequency, intensity, and spatial distribution conduct fisheries surveys in the LMR and its tributaries, other rivers and streams, and reservoirs throughout the basins using a variety of techniques that may include: electrofishing, gill netting, seining, ichthyoplankton nets, trammel netting, hoop netting, and trawling. Other state and federal agencies also conduct fish sampling. Fish kill investigations by various agencies are another source of information on Asian carp populations. These surveys may provide information through incidental collections or sightings of Asian carps. It is important to determine the spatial distribution of Asian carp populations, especially the leading edge of their expansion in tributaries and distributaries (i.e., Atchafalaya River).

2.3 Document Asian carp harvest by commercial fishers through required reporting by state natural resource agencies. (National Goal 2)

Commercial fishing has been a useful tool for gathering early detection information on Asian carps and should continue as a primary method of determining Asian carp distribution throughout the LMR basin. A timely monitoring program for commercial fishing effort, catch and harvest should be developed and/or continued for all commercial fishers. Collection data should contain, at a minimum, information on date, specific harvest location, species, number harvested, and pounds harvested. Ideally all states would develop and use the same reporting form and procedures.

2.4 Implement contract surveillance or targeted Asian carp sampling to monitor the distribution and abundance of Asian carps. (National Goal 2)

The current distribution of Asian carps in the basins is beyond some waters open to commercial fishers. In these locations, contractors (e.g., commercial fishers, natural resource consulting firms, and other private enterprises) could be hired to provide state natural resource agencies with an additional means to verify unconfirmed reports (e.g., a positive eDNA sample or public report) of Asian carps in new locations. Contract fishing would employ experienced fishing crews to intensively fish a specific area. Contractors may be useful for augmentation of agency efforts. States could require observers accompany contract fishers to monitor the catch. Resources of state agencies are often limited regarding their ability to adopt new monitoring or surveillance programs. Contractors could help augment information needs through labor-intensive, targeted Asian carp surveys.

2.5 Use eDNA testing to guide early detection efforts. (National Goal 2)

Low abundances of Asian carps are difficult to detect in large systems. Molecular tools such as environmental DNA (eDNA) have potential as surveillance methods for detecting incipient populations; however, this nascent technology requires further development and refinement before managers can confidently implement response actions based solely on eDNA results. While eDNA offers some utility in informing early detection efforts, eDNA alone does not confirm the presence of live Asian carps, nor does it provide quantifiable estimates of abundance. Controlled studies are needed to better relate eDNA detection results to abundance and distribution of live fish.

The eDNA surveillance technique is used to detect the genetic material of Asian carps in rivers and lakes. Its high sensitivity makes it an ideal method for early detection of Bighead Carp and Silver Carp (Asian Carp Regional Coordinating Committee (ACRCC) 2014), however, this technique is also prone to false positives. Asian carp eDNA technology has been used as part of early-detection efforts for Bighead Carp and Silver Carp in the Illinois and Mississippi rivers. It may prove useful in defining the extent of Bighead Carp and Silver Carp distribution and for identifying high-priority areas for targeted fish sampling.

2.6 Use new technology and techniques to aid in the detection of Asian carps outside their known distribution. (National Goal 2)

Otolith microchemistry and meta-genomic analysis of Asian carp tissue may have additional applications for early detection in the basins by characterizing Asian carp populations and determining if the fish are from a reproducing population. Such technologies are in development, and further research is warranted to refine these tools.

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

Reducing the abundance of established populations of Asian carps may minimize their impacts and slow their spread that will benefit and protect regional economies, river ecology, and recreation. Commercial harvest of Asian carps is currently the most practical method to reduce their densities. However, this

method is not without risks to public trust resources and its ultimate effectiveness is uncertain. Evaluation of the trade-offs of all control methods is needed to inform implementation of this goal.

Seibert et al. (2015) used a spawning potential ratio (SPR) to determine the size and exploitation needed to recruit overfish Silver Carp populations from several midwestern United State rivers, including the LMR. To achieve recruitment overfishing (SPR $\leq$ 0.2), they concluded that 27-33% of the population > 11.8" or 33-44% of the population > 15.8" must be removed.

On the Illinois River, a Spatially Explicit Asian carp Population (SEAcarP) model is being utilized to inform decisions to minimize the abundance of Asian Carp in the upper part of the system (ACRCC 2018). With additional data from the LMR basin and beyond, the model could be expanded to inform management decisions throughout the range.

Numerous strategies have been identified as having the potential to reduce Asian carp populations; however, research and development are needed before most will be ready for field evaluation. An integrated approach including commercial harvest and other methods will likely provide the best results long-term. Current research funded through the Great Lakes Restoration Initiative has provided insights regarding integrated control strategies and may lead to further development of sustainable and effective technologies for population control.

In 2010, an Asian Carp Marketing Summit was held to investigate the feasibility of commercial harvest and markets to control Asian carp populations in the Mississippi River basin (Charlebois et al. 2010). Priorities for future product development included the demand for the product, profit potential, and ease of exit (or transfer to native species) once the Asian carp populations declined. The group agreed that businesses should lead in developing markets with government agencies serving as partners, which is happening in several locations.

It is important that commercial interests recognize that the intent is not to maintain the fishery through regulations, but to overfish such that Asian carps are reduced to minimal or zero populations (extirpation). No effort should be made to maintain Asian carps for harvest, unlike other commercial native fishes with set regulations.

3.1 Develop a Rapid Response and Recovery Program that could be used by all natural resource agencies within the LMR basin that includes a mechanism for early identification, reporting, risk assessment, and eradication, where possible. (National Goal 3)

Among other elements, this plan should include: protocols for resolving potential jurisdictional conflicts; contact information for experts who can confirm the identity of Asian carps and recommend response actions; establishment of reporting mechanisms (e.g., toll-free phone numbers, web pages, etc.); and possible eradication options (e.g., traps, manual extraction, etc.). A comprehensive response plan will assist states in determining what types of actions are warranted depending upon the type of new information. This will allow agencies to implement pre-planned responses, most effectively implement appropriate actions, and communicate the response and the rationale for them with the public. In rare instances, a rapid response may be necessary using an Incident Command System (ICS) for an inter-

jurisdictional response. This may aid states when additional information is needed in a truncated time frame to determine whether localized eradication efforts may be feasible. When new detections occur within a single state, that state will be responsible for implementing any response action. The Mississippi River Basin Panel (MRBP) Model Rapid Response Plan for Aquatic Invasive Species in the Mississippi River Basin may be used as a template for the development of a basin rapid response plan (MRBP, 2010; http://www.mrbp.org/wp-content/uploads/2018/05/mrbp-model-rapid-response-plan-with-appendices.pdf).

3.2 Utilize commercial harvest and implement contract fishing of Asian carps to decrease densities. (National Goal 3)

As stated in 2.3 above, state natural resource agencies will continue to closely monitor commercial fishing effort and harvest. States will work to develop standardized monthly reporting forms for commercial harvest of Asian carps that will aid in determining population trends as control efforts are implemented. At a minimum, data obtained should include: date, specific harvest location, gear deployed, gear effort, species, number of each species harvested, and pounds harvested by species. Additionally, basin-level harvest data will be combined to quantify overall harvest in the basins.

3.3 State natural resource agencies will work within their authorities to increase opportunities for commercial harvest of Asian carps. States will work with commercial fishers, industry, and local communities to alleviate limiting factors (e.g., regulatory hurdles, low price, proximity of processing plants) that might encourage more commercial fishers to target Asian carps. (National Goal 3)

Alleviating logistical problems of moving harvested Asian carps to processing plants and enhancing financial gain (e.g., price per pound) for commercial fishers will likely result in more fishers targeting Asian carps, increased fishing effort, and greater harvest.

It is important for agencies to realize they may need to change fishing regulations and laws to be receptive of the needs and desires of commercial Asian carp fishermen. Agencies should experiment with special seasons and gears to increase commercial fishing efforts for Asian carps. Agencies must engage and coordinate with commercial fishing participants and state economic development offices to encourage expansion of this industry and the marketing of Asian carp products for human consumption.

