

# Missouri River Basin Asian Carp Control Strategy Framework

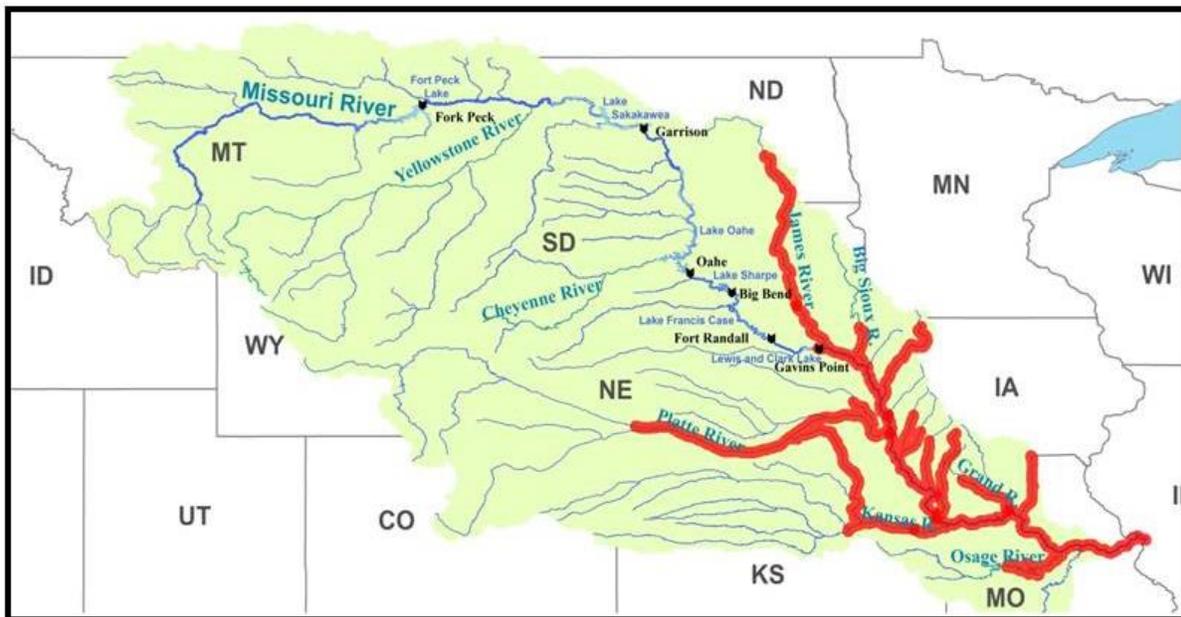
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## Acknowledgements

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Map: Bighead and Silver carp distribution in the Missouri River Basin, data from USGS Nonnative Aquatic Species database, map by USFWS, Lower Mississippi River Fish and Wildlife Conservation Office, March 2017.

Lower Left picture: Silver Carp (top) and Bighead Carp (bottom), courtesy of USFWS.

Lower right picture: School of Silver Carp jumping in the James River in South Dakota, 2012, courtesy of Cari-Ann Hayer.

## Executive Summary

The Missouri River Basin comprises one-sixth of the continental United States, including all or parts of 10 states, two Canadian provinces, and 25 Native American tribal reservations or lands. The economic resources that rely on the Missouri River Basin include municipal needs, agricultural practices, hydropower, recreation, flood control, navigation, and fish and wildlife. Recreation alone generates millions of dollars into the basin's economy. However, recreational use of the Missouri River basin is threatened by the establishment of invasive Asian carp.

The term "Asian carp" refers to four invasive fish species: Bighead Carp *Hypophthalmichthys nobilis*, Black Carp *Mylopharyngodon piceus*, Grass Carp *Ctenopharyngodon idella*, and Silver Carp *Hypophthalmichthys molitrix*. These four species can have major impacts on the ecosystem, economy, and human activities. Currently, Bighead and Silver carp are increasing in abundance and expanding their range in the Missouri River Basin. Populations are established in the mainstem Missouri River and tributaries downstream of Gavins Point Dam at the border of Nebraska and South Dakota. Grass Carp are widespread throughout the basin due to historic and current use for aquatic vegetation control, though evidence of reproduction is lacking in many areas. Black Carp pose a direct threat to native mussels, have been increasing throughout the Mississippi River Basin, and have been recently captured in the Missouri River Basin.

The U.S. Fish and Wildlife Service and the Aquatic Nuisance Species Task Force determined that Asian carp warrant active control by natural resource agencies and developed a National Plan to address these species. The Missouri River Basin Asian Carp Control Strategy Framework (Framework) implements the National Plan at the Missouri River sub-basin level. Six goals and associated strategies are identified in the Framework and relate to the National Plan as well as other regional plans. Implementation of the Framework will be coordinated through the Asian Carp Technical Committee of the Missouri River Natural Resources Committee with the intent to minimize the social, ecological, and economic impacts of these invasive fishes to the Missouri River Basin.

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## Introduction

The Missouri River Basin includes all or parts of 10 states, two Canadian provinces, and 25 Native American Tribal Reservations or Lands covering an area that exceeds 1.3 million square kilometers (km<sup>2</sup>) or one-sixth of the continental United States (Galat et al. 2005a, Galat et al. 2005b; USACE 2006). Draining a diverse landscape, the Missouri River extends over 3,000 km from its source in the mountains of western Montana to its confluence with the Mississippi River near St. Louis, Missouri. Approximately 12 million people live in the Missouri River Basin with nearly 10% residing in the larger population centers located on the Missouri River (e.g., Kansas City, MO; Omaha, NE; Sioux City, IA; Pierre, SD; Bismarck, ND; Great Falls, MT; USACE 2006).

Major uses of the Missouri River Basin waters include municipal, agricultural, hydropower, recreation, flood control, navigation, and fish and wildlife habitat (Galat et al. 2005b; BOR 2016). The U.S. Army Corps of Engineers (USACE) operates six mainstem dams on the Missouri River, the Bureau of Reclamation (BOR) has constructed more than 40 dams on Missouri River tributaries, and approximately 100 multipurpose and over 1,200 single-purpose reservoirs have been constructed in the basin (Galat et al. 2005b; USACE 2016; Reclamation 2016). Water, including rivers, lakes, reservoirs, and farm ponds, comprises 1.2 percent of the total basin area, yet is extremely important to the basin's overall economy (NRC 2002; USACE 2006). For example, the mainstem Missouri River in North Dakota supports an outstanding sport fishery with annual angler expenditures that contributed approximately \$35 million to local and regional economies in recent years (Fryda 2016). At the basin level, the 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation indicated that anglers in Missouri River Basin states expended approximately \$5 billion (DOI et al. 2011). The most popular fish targeted by anglers included trout species, Walleye or Sauger, and black bass (DOI et al. 2011). Commercial fishing has been used in Montana and North Dakota as a management technique to remove Common Carp from reservoirs and in the state of Missouri as a means of living where commercial fishing harvested 79,873 pounds in 2014 (Fryda 2014; Steffensen and Mestl 2016). Regardless of the state, commercial fishing has decreased in the Missouri River Basin since the early 1990s (Tripp et al. 2012; Steffensen and Mestl 2016).

