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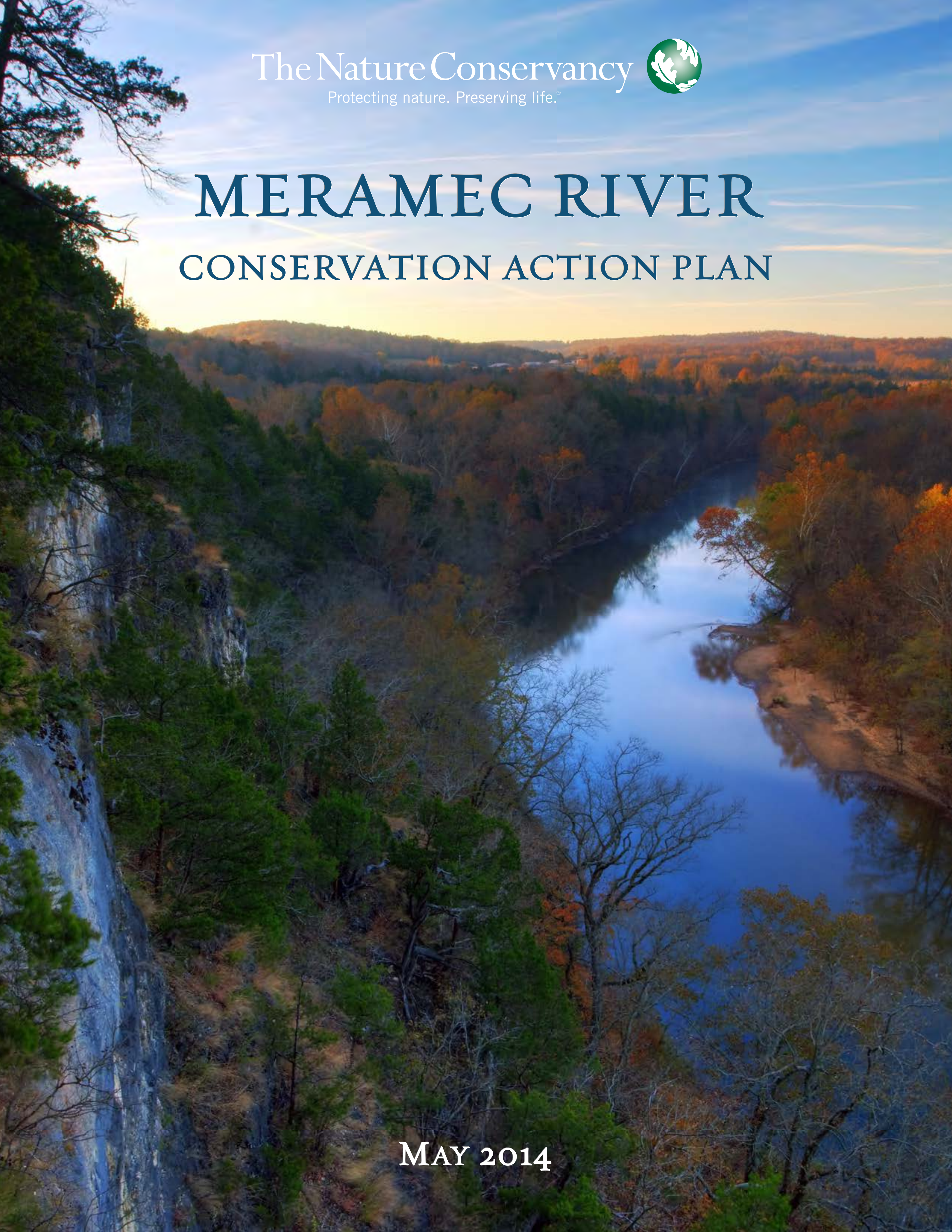
MERAMEC RIVER

CONSERVATION ACTION PLAN



May 2014

ACKNOWLEDGEMENTS

This plan would not have been possible without the time, input, data, and material contributions of numerous individuals and organizations. We would like to thank in particular Rob Pulliam and Kevin Meneau of the Missouri Department of Conservation, Abigail Lambert of Ozark Regional Land Trust, Ron Coleman and Brittany Barton of Open Space Council, Rob Jacobson of the U.S. Geological Survey, Bob Pavlowsky of Missouri State University, Dave Wilson of the East-West Gateway Council of Governments, and the many people who participated in workshops and meetings over the past years. Funding for this project was provided by Crystal Light through a “Collaboration for U.S. Freshwater Sustainability” grant. Support was also provided by The Boeing Company Charitable Trust and the Employees Community Fund of Boeing St. Louis. Finally, we would like to acknowledge the individuals who reviewed this plan and provided valuable comments.

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Conservation Federation of Missouri
East-West Gateway Council of Governments
Friends of LaBarque Creek
Great Rivers Greenway
Kayak Swarm
Meramec Regional Planning Commission
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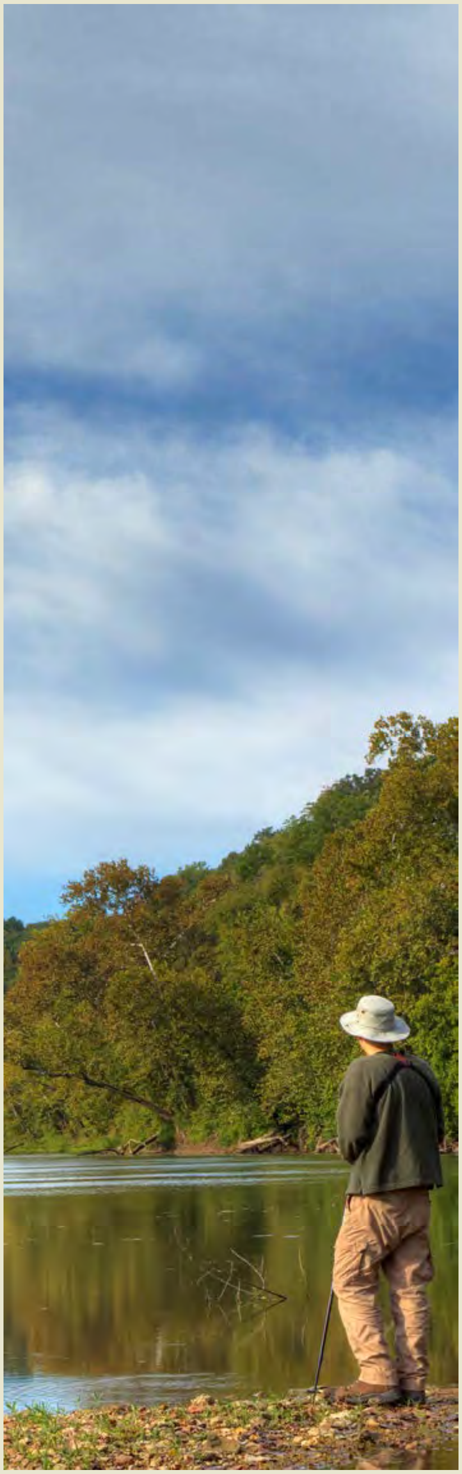
Meramec River overlook. © Bill Duncan

EXECUTIVE SUMMARY



Man overlooking the Meramec River. © Bill Duncan

The Meramec River flows over 200 miles northeast from the Ozarks in east-central Missouri to its confluence with the Mississippi River south of St. Louis. It is among the most biologically significant river basins in mid-continental North America, with diverse and rare aquatic and terrestrial plants, animals, and natural communities. The Meramec and its tributaries also provide important economic and social benefits to the region, including a productive fishery, significant tourism and recreational use and associated economic inputs, and drinking water supplies. Although considered in relatively good health, a number of problems and activities degrade aquatic habitats and fish and wildlife resources throughout the basin. Fortunately, the Meramec and its tributaries have benefitted from decades of conservation actions from a variety of conservation, planning, and environmental organizations and agencies.

The **Meramec River Conservation Action Plan** is the culmination of nearly four years of collaboration among 29 conservation stakeholders to develop a unified blueprint for ensuring the sustainability of aquatic resources in the Meramec River Basin. Developed using The Nature Conservancy's Conservation Action Planning Process, this plan comprehensively identifies and prioritizes target resources for conservation, the current health and problems affecting those resources, the source of the problems, and the best actions maximizing the benefit and long-term protection, restoration, and conservation of the Meramec River and its aquatic resources.

Eight conservation targets were selected to best capture the biodiversity and ecological processes of aquatic resources of the Meramec River Basin. The Lower Meramec River Drainage, Middle Meramec River Drainage, Upper Meramec River Drainage, Bourbeuse River Drainage, Big River Drainage, Huzzah and Courtois Creek Drainages, and LaBarque Creek Drainage were aquatic ecosystem targets, for which actions in those watersheds will ensure the conservation of all associated native biodiversity therein. Freshwater Mussels were designated as a separate target given their unique ecological vulnerabilities and special conservation needs.

Viability, or health, rankings for the targets in varied from "Poor" to "Very Good", with an overall rank of "Fair" for the Meramec River Basin. The Lower Meramec River was ranked "Poor" primarily due to the relatively widespread effects of urbanization on stream function throughout much of the lower river. The Middle and Upper Meramec were ranked "Good", reflecting relatively unimpaired floodplain connectivity and hydrology, though land floodplain conversion from agricultural practices are a concern. The Bourbeuse River was ranked "Fair" because of the high concentration of livestock farming and ranching throughout its tributaries and main stem floodplain, though its hydrology is minimally impaired and it supports a good sport fishery. Despite also having a good sport fishery and relatively unaltered hydrology and floodplain connectivity, the Big River was ranked "Fair" due to the presence of several main stem dams and the serious historical and current impacts to ecosystem function from heavy metal contamination. The Huzzah and Courtois Creek and LaBarque Creek drainages were the healthiest targets in the basin, being ranked "Very Good" for excellent hydrology, in-stream and floodplain connectivity, riparian corridor condition, and diverse biological communities. Freshwater mussels were ranked "Fair", reflecting recent patterns of biodiversity and population declines throughout the Meramec River Basin.

A variety of problems – or stresses – stemming from multiple sources – or threats – impair targets in the Meramec River Basin. Twelve stresses were identified as degrading targets in the basin, with Excessive Suspended & Bedded Sediments, Altered Floodplains &

Wetlands, Altered Riparian Corridor, and Contaminated Sediments being the most problematic. The first three stresses are interrelated and widespread throughout the basin, with streambank erosion as a potentially significant factor contributing excessive sedimentation in the Meramec River and its tributaries. Although geographically narrow in scope, Contaminated Sediments was also highly ranked because of its severe impacts when present and potential to degrade multiple targets, particularly those within or downstream of the Big River. Thirteen threats were identified as being the sources of the stresses degrading the targets. The six highest-ranked, or critical, threats were Livestock Farming & Ranching, Housing & Urban Areas, Mine Tailings & Industrial Effluents, In-Stream Gravel Mining & Reaming, Dams & Water Management, and Transportation, Utility, & Service Corridors. Livestock Farming & Ranching was the most widespread threat across the targets, reflecting the historical and current agricultural footprint within the river and tributary floodplains responsible for multiple stresses degrading targets. Housing & Urban Areas severely alters stream function in the St. Louis area is thus of particular concern to the Lower Meramec River, as well as the Big River, and Freshwater Mussel targets. Mine Tailings & Industrial Effluents from historical and current heavy metal mining in the Ozarks are the primary source of the Contaminated Sediments that most strongly affect the Big River. In-Stream Gravel Mining & Reaming and Dams & Water Management threats degrade targets in multiple ways, though the extent of their impact in the basin is poorly understood. Transportation, Utility, & Service Corridors are also widespread and impact targets in multiple ways. A situation analysis identified the root causes the critical threats, as well as conditions and stakeholders that could ameliorate their effects across the Meramec River Basin.

We extracted over 400 goals, objectives, and strategies, as well as research and data needs, from over 40 conservation plans, policies, and publications and for conserving aquatic resources in the Meramec River Basin. These were synthesized into 87 unified objectives to serve as a template for future conservation planning for this as well as other river basins. The planning team further refined these to 12 objectives and 14 strategic actions for addressing critical threats in the Meramec River Basin. Strategies were prioritized by ranking several factors relevant to how that action can best achieve objectives for targets, including stresses addressed, duration of outcome, ease of implementation, and costs. These strategies represent the first iteration of objective and strategy development across stakeholders in the basin, and future planning efforts are needed to further refine objectives and strategies. In addition to refining strategies, the next steps for implementing the Meramec River Conservation Action Plan include defining research for better understanding target viability and measuring results of conservation actions. In addition, the conservation partners should develop a work plan for implementing the highest-priority strategies, including the specific tasks that need to be completed and the monitoring tasks necessary for the project.

Suggested Citation:
The Nature Conservancy. 2014. Meramec River Conservation Action Plan. The Nature Conservancy, Missouri Chapter, St. Louis, MO.

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Meramec River. © Bill Duncan

INTRODUCTION

The vision of the Meramec River Conservation Action Plan is to ensure sustainability of aquatic resources in the Meramec River Basin.

The 10-step CAP Process includes:

- Identifying People Involved in the Project
- Defining the Project Scope and Focal Conservation Targets
- Assessing the Viability of Focal Conservation Targets
- Identifying Critical Stresses and Threats
- Completing a Situational Analysis
- Developing Strategies for Conservation
- Measuring Results
- Developing a Work Plan
- Implementing Actions and Measures
- Analyzing and Learning from Results, Adapting, and Sharing Findings

The Meramec River Basin is among the most biologically significant river systems in mid-continental North America, Basin, supporting 31 species of global significance, including several species found nowhere else on Earth (TNC OEAT 2003; Nigh and Sowa 2005; Sowa et al. 2005). Located in east central Missouri and flowing from the Ozarks into the Mississippi River south of St. Louis, the river is beloved as a favorite destination for floating, boating, fishing, and swimming (EWG 2012). It also provides important economic resources for local communities and supplies drinking water to approximately 340,000 households (A. Dettmer, Missouri American Water, personal communication). Although still considered in relatively good health (MDC 1998), impacts from agriculture, housing and urban development, and other activities have increasingly resulted in habitat degradation and loss of fish and wildlife resources, and in turn affect local economies which are closely tied to the condition of water resources in the basin.

Conservation Management and Partnerships

The Meramec River and its tributaries have been identified and/or managed as a conservation priority for decades via a wide range of activities by both public and private entities throughout the basin. In the late 1990's, the Missouri Department of Conservation (MDC) developed the first formal conservation assessments and management plans for the Meramec, Big, and Bourbeuse rivers (MDC 1997, 1998, 1999). These plans provided detailed, comprehensive information on geology, hydrology, land use, water quality, pollution, habitat conditions, biodiversity, and conservation strategies that still serve as primer for these basins. These were followed by other planning efforts by NGO's such as the Trust for Public Land, Open Space Council for the St. Louis Region, and East-West Gateway Council of Governments that focused primarily on conservation of the lower Meramec River and its tributaries (EWG 2007; TPL and OSC 2009; TPL 2010; EWG 2012). Other conservation and planning documents relevant to basin resources include planning and collaborations with the U.S. Forest Service (MTNF 2005; TPL 2010) and Missouri Department of Nature Resources (EWG 2012). There are also many best management practice guidelines (e.g., MDC 2000a – 2000h) and conservation plans for state-, federally, and regionally imperiled species (Briggler et al. 2007; USFWS 2010; FR 2012) that occur in the Meramec River Basin. Management activities have included expanding public or private parks, reserves, and other protected areas; establishing protection or easements of public or private lands; management of protected areas and other resource lands for conservation; controlling and/or preventing invasive species; restoring and/or enhancing habitats and ecosystem function; managing, enhancing, and/or restoring species populations of concern; repatriating species; raising conservation awareness through formal education, trainings, and outreach; advocating conservation-based legislation, policies, regulations, and voluntary standards (per CMP 2014; see "Taking Action to Conserve the Meramec River").

These efforts have produced significant conservation benefits; however, there had been no assessment that summarized these previous efforts into a comprehensive conservation plan for defining current condition, future threats, and prioritized actions for best protecting, restoring, and conserving aquatic resources across the entire river basin. From 2010-2013, The Nature Conservancy conducted four conservation planning workshops with representatives from 28 conservation organizations, subject area experts, and basin residents to develop this comprehensive Conservation Action Plan for the Meramec River Basin. A list of partners and participating organizations that provided input essential for developing this plan can be found in the Acknowledgments and sidebars of this document.

Conservation Planning

This **Meramec River Conservation Action Plan** was completed using The Nature Conservancy's "Conservation Action Planning (CAP)" process (TNC 2007). Conservation Action Planning uses an adaptive management framework to help practitioners focus natural resource conservation strategies on clearly defined elements of biodiversity/conservation targets and the threats to these targets, and to measure their success in a manner that enables them to adapt and learn over time (TNC 2007). The CAP is supported by a Microsoft Excel-based planning software program that uses inputs and rankings provided by practitioners to organize this information, and importantly, prioritize key elements of the plan so that strategies best address the most pressing problems while providing the maximum possible conservation benefit to biodiversity and targets in the plan (TNC 2010). In combination, the CAP provides a powerful, science-based design, management, and measurement tool for natural resource conservation that is used by conservation practitioners worldwide (CMP 2014).

The CAP uses a 10-step process for defining the conservation project, developing strategies and measures, implementing strategies and measures, and using results to adapt and improve conservation outcomes (TNC 2007). This document follows these steps and includes a brief description of methods, definitions, and results developed for the Meramec River Conservation Action Plan. Conservation Action Planning is supported and freely distributed by TNC. For detailed information about Conservation Action Planning, see http://www.conservationgateway.org/ConservationPlanning/ActionPlanning/Pages/conservation-action-plann.aspx and the references cited herein.

Project Scope and Vision

The purpose of this plan is to consolidate and summarize decades of work by stakeholders into a unified conservation plan for aquatic resources in the Meramec River Basin. The **project scope** includes all rivers, streams, creeks, and associated riparian and floodplain habitats of the Meramec River Basin, which encompasses the range of connected environments used by aquatic species and communities and threats affecting those ecosystems. The **project vision** is to ensure sustainability of aquatic resources in the Meramec River Basin. The Meramec River Conservation Action Plan provides a comprehensive blueprint for achieving this vision by consolidating existing management plans, research, and expert input to help focus the conservation actions of all stakeholders on clearly defined elements of biodiversity and fully articulated threats to these resources, and implementing the most effective strategies for long-term conservation.

This plan uses a **10-year timeframe (2014–2024)** for defining current conditions and forecast rankings for viability, stresses, threats, and strategies. For example, the threat of "Housing and Urban Development" was ranked "Very High" for the Lower Meramec River Drainage target (see "Factors Degrading Meramec River Targets"), reflecting expert judgment that this threat will greatly impact the target by the year 2024. This forecasting is important in that it allows conservation partners to predict trends that, while perhaps not impacting targets much at present, may (or may not) be important issues in the future.

Description of the Study Area

The physical, biological, and cultural resources of the Meramec River Basin have been well-documented elsewhere; specific references for source information are provided in this section and throughout the document and should serve as the main source for detailed information. The following is a brief summary from these references as it relates to the project scope.

Location and Basin Characteristics

The Meramec River Basin drains approximately 3,963 square miles of east central Missouri (MDC 1997, 1998, 1999; Sowa et al. 2005). It originates near Salem, flowing approximately 218 miles northeast to its confluence with the Mississippi River south of St. Louis (MDC 1998). Missouri counties primarily drained by the Meramec River watershed include Dent, Phelps, Crawford, Franklin, Jefferson, and St. Louis. Other counties also drained include Maries, Gasconade, Iron, Washington, Reynolds, St. Francois, St. Genevieve, and Texas. The Big River and Bourbeuse River are its largest tributaries. Other notable tributaries include Dry Fork Creek, Crooked Creek, Huzzah Creek, Courtois Creek, Indian Creek, and Little Meramec River. There are approximately 6,575 miles of primary channel streams within the basin, of which approximately 1,850 miles are classified as perennial (Sowa et al. 2005). There are no dams on the main stem of the Meramec River, though there are two and six dams on the main stems of the Bourbeuse and Big rivers, respectively, and numerous dams on headwater tributaries throughout the basin (MDC 1997, 1999; MDNR 2014).

Ecoregional Information: Physiography, Topography, and Soils

The Meramec River Basin lies entirely within the Salem Plateau and St. Francois Mountains in the northeast corner of the Ozarks Highlands Ecological Subregion of the U.S. (hereafter "Ozarks"; Nigh and Schroeder 2002). Parts of the Ozarks are among the oldest continuously exposed regions in the world, having been an exposed and unglaciated land surface since the end of the Paleozoic Era (at least 250 million years ago; TNC OEAT 2005). Ecological Subsections within the Ozarks which occur within the basin include the Central Plateau, Meramec River Hills, and the St. Francois Knobs and Basins (see Nigh and Schroeder 2002 for details). The basin is generally characterized by an underlying core of Precambrian igneous rocks overlain by nearly flat-lying Paleozoic sedimentary rocks dominated by cherty limestone and dolomite from the Cambrian, Ordovician, and Mississippian age (Nigh and Schroeder 2002; Sowa et al. 2005). Soils are typically shallow and generally considered poor and unsuitable for agriculture except within the floodplains of rivers and streams (MDC 1998; Sowa et al 2005). Topography within the basin is highly variable ranging from very steep in those areas bordering major streams to nearly level along many of the drainage divides (Sowa et al. 2005).

Stream Function

Hydrology and Hydraulics - Flows of rivers and streams the Meramec River Basin are generally comprised of a combination of surface runoff and groundwater inputs, resulting in relatively stable flows compared to surface runoff only drainages (Sowa et al. 2005). However, the combination of shallow soils and steep terrains can result in extraordinarily high peak flows from surface runoff during intense rainfall events (Sowa et al. 2005). Because of the high solubility of limestone and dolomite, a substantial karst system has developed in the basin, with numerous caves, sinkholes, springs, and losing streams that influence groundwater discharge into stream channels (MDC 1998; Sowa et al. 2005). Conversion of watersheds and springsheds due to urbanization and agriculture and silviculture can alter the natural flow regime of affected systems (Schueler et al. 2009; Richter et al. 2011).

Geomorphology - Stream geomorphology in the Meramec River Basin is variable and strongly influenced by watershed position, valley constraints, underlying hydrology, and human impacts (Sowa et al 2005). Headwaters typically have shallow valleys with steep gradients, resulting in low-sinuosity reaches characterized by short pools and well-defined riffles with substrates comprised of gravel, cobble, boulder, and bedrock (Sowa et al 2005). Larger streams have progressively deeper valleys and lower gradients than headwaters, resulting in more sinuous reaches with riffles comprised of gravel and cobble and deeper pools of detritus, sand, and silt in addition to coarser substrates (Sowa et al. 2005). Gravel bar development is common in these reaches, as are extensive stretches of exposed bedrock when channels are near to valley walls (Sowa et al. 2005)). Small- and large-rivers have the deepest valleys and lowest gradients, resulting in moderately to highly sinuous reaches with gravel riffles, long and deep pools of sand, silt, and detritus, and well-developed floodplains (Sowa et al. 2005).

Physiochemical - Water quality is influenced by climate, topography, geology, soils, and human impacts in the Meramec River Basin. Rivers and streams are typically clear with dissolved calcium magnesium bicarbonate given the prevalence of dolomite bedrock (Sowa et al. 2005). Temperatures are generally cool due to groundwater inputs but can vary based on stream size, surface flow to groundwater ratio, time of year, vegetated canopy, and human impacts (e.g., dams and impoundments; MDC 1997, 1998, 1999; Sowa et al. 2005). Nutrient (Phosphorus and Nitrogen) concentrations in streams with largely forested watersheds are among of the lowest in the Nation, whereas concentrations in streams draining agricultural and urban lands are some of the highest (Sowa et al. 2005). Pesticide and other organic compound concentrations are generally low, whereas concentrations of volatile organic compounds in bed sediments downstream from urban areas can be high (Sowa et al. 2005). Concentrations of lead and other heavy metals in mining current and historical mining areas such as the Big River Sub-basin are also higher than many other regions nationwide (Sowa et al. 2005; Pavlowsky et al. 2010; NRDAR 2013).

Climate
The Meramec River Basin has a mean annual temperature of 55° F, with mean January minimum temperatures of 16° F and mean July maximum temperatures of 90° F (Sowa et al. 2005). Mean annual precipitation is approximately 40 inches (Sowa et al. 2005). Precipitation is generally highest in the late spring to early fall, with winter mean monthly averages of 2–3 inches and mean spring and summer monthly averages of 3–5 inches, with a noticeable decrease in precipitation during late July and August. Estimated mean annual evapotranspiration is 30–35 inches/year (Sowa et al. 2005).

Vegetation
Oak and pine woodlands and some savannahs and prairies characterized pre-European settlement vegetation of uplands and valley slopes in the Meramec River Basin. Valley bottoms and floodplains during this period were typically deciduous woodlands, characterized by sycamore, cottonwood, maple, black walnut, butternut, hackberry, popular, and bur oaks (Jacobson and Primm 1997). In the pre-"timber-boom" period (early 1800's–1880), valley bottoms and floodplains were converted for livestock grazing with some cultivated crops, and fire suppression in upland lands and valley slopes converted many savannah and prairie areas to woodlands (Jacobson and Primm 1997). During the timber boom period (1880–1920), significant portions of watersheds were cleared of oak and pine for commercial timber operations (Jacobson and Primm 1997). During the post-Timber-boom period (1920–1960), previously cleared upland lands and valley slopes were often frequently burned and valley bottoms and floodplain areas were further converted for livestock grazing with some cultivated crops. Since the 1960's, uplands and valley slopes have been characterized by oak forests that are still logged, overgrown woodlands due to fire suppression, and relict savannahs and prairies (D. Ladd, TNC, personal communication). Valley bottoms and floodplains have increased livestock farming with fescue-dominated pastures and only sporadic cultivated croplands (MDC 1997, 1998, 1999). Land use changes since the 1800's have substantially reduced, degraded, and/or destroyed riparian corridor vegetation across these periods, though some affected areas have revegetated corridors (Jacobson and Primm 1997).

Biodiversity
The Meramec River Basin is notable for regionally high aquatic biodiversity, including numerous rare, sensitive, and state- and federally protected species and communities. There are 292 aquatic or aquatic- dependent species recorded from the basin, including plants (68 spp.), freshwater mussels (46 spp.), insects (19 spp.), crayfishes (8 spp.) and other crustacea (3 spp.), fishes (128 spp.), amphibians and reptiles (8 spp.), birds (4 spp.), and mammals (7 spp.; Nigh and Sowa 2002; Appendix A). According to the Missouri Natural Heritage Program there are 15 globally listed (rare, threatened, or endangered) species and 37 state-listed species (MDC 2014). The distinctiveness of the fish assemblage is in the unique combination of species that also occur in neighboring drainages to the west and south (Nigh and Sowa 2005). Except for the Meramec saddled darter, recognized in 2009 as the river's first and only endemic fish (Switzer and Wood 2009), there are no fish species restricted to the Meramec River Basin. Common and distinctive fish species include silverjaw minnow, striped shiner, steelcolor shiner, rainbow darter, river darter, and logperch (Nigh and Sowa 2002). Distinctive mussel species include the giant floater, fatmucket, northern brokenray, Ouachita kidneyshell, and the pondmussel. Smallmouth bass and sunfishes comprise a good sport fishery in the Meramec, Big, and Bourbeuse rivers (MDC 1997, 1998, 1999). Crayfishes include the belted, devil, freckled, spothanded, saddlebacked, and woodland crayfish (Nigh and Sowa 2002). Of the 177 fish, mussel, and crayfish species present in the basin, 103 are considered target species by the MDC (73 fish, 24 mussels, and 6 crayfish; see Nigh and Sowa 2002 for details). There are 33 natural communities (aquatic and terrestrial) found within the Meramec River Basin (MDC 1997, 1998, 1999, 2014; Nelson 2010; Appendix B).

Land and Water Use
Jacobson and Primm (1997) conducted a thorough review of historical land use impacts in

Washboard mussel. © Steve Herrington/TNC

Hine's emerald dragonfly. © USFWS

Virile crayfish. © Chris Lukhaup/MDC

Orangethroat darter. © L.R. Merry/MDC

the Ozarks and concluded that Ozark rivers and streams have been significantly disturbed and aggraded by substantial quantities of gravel resulting from land use since post-European settlement (see "Vegetation" above for a general description of activities). In general, land use accelerated erosion of upland areas, valley slopes, floodplains, and riparian corridors. This resulted in high levels of sediment deposition in stream channels, which in combination caused stream head-cutting, sedimentation of pools, channel widening, loss of in-stream habitat and floodplain connectivity, and other channel disturbances. This legacy of excessive sediment, particularly bedload – comprised of sand, gravel, cobble, and other sediments that deposit on the bottom of the channel – is still believed to be present and slowly moving downstream through the Meramec and other Ozark rivers. The authors concluded that present-day trends towards increased livestock grazing could continue the historical stream channel disturbance impacts by increasing runoff and sediment supply, a pattern presently observed by natural resource managers in the Meramec River Basin.

Meramec River Basin land cover currently consists of approximately one-half forest, one-quarter pasture, and one-quarter cropland, rural transportation, urban development, water, and other minor land uses combined (MDC 1997, 1998, 1999). There has been a general trend of increasing urbanization in and around existing cities in the basin, particularly in the greater St. Louis area (FLBC 2008; EWG 2012). There has also been a trend of increasing livestock grazing in valley bottoms and floodplain (MDC 1998, 1999). Timber operations continue to be an important land use on both public and private forested lands throughout the basin (MDC 1997, 1998, 1999). Portions of the Meramec River Basin, particularly the Big River Sub-basin, are among the largest historical and present-day lead production areas in the nation (MDC 1997). Unfortunately, heavy-metal mining and resulting contamination has polluted thousands of acres of terrestrial habitat and hundreds of miles of streams in the Meramec and other river basin in the southeast Missouri Ozarks (Pavlowsky et al. 2010; NRDAR 2013). In-stream mining for sand and gravel is also a significant historical and present-day use, with over 100 permitted operations and numerous unpermitted sites distributed throughout the basin. The Meramec River is an important municipal and industrial source of water for urban, suburban, and rural areas, providing drinking water for over 340,000 households in the St. Louis area alone (A. Dettmer, Missouri American Water, personal communication). There are over 450,000 acres (approximately 703 mi^2, or 17% of the basin) of public and private conservation lands and river access and recreation areas in the Meramec River Basin, including the U.S. Forest Service's Mark Twain National Forest and numerous properties owned and managed by the Missouri departments of Conservation and Natural Resources, counties, and cities (MDC 1997, 1998, 1999). The Meramec and its tributaries are also highly prized and heavily utilized for sport fishing, paddling, and floating, particularly the upper Meramec River and the Huzzah and Courtois creeks, and are an important economic driver for local communities and St. Louisans alike.

Meramec River planning meeting. © Kristen Blann/TNC

Paddlefish. © Steve Herrington/TNC

Eastern hellbender. © Brian Gratwicke/USFWS

Indiana bats. © USFWS

Smallmouth bass fishing is an important recreational activity in the basin. © MDC

CONSERVATION TARGETS FOR THE MERAMEC RIVER

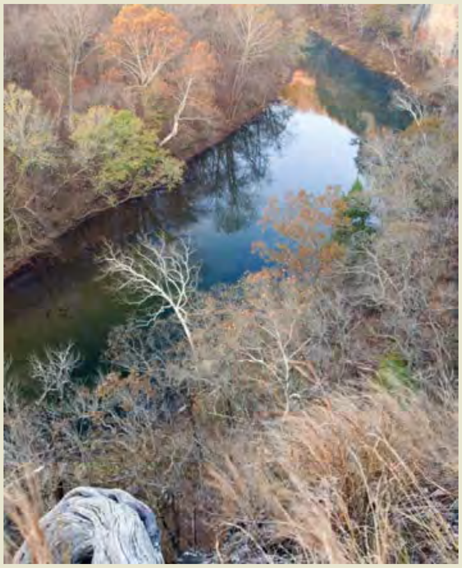
Conservation Targets (hereafter **Targets**) are ecological systems, ecological communities, or species that represent and encompass the biodiversity found in the project area. They are the basis for setting goals, carrying out conservation actions, and measuring conservation effectiveness. In theory, conservation of the targets will ensure the conservation of all associated native biodiversity therein. Eight targets are identified in the Meramec River Conservation Action Plan (Figure 1).

Lower Meramec River, Grand Glaize Creek..
© Steve Herrington/TNC

Conservation Targets for the Meramec River

1. **Lower Meramec River Drainage**
   The Lower Meramec River Drainage target is comprised of the main stem Meramec River from River Mile (RM) 0–42 and all tributary drainages and associated biota except the LaBarque Creek drainage. Notable tributaries include Brush, Fox, Hamilton, Keifer, Grand Glaize, and Fishpot creeks. The drainage area for this target is approximately 250 mi^2. Counties primarily drained by this target include Franklin, Jefferson, and St. Louis. Land use in this target is comprised of approximately 33% urban/developed, 29% vacant/undeveloped (including forested areas), 20% publically owned recreation lands, 10% agriculture, and the remainder in other uses (EWG 2012). This target is the most urbanized within the basin, draining the south St. Louis metropolitan area (MDC 1998; EWG 2012).