3.4 States can assist, where appropriate, in the development of new markets for Asian carps. Markets should be expanded both within the United States and abroad. (National Goal 3)

States should work with existing and emerging businesses utilizing commercially harvested Asian carps to influence business plans, strategies, and ideologies that minimize risk associated with increased commercial harvest. Potential products (such as fertilizer, meal, and oil) include consumption by people, pet food products, and protein additives for other products. The U.S. Department of Commerce and U.S. Department of Agriculture (USDA) would be appropriate partners. An example: A Missouri business that produces Asian carp products has received grants (VAGP – Value Added Grant Program) from the USDA and/or Missouri Department of Agriculture to outline business plans, conduct feasibility studies, etc. The

USDA is specifically interested in using this program to promote commercial fishing, particularly for Asian carps (Joe McMullen, personal communication).

States should also explore the opportunities that exist for the USDA to make commodity purchases of Asian carps for distribution in prisons and in school lunch programs. Federal agency purchases of Asian carps would help the commercial harvest industry grow and stabilize.

Kentucky Department of Fish and Wildlife Resources (KDFWR) has been working with Asian carp processors and commercial fishermen to increase Asian carp harvest, alleviate logistical problems, and enhance their business success. To that end KDFWR has created new regulations to allow increased commercial fishing for Asian carps, provided a $0.05 per pound subsidy for Asian carps harvested from certain waterbodies, and engaged in a public private partnership with the Kentucky Fish Center LLC (Jessica Morris, personal communication).

3.5 Utilize knowledge of Asian carp habitat requirements and preferences to target control efforts. (National Goal 3)

Asian carp have specific habitat needs during different life stages. Conducting control projects that target important specific habitats for the various life stages could be highly successful in reducing localized and basin-wide populations. (See 4.2.)

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 actually 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). (National Goal 4).

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.)

Goal 4 – Understanding Impacts and Research: Support and conduct research projects that will increase our knowledge of the species and methods of control.

The potential impacts of Asian carps on sportfish populations and aquatic ecosystems are not well understood. Conventional wisdom is clear that, as with other invasive species, they will become a detriment to aquatic communities. However, specific research and long-term monitoring are necessary to understand their role and long-term effects in these basins to facilitate control and mitigation.

4.1 Support and accelerate research on sustainable, cost-effective means of long-term control methods. (National Goal 3)

Additional tools are needed for development and implementation of integrated control programs for the long-term reduction of Asian carp populations. Interagency working groups could be used to identify research goals and accelerate research in these areas by also identifying a strategy for individual topics to be addressed in a way that reduces redundancy of such research among states. Continued research in this discipline is encouraged. For example, investigate the feasibility of YY genetic modifications to produce all male triploids and tetraploids in which the fish produce few viable progeny. Also, fish pumps could be utilized to pump Asian carps from areas of high concentrations such as below dams or other barriers, into a collection area for harvest or destruction. However, these fish pumps will pump other species as well, impacting their populations.

4.2 Identify habitat requirements for all life stages of Bighead Carp, Silver Carp, and Black Carp, including environmental conditions (e.g., physical, chemical, hydraulic, and hydrological) required by Asian carps for successful reproduction and recruitment. (National Goal 4)

Determining habitat requirements and preferences will be imperative to habitat restoration planning and eradication efforts. Evaluations of habitat restoration projects should, in part, determine the response of native fish species and Asian carps. Priority would likely be given to future habitat alterations (e.g., flow, depth, connectivity) that benefit native fish, but not Asian carps.

Knowledge of habitat requirements may also identify a critical habitat that can be manipulated to facilitate control measures. In the middle Mississippi River, several off-channel areas (i.e., Apple Creek) have been identified as key nursery areas for Asian carps (Quinton Phelps, personal communication). Identification of factors that make these areas ideal rearing habitats could help direct management and eradication efforts. In 2010, Asian carps suffered poor recruitment in Illinois River off-channel habitats for unknown reasons after a successful spawn, which indicates that post-spawn survival may be the greatest weakness of Asian carps (ACRCC 2014). In Louisiana recently, several large adult Asian carp fish kills have occurred for unknown reasons in LMR oxbow lakes (Alexander Perret, personal communication). Similar kills have occurred in Mississippi oxbow lakes adjacent to the Mississippi River since 2010 (Dennis Riecke, personal). Research that would provide a thorough knowledge of environmental conditions and habitat needs could be used to develop control measures that take advantage of these factors in reducing recruitment of Asian carps (ACRCC 2014).

4.3 Evaluate capabilities and effectiveness of alternative deterrent technologies listed in 1.4 above (e.g., sound, light, bubble curtains/screens, chemical, and electric barriers). (National Goal 4)

Increased knowledge of the effectiveness of these measures will ensure better decisions to deter range expansion. As new technologies are developed, their prompt assessments will be imperative.

4.4 Determine if competition for food (e.g., zooplankton and phytoplankton) is adversely affecting native fish species. (National Goal 6)

Asian carps are planktivores, therefore directly competing with the early life stages of many native fishes and competing with all life stages of native planktivores such as Gizzard Shad, Threadfin Shad, and Paddlefish (Sampson 2005 and Schrank et al. 2003). DeBoer et al. (2018) found compelling evidence of multiple trophic-level effects from the Silver Carp invasion with quick and negative impacts to zooplankton populations and perhaps phytoplankton populations. A reduction of prey species could impact piscivores such as the Interior Least Tern *Sternula antillarum* and a variety of fish (e.g. black basses, White Bass, Alligator Gar).

The use of historic sampling techniques (such as rotenone sampling) on population level fish community data, condition, species composition, biomass and density, compared with similar recent sampling data, could reveal the impacts of Asian carps on native fish communities. Comparative sampling of lakes where Asian carps are and are not present could also eliminate confounding effects of environmental conditions.

4.5 Improve capabilities to detect early stages of invasion and spawning populations of Asian carps. (National Goal 6)

Asian carps are difficult to capture using traditional sampling methods, especially when abundances are low. Research is needed to develop effective capture methods and sampling protocols (e.g., paupier nets). Further refinement is needed in the development of existing techniques (see 2.4, 2.5, and 2.6). Dual Frequency Identification Sonar (DIDSON) technology is being used to identify Asian carp net-avoidance behavior. Responses to different types of nets will enhance the effectiveness at harvesting Asian carps (ACRCC 2014). Additional research is needed to determine preferred habitats to guide early-detection sampling and surveillance for spawning populations of Bighead Carp and Silver Carp. (See 4.2.)

4.6 Identify and categorize the impacts of Asian carps on society. (National Goal 6)

Conventional wisdom indicates that Asian carps will have significant economic, social, and ecological impacts within the LMR basin. Part of understanding impacts is knowing the value of what is being impacted. Understanding value and economic data associated with impacts to native species will be important to relay to lawmakers when discussing funding opportunities for large projects.

Research should identify what these impacts will be and provide recommendations on how to avoid, minimize, and mitigate for these impacts. However, the impact of these fishes relative to their abundance and distribution is not well understood within the LMR basin complicating communication with stakeholders, agency messaging, public expectations, and mitigation needs.

Comparison of historic creel data to recent creel data in lakes with and without Asian carps could provide data on fisherman use, effort and catch to document any changes in angler behavior and fishery value after water bodies have been invaded by Asian carps.

4.7 Conduct collaborative inter-agency research to measure the distribution and movement of Asian carps in the basins. (National Goal 6)

Collaborative, inter-agency research efforts needed to address topics such as quantification of rates of Asian carp population expansion and movement are integral to implementation of control strategies. Such insights will facilitate prioritization of approaches and selection of strategies.

Goal 5 – Agency Communication: Collaboration, communication, and coordination within the three basins and nationwide is imperative for comprehensive success.

Effective communication between agencies will facilitate implementation of the Framework. State natural resource agencies, and their partners must coordinate and plan strategies, communicate status among regional partners, and provide information, education, and outreach to the public.

5.1 A Team has been established for the LMR basin states to enhance effective communication among the state natural resource agencies, partners, and regional coordinating groups. (National Goal 7)

The Team will meet annually. The Team will include representatives from all basin state natural resource agencies and partners including federal agencies, universities, and NGOs. The role of the Team is to identify the priority needs of the basin, develop project templates (proposals) and work plans, and assist in the development of annual monitoring and response plans. Topics of discussion could include, but will not be limited to, Asian carp policy, project proposals/templates and their prioritization, funding needs, research projects results, and progress of prevention and control activities. Communication can also be accomplished at Aquatic Nuisance Species (ANS) panel meetings such as the Mississippi River Basin Panel on ANS and through state ANS contacts.