The diverse habitats that comprise the Missouri River Basin support a wide array of aquatic species. The Missouri River contains 136 species of fish; hosts a multitude of migrating and nesting waterfowl, marsh birds, and shorebirds; supports populations of amphibians and reptiles; and contains a unique mussel community (Galat et al. 2005a; Galat et al. 2005b; Hoke 2011). Within these aquatic communities lie species of conservation concern including Paddlefish *Polyodon spathula* and the endangered Pallid Sturgeon *Scaphirhynchus albus*. These two fish

species and other aquatic species that are recreationally, commercially, and ecologically important may be negatively impacted by the establishment of invasive Asian carp (Schrank et al. 2003; Sampson et al. 2009; Hayer et al. 2014a; USFWS 2014).

The term “Asian carp” refers to a collection of four invasive species: Bighead Carp *Hypophthalmichthys nobilis*, Black Carp *Mylopharyngodon piceus*, Grass Carp *Ctenopharyngodon idella*, and Silver Carp *Hypophthalmichthys molitrix* (Conover et al. 2007; Chapman and Hoff 2011). Asian carp were imported into the United States several decades ago primarily to be used in aquaculture and wastewater treatment plants for control of algae (Bighead and Silver carp), snails (Black Carp), and vegetation (Grass Carp; Conover et al. 2007; Kolar et al. 2007; Chapman and Hoff 2011; Nico and Jelks 2011). All four species have subsequently escaped and established reproducing populations in the United States, thereby acting as a direct threat to native and recreational species with potential negative impacts on the economic benefits associated with recreation (Papoulias et al. 2006; Conover et al. 2007; Kolar et al. 2007; Deters et al. 2013; Hayer et al. 2014b; USFWS 2014; MDC 2016). Following are brief summaries of the invasion history, status, and spatial distribution of these four species in the Missouri River Basin. [Appendix A](#) presents associated maps.

### Asian Carp Distributions

#### Black Carp

Within the Missouri River Basin, Black Carp have only been documented in the state of Missouri. In 1994, thirty-plus Black Carp that were believed to be sterile were flooded out of an aquaculture facility into the Osage River, a tributary of the Missouri River in central Missouri (Nico and Williams 1996; Kolar et al. 2007; USGS 2017). In 2015, juvenile Black Carp were detected in the Mississippi River near the southeast corner of Missouri (MDC 2016).

#### Bighead Carp

Bighead Carp are established in the mainstem Missouri River from its confluence with the Mississippi River upstream to Gavins Point Dam near Yankton, South Dakota and in major tributaries to the Missouri River in multiple states, including Missouri, Kansas, Iowa, Nebraska, and South Dakota (Wanner and Klumb 2009; Hayer et al. 2014b; USGS 2017). Bighead carp have not been collected upstream of Gavins Point Dam in the mainstem Missouri River or associated tributaries (Klumb 2007; USGS 2017). The first Bighead Carp in Nebraska was documented in the late 1980s, the first juvenile was found in 2003, and the first year with significant reproduction in the Missouri River in Nebraska was 2008 (USACE 2009; Dave Tunink, Nebraska Game and Parks Commission, personal communication). The first Bighead Carp collected in Iowa from the Missouri River was sampled in 1995, with regular collections

beginning in 2008 (Kim Bogenschutz, Iowa Department of Natural Resources, personal communication). Unprecedented flooding in 2011 allowed Bighead Carp to move upstream of traditional barriers (low-head dams) on Missouri River tributaries in Iowa and South Dakota (Hayer et al. 2014a; Kim Bogenschutz, personal communication). This upstream movement allowed Bighead Carp to move into Iowa natural lakes and normally unconnected oxbow lakes along the Missouri River.

### Grass Carp

Grass Carp have historically been used for aquatic vegetation management in the Missouri River Basin (Klumb 2007; MICRA 2015). To date, three states in the basin still allow the use of diploid (fertile) Grass Carp: Iowa, Missouri, and Nebraska. The other states either prohibit Grass Carp or only allow the use of triploid (infertile) Grass Carp. In addition, state agencies that use Grass Carp for aquatic vegetation control in state-managed waters (Missouri, Kansas, Iowa, and Nebraska) have been using triploid Grass Carp for several years. However, historical use of diploid Grass Carp has led to widespread diploid Grass Carp populations in several states, including Missouri, Kansas, Iowa, Nebraska, and South Dakota. Grass Carp are believed to be extirpated in North Dakota after limited introductions in 1972 (Jessica Howell, North Dakota Game and Fish, personal communication). There are no known diploid populations of Grass Carp in Montana or Wyoming, though it is possible to import and use triploid Grass Carp in Wyoming with a permit and triploid certification (MICRA 2015; USGS 2017).

### Silver Carp

Silver Carp co-occur with Bighead Carp for the majority of their range, including an established population of Silver Carp in the Missouri River from its confluence with the Mississippi River up to Gavins Point Dam. No known populations of Silver Carp exist upstream of Gavins Point Dam in the mainstem Missouri River or associated tributaries (Wanner and Klumb 2009; Hayer et al. 2014b; USGS 2017). Silver Carp are established in major tributaries to the Missouri River in all the states downstream of Gavins Point Dam – Missouri, Kansas, Iowa, Nebraska, and South Dakota – and have been detected in low abundance in the James River of North Dakota (Hayer et al. 2014b; USGS 2017). The first Silver Carp in Nebraska was documented in 2002 and the first year with significant reproduction in the Missouri River in Nebraska was 2008 (USACE 2009; Dave Tunink, personal communication). Regular collections of Silver Carp in Iowa began in 2008, though early collections were not well documented (Kim Bogenschutz, personal communication). As seen with Bighead Carp, unprecedented flooding in 2011 allowed Silver Carp to move upstream of traditional barriers (lowhead dams) on Missouri River tributaries in Iowa and South Dakota (Hayer et al. 2014a; Kim Bogenschutz, personal communication). This allowed limited passage into North Dakota, as well as facilitated Silver

Carp movements into Iowa natural lakes and normally unconnected oxbow lakes along the Missouri River.

### **Framework Coordination and Implementation**

The U.S. Fish and Wildlife Service (USFWS) and the Aquatic Nuisance Species Task Force determined that Asian carp warranted active control by natural resource agencies and organized an Asian Carp Working Group to develop the Management and Control Plan for Bighead, Black, Grass, and Silver carps in the United States (National Plan, Conover et al. 2007). The National Plan presents an overview of the four species and identifies goals and strategies to manage and control Asian carp.