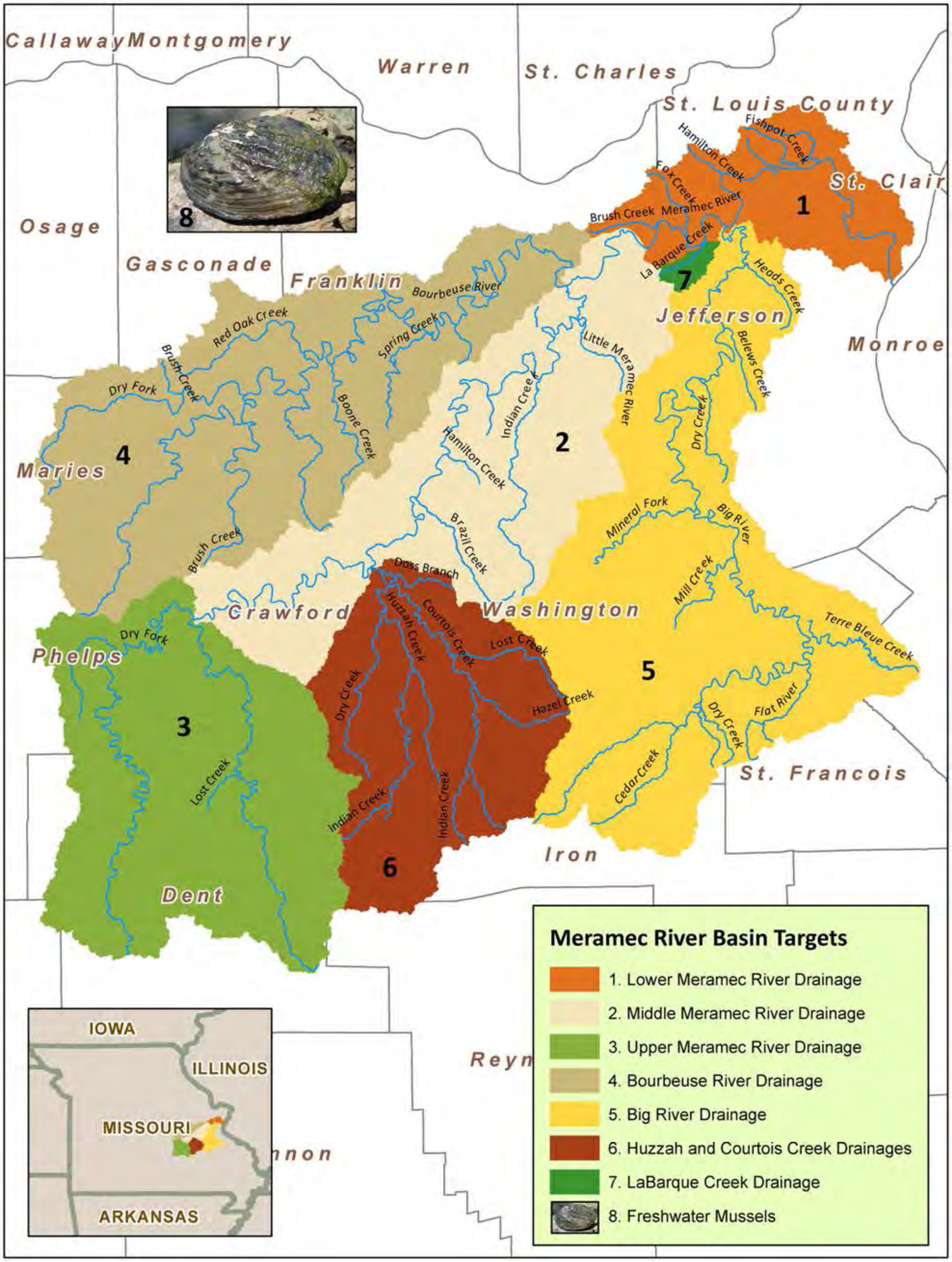
2. **Middle Meramec River Drainage**
   The Middle Meramec River Drainage target is comprised of the main stem Meramec River from RM 42–166 and all tributary drainages and associated biota except the Huzzah and Courtois creek drainages. Notable tributaries include Brazil and Indian creeks. The drainage area for this target is approximately 701 mi^2. Counties drained by this target include Crawford, Franklin, and Washington. The majority of lands in the target are privately owned. Land use in this target is mostly forest, followed by livestock pasture, hay meadow, row crop, and other land uses (MDC 1998). Livestock farming and in-stream gravel mining are important activities affecting aquatic resources in the Middle Meramec River Drainage (MDC 1998).



Middle Meramec River,
Vilander Bluff Natural Area. © Bill Duncan

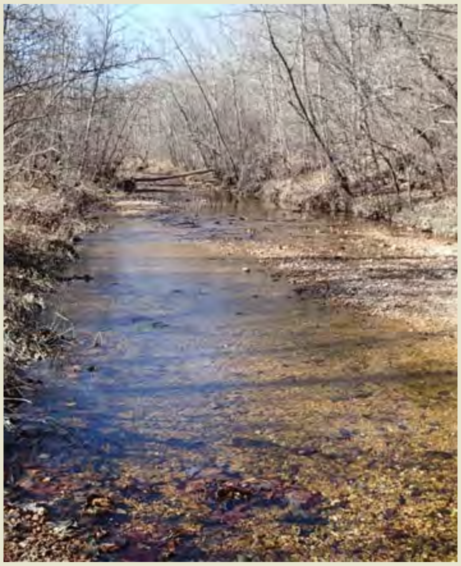
3. **Upper Meramec River Drainage**
   The Upper Meramec River Drainage target is comprised of the main stem Meramec River from RM 166–218 and Dry Fork, including all tributary drainages and associated biota. Notable tributaries include Little Dry Fork and Dry creeks. The drainage area for this target is approximately 728 mi^2. Counties primarily drained by this target include Dent, Phelps, and Crawford, as well as portions of Crawford, Reynolds, and Texas. Land use is predominantly forest and livestock pasture, with approximately one third of forest land owned by farmers, corporations, and forest industries, one third by the U.S. Forest Service's Mark Twain National Forest, and one third by other private landowners (MDC 1998). Livestock farming is an important activity affecting aquatic resources in the target (MDC 1998). Sport fishing, paddling, and floating are also important activities for local economies in the Upper Meramec River Drainage (MDC 1998).

Figure 1: Meramec River Conservation Targets



4. **Bourbeuse River Drainage**
The Bourbeuse River Drainage target is comprised of the main stem Bourbeuse River including all tributary drainages and associated biota. Notable tributaries include Spring Creek, Boone Creek, Brush Creek, Red Oak Creek, Dry Fork, and Little Bourbeuse River. The Bourbeuse River enters the Meramec River at RM 64.0. The drainage area is approximately 843 mi². Counties primarily drained include Phelps, Gasconade, and Franklin, as well as portions of Maries, Osage, and Crawford. The majority of lands in the target are privately owned, particularly by livestock farmers. There are two low-head dams (Noser Mill and Goodes Mill) on the main stem of the Bourbeuse River, Land use is predominantly forest (55%) and livestock pasture (32%), with the latter an important activity affecting aquatic resources of the Bourbeuse River Drainage (MDC 1999).

5. **Big River Drainage**
The Big River Drainage target is comprised of the main stem Big River including all tributary drainages and associated biota. Notable tributaries include Mineral Fork, Cedar, Terre Bleue, Flat River, Mill, Heads, Dry, and Belews creeks. The Big River enters the Meramec River at RM 35.7. The drainage area is approximately 955 mi². Counties primarily drained include Washington, St. Francois, and Jefferson counties, as well as portions of Iron, St. Genevieve, and Franklin. Approximately 95% of the target is privately owned (MDC 1997). Land use is predominately forest (72%) and livestock pasture (16%), though urbanization is increasing in lower portions of the drainage (MDC 1997). There are six dams on the main stem of the Big River, including Byrnesmill (RM 7.9), House Springs (RM 9.4), Byrnesville (RM 13.8), Cedar Hill (RM 18.8), Morse Mill (RM 29), and Council Bluff Lake (RM 132; MDC 1997). Historical and current mining for lead and other heavy metals is an important activity affecting aquatic resources throughout the target. Sport fishing, paddling, and floating are also important activities for local economies in the Big River Drainage (MDC 1999).



Huzzah Creek, Barney Fork.
© Steve Herrington/TNC

6. **Huzzah Creek and Courtois Creek Drainages**
The Huzzah Creek and Courtois Creek Drainage target is comprised of the main stem Huzzah and Courtois creeks including all tributary drainages and associated biota. Notable tributaries include Dry, Shoal, Lost, Hazel, and Doss Branch creeks. Courtois Creek joins Huzzah Creek approximately one mile upstream of its confluence with the Meramec River at RM 127.6. The drainage area is approximately 486 mi². Counties primarily drained include Dent, Crawford, and Washington, as well as portions of Reynolds and Iron. Approximately one half of the target is in public ownership (MDC 1998; MDC 2013b). Land use is approximately 85% forest and 11% livestock pasture, with woodlands, croplands, urban development, and other use comprising the remainder of the target (MDC 1998; MDC 2013b). Sport fishing, paddling, and floating are important activities for local economies (MDC 1998; MDC 2013b; EWG 2007). Although the Huzzah and Courtois creek drainages are located within the Middle Meramec River Drainage, they are segregated as a separate target because of differences in land use and ownership, higher biodiversity and viability, and stresses and threats affecting the creeks and their associated biota.

LaBarque Creek.
© Steve Herrington/TNC

7. **LaBarque Creek Drainage**
The LaBarque Creek Drainage target is comprised of the main stem LaBarque Creek, including all tributary drainages and associated biota. LaBarque Creek enters the Meramec River at RM 42. The drainage area is approximately 13 mi². The target lies entirely within northwest Jefferson County. Approximately 42% of the target is in public or semi-public ownership (FLBC 2008). Land use is approximately 90% forest, 4% urbanized, and the remainder a combination of livestock pasture and other uses (FLBC 2008). The LaBarque Creek Drainages is considered a separate target from the Lower Meramec River Drainage primarily because of differences in land use and ownership, viability, and stresses and threats affecting the creeks and their associated biota. Resource managers currently consider LaBarque Creek minimally impacted versus other tributaries in the Lower Meramec River Drainage, with notably high fish biodiversity and exceptional water quality. During initial development of this plan, Fox Creek was included with LaBarque Creek as a single target because of historically similar biodiversity and viability. However, increasing urbanization in the past 10 years has substantially degraded Fox Creek and its aquatic resources (K. Me-

"More than 70% of North America's freshwater mussels are extinct or imperiled."

- U.S. Geological Survey

neau, MDC, personal communication). Therefore, based on these trends and the recommendations of several expert contributors, Fox Creek was re-aligned to the Lower Meramec River Drainage target.

8. **Freshwater Mussels**

The Freshwater Mussels target is comprised of all native unionid freshwater mussels present throughout the entire Meramec River Basin. The Meramec River basin has one of the most diverse mussel faunas in the central U.S., with at least 46 species identified, including several of which are listed as state or federally threatened or endangered (Nigh and Sowa 2005; Hinck et al 2011; Hink et al. 2012; Appendix A). Freshwater mussels play important roles in aquatic ecosystems, such as "cleaning" water by filtering nutrients, organic matter, and chemicals, serving as food sources for other aquatic and terrestrial animals, and providing substrate for stream bottom stabilization and use by other organisms (USFWS 2014). Mussels are particularly sensitive to habitat and water quality degradation, including excessive sedimentation, altered stream geomorphology and flow, altered riparian vegetation and condition, dams and impoundments, invasive species, and water quality pollution from excessive nutrients, chemicals, heavy metals, and temperature and oxygen extremes (Hinck et al. 2011; Hinck et al. 2012; USFWS 2014).

Freshwater mussels are additionally segregated as a separate target to best recognize their notable vulnerability, declining trends, and disjunct distributions in the Meramec River Basin. Freshwater mussels share somewhat unique sensitivities versus other freshwater biota, from their relative immobility to lack of certain fish hosts needed to complete their life cycle, and thus may respond to stresses and threats differently than the other targets. As such, certain conservation measures that could help improve the health of other targets might have different conservation outcomes for freshwater mussels, and vice versa. Including Freshwater Mussels as a distinct target can therefore provide more focused conservation planning for this taxon in the Meramec River Basin.

Freshwater mussels.© Steve Herrington/TNC

HEALTH OF MERAMEC RIVER TARGETS

We determined the current status of the health – or **Viability** – of the targets using the CAP's Viability Assessment methodology. A **Viability Assessment** is an objective assessment of a target to determine how to measure its health over time, including how to identify how the target is doing currently and what a healthy state might look like in the future. It can be based on specific expert analyses or best assumptions using available data. This step is key to knowing which targets are most in need of immediate attention and how to measure success over time.

The first step in the viability assessments was identifying key ecological attributes and corresponding indicators for each target. **Key Ecological Attributes (KEAs)** are aspects of a target´s biology or ecology that, if missing or altered, would lead to the loss of that target over time. As such, KEAs define the most critical components of biological composition, structure, interactions and processes, environmental regimes, and landscape configuration that sustain a target´s viability or ecological integrity over space and time.

There are numerous measures – or **Indicators** – that can be used to determine the viability of a conservation target. We made a concerted effort to identify and rank a minimal amount of KEAs and indicators that most meaningfully and comprehensively measure viability based on peer-reviewed scientific literature and measures currently used by the State of Missouri and federal conservation agencies. **A total of 18 indicators** were selected to measure the full range of viability for targets in the Meramec River Basin (Appendix C). We selected these indicators for practical purposes, as many are currently used by conservation managers to measure resource health. In a viability assessment, indicators for at least one landscape context, condition, and size are ranked for each target (note that not all indicators were ranked for each target). It is important to note that research defining the viability of each target is often lacking, so expert knowledge and even rough estimates may be used to rank target viability, which in turn can help identify areas for future research on the health of the target.

In general, the goal for improving long-term resource viability is to implement conservation strategies that improve viability rankings by one level, for example, from "Fair" to "Good", over a 10-year period. Although this goal may be impractical given this time frame and the scale of these targets, partners should consider efforts to (1) improve certain KEAs that can reasonably be expected to increase one level, and (2) maintaining KEAss currently ranked "Good" or "Very Good" in order to maintain and improve target viability across the basin.

Health of Conservation Targets in the Meramec River Basin

Viability rankings for targets in the Meramec River Basin varied from "Poor" to "Very Good", with an overall project Biodiversity Health Rank of "Fair" (Table 1). This score is weighted by a "Poor" score for the Lower Meramec River Drainage and specific condition impairments in the Big River (see summaries below); otherwise, rankings suggest that the Meramec River Basin relatively healthy and viable, especially for a large river basin in the mid-continental North America. Specific viability rankings for each target are presented in Appendix D.

The **Lower Meramec River Drainage** was ranked as "Poor" due to a combination of landscape-level factors related to urban development, including land conversation and high levels of impervious surface, both of which are known to strongly degrade hydrology and overall stream function (Schueler et al. 2009; Richter et al/ 2011)). The Condition ranking of "Fair" reflects marginal stream habitat condition and a recent report of poor freshwater

Viability is the status or health of a conservation target. It indicates the ability of a target to withstand or recover from most natural or anthropogenic disturbances and thus to persist sustainably over long time periods.

Key ecological attributes are grouped into three classes:

Landscape context
An assessment of a target's environment, including (1) ecological processes and regimes that maintain the target's occurrence such as flooding; and (2) connectivity, such as access to habitats and resources or the ability to respond to environmental change through dispersal or migration

Condition
A measure of physical or biological composition, structure and biotic interactions that characterize the occurrence of a target.

Size
A measure of the area or abundance of the conservation target's occurrence.

Indicators are measures used to determine the status of a key ecological attribute. Good indicators meet the following criteria:

- Strongly relate to the status of the KEA
- Can provide an early warning to serious stresses
- Are efficient and affordable to measure

Bank stability (EPA; Barbour et al. 1999) is an indicator used to measure the KEA of riparian corridor condition.© Steve Herrington/TNC

mussel assemblage composition in the Lower Meramec; whereas the Size rating of "Poor" reflects poor population sizes of the degraded mussel assemblages and highly degraded riparian zones, particularly for tributaries to the target in the St. Louis area (MDC 1998; EWG 2012; Hinck et al. 2012)

The **Middle Meramec Drainage** and **Upper Meramec Drainage** were both ranked "Good" and had similar Landscape, Condition, and Size rankings. At the Landscape scale, both targets have very good floodplain connectivity and hydrology, though land floodplain conversion due primarily to agricultural practices is relatively common. Condition for both was considered "Fair" due primarily to marginal riparian corridor condition and degraded freshwater mussel assemblages (Hinck et al. 2012), though water quality measures indicate minimal impairment. Size was also ranked "Fair" for both targets as measured by population sizes of freshwater mussel species (Hinck et al. 2012) and relatively narrow riparian corridor, though the sport fishery for smallmouth bass and other sunfishes is considered healthy (MDC 1998; K. Meneau, MDC, personal communication).

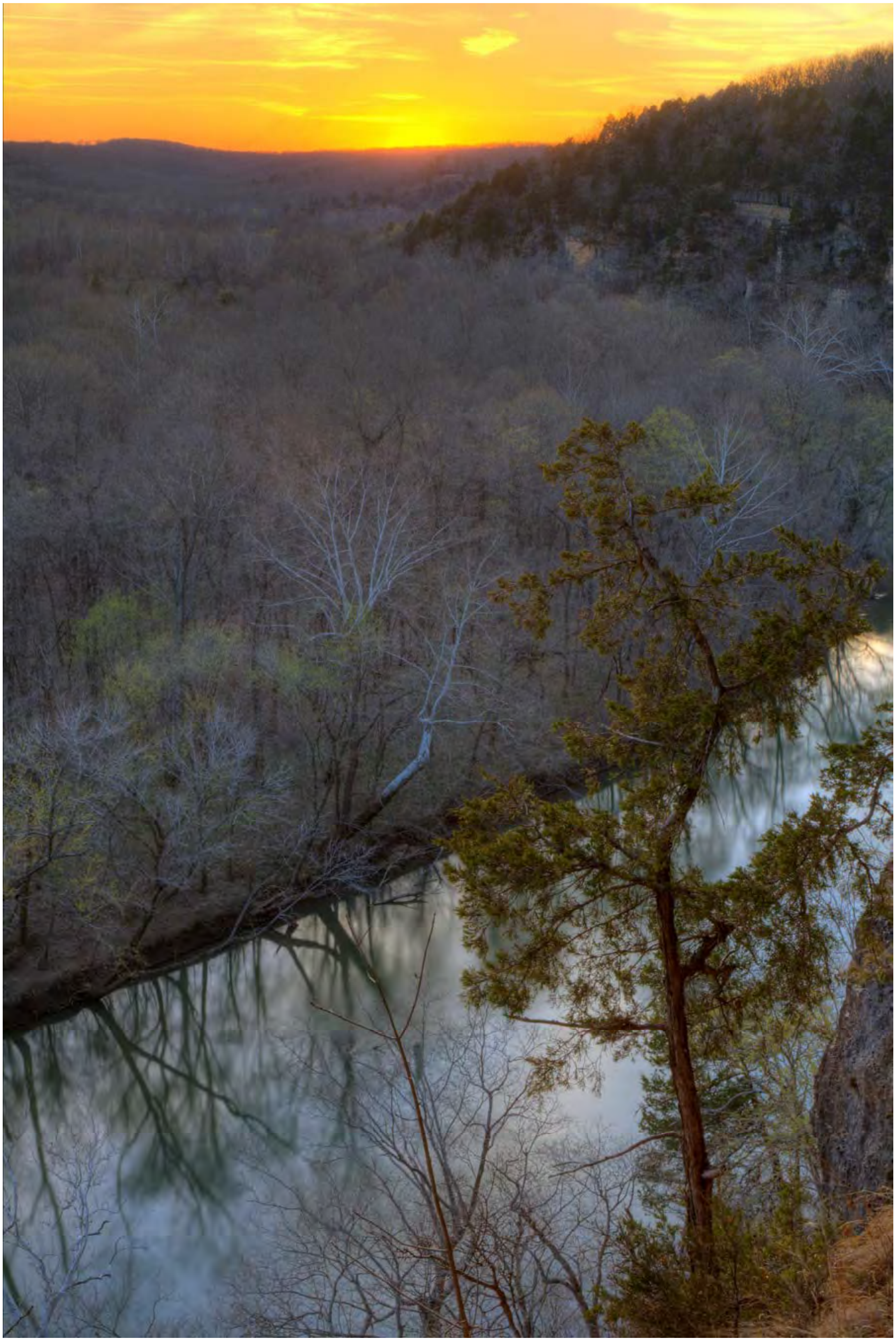
The **Bourbeuse River Drainage** was ranked "Fair" primarily due to indicators reflecting high agricultural use in the main stem and its tributaries. High levels of floodplain conversion to livestock farming and ranching degrades the target at the landscape level, though floodplain connectivity and hydrology are minimally impaired. Condition was ranked "Fair" due to marginal in-stream habitat (MDC 1999) and freshwater mussel assemblages (Hinck et al. 2012). Size was also ranked "Fair" for both targets as measured by population sizes of freshwater mussel species (Hinck et al. 2012) and relatively narrow riparian corridor, though the sport fishery for smallmouth bass and other sunfishes is considered healthy (MDC 1999; K. Meneau, MDC, personal communication). The **Big River Drainage** was ranked also ranked "Fair" due to a combination of factors related to key landscape-level impairments and the legacy of lead mining in the sub-basin. The Landscape Context ranked "Fair", balancing "Good" to "Very Good" scores for floodplain connectivity, relatively unaltered natural flow regime, and percent impervious surface, with "Fair" scores for land conversion and degraded in-stream connectivity due to main stem and tributary dams. Condition was ranked "Poor" primarily due to high levels of heavy metal contamination in stream sediments from historical and current mining activities (NRDAR 2013). Conversely, the Size ranking was "Good" owing to fisheries and riparian zone width, though freshwater mussel recruitment is impaired from heavy metal contamination (Hinck et al. 2012).

The **Huzzah and Courtois River Drainages** and **LaBarque Creek Drainage** both received an overall ranking of "Very Good", being the most viable targets in the basin. The "Very Good" Landscape Context ranking for Huzzah and Courtois creeks reflects excellent connectivity, hydrology, and floodplain structure (MDC 1998; MDC 2013b). Condition was also ranked "Very Good" based on in-stream habitat and water quality measures, though the riparian corridor received a score of "Good" due to some areas with streambank instability (MDC 1998; MDC 2013b). The Size was ranked "Good", reflecting the presence of a quality sport fishery and relatively good riparian zone width throughout the stream corridors (MDC 1998; MDC 2013b). LaBarque Creek had a "Very Good" Landscape Context ranking due to relatively un-impacted connectivity, hydrology, and floodplain structure (FLBC 2008). Condition and Size were also ranked Very Good, reflecting intact riparian corridor structure and size and relatively unimpaired aquatic biodiversity (FLBC 2008).

Lastly, **Freshwater Mussels** was ranked "Fair", chiefly as a result of diversity and population declines throughout the basin (Hinck et al. 2011; Hinck et al. 2012). The Landscape Context for mussels in the Meramec River Basin was ranked "Good" given relatively minimal impacts from in-stream connectivity and land conversion cumulatively across the basin. However, Condition and Size were both ranked "Fair" considering present-day reduction in species diversity and reduced population sizes of mussels at main stem and large tributary historical collection localities (Hinck et al. 2011; Hinck et al. 2012).

Table 1. Summary of viability assessment for Meramec River Basin targets.

Conservation Targets	Landscape Context	Condition	Size	Viability Rank
Lower Meramec River Drainage	Poor	Fair	Poor	Poor
Middle Meramec River Drainage	Very Good	Fair	Fair	Good
Upper Meramec River Drainage	Very Good	Fair	Fair	Good
Bourbeuse River Drainage	Fair	Fair	Fair	Fair
Big River Drainage	Good	Poor	Good	Fair
Huzzah Creek and Courtois Creek Drainages	Very Good	Very Good	Good	Very Good
LaBarque Creek Drainage	Very Good	Very Good	Very Good	Very Good
Freshwater Mussels	Good	Fair	Fair	Fair
Project Biodiversity Health Rank				Fair



Sunset on the Meramec River. © Bill Duncan

FACTORS DEGRADING MERAMEC RIVER TARGETS

Many factors can be responsible for degrading conservation targets. **Stresses** are impaired aspects of targets that result directly or indirectly from human activities. Simply put, stresses are the actual problems degrading a target. For example, altered riparian vegetation is a problem that degrades rivers and streams. Stresses can also be considered degraded KEAs. **Threats**, also known as the "sources of stress" or "direct threats", are the proximate activities or processes that directly have caused, are causing, or may cause a stress. Multiple threats are frequently responsible for causing a given stress, and often in different degrees. For example, livestock farming and timber operations are two threats responsible for altered riparian vegetation that degrades rivers and streams, though livestock farming may be much more responsible for the problem in a given area. **Critical Threats** are those threats that are the most problematic and thus are the highest priority for conservation focus. Critical threats are most often the Very High- and High-rated threats based on threat rating criteria of their impact on the targets.

Analyzing stresses and threats helps identify and rank the various factors that most affect the targets to best prioritize conservation actions where they are most needed. Criteria-based ranking provides an objective analysis of the degree certain problems are degrading a target, the sources of those problems, and which sources are the most critical. It also helps document assumptions so that they can be revisited at later dates.

A practical challenge in conservation science is developing a standard lexicon for communication. A given stress or threat is often referred to by various names, often restricting comparisons, causing confusion, inhibiting communication, and limiting collaborative conservation actions among partners. We made a concerted effort to classify a given stress or threat according to the most commonly used or formally accepted terminology in aquatic and conservation science and management. Our hope is that this will optimize communication and understanding across all stakeholders, allow transferability to other aquatic conservation planning efforts, and best position the use of this plan for collaboratively implementing the strategies described herein.

For stresses, we used terminology most commonly used in peer-reviewed scientific literature or as defined by the federal conservation agencies such as the U.S. Environmental Protection Agency (USEPA). For threats, we used the standardized lexicon for conservation threats as defined by the World Conservation Union (IUCN) and The Conservation Measures Partnership (hereafter "CMP taxonomy"; Salasky et al. 2008; CMP 2014). The names for most threats were modified to reflect local and project-specific terms used among stakeholders in the basin. In addition, some threats described below are a merger of two or more CMP taxonomies because of the interrelatedness of those threats and to simplify communication among stakeholders.

Stresses

Twelve stresses were identified as degrading or potentially degrading targets in the Meramec River Basin:

1. **Altered Connectivity**
   The alteration in the transport of water within the stream channel, onto the floodplain, and through sediments, commonly resulting in the reduction in size and/or scope of hydrologic and/or biological connection to floodplains (lateral connectivity), up- and/or down-stream reaches (longitudinal connectivity), and hyporheic zones (vertical connectivity). Examples include channel incision that reduces floodplain

Identifying and rating Stresses and Threats answers:

"What are the problems affecting our targets (the stresses)?"

"What factors are causing the stresses (the threats)?"

"Which stresses and threats are the most significant?"

Stress: Excessive Suspended & Bedded Sediments. LaBarque Creek. © Steve Herrington/TNC

Stress: Altered Floodplains & Wetlands. Bourbeuse River. © Google Earth

Stress Rating Criteria:

Severity

The level of damage to the conservation target by a stress that can reasonably be expected within 10 years under current circumstances (i.e., given the continuation of the existing situation).

- **Very High**
  The stress is likely to destroy or eliminate the conservation target over some portion of the target's occurrence at the site.

- **High**
  The stress is likely to seriously degrade the conservation target over some portion of the target's occurrence at the site.

- **Medium:**
  The stress is likely to moderately degrade the conservation target over some portion of the target's occurrence at the site.

- **Low:**
  The stress is likely to only slightly impair the conservation target over some portion of the target's occurrence at the site.

Stress: Altered Riparian Corridor. LaBarque Creek. © Steve Herrington/TNC

access, culverts which reduce aquatic organism passage, and changes in groundwater levels that reduce oxygen exchange in streambeds for biota that "bury" into the substrate.

2. **Altered Floodplains & Wetlands**
The alteration of terrestrial areas naturally prone to flooding located inland from the riparian buffer (see "Altered Riparian Buffer" below), as well as wetlands with physical and/or biological connections to the target. This stress differs from "Altered Riparian Corridor" in that it typically starts +100 ft. from the stream channel. Examples include conversion of floodplain forests to livestock pasture and draining of floodplain wetlands for commercial development.

3. **Altered Hydrology**
The alteration of the transport of water from the watershed to the stream channel typically resulting in deviations from the natural flow regime, including the magnitude, frequency, duration, timing, and rate of change of flows. Altering river or stream hydrology can result in wide-ranging changes in stream hydraulic, geomorphological, physiochemical, and biological function. As such, it is typically interrelated or influences to most other stresses identified herein. Examples of altered hydrology include impervious surfaces that make flooding more extreme and "flashy" (i.e., changing the magnitude and duration of floods) and municipal withdrawals that alter ground- and surface-water availability in stream channels.

4. **Altered Riparian Corridor**
The alteration of the riparian buffer within +100 ft. of the stream/river (differs from "Altered Floodplains and Wetlands"; see above). Examples include removal of trees directly from the streambank, narrowing the riparian zone, and conversion of deep-rooted vegetation (e.g., trees) to shallow-rooted vegetation (e.g., fescue).

5. **Altered Stream Geomorphology**
The alteration of the pattern, dimension, and profile of a stream/river over an extended portion (i.e., reach scale) of a stream channel. This stress differs from "In-Stream Habitat Modification" in being broader in scale; reflecting generally long-term, chronic changes in stream channel geomorphology versus more site-specific, fine-scale effects resulting from "In-Stream Habitat Modification" (see description below). Examples include stream channelization, channel incision, and channel widening.

6. **Chemical Pollution**
Inorganic chemicals and compounds including mercury, solvents, pesticides, pharmaceuticals, dioxins, petroleum products, and a wide variety of other related substances that can degrade targets. Chemical Pollution does not include heavy metals (see "Contaminated Sediments") or nitrogen-based compounds (see "Nutrient Pollution"). Effects of chemical pollution on aquatic ecosystems can be short-term to chronic, with a wide-range of outcomes including physical impairment to direct killing of biota (USEPA 2013). Sources of chemical pollutants can include both point-source discharges (e.g., municipal and industrial operations) and nonpoint-source discharges (e.g., stormwater runoff from housing and urban areas).

7. **Contaminated Sediments**
Heavy metals such as lead, cadmium, and barite present in sediments in streams above ambient levels that degrade the target. This stress differs from "Excessive Suspended and Bedded Sediments" in that it only addresses the presence and concentrations of the contaminants bound in sediments, whereas "Excessive Suspended and Bedded Sediments" accounts for the excessive amount of sediment above natural levels regardless of contamination (see below). Contaminated sediments in the Meramec River Basin are the result of historical and current mining practices, including the particularly in the Big River drainage, and are among the highest concentrations measured in rivers nationwide (Pavlowsky et al. 2010; NRDAR 2013). Aquatic biota such as macroinvertebrates and freshwater mussels are particularly sensitive to heavy metal contamination, experiencing sub-lethal or lethal effects at relatively low concentrations (Hinck et al. 2011). A recent study suggested that present-day contamina-

tion of sediments in the lower Big River is related to streambank erosion and ongoing weathering of sediment stored in upland areas (Pavlowsky et al. 2010). "Mine Tailings and Industrial Effluents" is the primary threat contributing to this stress (see "Threats").

8. **Excessive Suspended & Bedded Sediments**
As defined by the USEPA (2003), suspended and bedded sediments (SABs) are defined as particulate organic and inorganic matter that are suspended in or are carried by the water, and/or accumulate in a loose, unconsolidated form on the bottom of natural water bodies. This includes the frequently used terms of clean sediment, suspended sediment, total suspended solids, bedload, turbidity, or in common terms, dirt, soils or eroded materials, as well as organic solids such as algal material, particulate leaf, and other organic material (USEPA 2003). SABs occur naturally in water bodies in natural or background amounts and are essential to the ecological function of a water body. However, excessive SABs are considered the leading cause of impairment to rivers and streams nationwide (USEPA 2002; USEPA 2013). Excessive SABs can result in a wide-range of impacts to stream function, including aggradation and destabilization of stream channels, destruction of spawning areas for aquatic biota, and extirpation of species from degraded areas (USEPA 2003). Excesses SABs can originate from numerous sources, including the streambank erosion, unpaved roads, livestock pastures, and urban areas.

9. **In-Stream Habitat Modification**
Actions that directly and physically alter and/or disturb the stream channel or instream habitats at a site-specific location. In-stream habitat modifications can be transient to persistent over time, typically resulting in micro- and meso-habitat changes that in combination or over long time periods can contribute to local changes in stream geomorphology (see "Altered Stream Geomorphology"). Examples include concrete revetments, dikes and wing dams, rip-rap for streambank stabilization, instream gravel mining, cattle trampling, removal of large woody material, and ATV usage across stream-channel habitats.

10. **Invasive Species**
Includes all of the physical and biological effects of nonindigenous plants, animals, pathogens/microbes, or genetic materials that have the potential to measurably degrade the aquatic integrity of the target. Although there are numerous terrestrial invasive species within the project area, only those that pose a reasonable risk to aquatic ecosystems as described in the project scope are considered here. Effects from invasive species are wide-ranging, including habitat alteration and destruction, anoxia from decomposing individuals, competition, predation, and hybridization (Fuller et al. 1999). Common pathways for invasive species establishment include spread from other populations, introduction as fishing bait, intentional stocking for sporting purposes, release from aquaria, and aquaculture and ornamental escapes (Fuller et al. 1999). Examples include zebra mussels, Asian clams, and Asian carp, as well as local species that that have been introduced outside of their native range affecting targets in the Meramec River Basin, such as certain crayfishes, trout, and fishes used as bait. Of note, this differs from the threat "Invasive Species" because this stress is the combined result of the potential effects of invasive species on the targets.

11. **Nutrient Pollution**
Nitrogen, phosphorus, and ammonia-based compounds in streams/rivers above ambient levels that degrade targets. Nutrient pollution is considered among the leading cause of impairment to rivers and streams nationwide (USEPA 2002; USEPA 2013). Environmental effects of nutrient pollution include harmful (i.e., toxic) algal blooms, reduction in light availability, and anoxia, resulting in degraded aquatic habitats and direct harm to biota (USEPA 2013). This is typically a nonpoint-source pollutant originating from sources such as fertilizer and soil erosion from agricultural fields, stormwater runoff, wastewater discharge from sewer and septic systems, and fossil fuels.