5.2 Prioritize activities listed within the Framework. (National Goal 7)

Strategies outlined in the Framework will be addressed in specific projects as proposed by LMR basin states, and developed into project proposals/templates for immediate funding consideration. Prioritization will enable legislators, funding agencies, and potential donors to understand what is needed, why, and the desired outcomes. However, prioritization needs must be fluid and flexible to encourage and allow adaptive management practices as Asian carps continue their expansion; and as more is learned through research, and additional control and management techniques are developed. (See 5.1.)

5.3 Maintain effective communication with other national and regional Asian carp committees and groups. (National Goal 5)

Currently, Asian carp efforts in the Upper Mississippi River and Ohio River Basins are coordinated by MICRA. The MICRA Asian Carp Advisory Committee is an expansion of the MICRA executive board and includes state representatives from each of the six sub-basins and federal partners (USACE, USGS, USFWS, and National Park Service (NPS)). The advisory committee gives direction to and reviews project proposals and plans. The role of the committee is to ensure that efforts between basins are coordinated into a single basin-wide strategy. The Mississippi River Basin Panel of the Aquatic Nuisance Species Task

Force is also an important venue for communication and coordination among state and federal agencies.

5.4 Utilize the USGS Nonindigenous Aquatic Species (NAS) database website, http://nas.er.usgs.gov/SightingReport.aspx, to obtain current Asian carp distribution status. Each state will be responsible for updating Asian carp data. (National Goal 5)

It is imperative that each Team representative and their respective agencies, universities, and NGOs have access to current Asian carp data and status. Each Team representative will be responsible for providing updates to the database.

Goal 6 – Public Outreach and Education: An educated and well-informed public will understand impacts, report Asian carp sightings, and support legislation and funding.

6.1 Prevent and control the introduction/reintroduction of Asian carps through education about these species and pathways, targeting the general public (including schools), industries, user groups, government agencies, and NGOs. (National Goal 5)

Provide information to the public on the status, impacts, prevention, and control of Asian carps in the LMR basin using traditional outlets, social media, websites, and other communication tools to educate and engage the general public, user groups, and elected officials. Public understanding and support are essential to control Asian carp and limit expansion. An informed public will serve as a source of monitoring through reports of fish; take responsible actions to prevent the spread of Asian carps (e.g., not moving live bait between water bodies); and support state and federal efforts to address these issues. User groups should also be informed not only of potential economic damage but also of the potential danger of personal injury as well as possible damage to boats and equipment due to the propensity of Silver Carp to jump high out of the water near motorized boats.

6.2 Promote public reporting of Asian carps. (National Goal 5)

The public will be encouraged to report Asian carp sightings to their respective state natural resource agency. New collection reports will be forwarded to appropriate state natural resource agencies. Each state will forward all verified collections (public or agency) of Asian carps in new locations to the USGS NAS database website. Historic collection data should also be submitted as soon as possible to provide for a more accurate and complete collection record for the basins. (See 5.4 and 6.1.)

6.3 Conduct public awareness events to educate the public about Asian carps and their impacts on society, river ecology, recreation, and economics. (National Goal 5)

Either initiate public awareness events or participate in existing events. Examples include, but are not limited to, Day-on-the-River, riverside community festivals, river fishing tournaments, and state fairs.

Goal 7 – Funding and Financial Support: Sufficient and consistent funding will be critically important for the implementation of this Framework.

Funding will be imperative to implement the Framework. Agency budgets are limited, so acquiring sufficient funding is critical. Financial support will be sought from legislators, federal and state agencies, NGOs, and philanthropies.

7.1 Develop a permanent funding mechanism for Asian carp population control in the LMR basin. Implementation of this Framework will be expensive. (National Goal 7)

Identify funding sources that would aid in the implementation of the Framework for the prevention and control of Asian carps. Pursue Federal funding through the National Aquatic Nuisance Species Task Force, USFWS, NGOs, and philanthropies that focus on natural resources. Interagency cooperation and partnerships will enhance our ability to acquire needed funding. The Team, MICRA, and LMRCC would take key roles concerning congressional outreach and education that will promote congressional interest for funding the Framework and the national plan (Conover et al. 2007). Funding must be sufficient, consistent, and timely because many of these projects must be implemented expediently.

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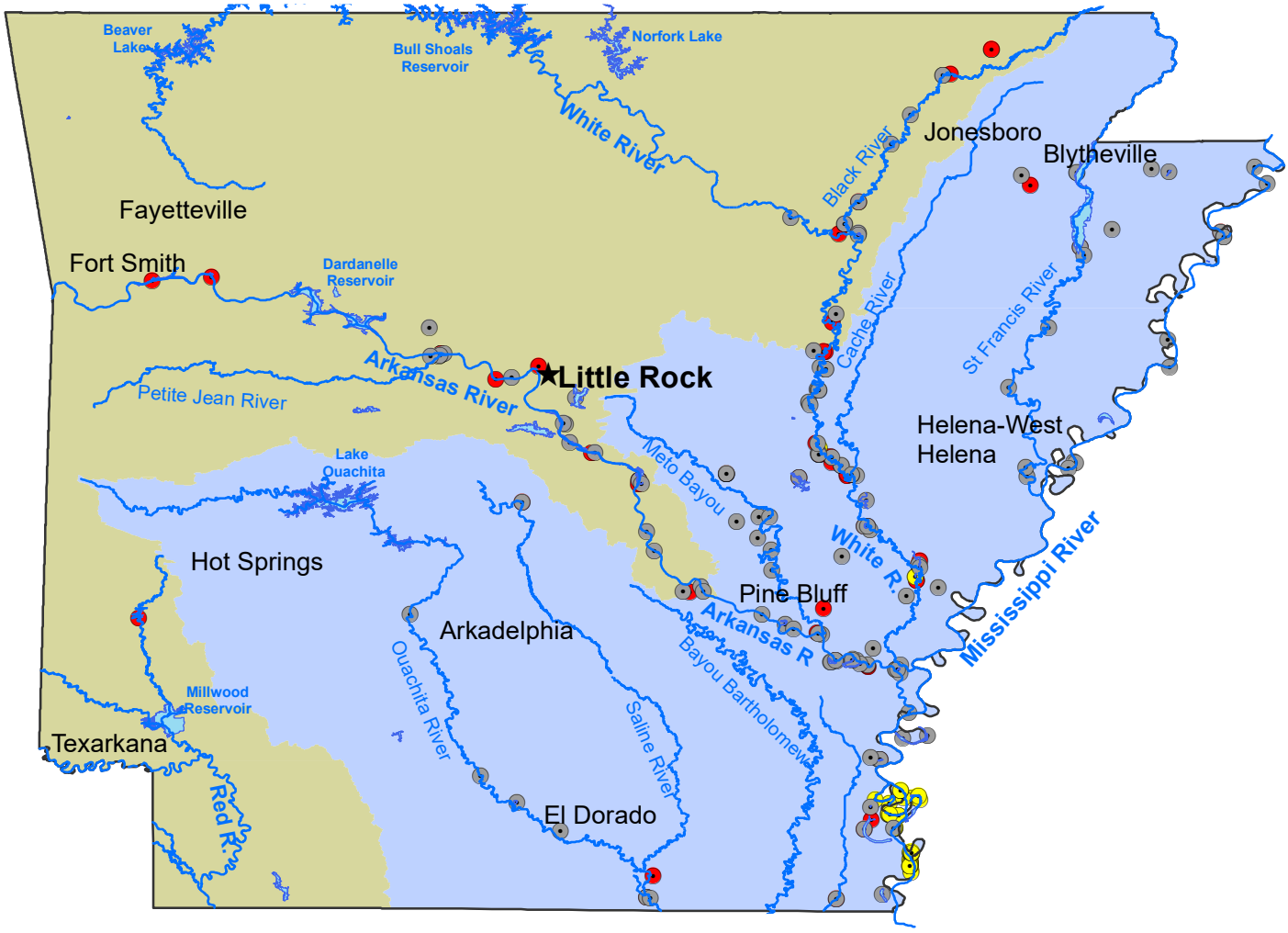
Appendix A. Distribution Maps of the Status and Spatial Distribution of Asian Carps in the LMR Basin States.