This Missouri River Basin Asian Carp Control Strategy Framework (Framework) was developed according to the needs of the Missouri River Basin while maintaining consistency with the National Plan and other regional plans (Conover et al. 2007; ORFMT 2014; GLRI 2014). The Framework addresses the invasion of Missouri River Basin waters by Asian carp through six primary goals: 1) prevention, 2) early detection and monitoring, 3) containment and control, 4) population management and eradication, 5) coordination, and 6) outreach and communication. Strategies for achieving these goals are identified and related to the National Plan in [Appendix B](#). Many of these goals need to be pursued concurrently while others will be prioritized depending on how well or when other goals are accomplished.

Implementation of the Framework will be guided by an Asian Carp Technical Committee (Committee) formed under the auspices of the Missouri River Natural Resource Committee (MRNRC). The MRNRC was formed in 1986 with the mission “to promote and facilitate the preservation, conservation, and enhancement of the natural resources of the Missouri River System,” (MRNRC 2017). Official MRNRC members consist of delegates from State natural resource agencies for Montana, North Dakota, South Dakota, Nebraska, Iowa, Kansas, and Missouri ([Appendix C](#)). Federal agencies, including USFWS and USACE, are ex-officio members. Other governmental agencies and private organizations are invited to participate as Cooperating Agencies.

The Committee will continue earlier efforts addressing Asian carp in the Missouri River Basin initiated by the Missouri River Basin Team of the 100<sup>th</sup> Meridian Initiative as well as state and federal agencies (Wanner and Klumb 2009). The Missouri River Basin Team of the 100<sup>th</sup> Meridian Initiative is composed of Aquatic Invasive Species (AIS) Coordinators from Montana, North Dakota, South Dakota, Wyoming, Nebraska, Iowa, Colorado, Kansas, Missouri, and USFWS Region 6 staff. Utilizing diverse experiences of AIS coordinators, fish biologists, and natural resource managers increases overall knowledge of the Missouri River system and it’s

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biota as well as outreach experience combatting AIS, thus strengthening the ability of the Committee to pursue the Framework goals.

The Committee will be comprised of one representative from each state in the Missouri River Basin ([Appendix D](#)) as well as one representative from BOR, National Park Service (NPS), USACE, USFWS, and U.S. Geological Survey (USGS). Additional agency staff, other governmental agencies, universities, and private organizations are encouraged to participate as cooperators. USFWS Region 3 will provide a coordinator for the committee to support efforts and facilitate communication. The Committee will use the Framework as a guide to determine highest priority projects for the Missouri River Basin, identify lead and cooperating agencies for each project, and develop project proposals for USFWS funding consideration. Project implementation will happen at the agency and cooperator level and the Committee will be responsible for evaluation and annual assessment of implemented projects. The Committee will provide action plans and annual reports to the Mississippi Interstate Cooperative Resources Association (MICRA) Asian Carp Advisory Committee for compilation with other sub-basins to inform the USFWS of Asian carp management and control in the greater Mississippi River Basin. The process of planning, implementation, and subsequent assessment will guide future priorities and actions.



**Figure 1.** Structure for inter-agency coordination and implementation of the Missouri River Basin Asian Carp Control Strategy Framework in association with the greater Mississippi River Basin through the Mississippi Interstate Cooperative Resources Association (MICRA). States listed include one representative from the lead natural resource agency for each State.

## Framework Goals and Strategies

### **Goal 1 – Prevention: Prevent the introduction and further spread of Asian carp into and within the Missouri River Basin.**

The most cost-effective management approach is preventing the introduction and establishment of Asian carp into uninhabited Missouri River Basin waters. Prevention efforts are warranted to avoid potential adverse ecological and economic effects and are generally more viable than attempting to manage and control a species that has already been introduced. The first step in identifying prevention strategies is to assess potential pathways for introduction or spread, whether natural or human-mediated, and their relative importance.

#### **Strategy 1.1. Assess human-mediated pathway risks for Asian carp introductions. (National Goal 1).**

Human-mediated vectors are a significant threat to range expansion. Some of the most likely vectors in the Missouri River Basin include incidental baitfish transfers, aquaculture, and the use of diploid (i.e., fertile) Grass Carp for aquatic vegetation control. Currently, regulations are one of the most effective tools identified to address human-mediated pathway risks, but regulations on the movement and sale of live Bighead, Black, diploid Grass, and Silver carp are variable, not always enforceable, and may not address all pathways or species of concern. Once pathways are identified, effective methods to address these pathways can be established. Enforcement of regulations is also a key component in preventing the spread of Asian carp.

#### **Strategy 1.2. Develop best management practices for preventing Asian carp introductions and spread and for minimizing impacts of established populations (National Goal 6).**

Once impacts of Asian carp and pathways for the introduction and spread of these species is better understood, best management practices should be developed to minimize impacts of current Asian carp populations, prevent new introductions, and stop the spread. To reduce delays in action, an adaptive management approach is recommended to implement the best management practices identified through scientific research, periodically reviewed, and updated as needed to meet goals. These actions will be available for natural resource agencies and organizations as well as the public through an outreach campaign as described in Goal 6 of this Framework.

#### **Strategy 1.3. Identify locations and implement efforts to prevent Asian carp expansion where feasible (National Goal 2).**

Given the immense size of the Missouri River Basin and current distribution of Asian carp, numerous opportunities exist for further expansion. Common physical barriers such as dams, fish weirs, fish traps, and habitat modifications have prevented the upstream migration of Asian carp

in many areas across the basin thus far. However, permanent and intermittent inter- or intra-watershed hydrological connections can provide Asian carp dispersal opportunities. Such connections should be identified, evaluated for Asian carp and native aquatic species passage under multiple hydrologic scenarios, and managed appropriately. Examples of existing management options addressing both human-mediated and natural pathways include deterrence technologies, regulations and policies affecting agency and public use of the waterways, concentrated removal efforts, and physical barriers.

**Strategy 1.4.** Evaluate habitat suitability and assess risk of establishing a population (National Goal 6).

Asian carp are not currently established upstream of Gavins Point Dam on the mainstem Missouri River. If the reservoir system is at risk of Asian carp establishment, the economic risk to the region greatly increases. It is necessary to assess whether the required conditions for Asian carp reproduction and recruitment are present and estimate the risk of establishment in tributaries and reservoirs upstream of Gavins Point Dam and in other parts of the basin where these species are not yet established. Priority areas can then be established for each species based on suitability and likelihood of introduction.

**Goal 2 – Early Detection and Monitoring: Define Asian carp populations in the Missouri River Basin and assess their response to management actions.**

Currently, more information on the abundance and distribution of Asian carp is needed to inform the strategic placement, development, and assessment of management actions across the Missouri River Basin. Assessments provide baseline population data to inform management decisions. Early detection sampling is used to detect new introductions and the spread of existing populations and can provide managers with critical information about the speed and mechanisms of spread. By detecting new populations early, actions can more effectively be taken to control the population. Monitoring provides empirical data about population changes over time and space, the ability to compare multiple populations, and a basis to evaluate the efficacy of management actions. These efforts may require long-term commitments of 3 to 10 years, depending on the complexity and scope of the situation.