12. **Organic Pollution**
Volatile, semi-volatile, and other organic compounds and pathogens in streams/rivers above ambient levels that degrade the target. Organic pollution often originates from

Stress Rating Criteria:

Scope

Most commonly defined spatially as the geographic scope of impact of a stress on a target at the site that can reasonably be expected within 10 years under current circumstances (i.e., given the continuation of the existing situation).

- **Very High**
  The threat is likely to be widespread or pervasive in its scope and affect the conservation target throughout the target's occurrences at the site.
- **High**
  The threat is likely to be widespread in its scope and affect the conservation target at many of its locations at the site.
- **Medium**
  The threat is likely to be localized in its scope and affect the conservation target at some of the target's locations at the site.
- **Low**
  The threat is likely to be very localized in its scope and affect the conservation target at a limited portion of the target's location at the site.

Stress: Contaminated Sediments.
© USGS

Threat: Climate Change.
© Byron Jorjorian

Threat: Dams & Water Management. Cedar Hill Dam, Big River Drainage. © Chris Naffziger, St. Louis Patina

Threat: Historical Agricultural & Forestry Practices.
© Library of Congress

wastewater, industrial effluents, and agricultural wastes (USEPA 2013). Like chemical pollution, effects of organic pollution on aquatic ecosystems can be short-term to chronic, with a wide-range of outcomes including physical impairment to direct killing of biota (USEPA 2013). Examples include *E. coli* and other oxygen-depleting pathogenic organisms/substances from sources, detergents, hydrocarbons, PCBs, and inorganic agricultural chemicals such as atrazine.

Threats

Thirteen threats[1] were identified as the sources of the stresses affecting targets in the Meramec River Basin.

1. **Climate Change**
   Threats from long-term climatic changes which may be linked to global warming and other severe climatic/weather events that are outside of the natural range of variation, or potentially can wipe out a vulnerable species or habitat. Includes major alterations and shifts in habitats, storms and flooding, droughts, and temperature extremes related to global climate change. CMP taxonomy = "Climate Change & Sever Weather" including the sub-categories "Habitat Shifting & Alteration", "Droughts", "Temperature Extremes", and "Storms & Flooding". Rankings follow guidance of Aldus et al. (2007).

2. **Dams & Water Management**
   Dams, farm ponds, and/ or similar structures that impound or alter the main stem of rivers and streams, changing the water flow patterns from their natural range of variation and typically limiting the up- and downstream passage of aquatic organisms. Includes dam construction, dam operations, sediment control, levees and dikes, surface water diversions, channelization, and construction of artificial lakes for purposes such as livestock watering. CMP taxonomy = "Dams & Water Management/Use".

3. **Garbage & Solid Waste**
   Rubbish and other solid materials including that degrade river and stream habitat and ecosystem function, including municipal waste, litter from cars, flotsam and jetsam from recreational boats, waste that entangles wildlife, and construction debris. CMP taxonomy = "Garbage & Solid Waste".

4. **Historical Agricultural & Forestry Practices**
   Reflects the ongoing legacy and target recovery from historical agricultural and forestry actions that converted or degraded watersheds in the Meramec River Basin. The legacy of excessive sedimentation resulting from over 130 years of historical land use practices continues to cause stream head-cutting, sedimentation of pools, channel widening, loss of in-stream habitat and floodplain connectivity, and other channel disturbances in the Meramec and other Ozark rivers (Jacobson and Primm 1997; see "Land and Water Use" above), and is therefore recognized as relevant threat to aquatic conservation in the basin. CMP taxonomy = "Other Ecosystem Modifications".

5. **Housing & Urban Areas**
   Cities, towns, and settlements including non-housing development typically integrated with housing, including urban and suburban areas, villages, vacation homes, shopping areas, offices, schools, hospitals, and most other areas with impervious surfaces. This threat also includes water-borne sewage and non-point runoff from housing and urban areas that include nutrients, toxic chemicals, and/or sediments, as well as the effects of these pollutants on the site where they are applied (e.g., discharge from municipal waste treatment plants, leaking septic systems, untreated sewage, outhouses, oil or sediments conveyed to roads, fertilizers and pesticides from lawns and golf-courses, and pet waste, and road salt). Combined CMP taxonomies = "Housing & Urban Areas" and "Household Sewage & Urban Waste Water".

6. **In-Stream Gravel Mining & Reaming**
   Includes all in-stream sand and gravel mining practices as well as "gravel reaming" or

[1] "Annual and Perennial Crops", "Atmospheric Deposition" and other potential threats (REF) were considered to minimally affect targets and were thus not retained as final threats in this analysis.

"gravel pushing", which is the dredging and/or pushing of sediments within a stream channel by large machinery commonly used to "improve" drainage, an apparently common private-land action in the Ozarks (MDC 1997, 1998, 1999). CMP taxonomy = "Mining & Quarrying".

7. **Invasive Species**
Threats from nonindigenous plants, animals, pathogens/microbes, or genetic materials that have or are predicted to have harmful effects on river and stream habitats and biodiversity following their introduction, spread, and/or increase in abundance. Examples include non-North American taxa such as zebra mussels, Asian clams, and Asian carp, local species that that have been introduced outside of their native range such as certain crayfishes, trout, and fishes used as bait, as well as potential future introductions of invasive freshwater taxa. CMP taxonomy = "Invasive Non-Native/Alien Species".

8. **Livestock Farming & Ranching**
Domestic terrestrial animals raised in one location on farms (farming), as well as domestic or semi-domesticated animals allowed to roam in the wild and supported by natural habitats (ranching) (e.g., cattle feed lots, chicken farms, dairy farms, cattle ranching, and horse ranches). This threat also includes nutrients, toxic chemicals and/or sediments from agricultural operations, including the effects of these pollutants to receiving waters where they are applied (e.g., nutrient, organic, and chemical pollution from fertilizer, herbicide, and manure run-off, excessive suspended and bedded sediments from soil erosion). Combined CMP taxonomies = "Livestock Farming & Ranching" and "Agricultural & Forestry Effluents" for agricultural effluents only.

9. **Mine Tailings & Industrial Effluents**
Water-borne pollutants from industrial and military sources including mining, energy production, and other resource extraction industries that include nutrients, toxic chemicals and/or sediments. Includes both past and current heavy metal mining operations, tailings, and their associated pollutants, as well as toxic chemicals from factories, illegal dumping of chemicals, leakage from fuel tanks, and PCBs in river sediments. CMP taxonomy = "Industrial & Military Effluents."

10. **Recreational Activities**
Threats from people spending time in nature or traveling in vehicles outside of established transport corridors, usually for recreational reasons. Includes off-road vehicles, motorboats, jet-skis, temporary campsites, and designated and undesignated recreational access that alters, disturbs, or destroys river and stream habitats and ecosystems. CMP Taxonomy = "Recreational Activities".

11. **Riverbank & Channel Hardening**
Use of concrete, rip-rap, refuse, or other non-organic materials for shoreline stabilization, in-stream flow deflection, or related actions for "managing" river and stream channels to protect infrastructure, reduce erosion, and improve human welfare. CMP taxonomy = "Other Ecosystem Modifications".

12. **Transportation, Utility, & Service Corridors**
Threats from long, narrow transport corridors (and the vehicles that use them) that impact river and stream ecosystem health. Includes paved and unpaved highways, secondary roads, logging roads, bridges and causeways, and culverts, as well as electrical and phone wires and oil and gas pipelines. Impacts from this threat include excessive sediment originating from unpaved roads and altered hydrology, connectivity, geomorphology, floodplains, and riparian zones. Nutrient, organic, and chemical pollution, which is often conveyed across this threat, are not included here; however, they are addressed per their respective source (e.g., "Housing & Urban Areas"). CMP taxonomy = "Roads & Railroads" and "Utility & Service Lines".

13. **Timber Operations**
Harvesting and management of trees and other woody vegetation for timber, fiber, or fuel, including clear-cutting of hardwoods, selective commercial logging, pulp or woodchip operations, and fuel-wood collection on both public and private properties.

Threat: In-Stream Gravel Mining & Reaming.
© MDC

Threat: Livestock Farming & Ranching.
© NRCS

Threat: Transportation, Utility, & Storage Corridors.
© Byron Jorjorian

Threat Rating Criteria:

Contribution

The expected contribution of a threat, acting alone, to the full expression of a given stress (as determined in the stress ranking) under current circumstances (i.e., given the continuation of the existing management/conservation situation).

- Very High
  The threat is a very large contributor of the particular stress.
- High
  The threat is a large contributor of the particular stress.
- Medium
  The threat is a moderate contributor of the particular stress.
- Low
  The threat is a low contributor of the particular stress.

Irreversibility

The degree to which the effects of a threat can be restored.

- Very High
  The threat produces a stress that is not reversible (e.g., wetlands converted to a shopping center).
- High
  The threat produces a stress that is reversible, but not practically affordable (e.g., wetland converted to agriculture).
- Medium
  The threat produces a stress that is reversible with a reasonable commitment of resources (e.g., ditching and draining of wetland).
- Low
  The threat produces a stress that is easily reversible at relatively low cost (e.g., off-road vehicles trespassing in wetland).

This threat also includes effects of pollutants and land disturbance to receiving waters in timbered areas (e.g., excessive suspended and bedded sediments from soil erosion due to clear cutting). Combined CMP taxonomies = "Logging & Wood Harvesting" and "Agricultural & Forestry Effluents" for forestry effluents only.

Rating Criteria for Stresses and Threats

Each stress was categorically ranked in terms of its Severity and Scope of its impact on a target. These ranks were combined, yielding a single rating categorizing the impact of a given stress on a target, ranging from "Very High" (severely degrading the target) to "Low" (minimally degrading the target). Each threat was categorically ranked in terms of its **Contribution** to the impact of a given stress on a target, and **Irreversibility** of its impact on a target. Multiple threats are commonly responsible for causing multiple stresses, usually in different degrees, for a given target. The overall influence of a threat impact on a target is calculated by combining the ranks for Contribution and Irreversibility of a threat for each ranked stress to a target (see "Summary of Stresses), yielding a single, combined rating of the impact of a given stress on a target, ranging from "Very High" (most problematic) to "Low" (least problematic).

These threats then are combined across all targets, resulting in an **Overall Threat Rank** defining the most problematic threats across all targets. In addition, all threat rankings for a target are combined, yielding an **Overall Threat Status for Each Target**. Lastly, the Overall Threat Ranks and Overall Threat Status for All Targets are combined, yielding a single **Overall Threat Status for the Project** (entire Meramec River Basin).

Stresses and Threats Most Degrading the Meramec River

Complete stresses and threats rankings for all targets are provided in Appendix E. The four **most pervasive stresses** to targets across the Meramec River Basin included (in ranked order; Table 2): 1) Excessive Suspended & Bedded Sediments; 2) Altered Floodplains & Wetlands; 3) Altered Riparian Corridor; and 4) Contaminated Sediments.

The first three of these stresses reflect impacts spatially located near the targets, suggesting that stresses proximate to the targets may be the most deleterious, a hypothesis also proposed for explaining historical patterns of degradation for Ozark streams (Jacobson and Primm 1997). **Altered Floodplains** and **Altered Riparian Corridor** are also interrelated to **Excessive Suspended & Bedded Sediments**, as conservation partners have identified streambank erosion as a potentially significant factor contributing excessive sedimentation in the Meramec River and its tributaries. Although geographically narrow in scope, **Contaminated Sediments** was also ranked as an important stress. This ranking results from the severe impacts of this stress to targets where it occurs, primarily the Big River Drainage (and Freshwater Mussels therein), and its increasing prevalence both downstream of its occurrence (e.g., the Lower Meramec River Drainage receives contaminated sediments from the Big River Drainage) and in other drainages that have a high-potential for incidents resulting in sediment contamination due to current and future mining activities (e.g., Huzzah and Courtois Creek Drainage).

Six **Critical Threats** were identified, including (in ranked order; Table 3): 1) Livestock Farming & Ranching; 2) Housing & Urban Areas; 3) Mine Tailings & Industrial Effluents; 4) In-Stream Gravel Mining & Reaming; 5) Dams & Water Management; and 6) Transportation, Utility, & Service Corridors.

Livestock Farming & Ranching and **Housing & Urban Areas** had an Overall Threat Rank as "Very High" across the eight targets. Livestock Farming & Ranching had "High" rankings for three targets and a "Very High" ranking for the Bourbeuse River Drainage, reflecting the high level of this activity and its influence on stresses degrading river health and function in that system. Of note, this threat was the most geographically pervasive threat in the Meramec River Basin. "Housing & Urban Areas" had "High" rankings for two of targets, and a "Very High" ranking for the Lower Meramec River Drainage, recognizing the strong influence of present-day and future urbanization and sprawl in the greater St. Louis area.

Table 2. Stress rankings for Meramec River Basin targets in ranked order. A "-" indicates that the stress was not applicable to the target.

Stresses Across Targets	Lower Meramec River Drainage	Middle Meramec River Drainage	Upper Meramec River Drainage	Bourbeuse River Drainage	Big River Drainage	Huzzah Creek and Courtois Creek Drainages	LaBarque Creek Drainage	Freshwater Mussels
Excessive suspended & bedded sediments	High	High	High	High	High	Medium	Medium	High
Contaminated sediments	Medium	Low	Low	Low	Very High	Medium	-	High
Altered floodplains & wetlands	High	High	High	High	Medium	Medium	Low	Medium
Altered riparian corridor	High	High	High	High	Medium	Medium	Low	Medium
In-stream habitat modification	High	High	Medium	Medium	Medium	Medium	Low	High
Altered stream geomorphology	High	Medium	Medium	Medium	Medium	Medium	Low	High
Altered hydrology	High	Medium	Medium	Medium	Low	Low	Medium	Medium
Nutrient pollution	Medium	Medium	Medium	High	Medium	Low	Low	Medium
Altered connectivity	Medium	Low	Medium	Medium	High	Low	Low	Medium
Organic pollution	High	Medium	Medium	Medium	Low	Low	Low	Medium
Chemical pollution	Medium	Medium	Medium	Low	Medium	Low	Low	Medium
Invasive species	Low	-	-	-	-	-	-	Low

Table 3. Summary of threat rankings for Meramec River Basin targets. A "-" indicates that the threat was not applicable to the target.

Threats Across Targets	Lower Meramec River Drainage	Middle Meramec River Drainage	Upper Meramec River Drainage	Bourbeuse River Drainage	Big River Drainage	Huzzah Creek and Courtois Creek Drainages	LaBarque Creek Drainage	Freshwater Mussels	Overall Threat Rank
Project-specific threats	1	2	3	4	5	6	7	8	
Livestock Farming & Ranching	Medium	High	High	Very High	Medium	Medium	Medium	High	Very High
Housing & Urban Areas	Very High	Medium	Medium	Medium	High	Medium	Medium	High	Very High
Mine Tailings & Industrial Effluents	Medium	Low	Low	Low	Very High	Medium	-	High	High
In-Stream Gravel Mining & Reaming	High	High	Medium	Medium	Medium	Low	-	High	High
Dams & Water Management	Medium	Medium	Medium	Medium	High	Medium	Medium	Medium	High
Transportation, Utility, & Service Corridors	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	High
Climate Change	Medium	Medium	Medium	Medium	Medium	Low	Low	Medium	Medium
Historical Agricultural & Forestry Practices	Medium	Medium	Medium	Medium	Low	Low	Low	Medium	Medium
Timber Operations	Low	Medium	Medium	Medium	Low	Low	Low	Medium	Medium
Riverbank & Channel Hardening	Medium	Low	Low	Low	Low	Low	Low	Medium	Medium
Utility & Service Lines	Medium	Low	Low	Medium	Low	Low	Low	Low	Medium
Garbage & Solid Waste	Medium	Low	Low	Low	Low	Low	Low	Low	Medium
Recreational Activities	Low	Low	Low	Low	Low	Low	Low	Medium	Medium
Invasive Species	Low	-	-	-	-	-	-	Medium	Low
Atmospheric Deposition	Low	Low	Low	Low	Low	Low	Low	Low	Low
Threat Status for Targets and Project	Very High	High	High	High	Very High	Medium	Medium	High	Very High

The other four critical threats had an Overall Threat rank of "High" across the targets. **Mine Tailings & Industrial Effluents** ranked "Very High" for the Big River and "High" for Freshwater Mussels, but were otherwise lower ranked across the basin. This again reflects the potential for severe local effects of this threat where it currently or may occur, though movement of contaminated sediments can increasingly degrade resources downstream of the immediate impact area over time. **In-Stream Gravel Mining & Reaming** ranked as a "High" stress for three of the targets, reflecting its importance across a wide range of targets within the basin. This threat is believed to me more widespread and thus potentially impactful than currently known (MDC 1997, 1998). Future research into these threats and their impacts on targets is needed to better understand the potential influence of this and other stresses and threats to aquatic resources in the Meramec River Basin.

Although **Dams & Water Management** was only considered a "High"-ranked threat for the Big River Drainage, its cumulative rankings across the other targets resulted in it being considered a Critical Threat. There are hundreds of small dams throughout the basin that are registered and permitted with the MDNR (and potentially many more that are not) for purposes such as agriculture and urban basin ponds (MDNR 2014). Almost all of these dams are located on small-sized tributaries (with notable exceptions in the Big River and Bourbeuse River main stems) and contribute to stresses such as Altered Connectivity and In-Stream Habitat Modification, though extent of their impacts on stream function where present is uncertain. Therefore, research is needed to better understand the effects of this threat in the Meramec River Basin. Similarly, **Transportation, Utility, & Service Corridors** was only considered "High" in the Lower Meramec but was cumulatively ranked a Critical Threat throughout the basin. This threat contributes to stresses such as Altered Hydrology and Excessive Suspended & Bedded Sediments, the latter particularly for unpaved/dirt roads without proper BMPs. Because its scope increases with increasing the Housing & Urban Development Critical Threat, strategic actions addressing Housing & Urban Development should be developed considering this threat to maximize long-term conservation effectiveness.

The **Lower Meramec River Drainage** and the **Big River Drainage** were considered the most imperiled targets, with Overall Threat Rankings of "Very High". However, impacts to aquatic biota likely differ between these targets, as the Lower Meramec River Drainage currently has the lowest aquatic biodiversity versus other targets in the Meramec River Basin (MDC 1998; Hinck et al. 2012) and conservation efforts focused there may not have the same level of benefits to biota compared to similar actions in other areas. Housing & Urban Areas, In-Stream Gravel Mining & Reaming, and Transportation, Utility, & Service corridors were the most critical threats in the Lower Meramec River Drainage, reflecting current and future forecasted urbanization and their strong effects on stream function (particularly hydrology; Schueler et al. 2009; Richter et al. 2011). Future expansion of existing urban areas is an important current and future threat in the Big River Drainage. Mine Tailings & Industrial Effluents continue to be a severe source of stress as well, and substantial funding (+$40 million) for remediating this threat is available and administered by state and federal agency trustees under the federal Natural Resource Damage Assessment and Restoration program (NRDAR 2013). It should be noted that NRDAR funds are available for various conservation actions (e.g., restoration) in the Big River as well as throughout the Meramec River Basin and may be an important source of funding for implementing conservation actions identified in this plan. Dams & Water Management was a "High" threat for the Big River due primarily to the six main stem impoundments. These dams pose an interesting challenge for conservation because although they contribute to important stresses such as Altered Connectivity, they also slow the downstream migration of contaminated sediments within the drainage and to other systems. These and other complex factors need to be considered when determining conservation actions for the Big River Drainage.

The **Middle Meramec River Drainage**, **Upper Meramec**, **Bourbeuse River Drainage**, and **Freshwater Mussels** were also considered imperiled based on "High" Overall Threat Rankings. The Middle and Upper Meramec drainages had similar threat rankings, with Livestock Farming & Ranching being the most problematic threat, though In-Stream Gravel Mining & Reaming activities was ranked "High" in the Middle Meramec as a result of numerous operations in the main stem as well as its major tributaries, Brazil and Indian creeks (MDC 1998). Although Livestock Farming & Ranching was the only Critical Threat in the Bourbeuse River Drainage, it is widespread in scope and impacts this target more than any other in the basin and thus should be the focus of future conservation

The four most pervasive stresses to targets across the Meramec River Basin (in ranked order; Table 2):

1. Excessive Suspended & Bedded Sediments,
2. Altered Floodplains & Wetlands,
3. Altered Riparian Corridor, and
4. Contaminated Sediments.

The six Critical Threats identified in the Meramec River Basin (in ranked order; Table 3):

1. Livestock Farming & Ranching,
2. Housing & Urban Areas,
3. Mine Tailings & Industrial Effluents,
4. In-Stream Gravel Mining & Reaming,
5. Dams & Water Management, and
6. Transportation, Utility, & Service Corridors.

A Situation Analysis helps answer:

"What factors positively & negatively affect our targets?"

"Who are the key stakeholders linked to each of these factors?"

Riverbank health assessment demonstration.
© Usman Khan/TNC

actions in its watershed. Four Critical Threats imperiled Freshwater Mussels throughout the basin, including Livestock Farming & Ranching, Housing & Urban Areas, Mine Tailings & Industrial Effluents, and In-Stream Gravel Mining & Reaming. There are two recent interagency studies defining freshwater mussel population trends, stresses and threats impacting them, and proposed research and conservation actions needed to ensure their long-term viability in the Meramec River Basin (Hinck et al. 2011; Hinck et al. 2012). These studies are a primary source for developing conservation strategies for conserving Freshwater Mussel targets throughout the basin.

In addition to having Very Good viability rankings, the **Huzzah Creek and Courtois Creek Drainage** and **LaBarque Creek Drainage** also ranked as the least threatened targets, with no Critical Threats ranked therein. Although their threats were similarly ranked, respective conservation actions may differ due based on differing trends in those watersheds based on contributors to this plan. For example, Livestock Farming & Ranching operations and private land owners with potentially timberable land (i.e., Timber Operations threat) are the foci of current watershed conservation efforts in those drainages (MDC 2013b). Conversely, increasing urbanization and sprawl is an emerging threat in the LaBarque Creek drainage due to its proximity to St. Louis (FLBC 2008). As evidence, the threat of Housing & Urban areas has recently degraded stream function in Fox Creek, an adjacent watershed with formerly high levels of fish and other taxa biodiversity (K. Meneau, MDC, personal communication). Results from this assessment support previous conservation planning recommendations that focus on ameliorating the threat of Housing & Urban Areas in the LaBarque Creek Drainage (FLBC 2008).

What Are Behind These Problems?

A **Situation Analysis** outlines the current understanding of the biological issues and human context of the project area. This analysis probes the root causes of what and who are really driving critical threats, what would motivate these conditions to change, and who can help make a difference for the better of the targets. A situation analysis helps bring explicit attention and consideration to contributing factors driving critical threats - the indirect threats, opportunities for successful action, and the key actors and stakeholders involved. **Indirect Threats** are the underlying factors that are drivers of threats, and are often entry points for conservation actions. For example, "poor logging policies" may be an underlying factor responsible for the threat "Timber Operations". **Opportunities** are the factors that can potentially have a positive effect on targets, either directly or indirectly, and are also often an entry point for conservation actions. For example, "demand for excellent fishing opportunities" may positively affect targets in the Meramec River Basin.

Below is a summary of situation analyses for four of the six critical threats in the Meramec River Basin[2]. Although not a critical threat, a situation analysis for "Timber Operations" was also completed because of its broad influence across the basin per the recommendation of the review team.

Livestock Farming & Ranching

Targets Most Affected: Upper Meramec River Drainage, Middle Meramec River Drainage, Bourbeuse River Drainage, Freshwater Mussels.

Indirect Threats: Farmers and ranchers need access to water; livestock use riparian corridor for shading; comfort with traditional practices; lack of demonstration of better alternatives; wariness of new technologies because of early failures; apathy towards conservation value of aquatic resources; lack of detailed personalized land owner contacts and follow-through.

Key Actors and Stakeholders: Producers; state/county Cattleman's Associations; county Soil and Water Conservation Districts; state and federal agencies, especially NRCS; University of Missouri extension; land owner committees.

Opportunities: Coordinate funds for incentivizing all best management practices; develop a unified message to build successful partnerships with key early adopters; target 1st -2nd order streams at landscape scale targeted at agencies, NGOs, and landowner committees; develop promotional/marketing strategy.

[2] "Transportation, Utility, and Service Corridors" and "Dams & Water Management" were not assessed because they were not ranked as critical threats at the time situational analyses were completed. Rankings based on final partner feedback subsequently elevated these to critical threat status.

Housing & Urban Areas

Targets Most Affected: Lower Meramec River Drainage, Big River Drainage, Freshwater Mussels.

Indirect Threats: Local government permitting and zoning for development lacks conservation designs and measures; lack of education across all stakeholders; poor zoning/rule enforcement; stresses and threats span multiple jurisdictions; financial barriers prevent public and private upgrades for better conservation outcomes; current infrastructure insufficient to handle increasing inputs; lack of expertise for best management practices; political biases against conservation actions.

Key Actors and Stakeholders: Not identified.

Opportunities: Educating land owners and municipalities; economic incentives and landowner assistance for development and conservation-minded upgrades.

In-Stream Gravel Mining & Reaming

Targets Most Affected: Lower Meramec River Drainage, Middle Meramec River Drainage, Freshwater Mussels.

Indirect Threats: Perception that excessive gravel in streams must be physically removed guides policies; too many exemptions (e.g., permitting) for counties; counties commonly dredge and ream around county roads; poor culverts management; insufficient enforcement; counties lack information on problems and better alternatives; county use and landscaping are major users.

Key Actors and Stakeholders: Private and small markets for gravel (e.g., landscaping); quarries: powerful political leaders with no real competition (80-90% of gravel is quarried limestone); landscaping industry.

Opportunities: Conservation commissions could advocate better crossings; better practices from other Missouri counties to educated Meramec River Basin counties; other states/cities (e.g., New York) provides policy and legal framework for better gravel management; canoe operators and private citizens with similar interests can help advocate better practices and policy changes.

Mine Tailings & Industrial Effluents

Targets Most Affected: Big River Drainage, Freshwater Mussels.

Indirect Threats: Legacy of historical practices; several mill dams on the Big River could fail and release stored contaminated sediments; developers continue to use contaminated sediments for urbanization; complex regulatory framework makes restoration difficult.

Key Actors and Stakeholders: NRDAR trustees (USFS, MDNR, USFS); EPA; MDNR's Our Missouri Rivers Initiative helping align stakeholders in Meramec River Basin; USACE; MODOT has historically used contaminated sediments for road constructions; NGOs; STREAM teams and local watershed partnerships; private land owners.

Opportunities: Mill dams are areas stopping contaminated sediment from moving downstream and can be used for clean-up; NRDAR and EPA provide substantial funding for direct clean-up and compensatory restoration throughout Meramec River Basin; private land owners will be key to implementing because most lands are privately owned.

Timber Operations (not a critical threat)

Targets Most Affected: Middle Meramec River Drainage, Upper Meramec River Drainage, Freshwater Mussels.

Indirect Threats: Loggers unfamiliar with forestry BMPs and leading operations on private lands; unscrupulous loggers ignoring BMPs for economic reasons, especially on private lands; lack of land owner education with regards to BMPs and quality foresters; depositing slash in stream channels; forest conversion a greater threat than harvesting; unpaved roads and stream crossings contributing to sediment inputs.

Key Actors and Stakeholders: Private land foresters; consulting foresters; loggers; state and federal land owners; NGO's and public trusts; timber mill operators, wood products industry members; engineers, designers, and builders of stream crossings; off-roaders (ATV's, four-wheel drives); University of Missouri extension.

Opportunities: Working forest conservation easements a major strategy for improving aquatic ecosystems.

Threat: Housing & Urban Areas. St. Louis, MO.
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Threat: Mine Tailings & Industrial Effluents.
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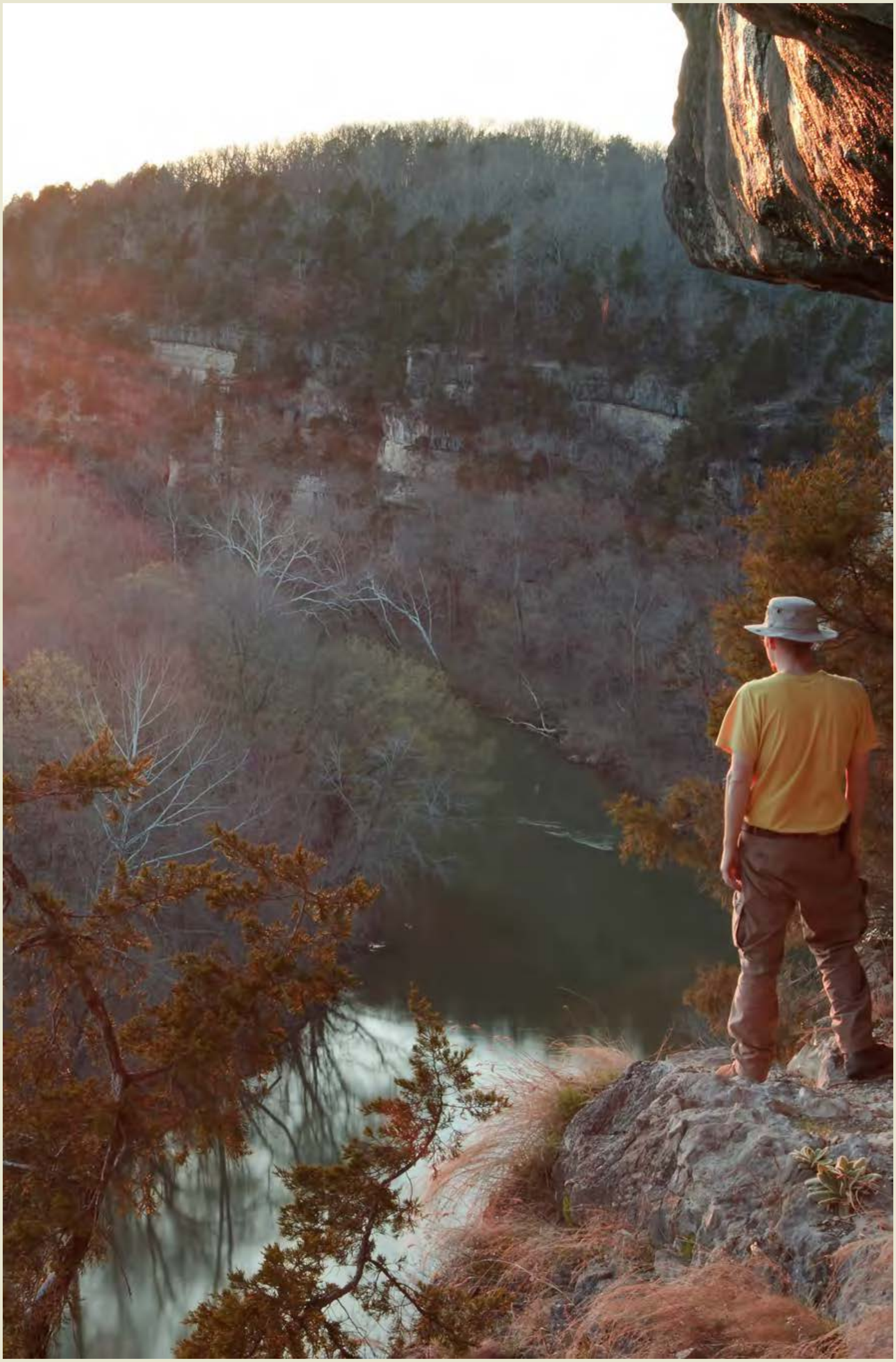

Meramec River. © Bill Duncan

TAKING ACTION TO CONSERVE THE MERAMEC RIVER

Developing effective objectives and strategic actions for overcoming critical threats and restoring degraded targets is an essential step in conservation planning (TNC 2007). If successfully implemented, conservation strategies collectively should result in conserving the targets and realizing the project vision.

Defining Objectives and Strategic Actions

Objectives are specific and measurable statements of what one hopes to achieve within a project. Ideally, realization of all the project´s objectives should lead to fulfillment of the project vision. Objectives developed for this plan follow the S.M.A.R.T criteria of being specific, measurable, achievable, relevant, and time-limited (TNC 2007). **Strategic Actions (Strategies)** are general or specific courses of action needed to help reach one or more of the project's objectives.

We completed a meta-analysis of over 40 federal, regional, state, local, academic, and stakeholder conservation plans, policies, and publications outlining objectives and strategies, as well as research and data needs for conserving aquatic resources in the Meramec River Basin. We extracted over 400 goals, objectives, and strategies from these references and sorted them into categories of "Threat Abatement", "Maintaining/Enhancing Target Viability (Reducing Stresses)", and "Other". Once sorted, we developed S.M.A.R.T. objectives which synthesized the various, often overlapping, intent of the original references. The result was 87 unified objectives for conserving aquatic resources in the Meramec River Basin. These objectives were intentionally general in nature in order to serve as the template for future conservation planning. This synthesis can serve as a foundation for optimal communication and understanding across all stakeholders, allow transferability to other aquatic conservation planning efforts, and best position the use of this plan for collaboratively implementing the strategies described herein. The unified objectives for the Meramec River Basin are provided in Appendix F.

Objectives and Strategic Actions for the Meramec River Basin

From the unified objectives, the planning team further specified **12 objectives** (Table 4) and **14 strategic actions** (Table 5) for addressing critical threats in the Meramec River Basin. The CAP Workbook contains spreadsheets and calculations that rank and prioritize objectives and strategic actions, incorporating all previous rankings of viability, stresses, threats, objectives, and strategic actions across all conservation targets (TNC 2010). The result is a prioritized list of the most impactful (i.e., the "biggest conservation bang for the buck") strategic actions for conserving aquatic resources in the Meramec River Basin. Strategies were prioritized by ranking these and other factors relevant to how that action can best achieve objectives for targets, including stresses addressed, duration of outcome, ease of implementation, and costs (Table 5). These strategies represent the first iteration of objective and strategy development across stakeholders in the basin. Although they provide the initial direction for conservation action, future planning efforts are needed to comprehensively define (and refine) objectives and strategies necessary for fully conserving targets in the Meramec River Basin.