In an effort to standardize the data used in the maps, the decision was made to use data derived from United States Geological Survey's Nonindigenous Aquatic Species (NAS) database (https://nas.er.usgs.gov/queries/default.aspx). Each state's spatially referenced fish data (Silver Carp, Bighead Carp, Hybrid Silver/Bighead, and Black Carp) was downloaded and clipped to the appropriate sub-basin. It should be noted these data may not contain all Asian Carp sites in a given state. It should also be noted Grass Carp were intentionally omitted from these maps as they are stocked in many states for biological control and data are underrepresented in the NAS database.

Asian Carp Sites in Arkansas

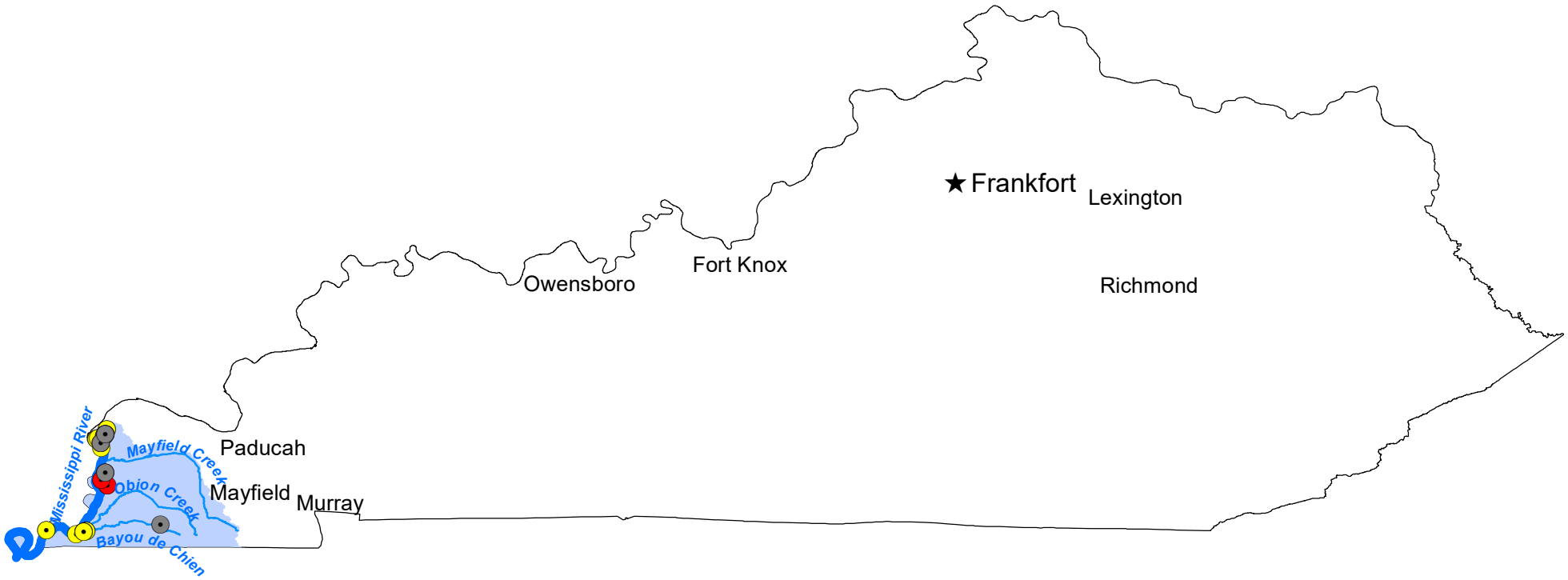


Asian Carp Sites in Kansas

Arkansas, White, and Red Rivers Sub-basin
Bighead Carp

N

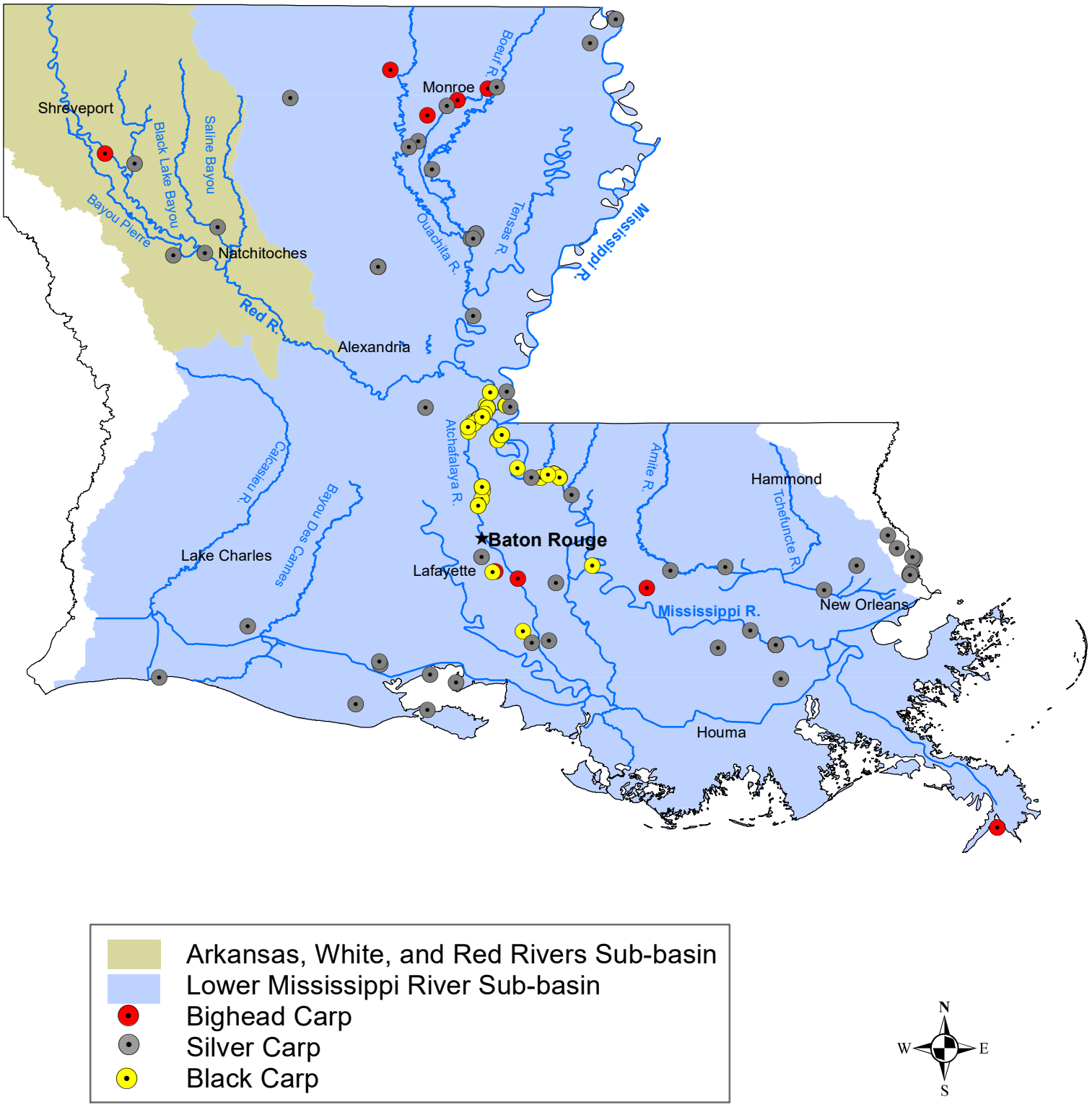
Asian Carp Sites in Kentucky



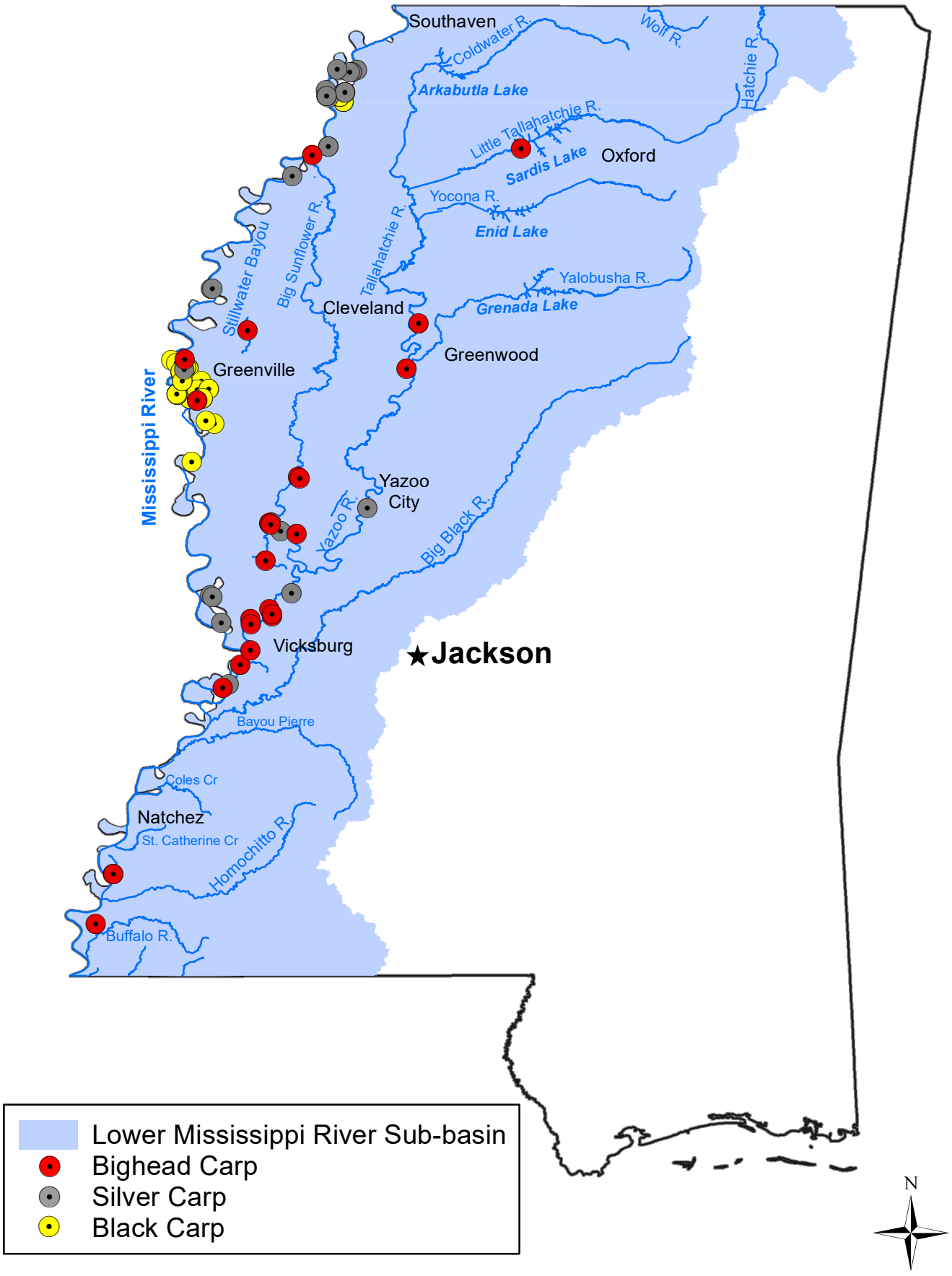
Lower Mississippi River Sub-basin
Bighead Carp
Silver Carp
Black Carp