**Strategy 2.1.** Develop and implement a monitoring plan to assess distribution and population dynamics of Asian carp in the Missouri River Basin (National Goal 6).

Specific information about the distribution and population structure of Asian carp in the Missouri River Basin is essential to develop targeted control strategies for these species and understand whether control tactics are successful. A basin-wide approach to determine population and

distribution information is imperative for fish that are capable of moving long-distances. Tracking population dynamics is essential for quantitatively measuring effects of management efforts. The size and scope of early detection and monitoring sampling efforts will likely require collaborative efforts among state and federal agencies, educational institutions, commercial fishermen, and contracted parties to fully explore the extent of Asian carp distribution and abundance within the Missouri River Basin. Information gained from sampling efforts will inform managers of where population expansion is occurring, the level of population control needed, and potential barriers to future population expansions.

**Strategy 2.2.** Utilize current and emerging technologies to define population variables that guide management and control of Asian carp (National Goal 6).

To effectively guide efforts to manage and control Asian carp in the Missouri River Basin, managers must understand the factors influencing population dynamics. Examples of population variables that should be accounted for in management actions include numbers and locations of distinct populations within the basin, population sources and sinks, and movement into, out of, and within the basin. Technologies to answer these questions are constantly advancing, and it would benefit managers to utilize emerging technologies that have been demonstrated to provide accurate and precise information. Examples of current technologies include environmental DNA (eDNA; presence/absence of DNA from the target species in the environment), otolith microchemistry (natal origin/movement within basin), and gene sequencing (population delineation). The scope of this work and the depth of specialized knowledge will likely require a collaborative effort among state and federal agencies or a contractual agreement with an educational institution or consulting agency.

**Strategy 2.3.** Encourage reporting of Asian carp in locations where they are not known to be established (National Goal 1).

Early detection is critical for measuring a population's response to management actions and the subsequent creation of future plans. As part of early detection efforts, agency personnel are encouraged to report new sightings of Asian carp where these species are not known to be established to the USGS Nonindigenous Aquatic Species (NAS) database (<https://nas.er.usgs.gov/>). Similarly, citizens should report new sightings of Asian carp to state agency personnel for local verification of Asian carp locations and eventual reporting to the NAS database. Up-to-date information about the presence of Asian carp in the NAS database is critical to resource managers and decision makers.

**Strategy 2.4.** Integrate Missouri River Basin susceptibility with Asian carp habitat preferences to develop management actions (National Goal 3).

One of the goals of identifying Missouri River Basin susceptibility to Asian carp is to assess and evaluate the basin for areas most likely to provide suitable habitat for various life stages. This information will help guide management efforts by identifying habitats and locations most likely to contain Asian carp. The use of life history information, habitat preferences, and known locations of carp combined with watershed characteristics can create a geospatial predictive model to assess invasion threats to Missouri River and its tributaries. Detection and monitoring sampling will support development and improvement of the model and guide future management efforts such as spawning disruption, focused removal efforts, or deterrence/barrier technologies deployed at critical locations or times.

**Strategy 2.5.** Identify and evaluate techniques and protocols to detect Asian carp and monitor populations (National Goal 6).

It is essential to have a high level of confidence in Asian carp sampling methods used to detect individuals and estimate populations. Protocols should be designed and implemented to answer research questions and provide accurate information to managers. As possible, standard methods and techniques should be adapted from other locations or developed to efficiently collect relevant data that is comparable across the basin.

### **Goal 3 – Containment: Contain the expansion of Asian carp populations in the Missouri River Basin.**

In an effort to protect recreation, economics, and ecology in the Missouri River Basin, it is critical to contain Asian carp populations to current distributions. Decreasing the overall Asian carp population and curbing the spread of these species into new areas within and out of the basin will further protect the resources of the basin. As Asian carp populations expand through natural or human-mediated pathways, managers must respond rapidly to prevent the establishment of new populations.

**Strategy 3.1.** Develop Rapid Response Plan for the Missouri River Basin (National Goal 2).

A planned and coordinated effort to reduce or eliminate a low density population of Asian carp in a newly populated area can be the most cost-effective response strategy once an introduction occurs. An effectual rapid response plan identifies key partners and staff, necessary authorities, and appropriate actions for a given finding prior to a new detection. These key elements help minimize response times, increase response effectiveness, and reduce conflict among stakeholders. Response actions may range from additional sampling to press releases to eradicating the developing population. Rapid response efforts should focus on waterbodies with

new populations instead of areas with established populations where targeted efforts may be less effective.

**Strategy 3.2.** Identify containment opportunities and implement efforts to control Asian carp expansion where feasible (National Goal 2).

While prevention (Goal 1) protects uninvaded areas from a new invasion by Asian carp, containment (Goal 3) prevents Asian carp from escaping a known population confined to its current geospatial distribution. Knowing the distribution of Asian carp in the Missouri River basin is a prerequisite for taking action and will allow for the identification of physical barriers or natural breaks in the landscape at the periphery of their range where deterrence technologies, concentrated removal efforts, and/or physical barriers can be utilized for containment. Identification and evaluation of containment locations can facilitate the enactment of rapid response plans and the implementation of deterrent and/or removal systems that may limit dispersal, reproduction, or recruitment of Asian carp.

**Strategy 3.3.** Understand habitat utilization of Asian carp in engineered and modified aquatic systems and utilize this information in management efforts (National Goals 3 & 6).

Agencies in control of public lands and waterways should strive to understand the effects of habitat manipulations on Asian carp and native fishes. Habitat manipulations have the potential for undesired effects. For example, some native fishes are adversely affected by migration barriers, or habitat conditions that favor native species may be similar to those preferred by Asian carp. The desirable and undesirable effects of habitat manipulations must be weighed before any such actions are taken and monitored to ensure that they are producing the desired results. A better understanding of the life history of Asian carp in the United States, as outlined in previous goals and strategies, is critical to devising most habitat manipulation strategies. Criteria should be developed based on this research to better inform managers on critical factors when they are reviewing proposals for new habitat manipulations or interbasin water connection projects.

**Goal 4 – Population Management: Eradicate or reduce the abundance of established populations of Asian carp.**

In general, Asian carp populations are managed with the goal of minimizing negative impacts to the ecosystem, economy, and human activities. This goal is achieved through reducing or eliminating Asian carp populations as feasible. Numerous approaches have been identified as having the potential to reduce Asian carp populations and integrated control strategies have been implemented in other basins, providing insights and leading to further development of sustainable and effective technologies. Although very difficult if not impossible to achieve with

current techniques and technologies, the ultimate goal would be to eliminate Asian carp populations from the Missouri River Basin. However, research and development are needed before field implementation of such large-scale endeavors.

**Strategy 4.1.** Assess and develop, as needed, control and removal methods targeting Asian carp that are economically viable and environmentally safe (National Goal 6).