Objectives can be stated in terms of:

Reducing the status of a critical threat (i.e., "threat abatement")

Maintaining/enhancing viability of targets (typically by reducing stresses)

Securing project resources

The outcomes of specific conservation actions.

Strategic actions meets the criteria of being:

Linked – directly related to a specific objective(s)

Strategic – maximizes leverage and efficiency

Focused – outlines specific steps for implementing the action

Feasible – achievable in light of the project's resources and constraints

Appropriate – acceptable to and fitting within project-specific cultural, social and ecological norms

Table 4. Objectives for the Meramec River CAP.

By 2024, stabilize and restore X% (or X units) of degraded riparian corridor habitats on existing private properties
By 2024 reduce by X% (from X% in a given catchment/watershed/sub-basin) the urban/suburban stream sites exceeding X ppm nitrate concentration.
By 2024 reduce by X% (from X% in a given catchment/watershed/sub-basin) the urban/suburban stream sites exceeding X ppm phosphorus concentration.
By 2024, ensure compliance of Missouri BMPs of all counties with in-steam gravel mining operations throughout the Meramec River Basin.
By 2024, implement X number/% of stormwater management techniques (LID/wet weather) for existing facilities on private property (sustainable operations, maintenance, and management focus; see EPA guidelines)
By 2024, implement X number/% of stormwater management techniques to maintain or restore sites development hydrology for new construction (design and construction focus) or major renovations on private property (see EPA guidelines)
By 2024, increase mussel species richness by 15% at existing mussel locations in the Big River from Cedar Hill to the confluence with the Meramec River
By 2024, increase vegetated riparian corridor buffers in urban/suburban areas by 25% (from current levels) within 100 feet of rivers and streams in the Lower Meramec River Basin
By 2024, reduce existing livestock access to springs, streams, and rivers by X% (from X% currently).
By 2024, reduce forest conversion rate in the Middle Meramec River Drainage by 50%.
By 2024, reduce stream modifications by farmers by 25% in the Bourbeuse River Drainage.
By 2024, reduce the scale (amount mined) of in-stream gravel mining projects from X amount (existing) to X amount per permitted project in a given catchment/watershed/sub-basin.

Table 5. Prioritized strategic actions for the Meramec River CAP.

Priority #	Strategic Actions	Objectives Supported by this Strategic Action	Targets and Key Attributes Supported by this Strategic Action	Threats Addressed	Benefits Overall Rank	Feasibility	Cost
1	Complete streambank stability assessment, including identification of causes and prioritization for stabilization/restoration.	-By 2024, increase vegetated riparian corridor buffers in urban/suburban areas by 25% (from current levels) within 100 feet of rivers and streams in the Lower Meramec River Basin	Lower Meramec River Drainage -Condition: Riparian corridor -Size: Riparian corridor size Middle Meramec River Drainage -Landscape Context: Stream geomorphology -Condition: Riparian corridor -Size: Riparian corridor size	-Housing & Urban Areas -Livestock Farming & Ranching -Riverbank & Channel Hardening	Very High	High	High
2	Assess forest conversion rate over the last ten years using GIS/aerial analyses for the Middle Meramec River Drainage.	-By 2024, reduce forest conversion rate in the Middle Meramec River Drainage by 50%.	Middle Meramec River Drainage -Landscape Context: Connectivity -Landscape Context: Connectivity -Landscape Context: Hydrology -Landscape Context: Landscape pattern (mosaic) & structure -Landscape Context: Landscape pattern (mosaic) & structure -Landscape Context: Stream geomorphology -Condition: Riparian corridor -Size: Riparian corridor size	-Utility & Service Lines -Timber Operations -Housing & Urban Areas -Livestock Farming & Ranching -Transportation, Utility, & Service Corridors -Historical Agricultural & Forestry Practices -Riverbank & Channel Hardening -Garbage & Solid Waste	High	Medium	Medium
3	Assess spatial distribution, scope, and scale of all current in-stream gravel mining activities throughout the Meramec River Basin.	-By 2024, ensure compliance of Missouri BMPs of all counties with in-steam gravel mining operations throughout the Meramec River Basin. -By 2024, reduce the scale (amount mined) of in-stream gravel mining projects from X amount (existing) to X amount per permitted project in a given catchment/watershed/sub-basin.	Lower Meramec River Drainage -Landscape Context: Stream geomorphology -Condition: In-stream habitat Middle Meramec River Drainage -Landscape Context: Stream geomorphology -Condition: In-stream habitat Upper Meramec River Drainage -Landscape Context: Stream geomorphology -Condition: In-stream habitat Bourbeuse River Drainage -Landscape Context: Stream geomorphology -Condition: In-stream habitat Big River Drainage -Landscape Context: Stream geomorphology -Condition: In-stream habitat Huzzah Creek and Courtois Creek Drainages -Landscape Context: Stream	-In-Stream Gravel Mining & Reaming	High	High	Medium

Table 5. Prioritized strategic actions for the Meramec River CAP.

Priority #	Strategic Actions	Objectives Supported by this Strategic Action	Targets and Key Attributes Supported by this Strategic Action	Threats Addressed	Benefits Overall Rank	Feasibility	Cost
			geomorphology -Condition: In-stream habitat Freshwater Mussels -Landscape Context: Stream geomorphology -Condition: In-stream habitat				
3	Develop (or distrubure current) a brochure re: septic system maintenance, effects on environment, and solutions, targeted at home owners and developers.	-By 2024 reduce by X% (from X% in a given catchment/watershed/sub-basin) the urban/suburban stream sites exceeding X ppm nitrate concentration. -By 2024 reduce by X% (from X% in a given catchment/watershed/sub-basin) the urban/suburban stream sites exceeding X ppm phosphorus concentration.	Lower Meramec River Drainage -Condition: Water chemistry -Condition: Water quality Middle Meramec River Drainage -Condition: Water chemistry -Condition: Water quality Upper Meramec River Drainage -Condition: Water chemistry -Condition: Water quality Bourbeuse River Drainage -Condition: Water chemistry -Condition: Water quality Big River Drainage -Condition: Water quality Huzzah Creek and Courtois Creek Drainages -Condition: Water chemistry -Condition: Water quality LaBarque Creek Drainage -Condition: Water chemistry -Condition: Water quality Freshwater Mussels -Condition: Water quality	-Housing & Urban Areas	High	Medium	Medium
3	Develop and implement partnership program (e.g., Woodlands for Wildlife) to secure revegetation for key subwatersheds in the Bourbeuse, Upper Meramec, Huzzah/Courtois, and Middle Meramec drainages	-By 2023, stabilize and restore X% (or X units) of degraded riparian corridor habitats on existing private properties -By 2024, reduce existing livestock access to springs, streams, and rivers by X% (from X% currently).	Middle Meramec River Drainage -Landscape Context: Landscape pattern (mosaic) & structure -Landscape Context: Stream geomorphology -Condition: Riparian corridor -Size: Riparian corridor size Bourbeuse River Drainage -Landscape Context: Landscape pattern (mosaic) & structure -Landscape Context: Stream geomorphology -Condition: Riparian corridor -Size: Riparian corridor size	-Livestock Farming & Ranching	Very High	Medium	Very High

Table 5. Prioritized strategic actions for the Meramec River CAP.

Priority #	Strategic Actions	Objectives Supported by this Strategic Action	Targets and Key Attributes Supported by this Strategic Action	Threats Addressed	Benefits Overall Rank	Feasibility	Cost
			Huzzah Creek and Courtois Creek Drainages -Landscape Context: Landscape pattern (mosaic) & structure -Landscape Context: Stream geomorphology -Condition: Riparian corridor -Size: Riparian corridor size				
3	Develop updated BMPs for minimizing damage caused by in-stream gravel mining and outreach to all counties/constituencies.	-By 2024, ensure compliance of Missouri BMPs of all counties with in-steam gravel mining operations throughout the Meramec River Basin.	Lower Meramec River Drainage -Landscape Context: Stream geomorphology -Condition: In-stream habitat Middle Meramec River Drainage -Landscape Context: Stream geomorphology -Condition: In-stream habitat Upper Meramec River Drainage -Landscape Context: Stream geomorphology -Condition: In-stream habitat Bourbeuse River Drainage -Landscape Context: Stream geomorphology -Condition: In-stream habitat Big River Drainage -Landscape Context: Stream geomorphology -Condition: In-stream habitat Huzzah Creek and Courtois Creek Drainages -Landscape Context: Stream geomorphology -Condition: In-stream habitat Freshwater Mussels -Landscape Context: Stream geomorphology -Condition: In-stream habitat	-Transportation, Utility, & Service Corridors -In-Stream Gravel Mining & Reaming	Very High	Low	Medium
3	Plant appropriate vegetation for reducing streambank erosion and overland flow in high-priority riparian buffer locations.	-By 2024, implement X number/% of stormwater management techniques (LID/wet weather) for existing facilities on private property (sustainable operations, maintenance, and management focus;	Lower Meramec River Drainage -Condition: Riparian corridor -Size: Riparian corridor size Middle Meramec River Drainage -Condition: Riparian corridor -Size: Riparian corridor size	-Utility & Service Lines -Housing & Urban Areas -Riverbank & Channel Hardening	Very High	Medium	High

Table 5. Prioritized strategic actions for the Meramec River CAP.

Priority #	Strategic Actions	Objectives Supported by this Strategic Action	Targets and Key Attributes Supported by this Strategic Action	Threats Addressed	Benefits Overall Rank	Feasibility	Cost
		see EPA guidelines) -By 2024, implement X number/% of stormwater management techniques to maintain or restore sites development hydrology for new construction (design and construction focus) or major renovations on private property (see EPA guidelines) -By 2024, increase vegetated riparian corridor buffers in urban/suburban areas by 25% (from current levels) within 100 feet of rivers and streams in the Lower Meramec River Basin	Bourbeuse River Drainage -Condition: Riparian corridor -Size: Riparian corridor size Big River Drainage -Condition: Riparian corridor -Size: Riparian corridor size Huzzah Creek and Courtois Creek Drainages -Condition: Riparian corridor -Size: Riparian corridor size LaBarque Creek Drainage -Condition: Riparian corridor -Size: Riparian corridor size Freshwater Mussels -Condition: Riparian corridor -Size: Riparian corridor size				
3	Provide economical water, shade, and fencing for cattle farmers in high-priority stream/river areas.	-By 2024, reduce stream modifications by farmers by 25% in the Bourbeuse River Drainage.	Bourbeuse River Drainage -Landscape Context: Stream geomorphology -Condition: Riparian corridor	-Livestock Farming & Ranching	Very High	Medium	Very High
3	Provide technological tools (e.g., software) to design better stormwater control consistent across the project area.	-By 2024, implement X number/% of stormwater management techniques (LID/wet weather) for existing facilities on private property (sustainable operations, maintenance, and management focus; see EPA guidelines) -By 2024, implement X number/% of stormwater management techniques to maintain or restore sites development hydrology for new construction (design and construction focus) or major renovations on private property (see EPA guidelines)	Lower Meramec River Drainage -Landscape Context: Hydrology Middle Meramec River Drainage -Landscape Context: Hydrology Upper Meramec River Drainage -Landscape Context: Hydrology Bourbeuse River Drainage -Landscape Context: Hydrology Big River Drainage -Landscape Context: Hydrology Huzzah Creek and Courtois Creek Drainages -Landscape Context: Hydrology LaBarque Creek Drainage -Landscape Context: Hydrology	-Housing & Urban Areas	Very High	Medium	High
3	Rebuild Cedar Hill dam to contain contaminated sediments in the Big River.	-By 2024, increase mussel species richness by 15% at existing mussel locations in the Big River from Cedar Hill to the confluence with the Meramec River	Big River Drainage -Condition: Water chemistry	-Mine Tailings & Industrial Effluents	Very High	High	Very High

Table 5. Prioritized strategic actions for the Meramec River CAP.

Priority #	Strategic Actions	Objectives Supported by this Strategic Action	Targets and Key Attributes Supported by this Strategic Action	Threats Addressed	Benefits Overall Rank	Feasibility	Cost
3	Complete stream clean-up actions to reduce garbage and solid waste and improve stewardship of aquatic resources.		Lower Meramec River Drainage -Condition: In-stream habitat	-Housing & Urban Areas	Low	Very High	Medium
3	Identify and communicate the economic benefits of intact forests.	-By 2024, reduce forest conversion rate in the Middle Meramec River Drainage by 50%.	Middle Meramec River Drainage -Landscape Context: Connectivity -Landscape Context: Hydrology -Landscape Context: Landscape pattern (mosaic) & structure -Landscape Context: Landscape pattern (mosaic) & structure -Landscape Context: Stream geomorphology	-Timber Operations	Medium	Medium	Medium
3	Identify N and P "hot spot" pollution areas and develop a plan for remediation/restoration.	-By 2024 reduce by X% (from X% in a given catchment/watershed/sub-basin) the urban/suburban stream sites exceeding X ppm nitrate concentration. -By 2024 reduce by X% (from X% in a given catchment/watershed/sub-basin) the urban/suburban stream sites exceeding X ppm phosphorus concentration.	Lower Meramec River Drainage -Condition: Water quality	-Housing & Urban Areas	Medium	High	Medium
3	Upgrade septic systems that most contribute to water quality degradation in the Lower Meramec River Drainage.	-By 2024 reduce by X% (from X% in a given catchment/watershed/sub-basin) the urban/suburban stream sites exceeding X ppm nitrate concentration. -By 2024 reduce by X% (from X% in a given catchment/watershed/sub-basin) the urban/suburban stream sites exceeding X ppm phosphorus concentration.	Lower Meramec River Drainage -Condition: Water chemistry -Condition: Water quality	-Housing & Urban Areas	Very High	Low	Very High

NEXT STEPS FOR IMPLEMENTING THE PLAN

Missouri State University

Missouri Stream Team

The Nature Conservancy
Protecting nature. Preserving life.

The Open Space Council for the St. Louis Region

Ozark Regional Land Trust

Saint Louis County Parks

Shaw Nature Reserve
a division of the Missouri Botanical Garden

Teaming With Wildlife
a natural investment

The Meramec River Conservation Action Plan provides a blueprint for implementing conservation actions in the basin using TNC's 10-step CAP process (see "Methodology"). This plan primarily addresses Steps 1–7 in order to provide the initial framework for completing Steps 8–10 as this plan is implemented. The following are recommendations for fully implementing this plan:

Develop a Work Plan

A well-developed work plan provides clear and specific guidance pertaining to the staffing, timeline, and costs associated implementing conservation actions. A work plan identifies the specific tasks that need to be completed, including the what, who, when and how of each of these actions, and the monitoring tasks necessary for the project. The process of completing a work plan also helps identify gaps in the availability of critical resources and capacity necessary to achieve objectives. The CAP process provides full integration for work planning and project tracking that incorporates all facets of conservation planning, implementing actions, and measuring results. We recommend that the Partners develop a work plan for implementing the conservation actions described herein. A work plan is essential in building upon the multi-year collaboration that generated the contents of this plan, and best ensures that we meet the project vision of ensuring the sustainability of aquatic resources in the Meramec River Basin.

Complete Targeted Research

A considerable amount of research is needed to better understand and refine target viability and indicator rankings, as well as implement monitoring efforts. In fact, several of the highest-ranked strategies are research and/or data collection actions (Table 5). In general, research should be focused on the highest-ranked stresses and threats (i.e., the critical threats) across the basin. During our meta-analysis of stakeholder conservation plans, policies, and publications (see "Unified Objectives for the Meramec River"; Appendix F), we also extracted over 64 research-based actions for conserving aquatic resources in the Meramec River Basin. These actions were categorized into "Biological", "Habitat-Based Research", "Hydrology and Water Quality", "Monitoring and Management", and "Socioeconomic" (Appendix G).

The effects of excessive SABs are a particular area that warrants further research. Although it is the highest-rated stress in the basin, our current understanding of its impacts are generally assumption-based and subjective. Per Dr. Robert B. Jacobson of the USGS Columbia Environmental Research Center:

> *"For many of the key ecological attributes it is clear how they have changed from a pre-European settlement reference condition. It is reasonable to assume, for example, that contaminated sediments were negligible, riparian corridors were intact, channels were not channelized or stabilized, etc. It is harder (actually impossible) to quantify suspended sediment and deposited fine sediment under the pre-European condition. There was certainly sediment in transit through the system and certainly places where it would be deposited in transient storage on the bed. We can infer that these have increased under present-day conditions, but we don't know how much. Where, for example, does excessive suspended sediment come from in the basin (there are many, spatially distributed threats), and how well do we know what level is excessive, and what level [of sediment abatement] is achievable?"*

Considering that is identified as the leading cause of impairment to rivers and streams nationwide (USEPA 2002; USEPA 2013) and likely impacting basin targets, we recommend a concerted effort to better quantify the sources and impacts of excessive suspended SABs on aquatic resources in the Meramec River Basin. For example, the highest-ranked strategic action in this plan – "Complete streambank stability assessment, including identification of causes and prioritization for stabilization/restoration" – directly addresses excessive SABs resulting from in-stream channel processes and should be considered as an initial research project.

Refine How to Measure Results

Measuring the results of conservation actions is essential in determining whether progress is being made towards desired results, assessing the effectiveness of management actions, and adapting the conservation action plan to get the best results. It can also enhance relationships with stakeholders both in- and outside the project area. Good measures also enhance accountability, credibility and transparency with among partners, the public, and funding sources that are increasingly looking for evidence of a return on investment. Importantly, they are the foundation for an improved understanding of what strategies work well under which circumstances that can in turn lead to better decisions on future priorities and strategies. One of the strengths of the CAP process is the full integration between conservation planning, taking action, and measuring results.

The indicators identified in the Viability Assessment provide a good foundation for measuring results of conservation actions in the project. Several indicators are currently monitored by the MDC, MDNR, USFWS, STREAM teams, and other stakeholders, though more specificity for categorizing indicator rankings and the specific physical or biological parameter to measure are needed. We recommend that stakeholders further refine measurements that will provide a list of the indicators for best measuring the effectiveness of each conservation action and the methods used for collecting each indicator.

Implement Strategic Actions and Adaptive Management

Lastly, conservation partners should collaborate under a defined work plan to implement the highest-ranked strategies described herein, measure the results, and use that information to evaluate objectives and actions on a frequent basis. Results from conservation actions should also be disseminated to conservation partners and all interested stakeholders in the basin. For example, providing information of current actions and developing partnerships with entities that can strongly influence conservation outcomes can leverage actions for greater conservation impact across the basin (see "Situation Analysis"). In addition, this plan should be updated as needed per the previous recommendations above to better define its elements, track progress on current progress, and provide measurable feedback on efforts to improve the viability of targets in the Meramec River Basin.

Meramec River at Castlewood State Park. © Steve Herrington/TNC

MIZZOU

NRCS Natural Resources Conservation Service

FSA FARM SERVICE AGENCY

U.S. FISH & WILDLIFE SERVICE DEPARTMENT OF THE INTERIOR

FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

USGS science for a changing world

Washington University in St. Louis

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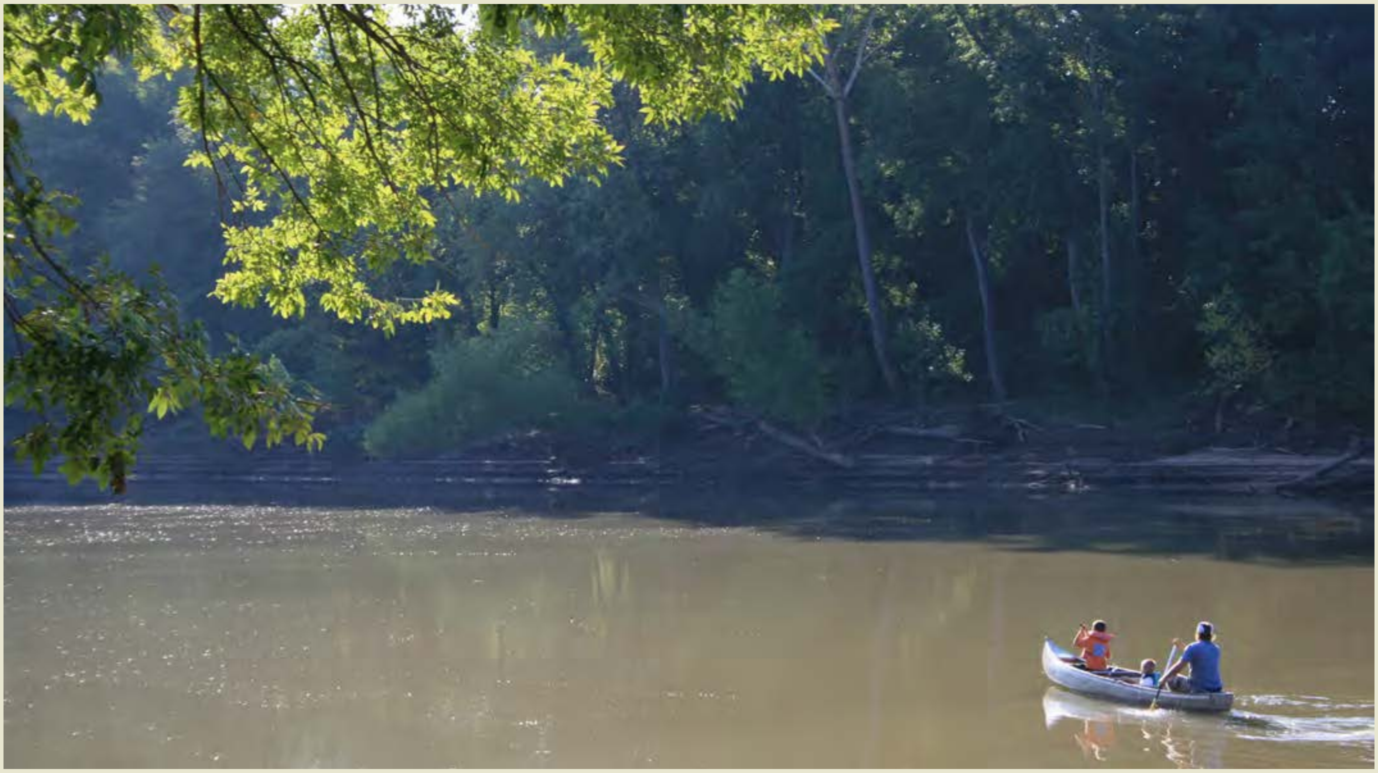
APPENDICES

Canoers on the Meramec River. © Mary Bargeron/TNC



Appendix A. Aquatic-dependent species in the Meramec River Basin (Nigh & Sowa 2005). Rankings courtesy of www.natureserve.org

Scientific Name	Common Name	State Rank	Global Rank	State Status	Federal Status
Mussels					
Actinonaias ligamentina	Mucket	S?	G5		
Alasmidonta marginata	Elktoe	S2?	G4		
Alasmidonta viridis	Slippershell mussel	S?	G4G5		
Amblema plicata	Threeridge	S?	G5		
Anodontoides ferussacianus	Cylindrical papershell	S1?	G5		
Arcidens confragosus	Rock pocketbook	S3	G4		
Corbicula fluminea	Asian clam	SE	G5		
Cumberlandia monodonta	Spectaclecase	S3	G2G3		
Cyclonaias tuberculata	Purple wartyback	S?	G5		
Dreissena polymorpha	Zebra mussel	SE	G5		
Ellipsaria lineolata	Butterfly	S?	G4		
Elliptio crassidens	Elephantear	S1	G5		
Elliptio dilatata	Spike	S?	G5		
Epioblasma triquetra	Snuffbox	S1	G3		
Fusconaia ebena	Ebonyshell	S1?	G4G5		
Fusconaia flava	Wabash pigtoe	S?	G5		
Lampsilis abrupta	Pink mucket	S2	G2		
Lampsilis cardium	Plain pocketbook	S?	G5		
Lampsilis reeveiana brittsi	Northern brokenray	S?	G3T2		
Lampsilis siliquoidea	Fatmucket	S?	G5		
Lampsilis teres	Yellow sandshell	S?	G5		
Lasmigona complanata	White heelsplitter	S?	G5		
Lasmigona costata	Flutedshell	S?	G5		
Leptodea fragilis	Fragile papershell	S?	G5		
Leptodea leptodon	Scaleshell	S1S2	G1		
Ligumia recta	Black sandshell	S1S2	G5		
Ligumia subrostrata	Pondmussel	S?	G4G5		
Megalonaias nervosa	Washboard	S?	G5		
Obliquaria reflexa	Threehorn wartyback	S?	G5		
Plethobasus cyphyus	Sheepnose	S1	G3		
Pleurobema sintoxia	Round pigtoe	S?	G4		
Potamilus alatus	Pink heelsplitter	S?	G5		
Potamilus ohiensis	Pink papershell	S?	G5		
Ptychobranchus occidentalis	Ouachita kidneyshell	S2S3	G3G4		
Pyganodon grandis	Giant floater	S?	G5		
Quadrula metanevra	Monkeyface	S?	G4		
Quadrula pustulosa	Pimpleback	S?	G5		
Quadrula quadrula	Mapleleaf	S?	G5		

Appendix A. Aquatic-dependent species in the Meramec River Basin (Nigh & Sowa 2005). Rankings courtesy of www.natureserve.org

Scientific Name	Common Name	State Rank	Global Rank	State Status	Federal Status
Simpsonaias ambigua	Salamander mussel	S1?	G3		
Strophitus undulatus	Creeper	S?	G5		
Toxolasma parvus	Lilliput	S?	G5		
Tritogonia verrucosa	Pistolgrip	S?	G4		
Truncilla donaciformis	Fawnsfoot	S?	G5		
Truncilla truncata	Deertoe	S?	G5		
Utterbackia imbecillis	Paper pondshell	S?	G5		
Venustaconcha ellipsiformis	Ellipse	S?	G3G4		
Insects					
Glyphopsyche missouri	Missouri Glyphopsyche caddisfly	S1	G1		
Agapetus artesus	Artesian agapetus caddisfly				
Anax longipes	Comet Darner	S3	G5		
Calephelis muticum	Swamp Metalmark	S3	G3		
Chalybion zimmermanni zimmermanni	A Blue Mud Dauber	SU	GNR		
Gomphus fraternus	Midland Clubtail	SU	G5		
Gomphus ozarkensis	Ozark Clubtail	S3	G4		
Gomphus ventricosus	Skillet Clubtail	SU	G3		
Leucotrichia pictipes	Ringhorn microcaddisfly				
Macromia pacifica	Gilded River Cruiser	S3	G4		
Metaleptea brevicornis	Short-horned Grasshopper				
Neoconocephalus retusus	Round-tipped conehead				
Ophiogomphus westfalli	Westfall's Snaketail	S3	G3		
Phyllobrotica physostegiae	Leaf beetle				
Somatochlora hineana	Hine's Emerald	S1	G2G3	E	E
Somatochlora ozarkensis	Ozark Emerald	S2S3	G3		
Stenonema bednariki	A Heptageniid Mayfly	S3	G2G4		
Tachopteryx thoreyi	Gray Petaltail	S3	G4		
Crayfish					
Cambarus hubrichti	Salem cave crayfish	S3	G2		
Cambarus diogenes	Devil crayfish	S4	G5		
Cambarus maculatus	Freckled crayfish	S3	G4		
Orconectes harrisonii	Belted crayfish	S3	G3		
Orconectes hylas	Woodland crayfish	S3?	G4		
Orconectes luteus	Golden crayfish	S?	G5		
Orconectes medius	Saddlebacked crayfish	S3?	G4		
Orconectes punctimanus	Spothanded crayfish	S?	G4G5		
Orconectes virilis	Virile crayfish	S?	G5		
Other invertebrates					
Allocrangonyx hubrichti	Hubricht's Long-tailed Amphipod	S3	G2G3		

Appendix A. Aquatic-dependent species in the Meramec River Basin (Nigh & Sowa 2005). Rankings courtesy of www.natureserve.org

Scientific Name	Common Name	State Rank	Global Rank	State Status	Federal Status
Hendersonia occulta	Cherrystone Snail	S3	G5		
Sinella avita	Avita Cave Springtail	SU	G3G4		
Stygobromus onondagaensis	Onondaga Cave Amphipod	S3?	G5		
Fishes					
Ammocrypta clara	Western sand darter	S2S3	G3	E	
Alosa alabamae	Alabama shad	S2	G3		
Alosa chrysochloris	Skipjack herring	S?	G5		
Ambloplites rupestris	Rock bass	S?	G5		
Ameiurus melas	Black bullhead	S?	G5		
Ameiurus natalis	Yellow bullhead	S?	G5		
Ameiurus nebulosus	Brown bullhead	S3?	G5		
Amia calva	Bowfin	S?	G5		
Anguilla rostrata	American eel	S?	G5		
Aplodinotus grunniens	Freshwater drum	S?	G5		
Campostoma anomalum	Central stoneroller	S?	G5		
Campostoma oligolepis	Largescale stoneroller	S?	G5		
Carassius auratus	Goldfish	SE	G5		
Carpiodes carpio	River carpsucker	S?	G5		
Carpiodes cyprinus	Quillback	S?	G5		
Carpiodes velifer	Highfin carpsucker	S2	G4G5		
Catostomus commersoni	White sucker	S?	G5		
Centrarchus macropterus	Flier	S3	G5		
Chaenobryttus gulosus	Warmouth	S?	G5		
Cottus bairdi	Mottled sculpin	S4	G5		
Cottus carolinae	Banded sculpin	S?	G5		
Crystallaria asprella	Crystal darter	S1	G3	E	
Cycleptus elongatus	Blue sucker	S3	G3G4		
Cyprinella lutrensis	Red shiner	S?	G5		
Cyprinella spiloptera	Spotfin shiner	S?	G5		
Cyprinella whipplei	Steelcolor shiner	S?	G5		
Cyprinus carpio	Common carp	SE	G5		
Dorosoma cepedianum	Gizzard shad	S?	G5		
Dorosoma petenense	Threadfin shad	S?	G5		
Erimystax x-punctatus	Gravel chub	S?	G4		
Erimyzon oblongus	Creek chubsucker	S?	G5		
Erimyzon sucetta	Lake chubsucker	S2	G5		
Esox americanus	Grass pickerel	S?	G5		
Esox lucius	Northern pike	S4	G5		
Etheostoma asprigene	Mud darter	S?	G4G5		

Appendix A. Aquatic-dependent species in the Meramec River Basin (Nigh & Sowa 2005). Rankings courtesy of www.natureserve.org

Scientific Name	Common Name	State Rank	Global Rank	State Status	Federal Status
Etheostoma blennioides	Greenside darter	S?	G5		
Etheostoma caeruleum	Rainbow darter	S?	G5		
Etheostoma flabellare	Fantail darter	S?	G5		
Etheostoma nigrum	Johnny darter	S?	G5		
Etheostoma punctulatum	Stippled darter	S?	G4		
Etheostoma spectabile	Orangethroat darter	S?	G5		
Etheostoma tetrazonum	Meramec River saddled darter	S?	G?		
Etheostoma tetrazonum	Missouri saddled darter	S?	G5		
Etheostoma zonale	Banded darter	S?	G5		
Fundulus catenatus	Northern studfish	S?	G5		
Fundulus notatus	Blackstripe topminnow	S?	G5		
Fundulus olivaceus	Blackspotted topminnow	S?	G5		
Fundulus sciadicus	Plains topminnow	S3	G4		
Gambusia affinis	Western mosquitofish	S?	G5		
Hiodon alosoides	Goldeye	S?	G5		
Hiodon tergisus	Mooneye	S3	G5		
Hybognathus argyritis	Western silvery minnow	S2	G4		
Hybognathus nuchalis	Mississippi silvery minnow	S3S4	G5		
Hybognathus placitus	Plains minnow	S2	G4		
Hypentelium nigricans	Northern hog sucker	S?	G5		
Ichthyomyzon castaneus	Chestnut lamprey	S?	G4		
Ichthyomyzon fossor	Northern brook lamprey	S4	G4		
Ictalurus punctatus	Channel catfish	S?	G5		
Ictiobus bubalus	Smallmouth buffalo	S?	G5		
Ictiobus cyprinellus	Bigmouth buffalo	S?	G5		
Ictiobus niger	Black buffalo	S?	G5		
Labidesthes sicculus	Brook silverside	S?	G5		
Lampetra aepyptera	Least brook lamprey	S4	G5		
Lepisosteus oculatus	Spotted gar	S5	G5		
Lepisosteus osseus	Longnose gar	S?	G5		
Lepisosteus platostomus	Shortnose gar	S?	G5		
Lepomis cyanellus	Green sunfish	S?	G5		
Lepomis gibbosus	Pumpkinseed	S?	G5		
Lepomis humilis	Orangespotted sunfish	S?	G5		
Lepomis macrochirus	Bluegill	S?	G5		
Lepomis megalotis	Longear sunfish	S?	G5		
Lepomis microlophus	Redear sunfish	S?	G5		
Lepomis miniatus	Redspotted sunfish	S4S5	G5		
Luxilus chrysocephalus	Striped shiner	S?	G5		

Appendix A. Aquatic-dependent species in the Meramec River Basin (Nigh & Sowa 2005). Rankings courtesy of www.natureserve.org

Scientific Name	Common Name	State Rank	Global Rank	State Status	Federal Status
Luxilus zonatus	Bleeding shiner	S?	G5		
Lythrurus umbratilis	Redfin shiner	S?	G5		
Macrhybopsis storeriana	Silver chub	S3	G5		
Micropterus dolomieu	Smallmouth bass	S?	G5		
Micropterus punctulatus	Spotted bass	S?	G5		
Micropterus salmoides	Largemouth bass	S?	G5		
Minytrema melanops	Spotted sucker	S?	G5		
Morone chrysops	White bass	S?	G5		
Moxostoma anisurum	Silver redhorse	S?	G5		
Moxostoma carinatum	River redhorse	S?	G4		
Moxostoma duquesnei	Black redhorse	S?	G5		
Moxostoma erythrurum	Golden redhorse	S?	G5		
Moxostoma macrolepidotum	Shorthead redhorse	S?	G5		
Nocomis biguttatus	Hornyhead chub	S?	G5		
Notemigonus crysoleucas	Golden shiner	S?	G5		
Notropis amblops	Bigeye chub	S?	G5		
Notropis amnis	Pallid shiner	SX	G4		
Notropis atherinoides	Emerald shiner	S?	G5		
Notropis blennius	River shiner	S?	G5		
Notropis boops	Bigeye shiner	S?	G5		
Notropis buccatus	Silverjaw minnow	S4	G5		
Notropis buchanani	Ghost shiner	S2	G5		
Notropis dorsalis	Bigmouth shiner	S?	G5		
Notropis greenei	Wedgespot shiner	S?	G5		
Notropis heterolepis	Blacknose shiner	S2	G4		
Notropis nubilus	Ozark minnow	S?	G5		
Notropis rubellus	Rosyface shiner	S?	G5		
Notropis stramineus	Sand shiner	S?	G5		
Notropis volucellus	Mimic shiner	S?	G5		
Notropis wickliffi	Channel shiner	S?	G5		
Noturus exilis	Slender madtom	S?	G5		
Noturus flavater	Checkered madtom	S3S4	G3G4		
Noturus flavus	Stonecat	S?	G5		
Noturus nocturnus	Freckled madtom	S?	G5		
Oncorhynchus mykiss	Rainbow trout	SE	G5		
Percina caprodes	Logperch	S?	G5		
Percina evides	Gilt darter	S?	G4		
Percina phoxocephala	Slenderhead darter	S?	G5		
Percina shumardi	River darter	S3	G5		

Appendix A. Aquatic-dependent species in the Meramec River Basin (Nigh & Sowa 2005). Rankings courtesy of www.natureserve.org

Scientific Name	Common Name	State Rank	Global Rank	State Status	Federal Status
Phenacobius mirabilis	Suckermouth minnow	S?	G5		
Phoxinus erythrogaster	Southern redbelly dace	S?	G5		
Pimephales notatus	Bluntnose minnow	S?	G5		
Pimephales promelas	Fathead minnow	S?	G5		
Pimephales vigilax	Bullhead minnow	S?	G5		
Platygobio gracilis	Flathead chub	S1	G5	E	
Polyodon spathula	Paddlefish	S3	G4		
Pomoxis annularis	White crappie	S?	G5		
Pomoxis nigromaculatus	Black crappie	S?	G5		
Pylodictis olivaris	Flathead catfish	S?	G5		
Salmo trutta	Brown trout	SE	G5		
Semotilus atromaculatus	Creek chub	S?	G5		
Stizostedion canadense	Sauger	S?	G5		
Stizostedion vitreum	Walleye	S?	G5		
Typhlichthys subterraneus	Southern Cavefish	S2S3	G4		
Amphibians and Reptiles					
Cryptobranchus alleganiensis alleganiensis	Eastern Hellbender	S1	G3G4		
Ambystoma annulatum	Ringed Salamander	S3	G4		
Ambystoma tigrinum tigrinum	Eastern Tiger Salamander	SU	G5T5		
Crotaphytus collaris collaris	Eastern Collared Lizard	S4	G5	E	
Hemidactylium scutatum	Four-toed Salamander	S4	G5		
Rana sylvatica	Wood Frog	S3	G5		
Scaphiopus holbrookii	Eastern Spadefoot	S2	G5		
Typhlotriton spelaeus	Grotto Salamander	S2S3	G4		
Mammals					
Myotis grisescens	Gray Bat	S3	G3		
Mustela frenata	Long-tailed Weasel	S2	G5	E	E
Myotis leibii	Eastern Small-footed Myotis	SU	G3		
Myotis septentrionalis	Northern Myotis	S3	G4		
Myotis sodalis	Indiana Bat	S1	G2	E	E
Ochrotomys nuttalli	Golden Mouse	S3?	G5		
Sylvilagus aquaticus	Swamp Rabbit	S2	G5		
Birds					
Accipiter striatus	Sharp-shinned Hawk	S3	G5		
Circus cyaneus	Northern Harrier	S2	G5		
Dendroica cerulea	Cerulean Warbler	S2S3	G4		
Haliaeetus leucocephalus	Bald Eagle	S3	G4		

Appendix B. Terrestrial natural communities within the Meramec River Basin (Nelson 2010).