N

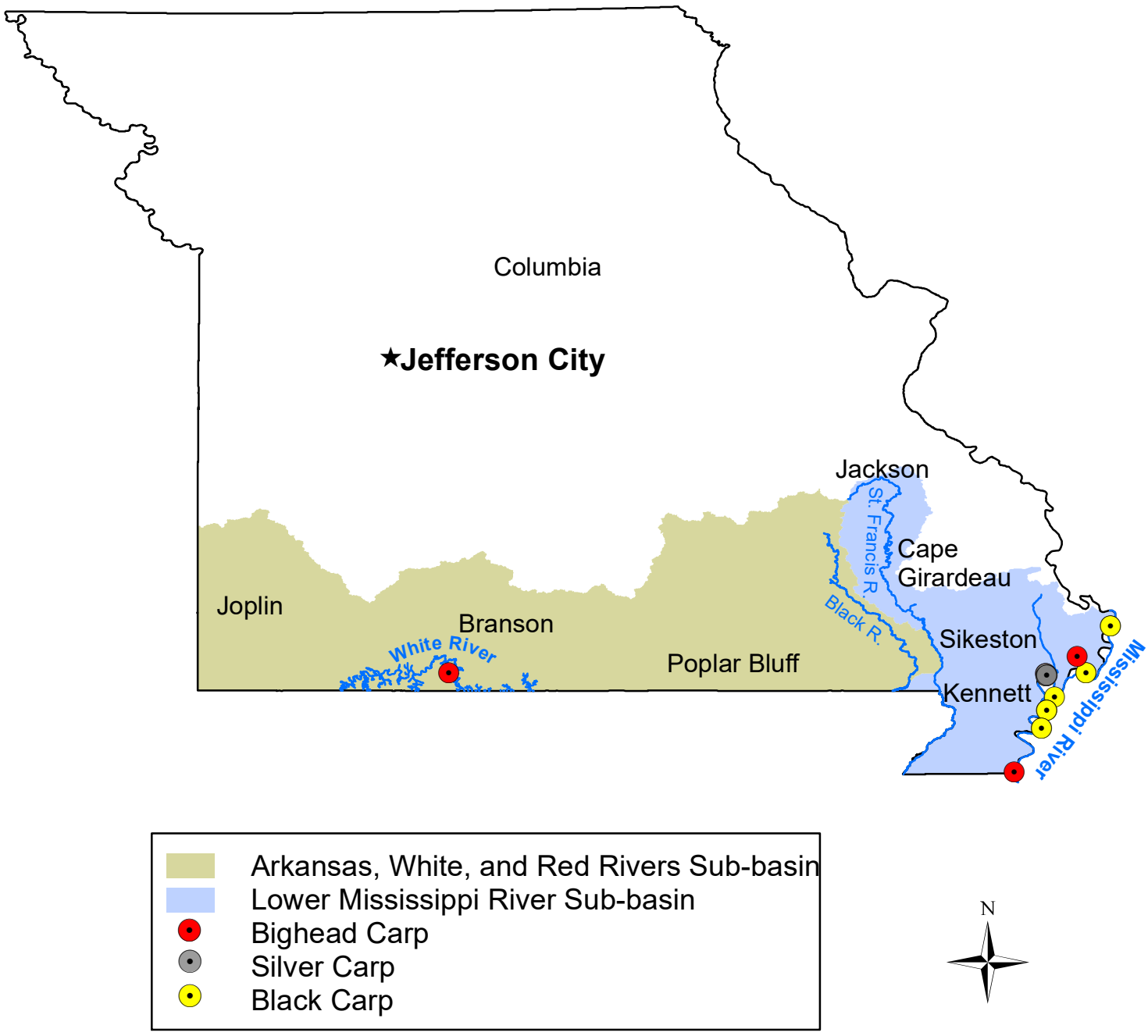
Asian Carp Sites in Louisiana



Asian Carp Sites in Mississippi



Asian Carp Sites in Missouri

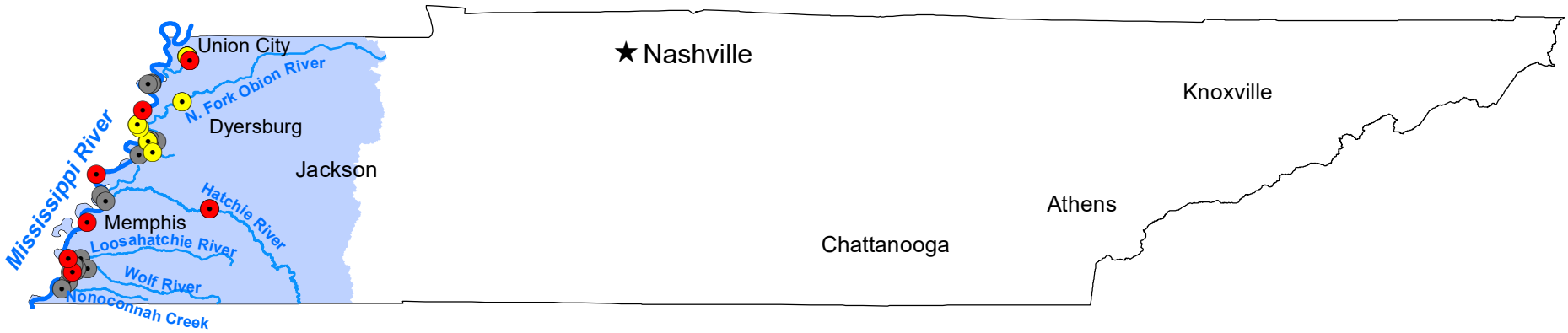


Asian Carp Sites in Oklahoma

Arkansas, White, and Red Rivers Sub-basin
Bighead Carp
Silver Carp

N

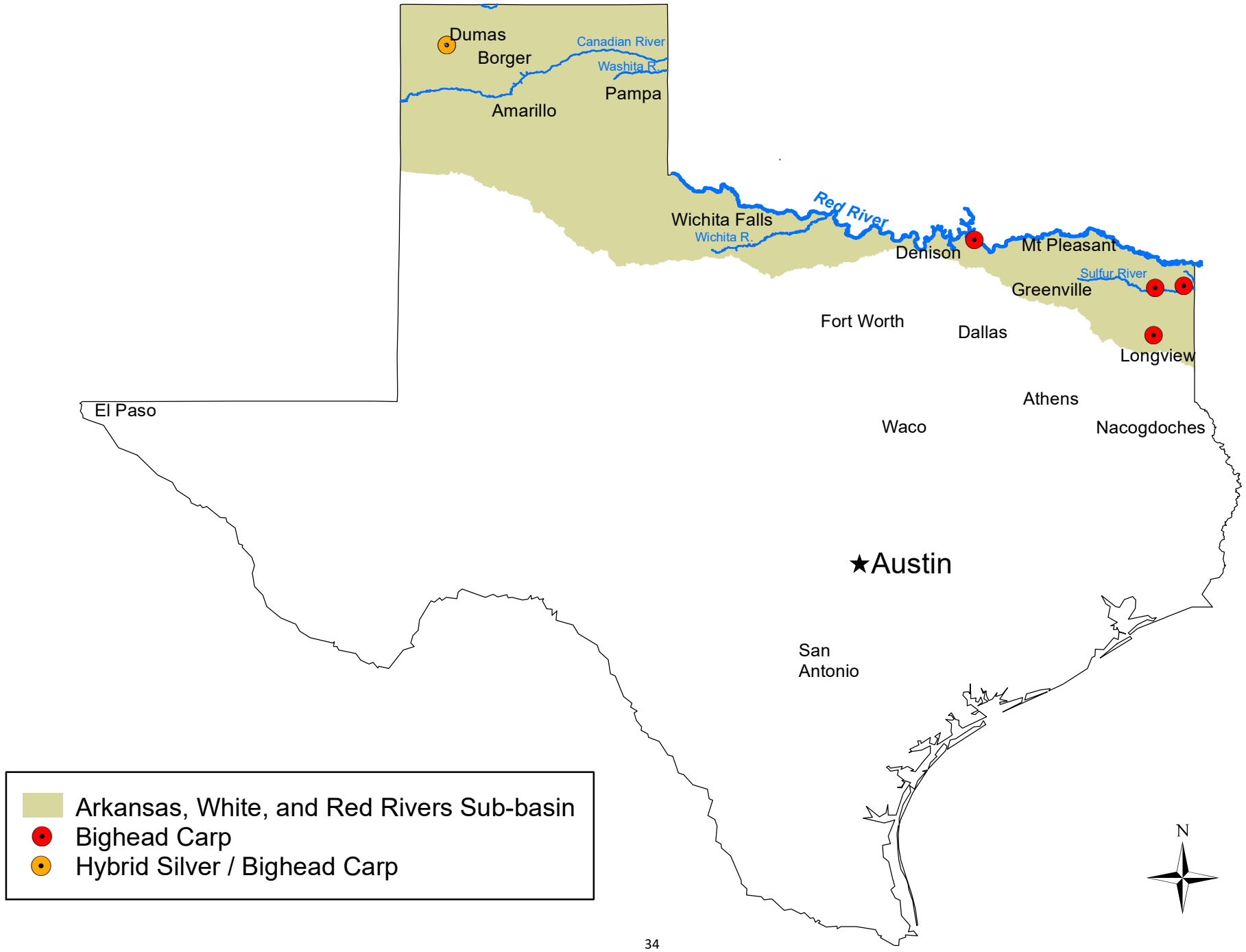
Asian Carp Sites in Tennessee



Lower Mississippi River Sub-basin
Bighead Carp
Silver Carp
Black Carp

N
W E
S

Asian Carp Sites in Texas



Appendix B. Description of the Status and Spatial Distribution of Asian Carps in the LMR Basin States.

Each Team Representative provided a summary of the distribution of Asian carps in their respective state.

Arkansas

Silver Carp and Bighead Carp have been collected sporadically in several of the state's river basins for 30 years (Freeze and Henderson 1982). In the present day, Silver Carp are abundant in Arkansas waters of the LMR. Silver Carp are abundant in the lower White River upstream to Batesville, Arkansas; lower Arkansas River below Dam 2 and upstream as far as Pine Bluff (Pool 4), but not to Lake Dardanelle (Pool 10); the lower Black River; and the lower St. Francis River. During 2015, Silver Carp were first documented in the Ouachita River in Felsenthal, Arkansas. Bighead Carp are common in the lower White River and uncommon to common in the Arkansas River. Larval Bighead Carp were first documented in Ozark Lake (Pool 12) of the Arkansas River during 2005. This was the first documented record of Asian carp upstream of Dardanelle Dam. Status of Bighead Carp in the lower Black and lower St. Francis rivers is uncertain. Arkansas does not collect commercial harvest information for Asian carp.

Colorado

There are no known populations of Silver, Bighead or Black Carp in Colorado.

Kansas

Silver Carp have never been documented in the Arkansas River basin, but there are records for the collection of Bighead Carp. The first record for Asian Carp in the Arkansas River basin in Kansas was for a single Bighead Carp that was collected in 1987 in the Upper Walnut River. This fish had likely escaped from an upstream aquaculture operation. Soon after this fish was found, the facility eliminated their entire population of Bighead Carp.