Controlling Asian carp distribution and, where possible, reducing abundances or eliminating unwanted populations requires techniques to eradicate or reduce juveniles and adults. Control methods should be highly efficient at targeting Asian carp without negatively impacting native species and their habitats. As needed, methods and gear should be developed to efficiently reduce existing Asian carp populations, disrupt spawning, eliminate emerging populations, and prevent dispersal.

**Strategy 4.2.** Utilize management approaches to eradicate or reduce to levels of insignificant effect Asian carp populations (National Goals 3 & 4).

Asian carp population reductions to a level of insignificant effect are needed to minimize impacts to native fish populations. This is especially true in areas with high densities or growing populations of Asian carp where impacts to native species may be amplified. Reducing the abundance of established populations of Asian carp may also slow the subsequent spread to new areas. To effectively reduce or eradicate Asian carp populations, a variety of disruptive or capture methods including commercial harvest as well as existing and emerging technologies will likely need to be employed to reduce reproduction and recruitment while simultaneously removing individuals from the system and preventing movements out of or into the invaded areas. Harvest may reduce Asian carp abundance over the near-term; however, over the long-term, harvest may be an important component of an integrated approach to reduce Asian carp numbers to mitigate impacts to aquatic ecosystems. Models will be an important tool for projecting the level of removal needed to have a significant impact on Asian carp populations. Likewise, defining the level of insignificant effect on other organisms is critical to measuring success.

**Strategy 4.3.** Understand hybridization between Bighead and Silver carp and evaluate its impact on Asian carp invasion (National Goal 6).

Hybridization between Bighead and Silver carp has been reported in the greater Mississippi River Basin. However, its impact on Asian carp invasion capability is unknown. Understanding the occurrence and impacts of hybridization in invasive populations of Asian carp in the United States may influence management as well as provide information to China where the decline of these species is a serious concern.

## **Goal 5 – Coordination: Maintain coordination and communication among partners regarding Asian carp management in the Missouri River Basin and beyond.**

A basin-wide, coordinated approach is required to successfully implement this Framework. Numerous groups, including federal, state, and tribal agencies, educational institutions, non-governmental organizations (NGOs), private commercial interests, and the public, have a vested interest in preventing the dispersal and colonization of Asian carp in aquatic ecosystems of the United States. The Missouri River is a sub-basin of the larger Mississippi River Basin. This physical connection requires coordination at the larger basin level. Nationally, much effort and many advances have been made in regards to controlling the spread of Asian carp. Internationally, researchers and governmental agencies in China and elsewhere have expertise regarding Asian carp biology, management, and market development. Implementation of this framework will be most effective when the efforts and strategies of these diverse groups are integrated and coordinated.

### **Strategy 5.1. Develop an implementation program that effectively coordinates, oversees, and drives implementation efforts (National Goal 7).**

Strategies and actions can be developed, but to successfully and efficiently manage and control Asian carp, these plans must be funded adequately, put into action, and effectively sequenced and coordinated. Strategies and actions should be prioritized and implemented in accordance with their strategic importance. Advance planning and coordination are essential for the most efficient use of resources.

### **Strategy 5.2. Coordinate with other regional and national Asian carp management efforts (National Goal 7).**

Formalizing communication and coordination with other regional and national plan implementation structures will reduce redundancy and provide opportunity to exchange ideas. The involvement of diverse stakeholders warrants the development of a defined process for communication and decision-making. This process would establish formal institutional agreements and arrangements. For successful implementation of this plan to prevent further introduction and spread, and to reduce or eradicate feral populations, coordination is paramount.

### **Strategy 5.3. Coordinate with other regional aquatic research and monitoring efforts (National Goal 7).**

Current fisheries research in the Missouri River Basin will continue to contribute information on the presence, abundance, and impacts of Asian carp in the Missouri River Basin. Establishing a communication framework to relay information relevant to the management of Asian carp in the

Missouri River Basin will expedite the transfer of information among projects, investigators, and managers. Efforts should be made to coordinate with other aquatic research taking place in the Missouri River Basin, such as limnology, hydrology, and other related fields that may have impact on or be impacted by the management of Asian carp.

**Goal 6 – Education: Educate the public on how and why to prevent the introduction and spread of Asian carp as well as inform them of current management efforts in the Missouri River Basin.**

It is important to develop and disseminate accurate and consistent science-based information concerning Asian carp. An effective education initiative will provide citizens, industry, and other entities with the information necessary to adopt practices that prevent accidental and deliberate unauthorized releases of Asian carp, thereby minimizing adverse effects of feral populations. This goal must be dynamic to reach and affect the diverse audiences associated with the Missouri River Basin. For greatest effectiveness, each component of the education program should be monitored, evaluated, and managed adaptively to ensure that objectives are being met.

**Strategy 6.1** Develop a campaign that provides accurate information on prevention and impacts of Asian carp (National Goal 5).

A basin-wide campaign that provides consistent messaging will be developed to promote actions that prevent the introduction and spread of Asian carp. Targeted audiences should include impacted communities, industries, researchers, governmental agencies, and others who have been identified as a potential for human-mediated pathways of spread. Where possible, this campaign will be broadened beyond the Missouri River Basin or, at a minimum, provide messaging that is consistent with other regional or national campaigns. The campaign should focus on information about Asian carp biology, impacts, and management as well as best management practices to prevent or minimize further spread of these invasive species. Messaging for the campaign will incorporate current information developed through peer-reviewed scientific research and other credible sources. Best management practices should address a variety of pathways to prevent introductions or spread of Asian carp and also promote ways to minimize the impacts of existing populations. Ideally this information would be consistent with regulations and best management practices developed in Goal 1 of this Framework.

**Strategy 6.2.** Evaluate ecological, recreational, and economic impacts of Asian carp in the Missouri River Basin (National Goal 6).

It is important to understand the impacts that Asian carp have in the Missouri River Basin. Native aquatic species may be impacted by competition for resources, recreational experiences

may be impacted by jumping fish, and all of these items may impact local economies. Understanding these effects will justify control efforts and increase the effectiveness of outreach messaging.

**Strategy 6.3** Engage stakeholders on management actions (National Goal 6).

Throughout the implementation of this Framework, it is important to educate impacted parties of management actions taking place. Public information should be available in appropriate forms, from press releases to public meetings. This is particularly true if management actions could be perceived as controversial, at which time stakeholders should be given an opportunity to provide input. By keeping impacted parties, such as anglers, aquaculture industry, environmental groups, and governmental agencies informed, management actions such as the adoption of regulations are likely to be implemented more quickly and with less hesitancy by the implementing entity. Understanding how management actions may affect impacted parties can also lead to the development of more feasible regulations, easily adopted best management practices, and targeted education materials.