Acid seep	Dry-mesic bottomland forest	Mesic limestone/dolomite forest
Cave	Dry-mesic chert forest	Mesic sandstone forest
Cave spring / effluent cave	Dry-mesic chert woodland	Moist limestone/dolomite cliff
Common Name	Dry-mesic limestone/dolomite forest	Moist sandstone cliff
Common Name	Dry-mesic loess/glacial till forest	Oxbows and sloughs (ozark)
Creeks and small rivers (ozark)	Headwater streams (ozark)	Ozark fen
Dolomite glade	Igneous glade	Pond swamp
Dry chert woodland	Influent cave	Prairie fen
Dry igneous woodland	Larger rivers (ozark)	Sandstone glade
Dry limestone/dolomite cliff	Limestone glade	Springs and spring branches (ozark)
Dry limestone/dolomite woodland	Limestone/dolomite talus	Upland flatwoods
Dry sandstone woodland	Mesic bottomland forest	

Appendix C. Master list of key ecological attributes (KEA's) and indicator for viability assessment in the Meramec River CAP.

Category	Key Attribute	Indicator	Indicator Reference	Indicator Ratings: Poor	Fair	Good	Very Good
Landscape Context	Connectivity	Floodplain accessibility	Qualitative	Poor or no floodplain access at bankfull discharge across target. Deeply incised channel and or/ channel restrictions widespread.	Fair floodplain access at reference bankfull discharge across target. Moderate channel incision and/or channel restrictions moderate-frequent in occurance.	Good but not complete floodplain access at reference bankfull discharge across target. Slight channel incision and/or some channel restrictions (but uncommon)	Very good floodplain access at reference bankfull discharge across target. No or little channel incision with channel restrictions rare or absent.
	Connectivity	Number of aquatic organism passage barriers	Qualitative	Numerous/major AOP barriers which severely fragment species populations	Some/marked AOP barriers which substantially fragment species populations	Few AOP barriers that minimally fragment species populations	No AOP barriers and no species population fragmentation
	Hydrology	Presumptive standard for ecologically sustainable flows	Richter et al. (2011)	>20% deviation from natural flow regime	10-20% deviation from natural flow regime	5-10% deviation from natural flow regime	<5% deviation from natural flow regime
	Landscape pattern (mosaic) & structure	Percent floodplain and wetland conversion (non-urban)	Qualitative	>30% land conversion	20-30% land conversion	10-20% land conversion	<10% land conversion
	Landscape pattern (mosaic) & structure	Percent impervious surface	Schueler et al. (2009)	>10% impervious surface. Significant impacts at 25%.	5-10% impervious surface	1-5% impervious surface	<1% impervious surface
	Stream geomorphology	Channel alteration (EPA)	Barbour et al. (1999)	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization or dredging absent or minimal; stream with normal pattern.
Condition	In-stream habitat	Substrate/avail able cover (EPA)	Barbour et al. (1999)	Less than 20% (10% for low gradient streams) stable habitat; lack of habitat is obvious; substrate unstable or lacking.	20-40% (10-30% for low gradient streams) mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	40-70% (30-50% for low gradient streams) mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization	Greater than 70% (50% for low gradient streams) of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/s

Appendix C. Master list of key ecological attributes (KEA's) and indicator for viability assessment in the Meramec River CAP.

Category	Key Attribute	Indicator	Indicator Reference	Indicator Ratings: Poor	Fair	Good	Very Good
	Riparian corridor	Bank stability (EPA)	Barbour et al. (1999)	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.
	Species assemblage & condition	Fish assemblage IBI	Doisy et al. (2008)	IBI score <29. Highly impaired.	IBI score 29-36. Impaired.	IBI score 37-41. No impairment.	IBI score 41-45. No impairment.
	Species assemblage & condition	Freshwater mussel assemblage	Qualitiative; per results of Hink et al (2012)	Few or no species present, with those present in low number or dominated by few or one tolerant taxa (taxon); rare species absent.	Fair species richness and abundance, with trends towards dominance of tolerant taxa; species from some habitats rare or absent; rare species absent.	Good species richness and abundance across habitats; some rare species present but in low numbers.	High species richness and abundance across habitats, including rare species.
	Species assemblage & condition	Stream Condition Index (MO)	Sarver et al. (2002)	Score 4-8. Non-biologically supporting.	Score 10-12. Partially biologically supporting	Score 12-14. Partially biologically supporting	Score 16-20. Fully biologically supporting
	Water chemistry	Chemical pollutants and contaminants	Qualitative	High contamination	Moderate contamination	Slight contamination	No contamination
	Water quality	Nitrogen and Phosphorus	Qualitiative	High elevation above ambient levels	Moderate elevation above ambient levels	Slight elevation above ambient levels	Very low/ambient levels
	Water quality	Sediment deposition (pools; EPA)	Barbour et al. (1999)	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Little or no enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.
	Water quality	Substrate embeddedness (riffles; EPA)	Barbour et al. (1999)	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.

Appendix C. Master list of key ecological attributes (KEA's) and indicator for viability assessment in the Meramec River CAP.

Category	Key Attribute	Indicator	Indicator Reference	Indicator Ratings: Poor	Fair	Good	Very Good
Size	Population size & dynamics	Freshwater mussel population size: indicator species	Qualitiative; per results of Hink et al (2012)	Poor or no juvenile recruitment (small mussels rare or absent); size structure missing several size classes; often only 1-2 size classes represented	Fair juvenile recruitment (small mussels present but infrequent); size structure indicates fair numbers with few and/or missing year classes.	Good juvenile recruitment (small mussels present but not numerous); size structure with moderate numbers of multiple year classes.	Very good juvenile recruitment (numerous small mussels); size structure indicates large numbers of multiple year classes.
	Population size & dynamics	Freshwater sport fish: indicator species	Qualitative	Poor sport fishery with very low catch rates or sport fish absent. Population structure suggests very poor/no recruitment and unsustainable fishery (if present).	Fair sport fishery with low catch rates of moderately-small sized fish (large fish absent). Population structure shows instability and poor recruitment	Good sport fishery with good catch rates of moderately-sized fish (large fish infrequent but not rare) and stable population structure and recruitment	Very good sport fishery with high catch rates of large-sized fish and stable population structure and recruitment
	Riparian corridor size	Riparian vegetative zone width (EPA)	Barbour et al. (1999)	Width of riparian zone <25 ft.	Width of riparian zone 25-50 ft.	Width of riparian zone 50-100 ft.	Width of riparian zone >100 ft.

Appendix D. Viability assement ratings for Meramec River Basin targets.

Conservation Targets	Category	Key Attribute	Indicator	Indicator Ratings: Poor	Fair	Good	Very Good	Ratings Source	Current Rating	Desired Rating
Lower Meramec River Drainage	Landscape Context	Connectivity	Floodplain accessibility	Poor or no floodplain access at bankfull discharge across target. Deeply incised channel and or/ channel restrictions widespread.	Fair floodplain access at reference bankfull discharge across target. Moderate channel incision and/or channel restrictions moderate-frequent in occurance.	Good but not complete floodplain access at reference bankfull discharge across target. Slight channel incision and/or some channel restrictions (but uncommon)	Very good floodplain access at reference bankfull discharge across target. No or little channel incision with channel restrictions rare or absent.	Rough Guess	Good	Good
		Connectivity	Number of aquatic organism passage barriers	Numerous/major AOP barriers which severely fragment species populations	Some/marked AOP barriers which substantially fragment species populations	Few AOP barriers that minimally fragment species populations	No AOP barriers and no species population fragmentation	Rough Guess	Good	Good
		Hydrology	Presumptive standard for ecologically sustainable flows	>20% deviation from natural flow regime	10-20% deviation from natural flow regime	5-10% deviation from natural flow regime	<5% deviation from natural flow regime	External Research	Fair	Good
		Landscape pattern (mosaic) & structure	Percent floodplain and wetland conversion (non-urban)	>30% land conversion	20-30% land conversion	10-20% land conversion	<10% land conversion	Rough Guess	Poor	Fair
		Landscape pattern (mosaic) & structure	Percent impervious surface	>10% impervious surface. Significant impacts at 25%.	5-10% impervious surface	1-5% impervious surface	<1% impervious surface	External Research	Poor	Fair

Appendix D. Viability assement ratings for Meramec River Basin targets.

Conservation Targets	Category	Key Attribute	Indicator	Indicator Ratings: Poor	Fair	Good	Very Good	Ratings Source	Current Rating	Desired Rating
		Stream geomorphology	Channel alteration (EPA)	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization or dredging absent or minimal; stream with normal pattern.	External Research	Fair	Good
	Condition	In-stream habitat	Substrate/available cover (EPA)	Less than 20% (10% for low gradient streams) stable habitat; lack of habitat is obvious; substrate unstable or lacking.	20-40% (10-30% for low gradient streams) mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	40-70% (30-50% for low gradient streams) mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (	Greater than 70% (50% for low gradient streams) of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/s	Rough Guess	Fair	Good
		Species assemblage & condition	Fish assemblage IBI	IBI score <29. Highly impaired.	IBI score 29-36. Impaired.	IBI score 37-41. No impairment.	IBI score 41-45. No impairment.	External Research	Fair	Good

Appendix D. Viability assement ratings for Meramec River Basin targets.

Conservation Targets	Category	Key Attribute	Indicator	Indicator Ratings: Poor	Fair	Good	Very Good	Ratings Source	Current Rating	Desired Rating
	Size	Species assemblage & condition	Freshwater mussel assemblage	Few or no species present, with those present in low number or dominated by few or one tolerant taxa (taxon); rare species absent.	Fair species richness and abundance, with trends towards dominance of tolerant taxa; species from some habitats rare or absent; rare species absent.	Good species richness and abundance across habitats; some rare species present but in low numbers.	High species richness and abundance across habitats, including rare species.	Expert Knowledge	Poor	Fair
	Size	Water chemistry	Chemical pollutants and contaminants	High contamination	Moderate contamination	Slight contamination	No contamination	Rough Guess	Fair	Very Good
	Size	Water quality	Nitrogen and Phosphorus	High elevation above ambient levels	Moderate elevation above ambient levels	Slight elevation above ambient levels	Very low/ambient levels	Rough Guess	Fair	Good
	Size	Population size & dynamics	Freshwater mussel population size: indicator species	Poor or no juvenile recruitment (small mussels rare or absent); size structure missing several size classes; often only 1-2 size classes represented	Fair juvenile recruitment (small mussels present but infrequent); size structure indicates fair numbers with few and/or missing year classes.	Good juvenile recruitment (small mussels present but not numerous); size structure with moderate numbers of multiple year classes.	Very good juvenile recruitment (numerous small mussels); size structure indicates large numbers of multiple year classes.	Rough Guess	Poor	Fair
	Size	Population size & dynamics	Freshwater sport fish: indicator species	Poor sport fishery with very low catch rates or sport fish absent. Population structure suggests very poor/no recruitment and unsustainable fishery (if present).	Fair sport fishery with low catch rates of moderately-small sized fish (large fish absent). Population structure shows instability and poor recruitment	Good sport fishery with good catch rates of moderately-sized fish (large fish infrequent but not rare) and stable population structure and recruitment	Very good sport fishery with high catch rates of large-sized fish and stable population structure and recruitment	Rough Guess	Fair	Good
	Size	Riparian corridor size	Riparian vegetative zone width (EPA)	Width of riparian zone <25 ft.	Width of riparian zone 25-50 ft.	Width of riparian zone 50-100 ft.	Width of riparian zone >100 ft.	Rough Guess	Poor	Fair

Appendix D. Viability assement ratings for Meramec River Basin targets.

Conservation Targets	Category	Key Attribute	Indicator	Indicator Ratings: Poor	Fair	Good	Very Good	Ratings Source	Current Rating	Desired Rating
Middle Meramec River Drainage	Landscape Context	Connectivity	Floodplain accessibility	Poor or no floodplain access at bankfull discharge across target. Deeply incised channel and or/ channel restrictions widespread.	Fair floodplain access at reference bankfull discharge across target. Moderate channel incision and/or channel restrictions moderate-frequent in occurance.	Good but not complete floodplain access at reference bankfull discharge across target. Slight channel incision and/or some channel restrictions (but uncommon)	Very good floodplain access at reference bankfull discharge across target. No or little channel incision with channel restrictions rare or absent.	Rough Guess	Very Good	Very Good
		Connectivity	Number of aquatic organism passage barriers	Numerous/major AOP barriers which severely fragment species populations	Some/marked AOP barriers which substantially fragment species populations	Few AOP barriers that minimally fragment species populations	No AOP barriers and no species population fragmentation	Rough Guess	Good	Good
		Hydrology	Presumptive standard for ecologically sustainable flows	>20% deviation from natural flow regime	10-20% deviation from natural flow regime	5-10% deviation from natural flow regime	<5% deviation from natural flow regime	External Research	Very Good	Very Good
		Landscape pattern (mosaic) & structure	Percent floodplain and wetland conversion (non-urban)	>30% land conversion	20-30% land conversion	10-20% land conversion	<10% land conversion	Rough Guess	Fair	Good
		Landscape pattern (mosaic) & structure	Percent impervious surface	>10% impervious surface. Significant impacts at 25%.	5-10% impervious surface	1-5% impervious surface	<1% impervious surface	External Research	Good	Good

Appendix D. Viability assement ratings for Meramec River Basin targets.

Conservation Targets	Category	Key Attribute	Indicator	Indicator Ratings: Poor	Fair	Good	Very Good	Ratings Source	Current Rating	Desired Rating
	Condition	In-stream habitat	Substrate/available cover (EPA)	Less than 20% (10% for low gradient streams) stable habitat; lack of habitat is obvious; substrate unstable or lacking.	20-40% (10-30% for low gradient streams) mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	40-70% (30-50% for low gradient streams) mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (	Greater than 70% (50% for low gradient streams) of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/s	Rough Guess	Good	Very Good
		Riparian corridor	Bank stability (EPA)	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	External Research	Fair	Good
		Species assemblage & condition	Freshwater mussel assemblage	Few or no species present, with those present in low number or dominated by few or one tolerant taxa (taxon); rare species absent.	Fair species richness and abundance, with trends towards dominance of tolerant taxa; species from some habitats rare or absent; rare species absent.	Good species richness and abundance across habitats; some rare species present but in low numbers.	High species richness and abundance across habitats, including rare species.	Expert Knowledge	Fair	Good
		Water chemistry	Chemical pollutants and contaminants	High contamination	Moderate contamination	Slight contamination	No contamination	Rough Guess	Very Good	Very Good

Appendix D. Viability assement ratings for Meramec River Basin targets.

Conservation Targets	Category	Key Attribute	Indicator	Indicator Ratings: Poor	Fair	Good	Very Good	Ratings Source	Current Rating	Desired Rating
Upper Meramec River Drainage	Size	Population size & dynamics	Freshwater mussel population size: indicator species	Poor or no juvenile recruitment (small mussels rare or absent); size structure missing several size classes; often only 1-2 size classes represented	Fair juvenile recruitment (small mussels present but infrequent); size structure indicates fair numbers with few and/or missing year classes.	Good juvenile recruitment (small mussels present but not numerous); size structure with moderate numbers of multiple year classes.	Very good juvenile recruitment (numerous small mussels); size structure indicates large numbers of multiple year classes.	Rough Guess	Fair	Good
		Population size & dynamics	Freshwater sport fish: indicator species	Poor sport fishery with very low catch rates or sport fish absent. Population structure suggests very poor/no recruitment and unsustainable fishery (if present).	Fair sport fishery with low catch rates of moderately-small sized fish (large fish absent). Population structure shows instability and poor recruitment	Good sport fishery with good catch rates of moderately-sized fish (large fish infrequent but not rare) and stable population structure and recruitment	Very good sport fishery with high catch rates of large-sized fish and stable population structure and recruitment	Rough Guess	Good	Good
	Landscape Context	Riparian corridor size	Riparian vegetative zone width (EPA)	Width of riparian zone <25 ft.	Width of riparian zone 25-50 ft.	Width of riparian zone 50-100 ft.	Width of riparian zone >100 ft.	External Research	Fair	Good
		Connectivity	Floodplain accessibility	Poor or no floodplain access at bankfull discharge across target. Deeply incised channel and or/ channel restrictions widespread.	Fair floodplain access at reference bankfull discharge across target. Moderate channel incision and/or channel restrictions moderate-frequent in occurance.	Good but not complete floodplain access at reference bankfull discharge across target. Slight channel incision and/or some channel restrictions (but uncommon)	Very good floodplain access at reference bankfull discharge across target. No or little channel incision with channel restrictions rare or absent.	Rough Guess	Very Good	Very Good
		Connectivity	Number of aquatic organism passage barriers	Numerous/major AOP barriers which severely fragment species populations	Some/marked AOP barriers which substantially fragment species populations	Few AOP barriers that minimally fragment species populations	No AOP barriers and no species population fragmentation	Rough Guess	Good	Very Good

Appendix D. Viability assement ratings for Meramec River Basin targets.

Conservation Targets	Category	Key Attribute	Indicator	Indicator Ratings: Poor	Fair	Good	Very Good	Ratings Source	Current Rating	Desired Rating
		Hydrology	Presumptive standard for ecologically sustainable flows	>20% deviation from natural flow regime	10-20% deviation from natural flow regime	5-10% deviation from natural flow regime	<5% deviation from natural flow regime	External Research	Very Good	Very Good
		Landscape pattern (mosaic) & structure	Percent floodplain and wetland conversion (non-urban)	>30% land conversion	20-30% land conversion	10-20% land conversion	<10% land conversion	Rough Guess	Fair	Good
		Landscape pattern (mosaic) & structure	Percent impervious surface	>10% impervious surface. Significant impacts at 25%.	5-10% impervious surface	1-5% impervious surface	<1% impervious surface	External Research	Very Good	Very Good
	Condition	In-stream habitat	Substrate/available cover (EPA)	Less than 20% (10% for low gradient streams) stable habitat; lack of habitat is obvious; substrate unstable or lacking.	20-40% (10-30% for low gradient streams) mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	40-70% (30-50% for low gradient streams) mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (	Greater than 70% (50% for low gradient streams) of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/s	Rough Guess	Good	Good
		Riparian corridor	Bank stability (EPA)	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	External Research	Fair	Good

Appendix D. Viability assement ratings for Meramec River Basin targets.

Conservation Targets	Category	Key Attribute	Indicator	Indicator Ratings: Poor	Fair	Good	Very Good	Ratings Source	Current Rating	Desired Rating
	Size	Species assemblage & condition	Freshwater mussel assemblage	Few or no species present, with those present in low number or dominated by few or one tolerant taxa (taxon); rare species absent.	Fair species richness and abundance, with trends towards dominance of tolerant taxa; species from some habitats rare or absent; rare species absent.	Good species richness and abundance across habitats; some rare species present but in low numbers.	High species richness and abundance across habitats, including rare species.	Expert Knowledge	Fair	Good
		Water chemistry	Chemical pollutants and contaminants	High contamination	Moderate contamination	Slight contamination	No contamination	Rough Guess	Very Good	Very Good
		Water quality	Nitrogen and Phosphorus	High elevation above ambient levels	Moderate elevation above ambient levels	Slight elevation above ambient levels	Very low/ambient levels	Rough Guess	Good	Very Good
		Population size & dynamics	Freshwater mussel population size: indicator species	Poor or no juvenile recruitment (small mussels rare or absent); size structure missing several size classes; often only 1-2 size classes represented	Fair juvenile recruitment (small mussels present but infrequent); size structure indicates fair numbers with few and/or missing year classes.	Good juvenile recruitment (small mussels present but not numerous); size structure with moderate numbers of multiple year classes.	Very good juvenile recruitment (numerous small mussels); size structure indicates large numbers of multiple year classes.	Rough Guess	Fair	Good
		Population size & dynamics	Freshwater sport fish: indicator species	Poor sport fishery with very low catch rates or sport fish absent. Population structure suggests very poor/no recruitment and unsustainable fishery (if present).	Fair sport fishery with low catch rates of moderately-small sized fish (large fish absent). Population structure shows instability and poor recruitment	Good sport fishery with good catch rates of moderately-sized fish (large fish infrequent but not rare) and stable population structure and recruitment	Very good sport fishery with high catch rates of large-sized fish and stable population structure and recruitment	Rough Guess	Very Good	Very Good
		Riparian corridor size	Riparian vegetative zone width (EPA)	Width of riparian zone <25 ft.	Width of riparian zone 25-50 ft.	Width of riparian zone 50-100 ft.	Width of riparian zone >100 ft.	External Research	Fair	Good

Appendix D. Viability assement ratings for Meramec River Basin targets.

Conservation Targets	Category	Key Attribute	Indicator	Indicator Ratings: Poor	Fair	Good	Very Good	Ratings Source	Current Rating	Desired Rating
Bourbeuse River Drainage	Landscape Context	Connectivity	Floodplain accessibility	Poor or no floodplain access at bankfull discharge across target. Deeply incised channel and or/ channel restrictions widespread.	Fair floodplain access at reference bankfull discharge across target. Moderate channel incision and/or channel restrictions moderate-frequent in occurance.	Good but not complete floodplain access at reference bankfull discharge across target. Slight channel incision and/or some channel restrictions (but uncommon)	Very good floodplain access at reference bankfull discharge across target. No or little channel incision with channel restrictions rare or absent.	Rough Guess	Very Good	Very Good
		Connectivity	Number of aquatic organism passage barriers	Numerous/major AOP barriers which severely fragment species populations	Some/marked AOP barriers which substantially fragment species populations	Few AOP barriers that minimally fragment species populations	No AOP barriers and no species population fragmentation	Rough Guess	Fair	Good
		Hydrology	Presumptive standard for ecologically sustainable flows	>20% deviation from natural flow regime	10-20% deviation from natural flow regime	5-10% deviation from natural flow regime	<5% deviation from natural flow regime	External Research	Very Good	Very Good
		Landscape pattern (mosaic) & structure	Percent floodplain and wetland conversion (non-urban)	>30% land conversion	20-30% land conversion	10-20% land conversion	<10% land conversion	Rough Guess	Poor	Fair
		Landscape pattern (mosaic) & structure	Percent impervious surface	>10% impervious surface. Significant impacts at 25%.	5-10% impervious surface	1-5% impervious surface	<1% impervious surface	External Research	Good	Good

Appendix D. Viability assement ratings for Meramec River Basin targets.

Conservation Targets	Category	Key Attribute	Indicator	Indicator Ratings: Poor	Fair	Good	Very Good	Ratings Source	Current Rating	Desired Rating
		Stream geomorphology	Channel alteration (EPA)	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization or dredging absent or minimal; stream with normal pattern.	External Research	Good	Good
	Condition	In-stream habitat	Substrate/available cover (EPA)	Less than 20% (10% for low gradient streams) stable habitat; lack of habitat is obvious; substrate unstable or lacking.	20-40% (10-30% for low gradient streams) mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	40-70% (30-50% for low gradient streams) mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (	Greater than 70% (50% for low gradient streams) of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/s	Rough Guess	Fair	Good
		Riparian corridor	Bank stability (EPA)	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	External Research	Fair	Good

Appendix D. Viability assement ratings for Meramec River Basin targets.

Conservation Targets	Category	Key Attribute	Indicator	Indicator Ratings: Poor	Fair	Good	Very Good	Ratings Source	Current Rating	Desired Rating
	Size	Species assemblage & condition	Freshwater mussel assemblage	Few or no species present, with those present in low number or dominated by few or one tolerant taxa (taxon); rare species absent.	Fair species richness and abundance, with trends towards dominance of tolerant taxa; species from some habitats rare or absent; rare species absent.	Good species richness and abundance across habitats; some rare species present but in low numbers.	High species richness and abundance across habitats, including rare species.	Expert Knowledge	Fair	Good
	Size	Water chemistry	Chemical pollutants and contaminants	High contamination	Moderate contamination	Slight contamination	No contamination	Rough Guess	Very Good	Very Good
	Size	Water quality	Nitrogen and Phosphorus	High elevation above ambient levels	Moderate elevation above ambient levels	Slight elevation above ambient levels	Very low/ambient levels	Rough Guess	Fair	Good
	Size	Population size & dynamics	Freshwater mussel population size: indicator species	Poor or no juvenile recruitment (small mussels rare or absent); size structure missing several size classes; often only 1-2 size classes represented	Fair juvenile recruitment (small mussels present but infrequent); size structure indicates fair numbers with few and/or missing year classes.	Good juvenile recruitment (small mussels present but not numerous); size structure with moderate numbers of multiple year classes.	Very good juvenile recruitment (numerous small mussels); size structure indicates large numbers of multiple year classes.	Rough Guess	Fair	Good
	Size	Population size & dynamics	Freshwater sport fish: indicator species	Poor sport fishery with very low catch rates or sport fish absent. Population structure suggests very poor/no recruitment and unsustainable fishery (if present).	Fair sport fishery with low catch rates of moderately-small sized fish (large fish absent). Population structure shows instability and poor recruitment	Good sport fishery with good catch rates of moderately-sized fish (large fish infrequent but not rare) and stable population structure and recruitment	Very good sport fishery with high catch rates of large-sized fish and stable population structure and recruitment	Rough Guess	Good	Good
	Size	Riparian corridor size	Riparian vegetative zone width (EPA)	Width of riparian zone <25 ft.	Width of riparian zone 25-50 ft.	Width of riparian zone 50-100 ft.	Width of riparian zone >100 ft.	External Research	Fair	Good

Appendix D. Viability assement ratings for Meramec River Basin targets.

Conservation Targets	Category	Key Attribute	Indicator	Indicator Ratings: Poor	Fair	Good	Very Good	Ratings Source	Current Rating	Desired Rating
Big River Drainage	Landscape Context	Connectivity	Floodplain accessibility	Poor or no floodplain access at bankfull discharge across target. Deeply incised channel and or/ channel restrictions widespread.	Fair floodplain access at reference bankfull discharge across target. Moderate channel incision and/or channel restrictions moderate-frequent in occurance.	Good but not complete floodplain access at reference bankfull discharge across target. Slight channel incision and/or some channel restrictions (but uncommon)	Very good floodplain access at reference bankfull discharge across target. No or little channel incision with channel restrictions rare or absent.	Rough Guess	Very Good	Very Good
		Connectivity	Number of aquatic organism passage barriers	Numerous/major AOP barriers which severely fragment species populations	Some/marked AOP barriers which substantially fragment species populations	Few AOP barriers that minimally fragment species populations	No AOP barriers and no species population fragmentation	Rough Guess	Fair	Good
		Hydrology	Presumptive standard for ecologically sustainable flows	>20% deviation from natural flow regime	10-20% deviation from natural flow regime	5-10% deviation from natural flow regime	<5% deviation from natural flow regime	External Research	Very Good	Very Good
		Landscape pattern (mosaic) & structure	Percent floodplain and wetland conversion (non-urban)	>30% land conversion	20-30% land conversion	10-20% land conversion	<10% land conversion	Rough Guess	Fair	Good
		Landscape pattern (mosaic) & structure	Percent impervious surface	>10% impervious surface. Significant impacts at 25%.	5-10% impervious surface	1-5% impervious surface	<1% impervious surface	External Research	Good	Good

Appendix D. Viability assement ratings for Meramec River Basin targets.

Conservation Targets	Category	Key Attribute	Indicator	Indicator Ratings: Poor	Fair	Good	Very Good	Ratings Source	Current Rating	Desired Rating
		Stream geomorphology	Channel alteration (EPA)	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization or dredging absent or minimal; stream with normal pattern.	External Research	Good	Good
	Condition	In-stream habitat	Substrate/available cover (EPA)	Less than 20% (10% for low gradient streams) stable habitat; lack of habitat is obvious; substrate unstable or lacking.	20-40% (10-30% for low gradient streams) mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	40-70% (30-50% for low gradient streams) mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (	Greater than 70% (50% for low gradient streams) of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/s	Rough Guess	Good	Good
		Riparian corridor	Bank stability (EPA)	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	External Research	Good	Very Good

Appendix D. Viability assement ratings for Meramec River Basin targets.

Conservation Targets	Category	Key Attribute	Indicator	Indicator Ratings: Poor	Fair	Good	Very Good	Ratings Source	Current Rating	Desired Rating
		Species assemblage & condition	Freshwater mussel assemblage	Few or no species present, with those present in low number or dominated by few or one tolerant taxa (taxon); rare species absent.	Fair species richness and abundance, with trends towards dominance of tolerant taxa; species from some habitats rare or absent; rare species absent.	Good species richness and abundance across habitats; some rare species present but in low numbers.	High species richness and abundance across habitats, including rare species.	Expert Knowledge	Fair	Good
		Water chemistry	Chemical pollutants and contaminants	High contamination	Moderate contamination	Slight contamination	No contamination	Rough Guess	Poor	Fair
		Water quality	Nitrogen and Phosphorus	High elevation above ambient levels	Moderate elevation above ambient levels	Slight elevation above ambient levels	Very low/ambient levels	Rough Guess	Very Good	Very Good
	Size	Population size & dynamics	Freshwater mussel population size: indicator species	Poor or no juvenile recruitment (small mussels rare or absent); size structure missing several size classes; often only 1-2 size classes represented	Fair juvenile recruitment (small mussels present but infrequent); size structure indicates fair numbers with few and/or missing year classes.	Good juvenile recruitment (small mussels present but not numerous); size structure with moderate numbers of multiple year classes.	Very good juvenile recruitment (numerous small mussels); size structure indicates large numbers of multiple year classes.	Rough Guess	Fair	Good
		Population size & dynamics	Freshwater sport fish: indicator species	Poor sport fishery with very low catch rates or sport fish absent. Population structure suggests very poor/no recruitment and unsustainable fishery (if present).	Fair sport fishery with low catch rates of moderately-small sized fish (large fish absent). Population structure shows instability and poor recruitment	Good sport fishery with good catch rates of moderately-sized fish (large fish infrequent but not rare) and stable population structure and recruitment	Very good sport fishery with high catch rates of large-sized fish and stable population structure and recruitment	Rough Guess	Very Good	Very Good
		Riparian corridor size	Riparian vegetative zone width (EPA)	Width of riparian zone <25 ft.	Width of riparian zone 25-50 ft.	Width of riparian zone 50-100 ft.	Width of riparian zone >100 ft.	External Research	Good	Good

Appendix D. Viability assement ratings for Meramec River Basin targets.