In western Kansas, a single Bighead Carp was collected from a farm pond in the Upper Salt Fork Watershed of the Arkansas River basin in 2005. The precise origin of this fish is unknown, but the pond owner had stocked commercially sourced fish on multiple occasions and the Bighead Carp may have been mixed in with those fish. The pond was completely renovated and no other Bighead Carp were found. Given the location of this pond and the infrequency of large rain events in that area of the state, it is unlikely Asian Carp would have traveled from the pond to other locations.

Lower in the Arkansas River basin there have been more frequent collections of Bighead Carp. From the Oklahoma border upstream to the Oswego Dam (approximately 20 river miles) Bighead Carp were collected in 2002 (1 fish), 2007 (1 fish), 2008 (1 fish), and 2009 (6 fish). The size of the fish captured varied widely over time; whether this is an indication of successful spawning or a result of multiple introductions is unknown.

There has never been any formal sampling for Asian Carp in the Arkansas River Basin in Kansas. Sampling is needed to better understand the upstream extend of Bighead Carp, as well as to determine if spawning is occurring in the river.

Kentucky

Bighead Carp and Silver Carp are abundant in Kentucky's short reach of the LMR. The reported commercial harvest of invasive Asian carp species is the only available measure of occurrence since these waters have not been sampled for Asian carps. In the 2016 commercial fishing season (March 2016-February 2017) commercial fishers reported the harvest of 64,600 pounds of Silver Carp and 9,078 pounds of Bighead Carp from the LMR. As Kentucky's border with the LMR spans approximately 50 miles, and ideal commercial fishing conditions only exist in small sections of that 50 miles, these numbers represent a substantial Asian carp abundance. Commercial harvest is driven by markets and river conditions, so harvest values provide only a rough estimate and vary from year to year.