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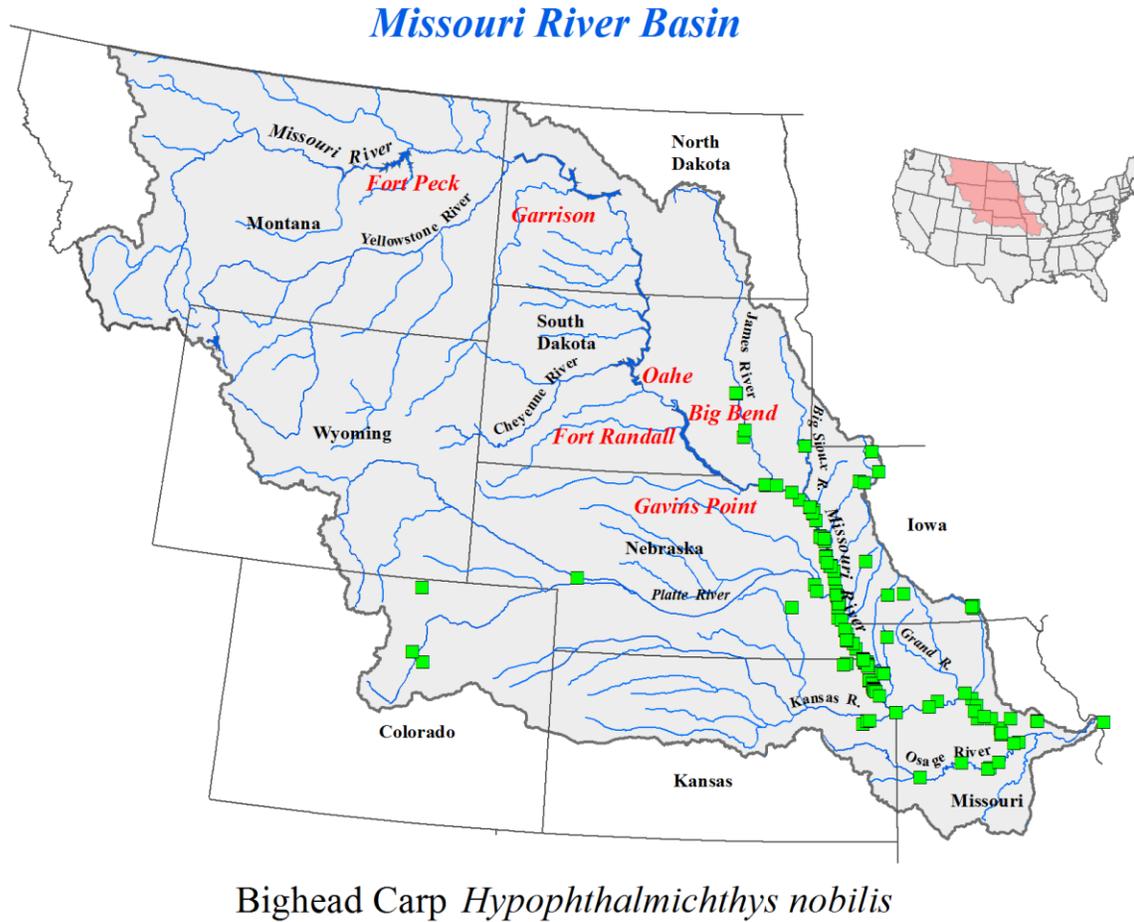
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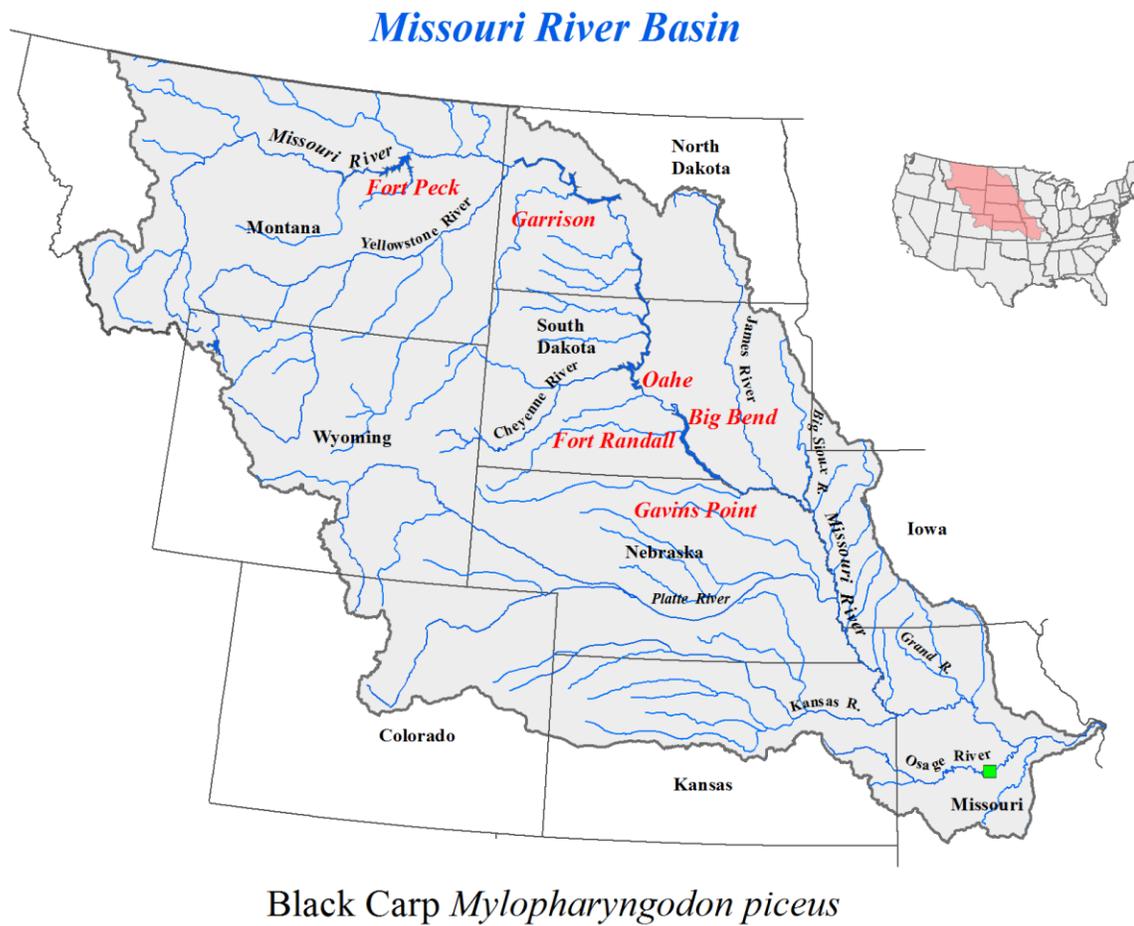
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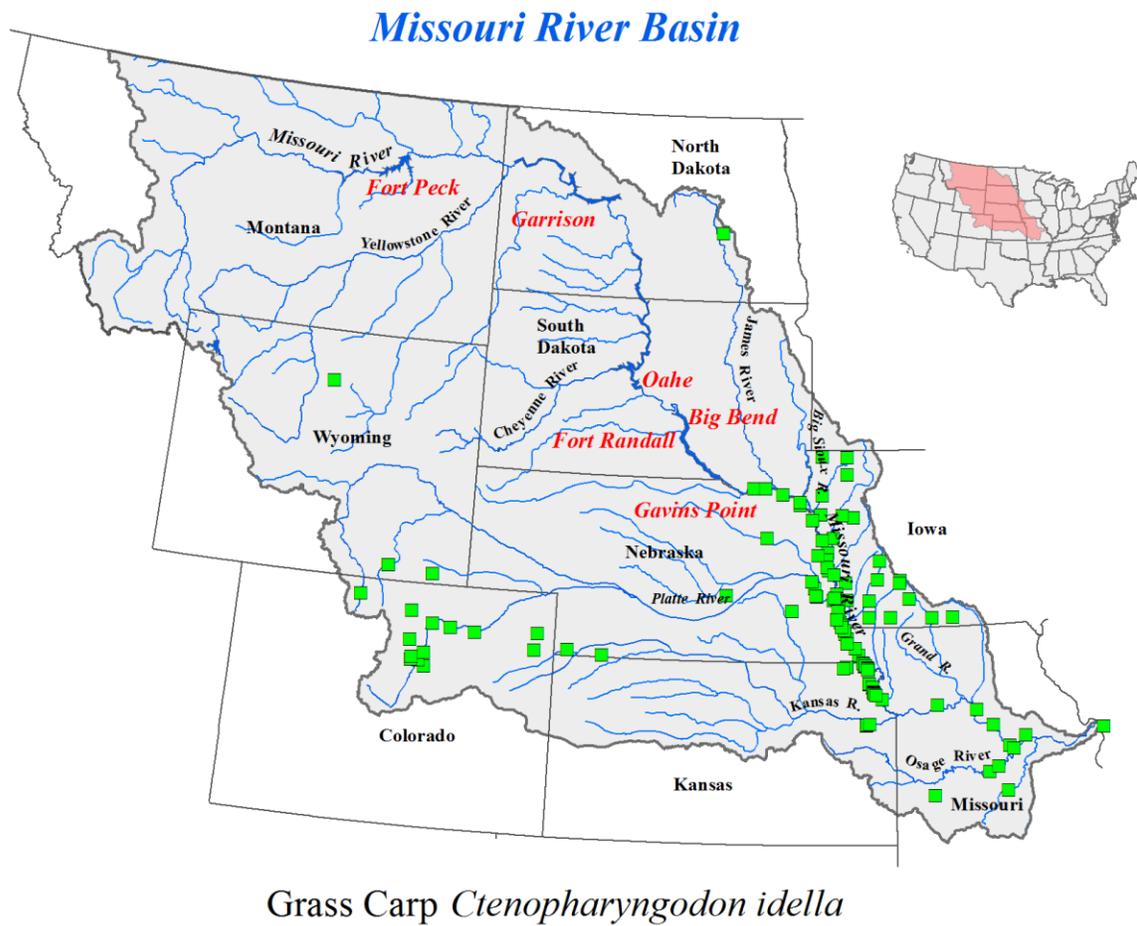
## Appendix A. Distribution Maps