Conservation Targets	Category	Key Attribute	Indicator	Indicator Ratings: Poor	Fair	Good	Very Good	Ratings Source	Current Rating	Desired Rating
Huzzah Creek and Courtois Creek Drainages	Landscape Context	Connectivity	Floodplain accessibility	Poor or no floodplain access at bankfull discharge across target. Deeply incised channel and or/ channel restrictions widespread.	Fair floodplain access at reference bankfull discharge across target. Moderate channel incision and/or channel restrictions moderate-frequent in occurance.	Good but not complete floodplain access at reference bankfull discharge across target. Slight channel incision and/or some channel restrictions (but uncommon)	Very good floodplain access at reference bankfull discharge across target. No or little channel incision with channel restrictions rare or absent.	Rough Guess	Very Good	Very Good
		Connectivity	Number of aquatic organism passage barriers	Numerous/major AOP barriers which severely fragment species populations	Some/marked AOP barriers which substantially fragment species populations	Few AOP barriers that minimally fragment species populations	No AOP barriers and no species population fragmentation	Rough Guess	Very Good	Very Good
		Hydrology	Presumptive standard for ecologically sustainable flows	>20% deviation from natural flow regime	10-20% deviation from natural flow regime	5-10% deviation from natural flow regime	<5% deviation from natural flow regime	External Research	Very Good	Very Good
		Landscape pattern (mosaic) & structure	Percent floodplain and wetland conversion (non-urban)	>30% land conversion	20-30% land conversion	10-20% land conversion	<10% land conversion	Rough Guess	Good	Very Good
		Landscape pattern (mosaic) & structure	Percent impervious surface	>10% impervious surface. Significant impacts at 25%.	5-10% impervious surface	1-5% impervious surface	<1% impervious surface	External Research	Very Good	Very Good

Appendix D. Viability assement ratings for Meramec River Basin targets.

Conservation Targets	Category	Key Attribute	Indicator	Indicator Ratings: Poor	Fair	Good	Very Good	Ratings Source	Current Rating	Desired Rating
	Condition	Stream geomorphology	Channel alteration (EPA)	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization or dredging absent or minimal; stream with normal pattern.	External Research	Good	Very Good
	Condition	In-stream habitat	Substrate/available cover (EPA)	Less than 20% (10% for low gradient streams) stable habitat; lack of habitat is obvious; substrate unstable or lacking.	20-40% (10-30% for low gradient streams) mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	40-70% (30-50% for low gradient streams) mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (	Greater than 70% (50% for low gradient streams) of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/s	Rough Guess	Very Good	Very Good
	Condition	Riparian corridor	Bank stability (EPA)	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	External Research	Good	Very Good

Appendix D. Viability assement ratings for Meramec River Basin targets.

Conservation Targets	Category	Key Attribute	Indicator	Indicator Ratings: Poor	Fair	Good	Very Good	Ratings Source	Current Rating	Desired Rating
LaBarque Creek Drainage	Landscape Context	Water chemistry	Chemical pollutants and contaminants	High contamination	Moderate contamination	Slight contamination	No contamination	Rough Guess	Very Good	Very Good
		Water quality	Nitrogen and Phosphorus	High elevation above ambient levels	Moderate elevation above ambient levels	Slight elevation above ambient levels	Very low/ambient levels	Rough Guess	Very Good	Very Good
		Population size & dynamics	Freshwater sport fish: indicator species	Poor sport fishery with very low catch rates or sport fish absent. Population structure suggests very poor/no recruitment and unsustainable fishery (if present).	Fair sport fishery with low catch rates of moderately-small sized fish (large fish absent). Population structure shows instability and poor recruitment	Good sport fishery with good catch rates of moderately-sized fish (large fish infrequent but not rare) and stable population structure and recruitment	Very good sport fishery with high catch rates of large-sized fish and stable population structure and recruitment	Rough Guess	Good	Good
		Riparian corridor size	Riparian vegetative zone width (EPA)	Width of riparian zone <25 ft.	Width of riparian zone 25-50 ft.	Width of riparian zone 50-100 ft.	Width of riparian zone >100 ft.	External Research	Good	Good
		Connectivity	Floodplain accessibility	Poor or no floodplain access at bankfull discharge across target. Deeply incised channel and or/ channel restrictions widespread.	Fair floodplain access at reference bankfull discharge across target. Moderate channel incision and/or channel restrictions moderate-frequent in occurance.	Good but not complete floodplain access at reference bankfull discharge across target. Slight channel incision and/or some channel restrictions (but uncommon)	Very good floodplain access at reference bankfull discharge across target. No or little channel incision with channel restrictions rare or absent.	Rough Guess	Very Good	Very Good
		Connectivity	Number of aquatic organism passage barriers	Numerous/major AOP barriers which severely fragment species populations	Some/marked AOP barriers which substantially fragment species populations	Few AOP barriers that minimally fragment species populations	No AOP barriers and no species population fragmentation	Rough Guess	Very Good	Very Good

Appendix D. Viability assement ratings for Meramec River Basin targets.

Conservation Targets	Category	Key Attribute	Indicator	Indicator Ratings: Poor	Fair	Good	Very Good	Ratings Source	Current Rating	Desired Rating
		Hydrology	Presumptive standard for ecologically sustainable flows	>20% deviation from natural flow regime	10-20% deviation from natural flow regime	5-10% deviation from natural flow regime	<5% deviation from natural flow regime	External Research	Very Good	Very Good
		Landscape pattern (mosaic) & structure	Percent floodplain and wetland conversion (non-urban)	>30% land conversion	20-30% land conversion	10-20% land conversion	<10% land conversion	Rough Guess	Good	Good
		Landscape pattern (mosaic) & structure	Percent impervious surface	>10% impervious surface. Significant impacts at 25%.	5-10% impervious surface	1-5% impervious surface	<1% impervious surface	External Research	Very Good	Very Good
		Stream geomorphology	Channel alteration (EPA)	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization or dredging absent or minimal; stream with normal pattern.	External Research	Very Good	Very Good

Appendix D. Viability assement ratings for Meramec River Basin targets.

Conservation Targets	Category	Key Attribute	Indicator	Indicator Ratings: Poor	Fair	Good	Very Good	Ratings Source	Current Rating	Desired Rating
	Condition	In-stream habitat	Substrate/available cover (EPA)	Less than 20% (10% for low gradient streams) stable habitat; lack of habitat is obvious; substrate unstable or lacking.	20-40% (10-30% for low gradient streams) mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	40-70% (30-50% for low gradient streams) mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (	Greater than 70% (50% for low gradient streams) of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/s	Rough Guess	Very Good	Very Good
		Riparian corridor	Bank stability (EPA)	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	External Research	Very Good	Very Good
		Species assemblage & condition	Fish assemblage IBI	IBI score <29. Highly impaired.	IBI score 29-36. Impaired.	IBI score 37-41. No impairment.	IBI score 41-45. No impairment.	External Research	Very Good	Very Good
		Species assemblage & condition	Missorui Stream Condition Index (MSCI)	Score 4-8. Non-biologically supporting.	Score 10-12. Partially biologically supporting	Score 12-14. Partially biologically supporting	Score 16-20. Fully biologically supporting	External Research	Very Good	Very Good
		Water chemistry	Chemical pollutants and contaminants	High contamination	Moderate contamination	Slight contamination	No contamination	Rough Guess	Very Good	Very Good
		Water quality	Nitrogen and Phosphorus	High elevation above ambient levels	Moderate elevation above ambient levels	Slight elevation above ambient levels	Very low/ambient levels	Rough Guess	Very Good	Very Good

Appendix D. Viability assement ratings for Meramec River Basin targets.

Conservation Targets	Category	Key Attribute	Indicator	Indicator Ratings: Poor	Fair	Good	Very Good	Ratings Source	Current Rating	Desired Rating
		Riparian corridor size	Riparian vegetative zone width (EPA)	Width of riparian zone <25 ft.	Width of riparian zone 25-50 ft.	Width of riparian zone 50-100 ft.	Width of riparian zone >100 ft.	External Research	Very Good	Very Good
		Connectivity	Number of aquatic organism passage barriers	Numerous/major AOP barriers which severely fragment species populations	Some/marked AOP barriers which substantially fragment species populations	Few AOP barriers that minimally fragment species populations	No AOP barriers and no species population fragmentation	Rough Guess	Good	Very Good
		Landscape pattern (mosaic) & structure	Percent floodplain and wetland conversion (non-urban)	>30% land conversion	20-30% land conversion	10-20% land conversion	<10% land conversion	Rough Guess	Good	Good
		Riparian corridor	Bank stability (EPA)	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	External Research	Fair	Good
		Species assemblage & condition	Freshwater mussel assemblage	Few or no species present, with those present in low number or dominated by few or one tolerant taxa (taxon); rare species absent.	Fair species richness and abundance, with trends towards dominance of tolerant taxa; species from some habitats rare or absent; rare species absent.	Good species richness and abundance across habitats; some rare species present but in low numbers.	High species richness and abundance across habitats, including rare species.	Expert Knowledge	Fair	Good
		Water chemistry	Chemical pollutants and contaminants	High contamination	Moderate contamination	Slight contamination	No contamination	Rough Guess	Fair	Good

Appendix D. Viability assement ratings for Meramec River Basin targets.

				Indicator Ratings						
Conservation Targets	Category	Key Attribute	Indicator	Poor	Fair	Good	Very Good	Ratings Source	Current Rating	Desired Rating
	Size	Population size & dynamics	Freshwater mussel population size: indicator species	Poor or no juvenile recruitment (small mussels rare or absent); size structure missing several size classes; often only 1-2 size classes represented	Fair juvenile recruitment (small mussels present but infrequent); size structure indicates fair numbers with few and/or missing year classes.	Good juvenile recruitment (small mussels present but not numerous); size structure with moderate numbers of multiple year classes.	Very good juvenile recruitment (numerous small mussels); size structure indicates large numbers of multiple year classes.	Rough Guess	Fair	Fair

Target #1 - Lower Meramec River Drainage

	Stresses	Severity	Scope	Stress Rank
1	Altered Floodplains & Wetlands	High	High	High
2	Altered Stream Geomorphology	High	High	High
3	Altered Hydrology	High	High	High
4	Altered Connectivity	Medium	High	Medium
5	Nutrient Pollution	Medium	Very High	Medium
6	Organic Pollution	High	Very High	High
7	Chemical Pollution	Medium	Very High	Medium
8	Contaminated Sediments	High	Medium	Medium
9	Excessive Suspended & Bedded Sediments	High	High	High
10	In-Stream Habitat Modification	High	High	High
11	Altered Riparian Corridor	High	High	High
12	Invasive Species	Low	Medium	Low

Target #1 -- Lower Meramec River Drainage

Threats - Sources of Stress	Altered Floodplains & Wetlands	Altered Stream Geomorphology	Altered Hydrology	Altered Connectivity	Nutrient Pollution	Organic Pollution	Chemical Pollution	Contaminated Sediments	Threat to Target Rank
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*High*	*High*	*High*	*Medium*	*Medium*	*High*	*Medium*	*Medium*	
Threat	Housing & Urban Areas								
Contribution	High	High	High	High	Very High	Very High	Very High		Very High
Irreversibility	Very High	Very High	Very High	Very High	Medium	Medium	Medium		
Threat Rank	High	High	High	Medium	Medium	High	Medium	-	
Threat	Livestock Farming & Ranching								
Contribution	Low	Low	Low	Low	Low	Low	Low		Medium
Irreversibility	High	High	High	Medium	Medium	Medium	Medium		
Threat Rank	Medium	Medium	Medium	Low	Low	Low	Low	-	
Threat	Timber Operations								
Contribution	Low	Low	Low						Low
Irreversibility	Medium	Medium	Medium						
Threat Rank	Low	Low	Low	-	-	-	-	-	

Target #1 -- Lower Meramec River Drainage

Threats - Sources of Stress	Altered Floodplains &	Altered Stream Geomorphology	Altered Hydrology	Altered Connectivity	Nutrient Pollution	Organic Pollution	Chemical Pollution	Contaminated Sediments	Threat to Target Rank

	Wetlands								
Stresses **#..**	1	2	3	4	5	6	7	8	
Rank..	*High*	*High*	*High*	*Medium*	*Medium*	*High*	*Medium*	*Medium*	
Threat	Transportation, Utility, & Service Corridors								High
Contribution	Medium	Medium	High	Medium					
Irreversibility	High	High	High	Medium					
Threat Rank	Medium	Medium	High	Low	-	-	-	-	
Threat	Historical Agricultural & Forestry Practices								Medium
Contribution	Low	Low							
Irreversibility	Medium	High							
Threat Rank	Low	Medium	-	-	-	-	-	-	

Target #1 -- Lower Meramec River Drainage

Threats - Sources of Stress	**Altered Floodplains & Wetlands**	**Altered Stream Geomorphology**	**Altered Hydrology**	**Altered Connectivity**	**Nutrient Pollution**	**Organic Pollution**	**Chemical Pollution**	**Contaminated Sediments**	**Threat to Target Rank**
Stresses **#..**	1	2	3	4	5	6	7	8	
Rank..	*High*	*High*	*High*	*Medium*	*Medium*	*High*	*Medium*	*Medium*	
Threat	In-Stream Gravel Mining & Reaming								High
Contribution		High							
Irreversibility		High							
Threat Rank	-	High	-	-	-	-	-	-	
Threat	Dams & Water Management								Medium
Contribution	Low	Low	Medium	High	Low				
Irreversibility	Medium	Medium	Medium	High	High				
Threat Rank	Low	Low	Medium	Medium	Low	-	-	-	
Threat	Mine Tailings & Industrial Effluents								Medium
Contribution							Very High	Very High	
Irreversibility							Medium	High	
Threat Rank	-	-	-	-	-	-	Medium	Medium	

Target #1 -- Lower Meramec River Drainage

Threats - Sources of Stress	**Altered Floodplains & Wetlands**	**Altered Stream Geomorphology**	**Altered Hydrology**	**Altered Connectivity**	**Nutrient Pollution**	**Organic Pollution**	**Chemical Pollution**	**Contaminated Sediments**	**Threat to Target Rank**
Stresses **#..**	1	2	3	4	5	6	7	8	
Rank..	*High*	*High*	*High*	*Medium*	*Medium*	*High*	*Medium*	*Medium*	

Threat	Riverbank & Channel Hardening								Medium
Contribution		Medium							
Irreversibility		High							
Threat Rank	-	Medium	-	-	-	-	-	-	
Threat	Garbage & Solid Waste								Medium
Contribution							Medium		
Irreversibility							High		
Threat Rank	-	-	-	-	-	-	Low	-	

Target #1 -- Lower Meramec River Drainage

Threats - Sources of Stress	**Altered Floodplains & Wetlands**	**Altered Stream Geomorphology**	**Altered Hydrology**	**Altered Connectivity**	**Nutrient Pollution**	**Organic Pollution**	**Chemical Pollution**	**Contaminated Sediments**	**Threat to Target Rank**
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*High*	*High*	*High*	*Medium*	*Medium*	*High*	*Medium*	*Medium*	
Threat	Invasive Species								Low
Contribution									
Irreversibility									
Threat Rank	-	-	-	-	-	-	-	-	
Threat	Recreational Activities								Low
Contribution	Low					Low			
Irreversibility	Medium					Medium			
Threat Rank	Low	-	-	-	-	Low	-	-	
Threat	Climate Change								Medium
Contribution	Low	Low	Low	Low					
Irreversibility	High	High	High	High					
Threat Rank	Medium	Medium	Medium	Low	-	-	-	-	

Target #1 -- Lower Meramec River Drainage

Threats - Sources of Stress	**Excessive Suspended & Bedded Sediments**	**In-Stream Habitat Modification**	**Altered Riparian Corridor**	**Invasive Species**	-	-	-	-	**Threat to Target Rank**
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*High*	*High*	*High*	*Low*	-	-	-	-	
Threat	Housing & Urban Areas								Very High
Contribution	High	High	High						
Irreversibility	High	High	High						

Threat Rank	High	High	High	-	-	-	-	-	
Threat	Livestock Farming & Ranching								
Contribution	Low	Low	Low						Medium
Irreversibility	High	Medium	Medium						
Threat Rank	Medium	Low	Low	-	-	-	-	-	
Threat	Timber Operations								
Contribution	Low		Low						Low
Irreversibility	Medium		Medium						
Threat Rank	Low	-	Low	-	-	-	-	-	

Target #1 -- Lower Meramec River Drainage

Threats - Sources of Stress	**Excessive Suspended & Bedded Sediments**	**In-Stream Habitat Modification**	**Altered Riparian Corridor**	**Invasive Species**	**-**	**-**	**-**	**-**	**Threat to Target Rank**
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*High*	*High*	*High*	*Low*	-	-	-	-	
Threat	Transportation, Utility, & Service Corridors								
Contribution	Medium	Low	Low						High
Irreversibility	High	Medium	Medium						
Threat Rank	Medium	Low	Low	-	-	-	-	-	
Threat	Historical Agricultural & Forestry Practices								
Contribution	Low	Low	Low						Medium
Irreversibility	High	Medium	Medium						
Threat Rank	Medium	Low	Low	-	-	-	-	-	

Target #1 -- Lower Meramec River Drainage

Threats - Sources of Stress	**Excessive Suspended & Bedded Sediments**	**In-Stream Habitat Modification**	**Altered Riparian Corridor**	**Invasive Species**	**-**	**-**	**-**	**-**	**Threat to Target Rank**
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*High*	*High*	*High*	*Low*	-	-	-	-	
Threat	In-Stream Gravel Mining & Reaming								
Contribution	High	High							High
Irreversibility	High	Medium							
Threat Rank	High	Medium	-	-	-	-	-	-	
Threat	Dams & Water Management								Medium

Contribution		Medium	Low						Medium
Irreversibility		Medium	Medium						
Threat Rank	-	Medium	Low	-	-	-	-	-	
Threat	Mine Tailings & Industrial Effluents								
Contribution									
Irreversibility									
Threat Rank	-	-	-	-	-	-	-	-	

Target #1 -- Lower Meramec River Drainage

Threats - Sources of Stress	**Excessive Suspended & Bedded Sediments**	**In-Stream Habitat Modification**	**Altered Riparian Corridor**	**Invasive Species**	**-**	**-**	**-**	**-**	**Threat to Target Rank**
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*High*	*High*	*High*	*Low*	-	-	-	-	
Threat	Riverbank & Channel Hardening								Medium
Contribution		High	Medium						
Irreversibility		Medium	Medium						
Threat Rank	-	Medium	Medium	-	-	-	-	-	
Threat	Garbage & Solid Waste								Medium
Contribution		Medium							
Irreversibility		Medium							
Threat Rank	-	Medium	-	-	-	-	-	-	

Target #1 -- Lower Meramec River Drainage

Threats - Sources of Stress	**Excessive Suspended & Bedded Sediments**	**In-Stream Habitat Modification**	**Altered Riparian Corridor**	**Invasive Species**	**-**	**-**	**-**	**-**	**Threat to Target Rank**
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*High*	*High*	*High*	*Low*	-	-	-	-	
Threat	Invasive Species								Low
Contribution				Very High					
Irreversibility				Very High					
Threat Rank	-	-	-	Low	-	-	-	-	
Threat	Recreational Activities								Low
Contribution	Low	Low	Low						

Irreversibility	Medium	Medium	Medium						
Threat Rank	Low	Low	Low	-	-	-	-	-	
Threat	Climate Change								
Contribution	Low		Low						Medium
Irreversibility	High		Medium						
Threat Rank	Medium	-	Low	-	-	-	-	-	

Target #2 -- Middle Meramec River Drainage

	Stresses	Severity	Scope	Stress Rank
1	Altered Hydrology	Medium	High	Medium
2	Altered Connectivity	Low	Medium	Low
3	Altered Floodplains & Wetlands	High	High	High
4	Altered Stream Geomorphology	Medium	Medium	Medium
5	Nutrient Pollution	Medium	Very High	Medium
6	Organic Pollution	Medium	Very High	Medium
7	Chemical Pollution	Medium	Medium	Medium
8	Contaminated Sediments	Low	Medium	Low
9	Excessive Suspended & Bedded Sediments	High	High	High
10	In-Stream Habitat Modification	High	High	High
11	Altered Riparian Corridor	High	High	High
12	Invasive Species			-

Target #2 -- Middle Meramec River Drainage

Threats - Sources of Stress	**Altered Hydrology**	**Altered Connectivity**	**Altered Floodplains & Wetlands**	**Altered Stream Geomorphology**	**Nutrient Pollution**	**Organic Pollution**	**Chemical Pollution**	**Contaminated Sediments**	**Threat to Target Rank**
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*Medium*	*Low*	*High*	*Medium*	*Medium*	*Medium*	*Medium*	*Low*	
Threat	Dams & Water Management								
Contribution	Low	High	Low	Low	Low				Medium
Irreversibility	Medium	Medium	Medium	Medium	High				
Threat Rank	Low	Low	Low	Low	Low	-	-	-	
Threat	Garbage & Solid Waste								
Contribution							Medium		Low
Irreversibility							High		
Threat Rank	-	-	-	-	-	-	Low	-	

Target #2 -- Middle Meramec River Drainage

Threats - Sources of Stress	**Altered Hydrology**	**Altered Connectivity**	**Altered Floodplains & Wetlands**	**Altered Stream Geomorphology**	**Nutrient Pollution**	**Organic Pollution**	**Chemical Pollution**	**Contaminated Sediments**	**Threat to Target Rank**
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*Medium*	*Low*	*High*	*Medium*	*Medium*	*Medium*	*Medium*	*Low*	
Threat	Historical Agricultural & Forestry Practices								
Contribution			Low	Low					Medium
Irreversibility			Medium	High					
Threat Rank	-	-	Low	Low	-	-	-	-	

Threat	Housing & Urban Areas								
Contribution	Low	Low	Low	Low	Low	Low	Medium		
Irreversibility	Very High	Very High	Very High	Very High	Medium	Medium	Medium		Medium
Threat Rank (override)									
Threat Rank	Low	Low	Medium	Low	Low	Low	Low	-	
Threat	In-Stream Gravel Mining & Reaming								
Contribution				High					
Irreversibility				High					High
Threat Rank	-	-	-	Medium	-	-	-	-	

Target #2 -- Middle Meramec River Drainage

Threats - Sources of Stress	**Altered Hydrology**	**Altered Connectivity**	**Altered Floodplains & Wetlands**	**Altered Stream Geomorphology**	**Nutrient Pollution**	**Organic Pollution**	**Chemical Pollution**	**Contaminated Sediments**	**Threat to Target Rank**
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*Medium*	*Low*	*High*	*Medium*	*Medium*	*Medium*	*Medium*	*Low*	
Threat	Invasive Species								
Contribution									-
Irreversibility									
Threat Rank	-	-	-	-	-	-	-	-	
Threat	Livestock Farming & Ranching								
Contribution	High	High	Very High	High	High	High	High		
Irreversibility	High	Medium	High	High	Medium	Medium	Medium		High
Threat Rank (override)									
Threat Rank	Medium	Low	High	Medium	Low	Low	Low	-	
Threat	Mine Tailings & Industrial Effluents								
Contribution							High	Very High	
Irreversibility							Medium	High	Low
Threat Rank	-	-	-	-	-	-	Low	Low	

Target #2 -- Middle Meramec River Drainage

Threats - Sources of Stress	**Altered Hydrology**	**Altered Connectivity**	**Altered Floodplains & Wetlands**	**Altered Stream Geomorphology**	**Nutrient Pollution**	**Organic Pollution**	**Chemical Pollution**	**Contaminated Sediments**	**Threat to Target Rank**
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*Medium*	*Low*	*High*	*Medium*	*Medium*	*Medium*	*Medium*	*Low*	
Threat	Recreational Activities								
Contribution			Low			Medium			
Irreversibility			Medium			Medium			Low
Threat Rank	-	-	Low	-	-	Low	-	-	
Threat	Riverbank & Channel Hardening								Low

Contribution				Medium					
Irreversibility				High					
Threat Rank	-	-	-	Low	-	-	-	-	
Threat	Transportation, Utility, & Service Corridors								
Contribution	Low	Low	Low	Low					Medium
Irreversibility	High	High	High	High					
Threat Rank	Low	Low	Medium	Low	-	-	-	-	

Target #2 -- Middle Meramec River Drainage

Threats - Sources of Stress	**Altered Hydrology**	**Altered Connectivity**	**Altered Floodplains & Wetlands**	**Altered Stream Geomorphology**	**Nutrient Pollution**	**Organic Pollution**	**Chemical Pollution**	**Contaminated Sediments**	**Threat to Target Rank**
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*Medium*	*Low*	*High*	*Medium*	*Medium*	*Medium*	*Medium*	*Low*	
Threat	Timber Operations								
Contribution	Low		Low	Low					Medium
Irreversibility	Medium		Medium	Medium					
Threat Rank	Low	-	Low	Low	-	-	-	-	
Threat	Climate Change								
Contribution	Low	Low	Low	Low					Medium
Irreversibility	High	High	High	High					
Threat Rank	Low	Low	Medium	Low	-	-	-	-	

Target #2 -- Middle Meramec River Drainage

Threats - Sources of Stress	**Excessive Suspended & Bedded Sediments**	**In-Stream Habitat Modification**	**Altered Riparian Corridor**	**Invasive Species**	-	-	-	-	**Threat to Target Rank**
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*High*	*High*	*High*	-	-	-	-	-	
Threat	Dams & Water Management								
Contribution		Low	Low						Medium
Irreversibility		Medium	Medium						
Threat Rank	-	Low	Low	-	-	-	-	-	
Threat	Garbage & Solid Waste								
Contribution		Low							Low
Irreversibility		Medium							
Threat Rank	-	Low	-	-	-	-	-	-	

Target #2 -- Middle Meramec River Drainage

Threats - Sources of Stress	**Excessive Suspended & Bedded**	**In-Stream Habitat Modification**	**Altered Riparian Corridor**	**Invasive Species**	-	-	-	-	**Threat to Target Rank**

	Sediments								
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*High*	*High*	*High*	-	-	-	-	-	
Threat	Historical Agricultural & Forestry Practices								
Contribution	Low	Low	Low						Medium
Irreversibility	High	Medium	Medium						
Threat Rank	Medium	Low	Low	-	-	-	-	-	
Threat	Housing & Urban Areas								
Contribution	Low	Low	Low						Medium
Irreversibility	High	High	High						
Threat Rank	Medium	Medium	Medium	-	-	-	-	-	
Threat	In-Stream Gravel Mining & Reaming								
Contribution	Medium	High							High
Irreversibility	High	High							
Threat Rank	Medium	High	-	-	-	-	-	-	

Target #2 -- Middle Meramec River Drainage

Threats - Sources of Stress	**Excessive Suspended & Bedded Sediments**	**In-Stream Habitat Modification**	**Altered Riparian Corridor**	**Invasive Species**	**-**	**-**	**-**	**-**	**Threat to Target Rank**
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*High*	*High*	*High*	-	-	-	-	-	
Threat	Invasive Species								
Contribution									-
Irreversibility									
Threat Rank	-	-	-	-	-	-	-	-	
Threat	Livestock Farming & Ranching								
Contribution	Medium	Medium	Medium						High
Irreversibility	High	Medium	High						
Threat Rank	Medium	Medium	Medium	-	-	-	-	-	
Threat	Mine Tailings & Industrial Effluents								
Contribution									Low
Irreversibility									
Threat Rank	-	-	-	-	-	-	-	-	

Target #2 -- Middle Meramec River Drainage

Threats - Sources of Stress	**Excessive Suspended & Bedded Sediments**	**In-Stream Habitat Modification**	**Altered Riparian Corridor**	**Invasive Species**	**-**	**-**	**-**	**-**	**Threat to Target Rank**

Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*High*	*High*	*High*	-	-	-	-	-	
Threat	Recreational Activities								Low
Contribution	Low	Low	Low						
Irreversibility	Medium	Medium	Medium						
Threat Rank	Low	Low	Low	-	-	-	-	-	
Threat	Riverbank & Channel Hardening								Low
Contribution		Low	Low						
Irreversibility		Medium	Medium						
Threat Rank	-	Low	Low	-	-	-	-	-	
Threat	Transportation, Utility, & Service Corridors								Medium
Contribution	Medium	Low	Low						
Irreversibility	Medium	Medium	Medium						
Threat Rank	Medium	Low	Low	-	-	-	-	-	

Target #2 -- Middle Meramec River Drainage

Threats - Sources of Stress	**Excessive Suspended & Bedded Sediments**	**In-Stream Habitat Modification**	**Altered Riparian Corridor**	**Invasive Species**	**-**	**-**	**-**	**-**	**Threat to Target Rank**
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*High*	*High*	*High*	-	-	-	-	-	
Threat	Timber Operations								Medium
Contribution	Medium		Medium						
Irreversibility	Medium		Medium						
Threat Rank	Medium	-	Medium	-	-	-	-	-	
Threat	Climate Change								Medium
Contribution	Low		Low						
Irreversibility	High		Medium						
Threat Rank	Medium	-	Low	-	-	-	-	-	

Target #3 -- Upper Meramec River Drainage

	Stresses	Severity	Scope	Stress Rank
1	Altered Floodplains & Wetlands	High	High	High
2	Altered Stream Geomorphology	Medium	High	Medium
3	Altered Hydrology	Medium	Very High	Medium
4	Altered Connectivity	Medium	Medium	Medium
5	Nutrient Pollution	Medium	Very High	Medium
6	Organic Pollution	Medium	Very High	Medium
7	Chemical Pollution	Medium	Medium	Medium
8	Contaminated Sediments	Low	Medium	Low
9	Excessive Suspended & Bedded Sediments	High	High	High
10	In-Stream Habitat Modification	Medium	Medium	Medium
11	Invasive Species			-
12	Altered Riparian Corridor	High	High	High

Target #3 -- Upper Meramec River Drainage

Threats - Sources of Stress	**Altered Floodplains & Wetlands**	**Altered Stream Geomorphology**	**Altered Hydrology**	**Altered Connectivity**	**Nutrient Pollution**	**Organic Pollution**	**Chemical Pollution**	**Contaminated Sediments**	**Threat to Target Rank**
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*High*	*Medium*	*Medium*	*Medium*	*Medium*	*Medium*	*Medium*	*Low*	
Threat	Housing & Urban Areas								
Contribution	Low	Low	Low	Low	Medium	Medium	Medium		Medium
Irreversibility	Very High	Very High	Very High	Very High	Medium	Medium	Medium		
Threat Rank	Medium	Low	Low	Low	Low	Low	Low	-	
Threat	Livestock Farming & Ranching								
Contribution	Very High	High	Medium	High	Very High	Very High	Medium		High
Irreversibility	High	High	High	Medium	Medium	Medium	Medium		
Threat Rank	High	Medium	Low	Low	Medium	Medium	Low	-	
Threat	Timber Operations								
Contribution	Low	Low	Low						Medium
Irreversibility	Medium	Medium	Medium						
Threat Rank	Low	Low	Low	-	-	-	-	-	

Target #3 -- Upper Meramec River Drainage

Threats - Sources of Stress	**Altered Floodplains & Wetlands**	**Altered Stream Geomorphology**	**Altered Hydrology**	**Altered Connectivity**	**Nutrient Pollution**	**Organic Pollution**	**Chemical Pollution**	**Contaminated Sediments**	**Threat to Target Rank**
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*High*	*Medium*	*Medium*	*Medium*	*Medium*	*Medium*	*Medium*	*Low*	
Threat	Transportation, Utility, & Service Corridors								Medium

Contribution	Low	Low	Low	Low					
Irreversibility	High	High	High	High					
Threat Rank	Medium	Low	Low	Low	-	-	-	-	
Threat	Historical Agricultural & Forestry Practices								
Contribution	Low	Low							
Irreversibility	Medium	High							Medium
Threat Rank	Low	Low	-	-	-	-	-	-	

Target #3 -- Upper Meramec River Drainage

Threats - Sources of Stress	**Altered Floodplains & Wetlands**	**Altered Stream Geomorphology**	**Altered Hydrology**	**Altered Connectivity**	**Nutrient Pollution**	**Organic Pollution**	**Chemical Pollution**	**Contaminated Sediments**	**Threat to Target Rank**
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*High*	*Medium*	*Medium*	*Medium*	*Medium*	*Medium*	*Medium*	*Low*	
Threat	In-Stream Gravel Mining & Reaming								
Contribution		High							Medium
Irreversibility		High							
Threat Rank	-	Medium	-	-	-	-	-	-	
Threat	Dams & Water Management								
Contribution	Low	Low	Low	High	Low				
Irreversibility	Medium	Medium	Medium	Medium	High				Medium
Threat Rank	Low	Low	Low	Low	Low	-	-	-	
Threat	Mine Tailings & Industrial Effluents								
Contribution							Medium	Very High	Low
Irreversibility							Medium	High	
Threat Rank	-	-	-	-	-	-	Low	Low	