The presence of Silver Carp and Bighead Carp in small tributaries and backwater lakes adjacent to the LMR in Kentucky is documented as well. However, precise abundance estimates are not available for these locations. The confluence of the LMR and Ohio River bordering Kentucky has facilitated the invasion of Asian carp species to the Ohio River basin tributaries, many of which are now inundated with Asian carps.

Louisiana

Bighead Carp and Silver Carp are abundant throughout the LMR from the Louisiana-Arkansas state line south to Head of Passes at the Gulf. Asian carps are found in the Red River from the Louisiana-Arkansas state line to the Old River Control. In the Atchafalaya River, a distributary of the LMR, Asian carps are abundant throughout the basin; they are uncommon in the Red River above Alexandria; and common to abundant in the lower Red River. Further expansion and increases in abundance above Alexandria are expected. Asian carps are common to abundant throughout the main-stem Ouachita River from the Louisiana-Arkansas state line to its confluence with the Red River.

In 2013, larval Asian carps *Hypophthalmichthys* spp. were first documented in the Atchafalaya, Mississippi, Ouachita, and Red rivers within Louisiana where their abundance comprised 13% of all larval fishes collected at 12 sampling stations (out of 61 stations statewide). Similarly, in 2014, larval Asian carps were found at 13 of 64 stations, comprising 14% of all larval fishes collected (Fontenot 2015). In both years, they were present at more stations in May than June, and most abundant in samples collected during May than June.

Floods in 2011 and 2016 continued to allow range expansion along the Gulf coast, with sightings now common in the tributaries along the north shore of lakes Pontchartrain, Maurepas, and the Pearl River system east of the Bonnet Carré spillway (Louisiana Department of Wildlife and Fisheries (LDWF) unpublished data). Additional sightings have been confirmed below Carnarvon and Davis Pond, the LMR freshwater diversion structures. In the lower Atchafalaya River system, juvenile Asian carps were first taken in marine fisheries trawl samples in Vermilion Bay, a coastal estuary, in June of 2011 (LDWF

unpublished data). In 2017, adult Asian carps were observed feeding in large rafts by commercial shrimpers near Marsh Island in West Cote Blanche Bay. Additional sightings of adults have occurred in the Vermilion and Mermentau rivers to the west (LDWF unpublished data 2017-2018), which are hydrologically connected to the Atchafalaya River by the Gulf Intracoastal Water Way.

While not specifically targeted in LDWF Inland fisheries sampling, Bighead and Silver carps were collected in 18% of all gill net and hoop net samples that were conducted from 2014-2016, for an average catch of 0.63 carp per net-night. Another measure of abundance in Louisiana is the commercial harvest data. At present, nearly all waters with Asian carps are open to commercial fishing. During 2016, Louisiana commercial fishers reported the combined harvest of 469,748 pounds for Bighead, Grass and Silver carps (LDWF Office of Fisheries-Inland Division-Asian Carp FACT sheet 2017). Current harvest rates are not a true reflection of stock densities within each river system because market demand remains low for Asian carps.

Mississippi

Silver Carp have been reported by commercial fishers from Pickwick Lake (Tennessee River) in Mississippi since July 2012. Silver Carp may expand their range in this system from Yellow Creek/Pickwick Lake downstream via a 36-mile canal to Bay Springs Lake, which is the first impoundment of the Tennessee-Tombigbee Waterway (TTW). The TTW extends southward and ultimately flows to the Mobile River and enters Mobile Bay in Alabama, and the Gulf of Mexico.

Bighead Carp and Silver Carp occur in the LMR, and its associated oxbow lakes, including: Eagle, Chotard, Albermarle, Mary, Claiborne bar pit, Desoto, Log Loader (Port of Rosedale), Whittington, Ferguson, Lee, Perry Martin, Moon and Beulah. Additionally, they occur in all river systems in the Yazoo River basin, including: Yazoo, Big Sunflower, Little Sunflower, Tallahatchie, and Yalobusha rivers and their tributaries. The majority of the oxbow lakes in the Yazoo River basin contain populations of Asian carps at various densities. Examples of these lakes are Wolf, George, Bee, Wasp, Roebuck, Minter City Cutoff, and Morningstar Cutoff. Asian carps expand their range in the Yazoo River Basin during flooding events, the most recent occurring in 2011. Asian carps are also present in the Big Black River, Lower Pearl River, Wolf River, and the tail waters of Ross Barnett Reservoir, Sardis Lake, Enid Lake, Grenada Lake, and Arkabutla Lake. Some commercial fishing for Asian carps occurs in the LMR and Yazoo River Basin. Between October 2015 and June 2016, one fish processor handled almost 909,000 lbs. of Asian carps from Mississippi waters, including 46,000 pounds of Bighead Carp, 55,000 pounds of Grass Carp, and 808,000 pounds of Silver Carp. In past years, Silver Carp and Bighead Carp were cultured in ponds on a limited basis within the state. Currently there are no farms raising Silver Carp and Bighead Carp (Dennis Riecke, personal communication).

Missouri

Bighead Carp are found throughout the Mississippi River, major un-impounded tributaries, Lake of the Ozarks, and Bull Shoals Lake; however, there does not appear to be reproduction in Lake of the Ozarks or Bull Shoals Lake. Silver Carp are common throughout the Mississippi River and many of its major

tributaries. Recently Silver Carp have been collected below Wappapello Dam on the St. Francis River, below Clearwater Dam on the Black River, and near Doniphan, Missouri, in the Current River. Both species are common in most of the drainage ditches in the Bootheel region of the state within the St. Johns Bayou/New Madrid Floodway, Little River, and St. Francis River basins.

Commercial fishers harvested an average of 44,778 pounds of Asian carps from the Mississippi River along Missouri from 1992-2014 (Missouri Department of Conservation (MDC 2014). Harvest peaked in 2002 (103,217 pounds), then declined during 2003-2012 to near average annual harvest levels of 48,727 pounds, then declined again in 2013 (23,964 pounds) and in 2014 (16,537 pounds.). Asian carp (Bighead Carp and Silver Carp) harvest has increased dramatically over the past few years: from 16,777 pounds in 2015 to 139,225 pounds in 2016 to 555,614 pounds in 2017 (the highest harvest ever recorded). Mississippi River harvest accounted for 99% of the total Bighead/Silver Carp harvest. Upper Mississippi River harvest was focused on Pool 24 (314,760 pounds), Pool 20 (129,068 pounds), and Pool 22 (82,587 pounds). Harvest from the middle Mississippi River (19,978 pounds) was highest from RM 0-50 (16,134 pounds) near Cape Girardeau; relatively little harvest occurred on the LMR (1,280 pounds). Bighead/Silver Carp harvest was reported from the St. Francis River for the first time since 1999. The 2017 Bighead/Silver Carp harvest was valued at $61,227.54 (MDC 2018)

New Mexico

There are no reports of Bighead Carp, Silver Carp, or Black Carp from New Mexico. All three species are listed as AIS Priority Class 1 in the 2008 New Mexico Aquatic Invasive Species Management Plan. Priority Class 1 species are currently not known to occur in the wild in New Mexico, but have a high potential to invade and for which there are limited or no known management techniques. Appropriate management for this class includes prevention of introductions and eradication of pioneering populations.

Grass Carp were first introduced into the State of New Mexico (illegal stocking) in 1972; Grass Carp can be found statewide in about 260 locations. Currently, New Mexico Department of Game and Fish (NMDGF) regulates importation of Grass Carp through NMSA 1978 § 17-3.32 (1963) and 19.35.15 NMAC which requires all Grass Carp are purchased from an approved vendor, have pathogen free certification, triploidy certification and written assurance from supplier that their facility is free of aquatic invasive species. Grass Carp can only be used for aquatic vegetation control. Since the year 2000, approximately 560 permits have been issued for Grass Carp importation, including those imported by NMDGF. NMDGF currently stocks eight public waters on a 3-5-year cycle.