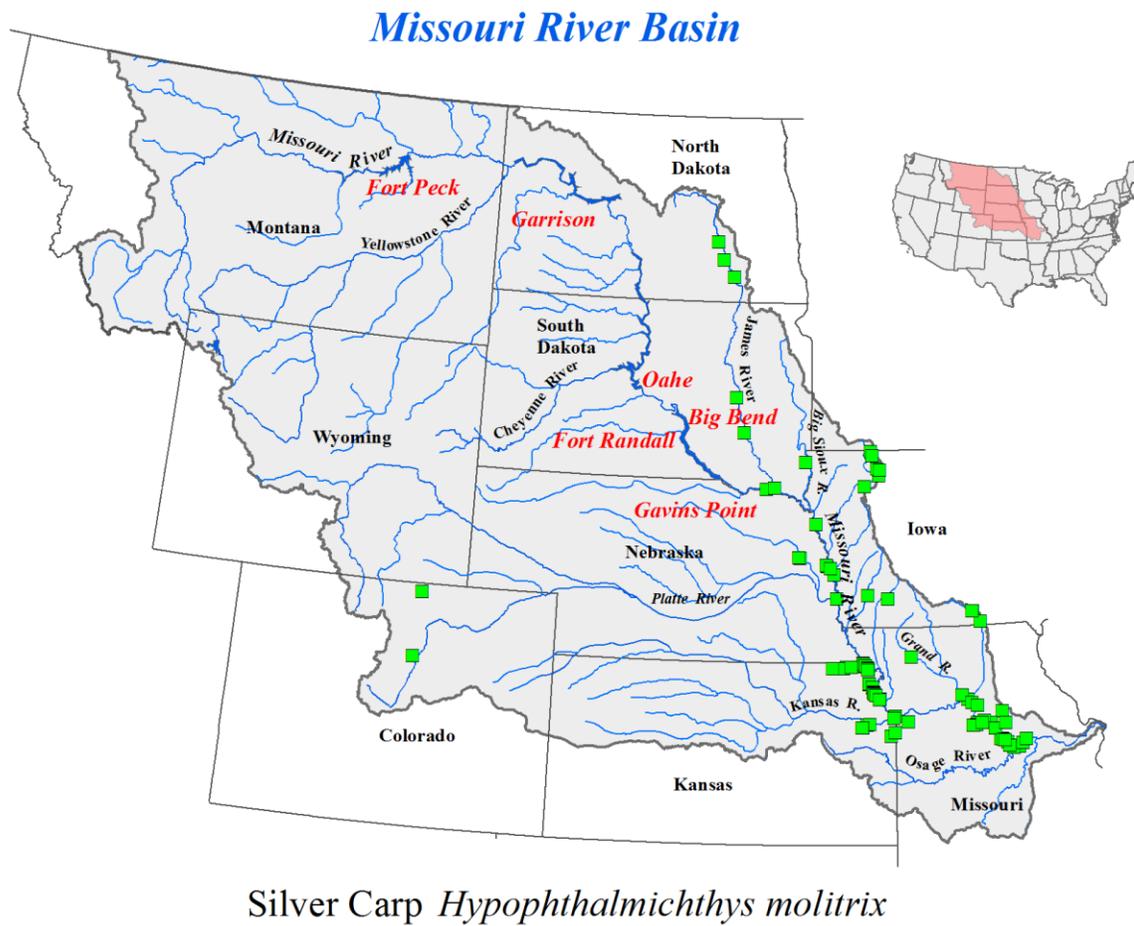
**Figure 2.** Distribution of Bighead Carp *Hypophthalmichthys nobilis* in the Missouri River Basin. Green boxes indicate the presence of Bighead Carp. Major Dams on the mainstem Missouri River are indicated with red text. States and major rivers are indicated with black text. Data source: U.S. Geological Survey, Nonindigenous Aquatic Species Database Program, July 2016.