Target #3 -- Upper Meramec River Drainage

Threats - Sources of Stress	**Altered Floodplains & Wetlands**	**Altered Stream Geomorphology**	**Altered Hydrology**	**Altered Connectivity**	**Nutrient Pollution**	**Organic Pollution**	**Chemical Pollution**	**Contaminated Sediments**	**Threat to Target Rank**
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*High*	*Medium*	*Medium*	*Medium*	*Medium*	*Medium*	*Medium*	*Low*	
Threat	Riverbank & Channel Hardening								
Contribution		Medium							Low
Irreversibility		High							
Threat Rank	-	Low	-	-	-	-	-	-	
Threat	Garbage & Solid Waste								
Contribution							Medium		Low
Irreversibility							High		
Threat Rank	-	-	-	-	-	-	Low	-	

Target #3 -- Upper Meramec River Drainage

Threats - Sources of Stress	Altered Floodplains & Wetlands	Altered Stream Geomorphology	Altered Hydrology	Altered Connectivity	Nutrient Pollution	Organic Pollution	Chemical Pollution	Contaminated Sediments	Threat to Target Rank
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*High*	*Medium*	*Medium*	*Medium*	*Medium*	*Medium*	*Medium*	*Low*	
Threat	Invasive Species								-
Contribution									
Irreversibility									
Threat Rank	-	-	-	-	-	-	-	-	
Threat	Recreational Activities								Low
Contribution	Low					Medium			
Irreversibility	Medium					Medium			
Threat Rank	Low	-	-	-	-	Low	-	-	
Threat	Climate Change								Medium
Contribution	Low	Low	Low	Low					
Irreversibility	High	High	High	High					
Threat Rank	Medium	Low	Low	Low	-	-	-	-	

Target #3 -- Upper Meramec River Drainage

Threats - Sources of Stress	Excessive Suspended & Bedded Sediments	In-Stream Habitat Modification	Invasive Species	Altered Riparian Corridor	-	-	-	-	Threat to Target Rank
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*High*	*Medium*	-	*High*	-	-	-	-	
Threat	Housing & Urban Areas								Medium
Contribution	Low	Low		Low					
Irreversibility	High	High		High					
Threat Rank	Medium	Low	-	Medium	-	-	-	-	
Threat	Livestock Farming & Ranching								High
Contribution	High	High		High					
Irreversibility	High	Medium		Medium					
Threat Rank	High	Low	-	Medium	-	-	-	-	
Threat	Timber Operations								Medium
Contribution	Medium			Medium					
Irreversibility	Medium			Medium					
Threat Rank	Medium	-	-	Medium	-	-	-	-	

Target #3 -- Upper Meramec River Drainage

Threats - Sources of Stress	Excessive Suspended & Bedded Sediments	In-Stream Habitat Modification	Invasive Species	Altered Riparian Corridor	-	-	-	-	Threat to Target Rank

	9	10	11	12	13	14	15	16	
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*High*	*Medium*	-	*High*	-	-	-	-	
Threat	Transportation, Utility, & Service Corridors								
Contribution	Medium	Low		Low					Medium
Irreversibility	Medium	Medium		Medium					
Threat Rank	Medium	Low	-	Low	-	-	-	-	
Threat	Historical Agricultural & Forestry Practices								
Contribution	Low	Low		Low					Medium
Irreversibility	High	Medium		Medium					
Threat Rank	Medium	Low	-	Low	-	-	-	-	

Target #3 -- Upper Meramec River Drainage

Threats - Sources of Stress	**Excessive Suspended & Bedded Sediments**	**In-Stream Habitat Modification**	**Invasive Species**	**Altered Riparian Corridor**	**-**	**-**	**-**	**-**	**Threat to Target Rank**
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*High*	*Medium*	-	*High*	-	-	-	-	
Threat	In-Stream Gravel Mining & Reaming								
Contribution	Medium	High							Medium
Irreversibility	High	High							
Threat Rank	Medium	Medium	-	-	-	-	-	-	
Threat	Dams & Water Management								
Contribution		Low		Low					Medium
Irreversibility		Medium		Medium					
Threat Rank	-	Low	-	Low	-	-	-	-	
Threat	Mine Tailings & Industrial Effluents								
Contribution									Low
Irreversibility									
Threat Rank	-	-	-	-	-	-	-	-	

Target #3 -- Upper Meramec River Drainage

Threats - Sources of Stress	**Excessive Suspended & Bedded Sediments**	**In-Stream Habitat Modification**	**Invasive Species**	**Altered Riparian Corridor**	**-**	**-**	**-**	**-**	**Threat to Target Rank**
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*High*	*Medium*	-	*High*	-	-	-	-	
Threat	Riverbank & Channel Hardening								
Contribution		Medium		Low					Low
Irreversibility		Medium		Medium					
Threat Rank	-	Low	-	Low	-	-	-	-	

Threat		Garbage & Solid Waste								Low
Contribution			Low							
Irreversibility			Medium							
Threat Rank		-	Low	-	-	-	-	-	-	

Target #3 -- Upper Meramec River Drainage

Threats - Sources of Stress		**Excessive Suspended & Bedded Sediments**	**In-Stream Habitat Modification**	**Invasive Species**	**Altered Riparian Corridor**	**-**	**-**	**-**	**-**	**Threat to Target Rank**
Stresses	**#..**	9	10	11	12	13	14	15	16	
Rank..		*High*	*Medium*	-	*High*	-	-	-	-	
Threat		Invasive Species								-
Contribution										
Irreversibility										
Threat Rank		-	-	-	-	-	-	-	-	
Threat		Recreational Activities								Low
Contribution		Low	Low		Low					
Irreversibility		Medium	Medium		Medium					
Threat Rank		Low	Low	-	Low	-	-	-	-	
Threat		Climate Change								Medium
Contribution		Low			Low					
Irreversibility		High			Medium					
Threat Rank		Medium	-	-	Low	-	-	-	-	

Target #4 -- Bourbeuse River Drainage

	Stresses	Severity	Scope	Stress Rank
1	Altered Floodplains & Wetlands	High	High	High
2	Altered Stream Geomorphology	Medium	High	Medium
3	Altered Hydrology	Medium	Medium	Medium
4	Altered Connectivity	Medium	High	Medium
5	Nutrient Pollution	High	Very High	High
6	Organic Pollution	Medium	High	Medium
7	Chemical Pollution	Low	Very High	Low
8	Contaminated Sediments	Low	Low	Low
9	Excessive Suspended & Bedded Sediments	High	Very High	High
10	In-Stream Habitat Modification	Medium	Medium	Medium
11	Invasive Species			-
12	Altered Riparian Corridor	High	Very High	High

Target #4 -- Bourbeuse River Drainage

Threats - Sources of Stress	Altered Floodplains & Wetlands	Altered Stream Geomorphology	Altered Hydrology	Altered Connectivity	Nutrient Pollution	Organic Pollution	Chemical Pollution	Contaminated Sediments	Threat to Target Rank
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*High*	*Medium*	*Medium*	*Medium*	*High*	*Medium*	*Low*	*Low*	
Threat	Housing & Urban Areas								Medium
Contribution	Low	Low	Low	Low	Low	Medium	Medium		
Irreversibility	Very High	Very High	Very High	Very High	Medium	Medium	Medium		
Threat Rank	Medium	Low	Low	Low	Low	Low	Low	-	
Threat	Livestock Farming & Ranching								Very High
Contribution	Very High	High	High	High	Very High	Very High	Very High		
Irreversibility	High	High	High	Medium	Medium	Medium	Medium		
Threat Rank	High	Medium	Medium	Low	High	Medium	Low	-	
Threat	Timber Operations								Medium
Contribution	Low	Low	Low						
Irreversibility	Medium	Medium	Medium						
Threat Rank	Low	Low	Low	-	-	-	-	-	

Target #4 -- Bourbeuse River Drainage

Threats - Sources of Stress	Altered Floodplains & Wetlands	Altered Stream Geomorphology	Altered Hydrology	Altered Connectivity	Nutrient Pollution	Organic Pollution	Chemical Pollution	Contaminated Sediments	Threat to Target Rank
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*High*	*Medium*	*Medium*	*Medium*	*High*	*Medium*	*Low*	*Low*	
Threat	Transportation, Utility, & Service Corridors								Medium

Contribution	Low	Low	Low	Low					Medium
Irreversibility	High	High	High	High					
Threat Rank	Medium	Low	Low	Low	-	-	-	-	
Threat	Historical Agricultural & Forestry Practices								
Contribution	Low	Low							
Irreversibility	Medium	High							
Threat Rank	Low	Low	-	-	-	-	-	-	

Target #4 -- Bourbeuse River Drainage

Threats - Sources of Stress	**Altered Floodplains & Wetlands**	**Altered Stream Geomorphology**	**Altered Hydrology**	**Altered Connectivity**	**Nutrient Pollution**	**Organic Pollution**	**Chemical Pollution**	**Contaminated Sediments**	**Threat to Target Rank**
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*High*	*Medium*	*Medium*	*Medium*	*High*	*Medium*	*Low*	*Low*	
Threat	In-Stream Gravel Mining & Reaming								Medium
Contribution		Medium							
Irreversibility		High							
Threat Rank	-	Low	-	-	-	-	-	-	
Threat	Dams & Water Management								Medium
Contribution	Medium	Medium	Medium	High	Low				
Irreversibility	Medium	Medium	Medium	Medium	High				
Threat Rank	Medium	Low	Low	Low	Medium	-	-	-	
Threat	Mine Tailings & Industrial Effluents								Low
Contribution							Medium	Very High	
Irreversibility							Medium	High	
Threat Rank	-	-	-	-	-	-	Low	Low	

Target #4 -- Bourbeuse River Drainage

Threats - Sources of Stress	**Altered Floodplains & Wetlands**	**Altered Stream Geomorphology**	**Altered Hydrology**	**Altered Connectivity**	**Nutrient Pollution**	**Organic Pollution**	**Chemical Pollution**	**Contaminated Sediments**	**Threat to Target Rank**
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*High*	*Medium*	*Medium*	*Medium*	*High*	*Medium*	*Low*	*Low*	
Threat	Riverbank & Channel Hardening								Low
Contribution		Medium							
Irreversibility		High							
Threat Rank	-	Low	-	-	-	-	-	-	
Threat	Garbage & Solid Waste								Low
Contribution							Medium		
Irreversibility							High		
Threat Rank	-	-	-	-	-	-	Low	-	

Target #4 -- Bourbeuse River Drainage

Threats - Sources of Stress	Altered Floodplains & Wetlands	Altered Stream Geomorphology	Altered Hydrology	Altered Connectivity	Nutrient Pollution	Organic Pollution	Chemical Pollution	Contaminated Sediments	Threat to Target Rank
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*High*	*Medium*	*Medium*	*Medium*	*High*	*Medium*	*Low*	*Low*	
Threat	Invasive Species								-
Contribution									
Irreversibility									
Threat Rank	-	-	-	-	-	-	-	-	
Threat	Recreational Activities								Low
Contribution	Low					Medium			
Irreversibility	Medium					Medium			
Threat Rank	Low	-	-	-	-	Low	-	-	
Threat	Climate Change								Medium
Contribution	Low	Low	Low	Low					
Irreversibility	High	High	High	High					
Threat Rank	Medium	Low	Low	Low	-	-	-	-	

Target #4 -- Bourbeuse River Drainage

Threats - Sources of Stress	Excessive Suspended & Bedded Sediments	In-Stream Habitat Modification	Invasive Species	Altered Riparian Corridor	-	-	-	-	Threat to Target Rank
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*High*	*Medium*	-	*High*	-	-	-	-	
Threat	Housing & Urban Areas								Medium
Contribution	Low	Low		Low					
Irreversibility	High	High		High					
Threat Rank	Medium	Low	-	Medium	-	-	-	-	
Threat	Livestock Farming & Ranching								Very High
Contribution	High	High		Very High					
Irreversibility	High	Medium		Medium					
Threat Rank	High	Low	-	High	-	-	-	-	
Threat	Timber Operations								Medium
Contribution	Medium			Medium					
Irreversibility	Medium			Medium					
Threat Rank	Medium	-	-	Medium	-	-	-	-	

Target #4 -- Bourbeuse River Drainage

Threats - Sources of Stress	Excessive Suspended & Bedded Sediments	In-Stream Habitat Modification	Invasive Species	Altered Riparian Corridor	-	-	-	-	Threat to Target Rank

Stresses	#..	9	10	11	12	13	14	15	16	
Rank..		*High*	*Medium*	-	*High*	-	-	-	-	
Threat		Transportation, Utility, & Service Corridors								
Contribution		Medium	Low		Low					Medium
Irreversibility		Medium	Medium		Medium					
Threat Rank		Medium	Low	-	Low	-	-	-	-	
Threat		Historical Agricultural & Forestry Practices								
Contribution		Low	Low		Low					Medium
Irreversibility		High	Medium		Medium					
Threat Rank		Medium	Low	-	Low	-	-	-	-	

Target #4 -- Bourbeuse River Drainage

Threats - Sources of Stress	Excessive Suspended & Bedded Sediments	In-Stream Habitat Modification	Invasive Species	Altered Riparian Corridor	-	-	-	-	Threat to Target Rank
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*High*	*Medium*	-	*High*	-	-	-	-	
Threat	In-Stream Gravel Mining & Reaming								Medium
Contribution	Medium	Medium							
Irreversibility	High	High							
Threat Rank	Medium	Low	-	-	-	-	-	-	
Threat	Dams & Water Management								Medium
Contribution		High		Medium					
Irreversibility		Medium		Medium					
Threat Rank	-	Low	-	Medium	-	-	-	-	
Threat	Mine Tailings & Industrial Effluents								Low
Contribution									
Irreversibility									
Threat Rank	-	-	-	-	-	-	-	-	

Target #4 -- Bourbeuse River Drainage

Threats - Sources of Stress	Excessive Suspended & Bedded Sediments	In-Stream Habitat Modification	Invasive Species	Altered Riparian Corridor	-	-	-	-	Threat to Target Rank
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*High*	*Medium*	-	*High*	-	-	-	-	
Threat	Riverbank & Channel Hardening								Low
Contribution		Medium		Low					
Irreversibility		Medium		Medium					
Threat Rank	-	Low	-	Low	-	-	-	-	
Threat	Garbage & Solid Waste								Low
Contribution		Low							
Irreversibility		Medium							
Threat Rank	-	Low	-	-	-	-	-	-	

Target #4 -- Bourbeuse River Drainage

Threats - Sources of Stress	Excessive Suspended & Bedded Sediments	In-Stream Habitat Modification	Invasive Species	Altered Riparian Corridor	-	-	-	-	Threat to Target Rank
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*High*	*Medium*	-	*High*	-	-	-	-	
Threat	Invasive Species								-
Contribution									
Irreversibility									
Threat Rank	-	-	-	-	-	-	-	-	
Threat	Recreational Activities								Low
Contribution	Low	Low		Low					
Irreversibility	Medium	Medium		Medium					
Threat Rank	Low	Low	-	Low	-	-	-	-	
Threat	Climate Change								Medium
Contribution	Low			Low					
Irreversibility	High			Medium					
Threat Rank	Medium	-	-	Low	-	-	-	-	

Target #5 -- Big River Drainage

	Stresses	Severity	Scope	Stress Rank
1	Altered Hydrology	Medium	Medium	Medium
2	Altered Connectivity	High	High	High
3	Altered Floodplains & Wetlands	Medium	Medium	Medium
4	Altered Stream Geomorphology	Medium	Medium	Medium
5	Nutrient Pollution	Medium	Medium	Medium
6	Organic Pollution	Low	Medium	Low
7	Chemical Pollution	High	Medium	Medium
8	Contaminated Sediments	Very High	Very High	Very High
9	Excessive Suspended & Bedded Sediments	High	Medium	Medium
10	In-Stream Habitat Modification	Medium	High	Medium
11	Altered Riparian Corridor	Medium	High	Medium
12	Invasive Species			-

Target #5 -- Big River Drainage

Threats - Sources of Stress	**Altered Hydrology**	**Altered Connectivity**	**Altered Floodplains & Wetlands**	**Altered Stream Geomorphology**	**Nutrient Pollution**	**Organic Pollution**	**Chemical Pollution**	**Contaminated Sediments**	**Threat to Target Rank**
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*Medium*	*High*	*Medium*	*Medium*	*Medium*	*Low*	*Medium*	*Very High*	
Threat	Dams & Water Management								High
Contribution	Medium	Very High	Medium	Medium	Low				
Irreversibility	High	High	High	High	High				
Threat Rank	Low	High	Low	Low	Low	-	-	-	
Threat	Historical Agricultural & Forestry Practices								Low
Contribution			Low	Low					
Irreversibility			Medium	High					
Threat Rank	-	-	Low	Low	-	-	-	-	

Target #5 -- Big River Drainage

Threats - Sources of Stress	Altered Hydrology	Altered Connectivity	Altered Floodplains & Wetlands	Altered Stream Geomorphology	Nutrient Pollution	Organic Pollution	Chemical Pollution	Contaminated Sediments	Threat to Target Rank
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*Medium*	*High*	*Medium*	*Medium*	*Medium*	*Low*	*Medium*	*Very High*	
Threat	Housing & Urban Areas								High
Contribution	High	Medium	Medium	Medium	Medium	Medium	Medium		
Irreversibility	Very High	Very High	Very High	Very High	Medium	Medium	Medium		
Threat Rank	Medium	High	Medium	Medium	Low	Low	Low	-	
Threat	In-Stream Gravel Mining & Reaming								Medium
Contribution				High					
Irreversibility				High					
Threat Rank	-	-	-	Medium	-	-	-	-	
Threat	Invasive Species								-
Contribution									
Irreversibility									
Threat Rank	-	-	-	-	-	-	-	-	

Target #5 -- Big River Drainage

Threats - Sources of Stress	Altered Hydrology	Altered Connectivity	Altered Floodplains & Wetlands	Altered Stream Geomorphology	Nutrient Pollution	Organic Pollution	Chemical Pollution	Contaminated Sediments	Threat to Target Rank
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*Medium*	*High*	*Medium*	*Medium*	*Medium*	*Low*	*Medium*	*Very High*	
Threat	Livestock Farming & Ranching								Medium
Contribution	Medium	Medium	High	High	High	High	High		
Irreversibility	High	Medium	High	High	Medium	Medium	Medium		
Threat Rank	Low	Medium	Medium	Medium	Low	Low	Low	-	
Threat	Mine Tailings & Industrial Effluents								Very High
Contribution							High	Very High	
Irreversibility							High	High	
Threat Rank (override)									
Threat Rank	-	-	-	-	-	-	Medium	Very High	
Threat	Recreational Activities								Low
Contribution			Low			Medium			
Irreversibility			Medium			Medium			
Threat Rank	-	-	Low	-	-	Low	-	-	

Target #5 -- Big River Drainage

Threats - Sources of Stress	Altered Hydrology	Altered Connectivity	Altered Floodplains & Wetlands	Altered Stream Geomorphology	Nutrient Pollution	Organic Pollution	Chemical Pollution	Contaminated Sediments	Threat to Target Rank
Stresses **#..**	1	2	3	4	5	6	7	8	
Rank..	*Medium*	*High*	*Medium*	*Medium*	*Medium*	*Low*	*Medium*	*Very High*	
Threat	Riverbank & Channel Hardening								Low
Contribution				Medium					
Irreversibility				High					
Threat Rank	-	-	-	Low	-	-	-	-	
Threat	Transportation, Utility, & Service Corridors								Medium
Contribution	Medium	Medium	Low	Low					
Irreversibility	High	High	High	High					
Threat Rank	Low	Medium	Low	Low	-	-	-	-	

Target #5 -- Big River Drainage

Threats - Sources of Stress	Altered Hydrology	Altered Connectivity	Altered Floodplains & Wetlands	Altered Stream Geomorphology	Nutrient Pollution	Organic Pollution	Chemical Pollution	Contaminated Sediments	Threat to Target Rank
Stresses **#..**	1	2	3	4	5	6	7	8	
Rank..	*Medium*	*High*	*Medium*	*Medium*	*Medium*	*Low*	*Medium*	*Very High*	
Threat	Timber Operations								Low
Contribution	Low		Low	Low					
Irreversibility	Medium		Medium	Medium					
Threat Rank	Low	-	Low	Low	-	-	-	-	
Threat	Climate Change								Medium
Contribution	Low	Low	Low	Low					
Irreversibility	High	High	High	High					
Threat Rank	Low	Medium	Low	Low	-	-	-	-	
Threat	Garbage & Solid Waste								Low
Contribution							Medium		
Irreversibility							High		
Threat Rank	-	-	-	-	-	-	Low	-	

Target #5 -- Big River Drainage

Threats - Sources of Stress	Excessive Suspended & Bedded	In-Stream Habitat Modification	Altered Riparian Corridor	Invasive Species	-	-	-	-	Threat to Target Rank

		Sediments								
Stresses	**#..**	9	10	11	12	13	14	15	16	
Rank..		*Medium*	*Medium*	*Medium*	-	-	-	-	-	
Threat		Dams & Water Management								
Contribution			High	Medium						High
Irreversibility			High	High						
Threat Rank		-	Medium	Low	-	-	-	-	-	
Threat		Historical Agricultural & Forestry Practices								
Contribution		Low	Low	Low						Low
Irreversibility		High	Medium	Medium						
Threat Rank		Low	Low	Low	-	-	-	-	-	

Target #5 -- Big River Drainage

Threats - Sources of Stress		**Excessive Suspended & Bedded Sediments**	**In-Stream Habitat Modification**	**Altered Riparian Corridor**	**Invasive Species**	-	-	-	-	**Threat to Target Rank**
Stresses	**#..**	9	10	11	12	13	14	15	16	
Rank..		*Medium*	*Medium*	*Medium*	-	-	-	-	-	
Threat		Housing & Urban Areas								
Contribution		High	High	High						High
Irreversibility		High	High	High						
Threat Rank		Medium	Medium	Medium	-	-	-	-	-	
Threat		In-Stream Gravel Mining & Reaming								
Contribution		Medium	Medium							Medium
Irreversibility		High	Medium							
Threat Rank		Low	Low	-	-	-	-	-	-	
Threat		Invasive Species								
Contribution										-
Irreversibility										
Threat Rank		-	-	-	-	-	-	-	-	

Target #5 -- Big River Drainage

Threats - Sources of Stress	**Excessive Suspended & Bedded Sediments**	**In-Stream Habitat Modification**	**Altered Riparian Corridor**	**Invasive Species**	-	-	-	-	**Threat to Target Rank**

Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*Medium*	*Medium*	*Medium*	-	-	-	-	-	
Threat	Livestock Farming & Ranching								Medium
Contribution	High	High	High						
Irreversibility	High	Medium	Medium						
Threat Rank	Medium	Low	Low	-	-	-	-	-	
Threat	Mine Tailings & Industrial Effluents								Very High
Contribution									
Irreversibility									
Threat Rank	-	-	-	-	-	-	-	-	
Threat	Recreational Activities								Low
Contribution	Low	Low	Low						
Irreversibility	Medium	Medium	Medium						
Threat Rank	Low	Low	Low	-	-	-	-	-	

Target #5 -- Big River Drainage

Threats - Sources of Stress	**Excessive Suspended & Bedded Sediments**	**In-Stream Habitat Modification**	**Altered Riparian Corridor**	**Invasive Species**	**-**	**-**	**-**	**-**	**Threat to Target Rank**
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*Medium*	*Medium*	*Medium*	-	-	-	-	-	
Threat	Riverbank & Channel Hardening								Low
Contribution		Medium	Low						
Irreversibility		Medium	Medium						
Threat Rank	-	Low	Low	-	-	-	-	-	
Threat	Transportation, Utility, & Service Corridors								Medium
Contribution	Medium	Low	Low						
Irreversibility	Medium	Medium	Medium						
Threat Rank	Low	Low	Low	-	-	-	-	-	

Target #5 -- Big River Drainage

Threats - Sources of Stress		Excessive Suspended & Bedded Sediments	In-Stream Habitat Modification	Altered Riparian Corridor	Invasive Species	-	-	-	-	Threat to Target Rank
Stresses	**#..**	9	10	11	12	13	14	15	16	
Rank..		*Medium*	*Medium*	*Medium*	-	-	-	-	-	
Threat		Timber Operations								
Contribution		Medium		Medium						Low
Irreversibility		Medium		Medium						
Threat Rank		Low	-	Low	-	-	-	-	-	
Threat		Climate Change								
Contribution		Low		Low						Medium
Irreversibility		High		Medium						
Threat Rank		Low	-	Low	-	-	-	-	-	
Threat		Garbage & Solid Waste								
Contribution			Low							Low
Irreversibility			Medium							
Threat Rank		-	Low	-	-	-	-	-	-	

Target #6 -- Huzzah Creek and Courtois Creek Drainages

	Stresses	**Severity**	**Scope**	**Stress Rank**
1	Altered Hydrology	Low	Medium	Low
2	Altered Connectivity	Low	High	Low
3	Altered Floodplains & Wetlands	Medium	Medium	Medium
4	Altered Stream Geomorphology	Medium	Medium	Medium
5	Nutrient Pollution	Low	High	Low
6	Organic Pollution	Low	High	Low
7	Chemical Pollution	Low	High	Low
8	Contaminated Sediments	High	Medium	Medium
9	Excessive Suspended & Bedded Sediments	Medium	High	Medium
10	In-Stream Habitat Modification	Medium	Medium	Medium
11	Altered Riparian Corridor	Medium	High	Medium
12	Invasive Species			-

Target #6 -- Huzzah Creek and Courtois Creek Drainages

Threats - Sources of Stress	**Altered Hydrology**	**Altered Connectivity**	**Altered Floodplains & Wetlands**	**Altered Stream Geomorphology**	**Nutrient Pollution**	**Organic Pollution**	**Chemical Pollution**	**Contaminated Sediments**	**Threat to Target Rank**
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*Low*	*Low*	*Medium*	*Medium*	*Low*	*Low*	*Low*	*Medium*	
Threat	Dams & Water Management								
Contribution	Low	High	Low	Low	Low				Medium
Irreversibility	Medium	Medium	Medium	Medium	High				
Threat Rank	Low	Low	Low	Low	Low	-	-	-	
Threat	Garbage & Solid Waste								
Contribution							Medium		Low
Irreversibility							High		
Threat Rank	-	-	-	-	-	-	Low	-	

Target #6 -- Huzzah Creek and Courtois Creek Drainages

Threats - Sources of Stress		Altered Hydrology	Altered Connectivity	Altered Floodplains & Wetlands	Altered Stream Geomorphology	Nutrient Pollution	Organic Pollution	Chemical Pollution	Contaminated Sediments	Threat to Target Rank
Stresses	**#..**	1	2	3	4	5	6	7	8	
Rank..		*Low*	*Low*	*Medium*	*Medium*	*Low*	*Low*	*Low*	*Medium*	
Threat		Historical Agricultural & Forestry Practices								Low
Contribution				Low	Low					
Irreversibility				Medium	High					
Threat Rank		-	-	Low	Low	-	-	-	-	
Threat		Housing & Urban Areas								Medium
Contribution		Low	Low	Low	Low	Low	Low	Low		
Irreversibility		Very High	Very High	Very High	Very High	Medium	Medium	Medium		
Threat Rank		Low	Low	Low	Low	Low	Low	Low	-	
Threat		In-Stream Gravel Mining & Reaming								Low
Contribution				Medium	Medium			Low		
Irreversibility				Medium	Medium			Low		
Threat Rank		-	-	Low	Low	-	-	Low	-	

Target #6 -- Huzzah Creek and Courtois Creek Drainages

Threats - Sources of Stress		Altered Hydrology	Altered Connectivity	Altered Floodplains & Wetlands	Altered Stream Geomorphology	Nutrient Pollution	Organic Pollution	Chemical Pollution	Contaminated Sediments	Threat to Target Rank
Stresses	**#..**	1	2	3	4	5	6	7	8	
Rank..		*Low*	*Low*	*Medium*	*Medium*	*Low*	*Low*	*Low*	*Medium*	
Threat		Invasive Species								-
Contribution										
Irreversibility										
Threat Rank		-	-	-	-	-	-	-	-	
Threat		Livestock Farming & Ranching								Medium
Contribution		High	High	Very High	High	Very High	Very High	Very High		
Irreversibility		High	Medium	High	High	Medium	Medium	Medium		
Threat Rank		Low	Low	Medium	Medium	Low	Low	Low	-	
Threat		Mine Tailings & Industrial Effluents								Medium
Contribution								High	Very High	
Irreversibility								Medium	High	
Threat Rank		-	-	-	-	-	-	Low	Medium	

Target #6 -- Huzzah Creek and Courtois Creek Drainages

Threats - Sources of Stress		Altered Hydrology	Altered Connectivity	Altered Floodplains & Wetlands	Altered Stream Geomorphology	Nutrient Pollution	Organic Pollution	Chemical Pollution	Contaminated Sediments	Threat to Target Rank
Stresses	**#..**	1	2	3	4	5	6	7	8	
Rank..		*Low*	*Low*	*Medium*	*Medium*	*Low*	*Low*	*Low*	*Medium*	
	Threat	Recreational Activities								Low
	Contribution			Low			Medium			
	Irreversibility			Medium			Medium			
	Threat Rank	-	-	Low	-	-	Low	-	-	
	Threat	Riverbank & Channel Hardening								Low
	Contribution				Medium					
	Irreversibility				High					
	Threat Rank	-	-	-	Low	-	-	-	-	
	Threat	Transportation, Utility, & Service Corridors								Medium
	Contribution	Low	Low	Low	Low					
	Irreversibility	High	High	High	High					
	Threat Rank	Low	Low	Low	Low	-	-	-	-	

Target #6 -- Huzzah Creek and Courtois Creek Drainages

Threats - Sources of Stress		Altered Hydrology	Altered Connectivity	Altered Floodplains & Wetlands	Altered Stream Geomorphology	Nutrient Pollution	Organic Pollution	Chemical Pollution	Contaminated Sediments	Threat to Target Rank
Stresses	**#..**	1	2	3	4	5	6	7	8	
Rank..		*Low*	*Low*	*Medium*	*Medium*	*Low*	*Low*	*Low*	*Medium*	
	Threat	Timber Operations								Low
	Contribution	Low		Low	Low					
	Irreversibility	Medium		Medium	Medium					
	Threat Rank	Low	-	Low	Low	-	-	-	-	
	Threat	Climate Change								Low
	Contribution	Low	Low	Low	Low					
	Irreversibility	High	High	High	High					
	Threat Rank	Low	Low	Low	Low	-	-	-	-	

Target #6 -- Huzzah Creek and Courtois Creek Drainages

Threats - Sources of Stress	Excessive Suspended & Bedded Sediments	In-Stream Habitat Modification	Altered Riparian Corridor	Invasive Species	-	-	-	-	Threat to Target Rank
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*Medium*	*Medium*	*Medium*	-	-	-	-	-	
Threat	Dams & Water Management								Medium
Contribution		Medium	Low						
Irreversibility		Medium	Medium						
Threat Rank	-	Low	Low	-	-	-	-	-	
Threat	Garbage & Solid Waste								Low
Contribution			Low						
Irreversibility			Medium						
Threat Rank	-	-	Low	-	-	-	-	-	

Target #6 -- Huzzah Creek and Courtois Creek Drainages

Threats - Sources of Stress	Excessive Suspended & Bedded Sediments	In-Stream Habitat Modification	Altered Riparian Corridor	Invasive Species	-	-	-	-	Threat to Target Rank
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*Medium*	*Medium*	*Medium*	-	-	-	-	-	
Threat	Historical Agricultural & Forestry Practices								Low
Contribution	Low	Low	Low						
Irreversibility	High	Medium	Medium						
Threat Rank	Low	Low	Low	-	-	-	-	-	
Threat	Housing & Urban Areas								Medium
Contribution	Low	Low	Low						
Irreversibility	High	High	High						
Threat Rank	Low	Low	Low	-	-	-	-	-	
Threat	In-Stream Gravel Mining & Reaming								Low
Contribution	Medium	Low	Medium						
Irreversibility	High	High	Medium						
Threat Rank	Low	Low	Low	-	-	-	-	-	

Target #6 -- Huzzah Creek and Courtois Creek Drainages

Threats - Sources of Stress	Excessive Suspended & Bedded Sediments	In-Stream Habitat Modification	Altered Riparian Corridor	Invasive Species	-	-	-	-	Threat to Target Rank
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*Medium*	*Medium*	*Medium*	-	-	-	-	-	
Threat	Invasive Species								-
Contribution									
Irreversibility									
Threat Rank	-	-	-	-	-	-	-	-	
Threat	Livestock Farming & Ranching								Medium
Contribution	High	High	High						
Irreversibility	High	Medium	Medium						
Threat Rank	Medium	Low	Low	-	-	-	-	-	
Threat	Mine Tailings & Industrial Effluents								Medium
Contribution									
Irreversibility									
Threat Rank	-	-	-	-	-	-	-	-	

Target #6 -- Huzzah Creek and Courtois Creek Drainages

Threats - Sources of Stress	Excessive Suspended & Bedded Sediments	In-Stream Habitat Modification	Altered Riparian Corridor	Invasive Species	-	-	-	-	Threat to Target Rank
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*Medium*	*Medium*	*Medium*	-	-	-	-	-	
Threat	Recreational Activities								Low
Contribution	Low	Low	Low						
Irreversibility	Medium	Medium	Medium						
Threat Rank	Low	Low	Low	-	-	-	-	-	
Threat	Riverbank & Channel Hardening								Low
Contribution		Medium	Low						
Irreversibility		Medium	Medium						
Threat Rank	-	Low	Low	-	-	-	-	-	
Threat	Transportation, Utility, & Service Corridors								Medium
Contribution	Medium	Low	Low						
Irreversibility	Medium	Medium	Medium						
Threat Rank	Low	Low	Low	-	-	-	-	-	