Oklahoma

Bighead carp have been present in the Neosho River system since 1992 including Grand Lake O' The Cherokees, the Spring River and the Elk River, which are both tributaries to the Neosho River. A handful of individuals are routinely snagged by anglers during spring months which coincide with the annual paddlefish spawning migrations. The Oklahoma Department of Wildlife Conservation (ODWC) has not documented Bighead Carp spawning or recruitment in this system. All individual fish encountered have been large, mature fish. Active and passive sampling was conducted within this system with very low

success during 2015 and 2016. The population of Bighead Carp in this system appears to be very low in density with the majority of the fish being large fish of older year classes. More information is needed about the population within Grand Lake and the Neosho River because of the potential threat to native fish communities, particularly those species of greatest conservation need, as well as sportfish populations including the renowned paddlefish fishery (ODWC State Wildlife Grant Report F13AF01308). Silver Carp and Bighead Carp have more recently become established in the Red River Basin in Oklahoma downstream from Lake Texoma. Silver Carp and Bighead Carp were captured in the Kiamichi River during Spring of 2012. Silver Carp and Bighead Carp are established in southeastern Oklahoma, and are most likely reproducing populations (Patton and Tackett 2012). Silver and Bighead Carp have now been documented within the Lower Red River to the Arkansas state line, as well as all main tributaries including the Kiamichi River, Muddy Boggy River, and Blue River. ODWC has evidence that Bighead and Silver Carp are using the Kiamichi River as a potential spawning tributary because large sexually mature fish have been captured during spring flow events. However, their upstream movement is limited due to Hugo Dam.

Tennessee

Silver Carp and Bighead Carp are commonly reported by sport and commercial fishers from the LMR (RM 905 to RM 714.5) and its tributaries. Reelfoot Lake, the largest natural lake in Tennessee, is not directly connected to the LMR but Asian carps have accessed the lake from the LMR via the Obion River, a Mississippi River tributary. During flood events, high water would result in Asian carps entering the lake when the Obion River backs up against the old spillway structure. Bighead, Silver, Grass and Black Carp have been collected in Reelfoot Lake. The addition of a new spillway may limit future migration of Asian carps into this lake. Commercial harvest data is the only measure of abundance that is available at this time. At present nearly all waters in Tennessee with Asian carps are open to commercial fishing. There are approximately 20 commercial fishermen harvesting fish from the Mississippi River and Reelfoot Lake. For the 2018 fiscal year (July 1, 2017 through June 30, 2018), approximately 48,000 pounds of Asian carps were harvested from the Tennessee portion of the Mississippi River but data related to Reelfoot Lake is unavailable at this time.

Texas

Grass Carp have been present in Texas waters since the early 1980s, when diploid Grass Carp were stocked in Lake Conroe in the San Jacinto River Basin (Walker & Montgomery Counties). Subsequently, Grass Carp were found spawning in Lake Conroe as well as below the Lake Livingston dam (Trinity, Walker, San Jacinto, Polk Counties). These have been noted as the first successful reproductions in North America outside of the Mississippi River Basin. Grass Carp also moved downstream from Lake Conroe into the Trinity River and Bay. Triploid Grass Carp (TGC) have also been stocked in public waters for control of invasive aquatic plants (e.g., hydrilla) and downstream emigration to a distance of 184 river miles, crossing 10 dams, was documented during flooding events in the Guadalupe River. It has also been suggested that some introductions of diploid Grass Carp were the result of historical, illegal stockings in private ponds. Currently, TGC may be possessed, sold, and stocked in public or private

waters under Exotic Species permits (Texas Administrative Code, Title 31, Chapter 57, Subchapter A). Permit transport invoices from aquaculture permit holders for 2014-2017 indicate an average of 33,519 TGC were sold per year in Texas primarily for pond and lake management. There are now records of TGC occurrence from most river basins in Texas, most of which are likely the result of escapement from private ponds during heavy rains or natural disaster events (e.g., hurricanes). Data from permits issued for TGC stocking in private ponds for the period of 1992-2017 indicate TGC have been stocked in all counties in Texas except for Hudspeth, Loving, and Winkler Counties in the Upper Pecos River Basin.

The earliest records of Bighead Carp from Texas date back to a 1991 landing record from Victor Braunig Reservoir in the San Antonio River Basin in Bexar County. Although initially this species was believed to have failed in this reservoir, there have been periodic landing reports with the most recent in 2015. There was also a 1993 Texas Parks and Wildlife Department (TPWD) stocking of Bighead Carp and Bighead/Silver Carp hybrids in Rita Blanca Lake, an impoundment of Rita Blanca Creek, a Canadian River Tributary upstream of Lake Meredith) just south of Dalhart, Texas, in Hartley County. However, there are no documented records of Bighead Carp or hybrids from this lake from subsequent years. Since 1998, there have been periodic landing reports for Bighead Carp from the Red River downstream of Lake Texoma on the Oklahoma-Texas border. There have also been isolated landing records from Fort Phantom Hill Reservoir (one record) and the upstream Kirby Lake (two records) from 1999 and 2000, respectively; these lakes are located in the Upper Clear Fork Brazos River in Jones and Taylor Counties in the Abilene, Texas, area. Bighead Carp landings have also been reported from the Sulphur River below Wright Patman Lake on the Bowe-Cass County boundary in 2009 and 2018 and from the Cypress River Basin in 2009 and 2010 from Big Cypress Creek below Lake of the Pines spillway in Harrison County and the river in Marion County. An additional Bighead Carp landing was reported (USGS-NAS; year unknown) in the San Jacinto River just west of Houston in Harris County.

To date, no Black Carp have been reported in Texas. Information provided here for Asian carps was gleaned from TPWD Inland Fisheries Division lake management and permitting records and angling reports, (Howells 1999), and the USGS Nonindigenous Aquatic Species database (https://nas.er.usgs.gov/; last accessed 5 November 2018).

Regulations to address potential transfer of Asian carps prohibit transfer of live nongame fish from (1) the Red River below Lake Texoma downstream to the Texas-Arkansas border, (2) Big Cypress Bayou downstream of the Lake O' the Pines dam including the Texas waters of Caddo Lake, and (3) the Sulphur River downstream of the Lake Wright Patman dam to the Texas/Arkansas border (Texas Administrative Code, Title 31, Chapter 57, Subchapter N, Division 4). Research conducted in 2016 confirmed the geographic scope of these regulations is likely adequate to prevent transfer of Asian carps. The study employed traditional electrofishing and eDNA sampling in the Red and Sulphur Rivers and the adjacent Sabine River system and detected eDNA (Bighead and Silver Carp) only in the Sulphur River below Lake Wright Patman dam and electrofishing resulted in no captures (Barnes, 2017). A subsequent landing of a Bighead Carp from the Lake Texoma tailrace in the Red River Basin, combined with these eDNA results, suggest that Asian Carp are present but not abundant in these basins.

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Appendix D. Summary of Control Strategy Framework Goals

Goal 1 – Prevention: Stop the introduction and population expansion into basin waters that do not contain Asian carps.

Goal 2 – Monitoring and Population Status: Determine the spatial extent of Asian carp populations and evaluate responses to control efforts.

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

Goal 4 – Understanding Impacts and Research: Support and conduct research projects that will increase our knowledge of the species and methods of control.

Goal 5 – Agency Communication: Collaboration, communication, and coordination within the three basins and nationwide is imperative for comprehensive success.

Goal 6 – Public Outreach and Education: An educated and well-informed public will understand impacts, provide species sightings, and, support legislation and funding.

Goal 7 – Funding and Financial Support: A sufficient and consistent funding will be critically important for the implementation of this Control Strategy Framework.

Appendix E. Summary Goals for the Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States (Conover et al. 2007)

Goal 1 – Prevent accidental and deliberate unauthorized introductions of bighead, black, grass, and silver carps in the United States.

Goal 2 – Contain and control the expansion of feral populations of bighead, black, grass, and silver carps in the United States.

Goal 3 – Extirpate, or reduce to levels of insignificant effect, feral populations of bighead, black, grass, and silver carps in the United States.

Goal 4 – Minimize potential adverse effects of feral bighead, black, grass, and silver carps in the United States.

Goal 5 – Provide information to the public, commercial entities, and government agencies to improve effective management and control of bighead, black, grass, and silver carps in the United States.

Goal 6 – Conduct research to provide accurate and scientifically valid information necessary for the effective management and control of bighead, black, grass, and silver carps in the United States.

Goal 7 – Effectively plan, implement, and evaluate management and control efforts for bighead, black, grass, and silver carps in the United States.