**Figure 3.** Distribution of Black Carp *Mylopharyngodon piceus* in the Missouri River Basin. Green boxes indicate the presence of Black Carp. Major Dams on the mainstem Missouri River are indicated with red text. States and major rivers are indicated with black text. Data source: U.S. Geological Survey, Nonindigenous Aquatic Species Database Program, July 2016.



**Figure 4.** Distribution of Grass Carp *Ctenopharyngodon idella* in the Missouri River Basin. Green boxes indicate the presence of Grass Carp. Major Dams on the mainstem Missouri River are indicated with red text. States and major rivers are indicated with black text. Data source: U.S. Geological Survey, Nonindigenous Aquatic Species Database Program, July 2016.



**Figure 5.** Distribution of Silver Carp *Hypophthalmichthys molitrix* in the Missouri River Basin. Green boxes indicate the presence of Silver Carp. Major Dams on the mainstem Missouri River are indicated with red text. States and major rivers are indicated with black text. Data source: U.S. Geological Survey, Nonindigenous Aquatic Species Database Program, July 2016.

## Appendix B. Summary of Missouri River Asian Carp Control Strategy Framework Goals and Strategies.

**Table 1.** Summary of goals and strategies for the management and control of Asian carp in the Missouri River Basin with corresponding goals from the National Plan (Conover et al. 2007).

Missouri River Basin Strategies	Corresponding National Plan Goals
<b>Goal 1 – Prevention</b>	
<b>Prevent the introduction and further spread of Asian carp into and within the Missouri River Basin.</b>	
<b>Strategy 1.1.</b> Assess human-mediated pathway risks for Asian carp introductions.	<b>Goal 1:</b> Prevent accidental and deliberate unauthorized introductions of bighead, black, grass, and silver carps in the United States.
<b>Strategy 1.2.</b> Develop best management practices for preventing Asian carp introductions and spread and for minimizing impacts of established populations.	<b>Goal 6:</b> 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.
<b>Strategy 1.3.</b> Identify locations and implement efforts to prevent Asian carp expansion where feasible.	<b>Goal 2:</b> Contain and control the expansion of feral populations of bighead, black, grass, and silver carps in the United States.
<b>Strategy 1.4.</b> Evaluate habitat suitability and assess risk of establishing a population.	<b>Goal 6:</b> 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.
<b>Goal 2 – Early Detection and Monitoring</b>	
<b>Define Asian carp populations in the Missouri River Basin and assess their response to management actions.</b>	
<b>Strategy 2.1.</b> Develop and implement a monitoring plan to assess distribution and population dynamics of Asian carp in the Missouri River Basin	<b>Goal 6.</b> Conduct research to provide accurate and scientifically valid information necessary for the effective management and control of Bighead, Black, Grass, and Silver carp in the United States.
<b>Strategy 2.2.</b> Utilize current and emerging technologies to define population variables that guide management and control of Asian carp.	

Missouri River Basin Asian Carp Control Strategy Framework

Missouri River Basin Strategies	Corresponding National Plan Goals
<p><b>Strategy 2.3.</b> Encourage reporting of Asian carp in locations where they are not known to be established.</p>	<p><b>Goal 1.</b> Prevent accidental and deliberate unauthorized introductions of bighead, black, grass, and silver carps in the United States.</p>
<p><b>Strategy 2.4.</b> Integrate Missouri River Basin susceptibility with Asian carp habitat preferences to develop management actions.</p>	<p><b>Goal 3.</b> Extirpate, or reduce to levels of insignificant effect, feral populations of bighead, black, grass, and silver carps in the United States.</p>
<p><b>Strategy 2.5.</b> Identify and evaluate techniques and protocols to detect Asian carp and monitor populations.</p>	<p><b>Goal 6:</b> 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.</p>
<p><b>Goal 3 – Containment</b></p> <p><b>Contain the expansion of Asian carp populations in the Missouri River Basin.</b></p>	
<p><b>Strategy 3.1.</b> Develop Rapid Response Plan for the Missouri River Basin</p>	<p><b>Goal 2:</b> Contain and control the expansion of feral populations of bighead, black, grass, and silver carps in the United States.</p>
<p><b>Strategy 3.2.</b> Identify containment opportunities and implement efforts to control Asian carp expansion where feasible.</p>	<p><b>Goal 3.</b> Extirpate, or reduce to levels of insignificant effect, feral populations of bighead, black, grass, and silver carps in the United States.</p>
<p><b>Strategy 3.3.</b> Understand habitat utilization of Asian carp in engineered and modified aquatic systems and utilize this information in management efforts.</p>	<p><b>Goal 6:</b> 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.</p>

Missouri River Basin Strategies	Corresponding National Plan Goals
<b>Goal 4 – Population Management</b>	
<b>Eradicate or reduce the abundance of established populations of Asian carp.</b>	
<p><b>Strategy 4.1.</b> Assess and develop, as needed, control and removal methods targeting Asian carp that are economically viable and environmentally safe.</p>	<p><b>Goal 6:</b> 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.</p>
<p><b>Strategy 4.2.</b> Utilize management approaches to eradicate or reduce to levels of insignificant effect Asian carp populations.</p>	<p><b>Goal 3.</b> Extirpate, or reduce to levels of insignificant effect, feral populations of bighead, black, grass, and silver carps in the United States.</p>
<p><b>Strategy 4.3.</b> Understand hybridization between Bighead and Silver carp and evaluate its impact on Asian carp invasion.</p>	<p><b>Goal 4:</b> Minimize potential adverse effects of feral bighead, black, grass, and silver carps in the United States.</p>
<b>Goal 5 – Coordination</b>	
<b>Maintain coordination and communication among partners regarding Asian carp management in the Missouri River Basin and beyond.</b>	
<p><b>Strategy 5.1</b> Develop an implementation program that effectively coordinates, oversees, and drives implementation efforts.</p>	<p><b>Goal 7:</b> Effectively plan, implement, and evaluate management and control efforts for bighead, black, grass, and silver carps in the United States.</p>
<p><b>Strategy 5.2.</b> Coordinate with other regional and national Asian carp management efforts.</p>	
<p><b>Strategy 5.3.</b> Coordinate with other regional aquatic research and monitoring efforts.</p>	

Missouri River Basin Strategies	Corresponding National Plan Goals
<b>Goal 6 – Education</b>	
<b>Educate the public on how and why to prevent the introduction and spread of Asian carp as well as inform them of current management efforts in the Missouri River Basin.</b>	
<b>Strategy 6.1.</b> Develop a campaign that provides accurate information on prevention and impacts of Asian carp.	<b>Goal 5:</b> 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.
<b>Strategy 6.2.</b> Evaluate ecological, recreational, and economic impacts of Asian carp in the Missouri River Basin.	<b>Goal 6:</b> 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.
<b>Strategy 6.3.</b> Engage stakeholders on management actions.	<b>Goal 5:</b> 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.

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