Target #6 -- Huzzah Creek and Courtois Creek Drainages

Threats - Sources of Stress	Excessive Suspended &	In-Stream Habitat	Altered Riparian	Invasive Species	-	-	-	-	Threat to Target Rank

		Bedded Sediments	Modification	Corridor						
Stresses	**#..**	9	10	11	12	13	14	15	16	
Rank..		*Medium*	*Medium*	*Medium*	-	-	-	-	-	
	Threat	Timber Operations								
	Contribution	Low		High						Low
	Irreversibility	Medium		Medium						
	Threat Rank	Low	-	Low	-	-	-	-	-	
	Threat	Climate Change								
	Contribution	Low		Low						Low
	Irreversibility	High		Medium						
	Threat Rank	Low	-	Low	-	-	-	-	-	

Target #7 -- LaBarque Creek Drainage

	Stresses	Severity	Scope	Stress Rank
1	Altered Hydrology	Medium	High	Medium
2	Altered Connectivity	Low	Medium	Low
3	Altered Floodplains & Wetlands	Low	Medium	Low
4	Altered Stream Geomorphology	Low	Medium	Low
5	Nutrient Pollution	Low	Medium	Low
6	Organic Pollution	Low	Medium	Low
7	Chemical Pollution	Low	Low	Low
8	Contaminated Sediments			-
9	Excessive Suspended & Bedded Sediments	Medium	Medium	Medium
10	In-Stream Habitat Modification	Medium	Low	Low
11	Altered Riparian Corridor	Medium	Low	Low
12	Invasive Species			-

Target #7 -- LaBarque Creek Drainage

Threats - Sources of Stress	Altered Hydrology	Altered Connectivity	Altered Floodplains & Wetlands	Altered Stream Geomorphology	Nutrient Pollution	Organic Pollution	Chemical Pollution	Contaminated Sediments	Threat to Target Rank
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*Medium*	*Low*	*Low*	*Low*	*Low*	*Low*	*Low*	-	
Threat	Dams & Water Management								
Contribution	Low	Medium	Low	Low	Low				Medium
Irreversibility	Medium	Medium	Medium	Medium	High				
Threat Rank	Low	Low	Low	Low	Low	-	-	-	
Threat	Garbage & Solid Waste								
Contribution							Medium		Low
Irreversibility							High		
Threat Rank	-	-	-	-	-	-	Low	-	

Target #7 -- LaBarque Creek Drainage

Threats - Sources of Stress	Altered Hydrology	Altered Connectivity	Altered Floodplains & Wetlands	Altered Stream Geomorphology	Nutrient Pollution	Organic Pollution	Chemical Pollution	Contaminated Sediments	Threat to Target Rank
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*Medium*	*Low*	*Low*	*Low*	*Low*	*Low*	*Low*	-	
Threat	Historical Agricultural & Forestry Practices								
Contribution			Low	Low					Low
Irreversibility			Medium	High					
Threat Rank	-	-	Low	Low	-	-	-	-	
Threat	Housing & Urban Areas								Medium

Contribution	High	High	High	High	High	High	High		
Irreversibility	Very High	Very High	Very High	Very High	Medium	Medium	Medium		
Threat Rank	Medium	Low	Low	Low	Low	Low	Low	-	
Threat	In-Stream Gravel Mining & Reaming								-
Contribution									
Irreversibility									
Threat Rank	-	-	-	-	-	-	-	-	

Target #7 -- LaBarque Creek Drainage

Threats - Sources of Stress	**Altered Hydrology**	**Altered Connectivity**	**Altered Floodplains & Wetlands**	**Altered Stream Geomorphology**	**Nutrient Pollution**	**Organic Pollution**	**Chemical Pollution**	**Contaminated Sediments**	**Threat to Target Rank**
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*Medium*	*Low*	*Low*	*Low*	*Low*	*Low*	*Low*	-	
Threat	Invasive Species								-
Contribution									
Irreversibility									
Threat Rank	-	-	-	-	-	-	-	-	
Threat	Livestock Farming & Ranching								Medium
Contribution	Medium	High	Very High	High	High	High	Medium		
Irreversibility	High	Medium	High	High	Medium	Medium	Medium		
Threat Rank	Low	Low	Low	Low	Low	Low	Low	-	
Threat	Mine Tailings & Industrial Effluents								-
Contribution									
Irreversibility									
Threat Rank	-	-	-	-	-	-	-	-	

Target #7 -- LaBarque Creek Drainage

Threats - Sources of Stress	**Altered Hydrology**	**Altered Connectivity**	**Altered Floodplains & Wetlands**	**Altered Stream Geomorphology**	**Nutrient Pollution**	**Organic Pollution**	**Chemical Pollution**	**Contaminated Sediments**	**Threat to Target Rank**
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*Medium*	*Low*	*Low*	*Low*	*Low*	*Low*	*Low*	-	
Threat	Recreational Activities								Low
Contribution			Low			Medium			
Irreversibility			Medium			Medium			
Threat Rank	-	-	Low	-	-	Low	-	-	
Threat	Riverbank & Channel Hardening								Low
Contribution				Medium					
Irreversibility				High					
Threat Rank	-	-	-	Low	-	-	-	-	
Threat	Transportation, Utility, & Service Corridors								Medium

Contribution	Medium	Low	Low	Low					
Irreversibility	High	Medium	Medium	Medium					
Threat Rank	Low	Low	Low	Low	-	-	-	-	

Target #7 -- LaBarque Creek Drainage

Threats - Sources of Stress	**Altered Hydrology**	**Altered Connectivity**	**Altered Floodplains & Wetlands**	**Altered Stream Geomorphology**	**Nutrient Pollution**	**Organic Pollution**	**Chemical Pollution**	**Contaminated Sediments**	**Threat to Target Rank**
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*Medium*	*Low*	*Low*	*Low*	*Low*	*Low*	*Low*	-	
Threat	Timber Operations								Low
Contribution	Low		Low	Low					
Irreversibility	Medium		Medium	Medium					
Threat Rank	Low	-	Low	Low	-	-	-	-	
Threat	Climate Change								Low
Contribution	Low	Low	Low	Low					
Irreversibility	High	High	High	High					
Threat Rank	Low	Low	Low	Low	-	-	-	-	

Target #7 -- LaBarque Creek Drainage

Threats - Sources of Stress	**Excessive Suspended & Bedded Sediments**	**In-Stream Habitat Modification**	**Altered Riparian Corridor**	**Invasive Species**	-	-	-	-	**Threat to Target Rank**
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*Medium*	*Low*	*Low*	-	-	-	-	-	
Threat	Dams & Water Management								Medium
Contribution		Low	Low						
Irreversibility		Medium	Medium						
Threat Rank	-	Low	Low	-	-	-	-	-	
Threat	Garbage & Solid Waste								Low
Contribution		Low							
Irreversibility		Medium							
Threat Rank	-	Low	-	-	-	-	-	-	

Target #7 -- LaBarque Creek Drainage

Threats - Sources of Stress	**Excessive Suspended & Bedded Sediments**	**In-Stream Habitat Modification**	**Altered Riparian Corridor**	**Invasive Species**	-	-	-	-	**Threat to Target Rank**
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*Medium*	*Low*	*Low*	-	-	-	-	-	
Threat	Historical Agricultural & Forestry Practices								Low
Contribution	Low	Low	Low						

Irreversibility	High	Medium	Medium						
Threat Rank	Low	Low	Low	-	-	-	-	-	
Threat	Housing & Urban Areas								Medium
Contribution	Medium	High	High						
Irreversibility	High	High	High						
Threat Rank	Low	Low	Low	-	-	-	-	-	
Threat	In-Stream Gravel Mining & Reaming								-
Contribution									
Irreversibility									
Threat Rank	-	-	-	-	-	-	-	-	

Target #7 -- LaBarque Creek Drainage

Threats - Sources of Stress	**Excessive Suspended & Bedded Sediments**	**In-Stream Habitat Modification**	**Altered Riparian Corridor**	**Invasive Species**	**-**	**-**	**-**	**-**	**Threat to Target Rank**
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*Medium*	*Low*	*Low*	-	-	-	-	-	
Threat	Invasive Species								-
Contribution									
Irreversibility									
Threat Rank	-	-	-	-	-	-	-	-	
Threat	Livestock Farming & Ranching								Medium
Contribution	Medium	Medium	Medium						
Irreversibility	High	Medium	Medium						
Threat Rank	Low	Low	Low	-	-	-	-	-	
Threat	Mine Tailings & Industrial Effluents								-
Contribution									
Irreversibility									
Threat Rank	-	-	-	-	-	-	-	-	

Target #7 -- LaBarque Creek Drainage

Threats - Sources of Stress	**Excessive Suspended & Bedded Sediments**	**In-Stream Habitat Modification**	**Altered Riparian Corridor**	**Invasive Species**	**-**	**-**	**-**	**-**	**Threat to Target Rank**
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*Medium*	*Low*	*Low*	-	-	-	-	-	
Threat	Recreational Activities								Low
Contribution	Low	Low	Low						
Irreversibility	Medium	Medium	Medium						
Threat Rank	Low	Low	Low	-	-	-	-	-	

Threat	Riverbank & Channel Hardening								
Contribution		Medium	Low						Low
Irreversibility		Medium	Medium						
Threat Rank	-	Low	Low	-	-	-	-	-	
Threat	Transportation, Utility, & Service Corridors								
Contribution	Low	Low	Low						Medium
Irreversibility	Medium	Medium	Medium						
Threat Rank	Low	Low	Low	-	-	-	-	-	

Target #7 -- LaBarque Creek Drainage

Threats - Sources of Stress	**Excessive Suspended & Bedded Sediments**	**In-Stream Habitat Modification**	**Altered Riparian Corridor**	**Invasive Species**	**-**	**-**	**-**	**-**	**Threat to Target Rank**
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*Medium*	*Low*	*Low*	-	-	-	-	-	
Threat	Timber Operations								
Contribution	Medium		Medium						Low
Irreversibility	Medium		Medium						
Threat Rank	Low	-	Low	-	-	-	-	-	
Threat	Climate Change								
Contribution	Low		Low						Low
Irreversibility	High		Medium						
Threat Rank	Low	-	Low	-	-	-	-	-	

Target #8 -- Freshwater Mussels

	Stresses	**Severity**	**Scope**	**Stress Rank**
1	Altered Hydrology	High	Medium	Medium
2	Altered Connectivity	Medium	High	Medium
3	Altered Floodplains & Wetlands	Medium	High	Medium
4	Altered Stream Geomorphology	High	High	High
5	Nutrient Pollution	Medium	Medium	Medium
6	Organic Pollution	Medium	High	Medium
7	Chemical Pollution	Very High	Medium	Medium
8	Contaminated Sediments	Very High	High	High
9	Excessive Suspended & Bedded Sediments	Very High	High	High
10	In-Stream Habitat Modification	High	High	High
11	Altered Riparian Corridor	Medium	High	Medium
12	Invasive Species	Medium	High	Medium

Target #8 -- Freshwater Mussels

Threats - Sources of Stress	**Altered Hydrology**	**Altered Connectivity**	**Altered Floodplains & Wetlands**	**Altered Stream Geomorphology**	**Nutrient Pollution**	**Organic Pollution**	**Chemical Pollution**	**Contaminated Sediments**	**Threat to Target Rank**
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*Medium*	*Medium*	*Medium*	*High*	*Medium*	*Medium*	*Medium*	*High*	
Threat	Dams & Water Management								
Contribution	Medium	High	Medium	Medium	Low				Medium
Irreversibility	High	High	High	High	High				
Threat Rank	Low	Medium	Low	Medium	Low	-	-	-	
Threat	Garbage & Solid Waste								
Contribution							Medium		Low
Irreversibility							Medium		
Threat Rank	-	-	-	-	-	-	Low	-	

Target #8 -- Freshwater Mussels

Threats - Sources of Stress	Altered Hydrology	Altered Connectivity	Altered Floodplains & Wetlands	Altered Stream Geomorphology	Nutrient Pollution	Organic Pollution	Chemical Pollution	Contaminated Sediments	Threat to Target Rank
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*Medium*	*Medium*	*Medium*	*High*	*Medium*	*Medium*	*Medium*	*High*	
Threat	Historical Agricultural & Forestry Practices								
Contribution	Low			Low					Medium
Irreversibility	Medium			High					
Threat Rank	Low	-	-	Medium	-	-	-	-	
Threat	Housing & Urban Areas								
Contribution	Medium	Medium	Medium	Medium	Medium	Medium	Medium		High
Irreversibility	Very High	Very High	Very High	Very High	Medium	Medium	Medium		
Threat Rank	Medium	Medium	Medium	High	Low	Low	Low	-	
Threat	In-Stream Gravel Mining & Reaming								
Contribution				High					High
Irreversibility				High					
Threat Rank	-	-	-	High	-	-	-	-	

Target #8 -- Freshwater Mussels

Threats - Sources of Stress	Altered Hydrology	Altered Connectivity	Altered Floodplains & Wetlands	Altered Stream Geomorphology	Nutrient Pollution	Organic Pollution	Chemical Pollution	Contaminated Sediments	Threat to Target Rank
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*Medium*	*Medium*	*Medium*	*High*	*Medium*	*Medium*	*Medium*	*High*	
Threat	Invasive Species								
Contribution						Low			Medium
Irreversibility						Very High			
Threat Rank	-	-	-	-	-	Low	-	-	
Threat	Livestock Farming & Ranching								
Contribution	Medium	High	High	High	High	High	High		High
Irreversibility	High	Medium	High	High	Medium	Medium	Medium		
Threat Rank	Low	Low	Medium	High	Low	Low	Low	-	
Threat	Mine Tailings & Industrial Effluents								
Contribution							High	Very High	High
Irreversibility							High	High	
Threat Rank	-	-	-	-	-	-	Medium	High	

Target #8 -- Freshwater Mussels

Threats - Sources of Stress	Altered Hydrology	Altered Connectivity	Altered Floodplains & Wetlands	Altered Stream Geomorphology	Nutrient Pollution	Organic Pollution	Chemical Pollution	Contaminated Sediments	Threat to Target Rank
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*Medium*	*Medium*	*Medium*	*High*	*Medium*	*Medium*	*Medium*	*High*	
Threat	Recreational Activities								
Contribution			Low			Low			Medium
Irreversibility			Medium			Medium			
Threat Rank	-	-	Low	-	-	Low	-	-	
Threat	Riverbank & Channel Hardening								
Contribution				Medium					Medium
Irreversibility				Medium					
Threat Rank	-	-	-	Medium	-	-	-	-	
Threat	Transportation, Utility, & Service Corridors								
Contribution	Medium	Medium	Medium	Medium					Medium
Irreversibility	High	High	High	High					
Threat Rank	Low	Low	Low	Medium	-	-	-	-	

Target #8 -- Freshwater Mussels

Threats - Sources of Stress	Altered Hydrology	Altered Connectivity	Altered Floodplains & Wetlands	Altered Stream Geomorphology	Nutrient Pollution	Organic Pollution	Chemical Pollution	Contaminated Sediments	Threat to Target Rank
Stresses #..	1	2	3	4	5	6	7	8	
Rank..	*Medium*	*Medium*	*Medium*	*High*	*Medium*	*Medium*	*Medium*	*High*	
Threat	Timber Operations								
Contribution	Low		Low	Low					Medium
Irreversibility	Medium		Medium	Medium					
Threat Rank	Low	-	Low	Low	-	-	-	-	
Threat	Climate Change								
Contribution	Low	Low	Low	Low					Medium
Irreversibility	High	High	High	High					
Threat Rank	Low	Low	Low	Medium	-	-	-	-	

Target #8 -- Freshwater Mussels

Threats - Sources of Stress	Excessive Suspended & Bedded Sediments	In-Stream Habitat Modification	Altered Riparian Corridor	Invasive Species	-	-	-	-	Threat to Target Rank
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*High*	*High*	*Medium*	*Medium*	-	-	-	-	
Threat	Dams & Water Management								
Contribution		Medium	Medium						Medium
Irreversibility		Medium	Medium						

Threat Rank	-	Medium	Low	-	-	-	-	-	
Threat	Garbage & Solid Waste								Low
Contribution									
Irreversibility									
Threat Rank	-	-	-	-	-	-	-	-	

Target #8 -- Freshwater Mussels

Threats - Sources of Stress	**Excessive Suspended & Bedded Sediments**	**In-Stream Habitat Modification**	**Altered Riparian Corridor**	**Invasive Species**	**-**	**-**	**-**	**-**	**Threat to Target Rank**
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*High*	*High*	*Medium*	*Medium*	-	-	-	-	
Threat	Historical Agricultural & Forestry Practices								Medium
Contribution	Low	Low	Low						
Irreversibility	High	Medium	Medium						
Threat Rank	Medium	Low	Low	-	-	-	-	-	
Threat	Housing & Urban Areas								High
Contribution	Medium	Medium	Medium						
Irreversibility	High	High	High						
Threat Rank	Medium	Medium	Low	-	-	-	-	-	
Threat	In-Stream Gravel Mining & Reaming								High
Contribution	Medium	High	Medium						
Irreversibility	High	High	Medium						
Threat Rank	Medium	High	Low	-	-	-	-	-	

Target #8 -- Freshwater Mussels

Threats - Sources of Stress	**Excessive Suspended & Bedded Sediments**	**In-Stream Habitat Modification**	**Altered Riparian Corridor**	**Invasive Species**	**-**	**-**	**-**	**-**	**Threat to Target Rank**
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*High*	*High*	*Medium*	*Medium*	-	-	-	-	
Threat	Invasive Species								Medium
Contribution				Very High					
Irreversibility				Very High					
Threat Rank	-	-	-	Medium	-	-	-	-	
Threat	Livestock Farming & Ranching								High
Contribution	Medium	Medium	High						
Irreversibility	High	Medium	Medium						
Threat Rank	Medium	Medium	Low	-	-	-	-	-	
Threat	Mine Tailings & Industrial Effluents								High

Contribution	Medium	High	Medium						
Irreversibility	High	Medium	Medium						
Threat Rank	Medium	Medium	Low	-	-	-	-	-	

Target #8 -- Freshwater Mussels

Threats - Sources of Stress	**Excessive Suspended & Bedded Sediments**	**In-Stream Habitat Modification**	**Altered Riparian Corridor**	**Invasive Species**	**-**	**-**	**-**	**-**	**Threat to Target Rank**
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*High*	*High*	*Medium*	*Medium*	-	-	-	-	
Threat	Recreational Activities								Medium
Contribution	Low	Medium	Low						
Irreversibility	Medium	Medium	Medium						
Threat Rank	Low	Medium	Low	-	-	-	-	-	
Threat	Riverbank & Channel Hardening								Medium
Contribution		Medium	Low						
Irreversibility		Medium	Medium						
Threat Rank	-	Medium	Low	-	-	-	-	-	
Threat	Transportation, Utility, & Service Corridors								Medium
Contribution	Medium	High	Medium						
Irreversibility	Medium	Medium	Medium						
Threat Rank	Medium	Medium	Low	-	-	-	-	-	

Target #8 -- Freshwater Mussels

Threats - Sources of Stress	**Excessive Suspended & Bedded Sediments**	**In-Stream Habitat Modification**	**Altered Riparian Corridor**	**Invasive Species**	**-**	**-**	**-**	**-**	**Threat to Target Rank**
Stresses #..	9	10	11	12	13	14	15	16	
Rank..	*High*	*High*	*Medium*	*Medium*	-	-	-	-	
Threat	Timber Operations								Medium
Contribution	Medium		Medium						
Irreversibility	Medium		Medium						
Threat Rank	Medium	-	Low	-	-	-	-	-	
Threat	Climate Change								Medium
Contribution	Low		Low						
Irreversibility	High		Medium						
Threat Rank	Medium	-	Low	-	-	-	-	-	

APPENDIX F: ALL UNIFIED OBJECTIVES WITH REFERENCES

We compiled and analyzed over 40 federal, regional, state, local, academic, and stakeholder conservation plans, policies, and publications relevant to aquatic resources in the Meramec River Basin[1]. We extracted over 400 goals, objectives, and strategies from the references and sorted them into categories of "Threat Abatement", "Maintaining/Enhancing Target Viability (Reducing Stresses)", and "Other". Once sorted, we developed S.M.A.R.T. objectives which synthesized the various, often overlapping, intent of the original references. The result was 87 unified objectives for conserving aquatic resources in the Meramec River Basin.

Threat Abatement

Note: Percentages are typically used for measurables because targets usually vary in scale/scope per a given objective. Non-percentage (i.e., unit-based) measurables may be defined under a separate, Target-specific objective if known.

Livestock Farming & Ranching

1. *By 2023, reduce existing livestock access to springs, streams, and rivers by X% (from X% currently).*
    a. Livestock exclusion from fens, seeps, wetlands, sedge meadows, and slow moving streams or intermittent stream pools (MDC 2010a).
    b. Grazing is not allowed within 100 feet of springs, significant seeps, fens, other wetland features or the break of a sinkhole basin (MTNF 2005).
    c. Grazing is allowed within the RMZ only under the following conditions: Grazing may continue on existing improved pastures that are under an active permit as of September 2005; Livestock are fenced at least 100 feet away from stream banks; and Grazing on these allotments must be foreclosed at the earliest opportunity (MTNF 2005).
    d. Grazing shall not be allowed to degrade the RMZ or WPZ, or their functionality (MTNF 2005).
    e. Reduce livestock impacts and achieve desired structure and species composition objectives within the WPZ and RMZ by using tools such as hardened crossings, fencing, and controlled timing, duration, and intensity of grazing (MTNF 2005).
    f. Place livestock distribution tools such as feeding troughs, water troughs, salt and mineral blocks outside the RMZ, unless there is no other feasible alternative. Where there are no other feasible alternatives, place livestock distribution tools so as to minimize use with the RMZ, unless needed to meet specific restoration objectives or desired conditions (MTNF 2005).
    g. Place livestock distribution tools to minimize use within the WPZ, unless needed to meet specific restoration objectives or desired conditions (MTNF 2005).
    h. Haying is allowed within the RMZ and WPZ only if it meets the management area direction and contributes toward meeting the desired condition (MTNF 2005).
2. *By 2023 reduce by X% (from X% in a given catchment/watershed/sub-basin) the farmland stream sites exceeding X ppm nitrate concentration.*
    a. By 2022 reduce to 40% (from 48% nationally) the farmland stream sites in the Southeast exceeding 2 ppm nitrate concentration (SARP 2008).
3. *By 2023 reduce by X% (from X% in a given catchment/watershed/sub-basin) the farmland stream sites exceeding X ppm phosphorus concentration.*
    a. By 2022 reduce to 65% (from 73%) the farmland stream sites in the Southeast exceeding 0.1 ppm phosphorus concentration (SARP 2008).
4. *By 2023 reduce by X% (from X% in a given catchment/watershed/sub-basin) the farmland stream sites with at least one pesticide exceeding aquatic life guidelines.*
    a. By 2022 reduce to 75% (from 83%) the farmland stream sites in the Southeast with at least one pesticide exceeding aquatic life guidelines (SARP 2008).
    b. Minimize the use of aquatic-grade pesticides using hand- and single plant application in the RMZ, WPZ, and within 100 feet of sinkholes, springs, and wetlands (MTNF 2005).

[1] Recommendations from the Deer Creek Watershed Management Plan (DCWA 2011), a stream that flows through urbanized St. Louis (River De Peres/Mississippi River Drainage), were included because of their proximity and relevancy to Meramec River targets.

Other related objectives/strategies

- Nutrient and pest management on adjacent agricultural fields that results in reduced opportunities for runoff (MDC 2010a).
- Fertilization shall not be allowed within RMZ, WPZ, on glades or other natural communities (MTNF 2005).
- Disruption of (or not repairing) agricultural drain systems (wetland/floodplain/riparian) (NRDAR 2013).

Dams & Water Managements

5. *By 2023 reduce the rate of new dam construction to X% (from X% in a given catchment/watershed/sub-basin) and ensure minimal degradation of key ecological attributes.*
    a. Dams and other impoundment structures that alter water depth and turbidity and promote siltation should be avoided in rivers that contain habitat for the sensitive biota (MDC 2000b), (MDC 2000c), (MDC 2000e), (MDC 2000f), (MDC 2000g), (MDC 2000h), (MDC 2000d), (MDC 2000a).
    b. Prohibit new constructed impoundments, mine tailing ponds, and water diversions within the RMZ (MTNF 2005).
    c. Provide technical assistance to landowners on pond placement, design, construction, and management to minimize watershed impacts (FLBC 2008).
    d. Evaluate the impact of existing and future dam design (BCWP 2008).
6. *By 2023 remove X % of dams (from X number in a given catchment/watershed/sub-basin) and restore ecosystem function in target area.*
    a. Limit beaver dams in Grasshopper Hollow for HED recovery (USFWS 2001).

Housing & Urban Areas

7. *By 2023 reduce by X% (from X% in a given catchment/watershed/sub-basin) the urban/suburban stream sites exceeding X ppm nitrate concentration.*
    a. By 2022 reduce to 10% the urban/suburban stream sites in the Southeast exceeding 2 ppm nitrate concentration (SARP 2008).
8. *By 2023 reduce by X% (from X% in a given catchment/watershed/sub-basin) the urban/suburban stream sites exceeding X ppm phosphorus concentration.*
    a. By 2022 reduce to 60% (from 68%) the urban/suburban stream sites in the Southeast exceeding 0.1 ppm phosphorus concentration (SARP 2008).
9. *By 2023, implement X number/% of stormwater management techniques to maintain or restore sites development hydrology for new construction (design and construction focus) or major renovations on public land (see EPA guidelines).*
    a. To demonstrate or recommend effective strategies for water quality protection and improvement and utilize stormwater best management practices on public land (EWG 2012).
    b. Retain stormwater onsite through the following identified green infrastructure efforts (DCWA 2011).
10. *By 2023, implement X number/% of stormwater management techniques (LID/wet weather) for existing facilities on public land (sustainable operations, maintenance, and management focus; see EPA guidelines).*
    a. To demonstrate or recommend effective strategies for water quality protection and improvement and utilize stormwater best management practices on public land (EWG 2012).
11. *By 2023, implement X number/% of stormwater management techniques to maintain or restore sites development hydrology for new construction (design and construction focus) or major renovations on private property (see EPA guidelines).*
12. *By 2023, implement X number/% of stormwater management techniques (LID/wet weather) for existing facilities on private property (sustainable operations, maintenance, and management focus; see EPA guidelines).*
    a. To improve water quality in small tributaries especially by managing stormwater runoff in order to reduce extreme fluctuations in stream flow following storm events and to limit the amount of pollutants being carried by stormwater into the stream (EWG 2012).
    b. Implementation of permeable pavement and other projects designed to minimize storm water runoff to surface water (Groundwater) (NRDAR 2013).
    c. Improve stormwater management (FLBC 2008).

d. Wetlands Restoration/ Stormwater Storage (EWG 2012).

e. Assess, implement, and maintain private on-site basins to manage channel protection (DCWA 2011).

f. Stormwater Management/ Low Impact (EWG 2012).

g. Minimize runoff impact in the area of sinkholes and losing streams (BCWP 2008).

h. Facilitate sustainable development and re-development as it impacts water quality and water quantity (DCWA 2011).

i. To reduce the flooding and erosion problems during high flow, and increase the volume of water during low flow, in order to maintain a better water quality, support an improved and stabilized stream channel, reduce property loss to residents and reduce costs of road, bridge and infrastructure maintenance to local governments (EWG 2012).

j. Develop and implement a voluntary demonstration green stormwater infrastructure enhancement project (DCWA 2011).

k. Encourage downspout disconnections (DCWA 2011).

l. Reduce identified pollutants and other impairments, including trash, yard waste, and organic debris; pet waste; road salt; illicit discharge; and other urban pollutants (DCWA 2011).

m. Reduce nutrient, septic, and other pollutants in Lower Meramec Basin (TPL 2010).

Other related objectives/strategies

- Improve wastewater treatment (FLBC 2008).
- Reduction of Septic System problems (EWG 2012).
- Control solid waste, litter, and dumping (FLBC 2008).
- Animal/ Organic Waste Management (EWG 2012).
- Increase pervious surfaces and riparian zones (TPL 2010).
- Reduce negative effects of urbanization (MDC 1997).
- Prevent flood damage to infrastructure (STL 2003).

In-Stream Gravel Mining & Reaming

13. *By 2023, reduce the number (total incidents) of in-stream gravel mining projects from by X% (from X number in a given catchment/watershed/sub-basin).*

    a. Limiting the effects of in-stream sand and gravel mining could help reduce substrate instability, bank erosion, sedimentation, pollutant release, and the risk of physical habitat changes to existing mussel beds (Hinck et al. 2012).

    b. Discourage channel alteration and gravel dredging (FLBC 2008).

14. *By 2023, reduce the scope (geographic area) of in-stream gravel mining projects from X% (existing) scope to X% scope in a given catchment/watershed/sub-basin).*

15. *By 2023, reduce the scale (amount mined) of in-stream gravel mining projects from X amount (existing) to X amount per permitted project in a given catchment/watershed/sub-basin).*

    a. Limit in-stream use of heavy equipment to the minimal amount of time necessary for completion of the project (MTNF 2005).

16. *By 2023, restrict all in-stream gravel mining in specific (i.e., sensitive) areas of a given catchment/watershed/sub-basin.*

    a. Avoid gravel and stone dredging in creeks and rivers that contain habitat for the elephant-ear (MDC 2000c), (MDC 2000d), (MDC 2000a).

    b. Channel alterations that limit or eliminate shallow waters and remove cover rocks should be avoided (MDC 2000d).

17. *By 2023, ensure permitting and compliance to Missouri BMPs (MDNR and MDC) of all (or X%) of in-stream gravel mining projects which require permitting (from X number in a given catchment/watershed/sub-basin).*

    a. No work should be allowed below the high bank of the stream from April 1 to August 30 (MDC 2000b), (MDC 2000c), (MDC 2000e), (MDC 2000f), (MDC 2000g), (MDC 2000h), (MDC 2000a).

    b. Minimize in-stream management activities between March 15 to June 15 that could increase sedimentation and adversely affect spawning (MTNF 2005).

c. Whenever possible, conduct in-stream construction activities from August through October and avoid the period between March and June, to avoid disrupting aquatic species during spawning season (MTNF 2005).

Invasive Species

18. *Ensure that no new aquatic invasive species are established in the project area.*

   a. By 2022 reduce the average annual rate of increase for established NAS in states in the FWS Southeast Region to 3% (SARP 2008).

   b. Prevent new invasions and control or reduce existing occurrences of non-native invasive species (MTNF 2005).

19. *By 2023, reduce the distribution of existing aquatic invasive species by X% (from X% currently).*

   a. Control invasive species (FLBC 2008).

   b. All equipment that enters the waterway should be washed and checked for juvenile zebra mussels before entering another body of water. This will help prevent the spread of this exotic European mussel species that can negatively affect native aquatic organisms and mussel species like the ebonyshell (MDC 2000b), (MDC 2000c), (MDC 2000e), (MDC 2000f), (MDC 2000g), (MDC 2000h).

   c. Restoration of above habitats with techniques such as restoring hydrology or by controlling invasive species and woody brush invasion (MDC 2010a).

   d. Develop management options to reduce or eliminate the threat of non-native introduced aquatic species (USFWS 2010).

   e. Removal of invasive plant species (wetland/floodplain/riparian) (NRDAR 2013).

   f. Promote invasive species removal and native plant establishment (DCWA 2011).

Mine Tailings & Industrial Effluents

20. *By 2023, reduce to X% the number of stream sites exceeding the EPA aquatic life criteria for lead and other heavy metal contamination.*

   a. WQ: By 2022 reduce to 45% (from 48% nationwide) the stream sites in the Southeast exceeding at least one standard or guideline for contaminants in sediments affecting aquatic life (SARP 2008).

   b. Objective 1.1: Reduce or eliminate the threat of mine waste contamination of Big River basin streams (MDC 1997).

   c. WQ: By 2022 reduce to 70% (from 77% nationwide) the stream sites in the Southeast exceeding at least one standard or guideline for contaminants or emerging contaminants in water affecting aquatic life (SARP 2008).

21. *By 2023, reduce to X% the number of groundwater sites exceeding the EPA aquatic life criteria for lead and other heavy metal contamination.*

   a. Removal and disposal of contaminated soils and overburden that contribute to injured groundwater (Groundwater) (NRDAR 2013).

   b. Implementation of water treatment structure projects to intercept and treat groundwater discharge to surface water (Groundwater) (NRDAR 2013).

   c. Treatment of contaminated groundwater for beneficial use (Groundwater) (NRDAR 2013).

22. *By 2023, reduce to X% (from X% currently) the occurrence of fish tissue contaminants exceeding the EPA criteria for safe consumption.*

   a. By 2022 reduce the percentage of the Southeast Coast and Gulf Coast estuarine areas rated as being in poor condition with respect to fish tissue contaminants to 4% and 11% (from 5% and 14%), respectively (SARP 2008).

Recreational Activities

23. *By 2023, X% of existing public recreational areas will implement LID, wet-weather green infrastructure, and best practices for on-site erosion and sediment control and stormwater management.*

   a. Avoid development of new recreation facilities and opportunities within the RMZ and WPZ. If necessary, follow MTNF guidelines to control erosion, water quality to minimize impacts (MTNF 2005).

   b. Improve existing public utility/river access areas (URS 2012).

24. *By 2023, 100% of new public recreational areas will implement LID, wet-weather green infrastructure, and best practices for on-site erosion and sediment control and stormwater management.*

a. Expand Recreational Opportunities and Facilities (STL 2003).

b. Improve access to basin streams (MDC 1997).

c. Access sites, bank fishing, and trails will be developed and maintained in sufficient numbers to accommodate public use (MDC 1998).

d. Incorporate conservation practices or natural community restoration in greenways while improving access and connectivity to natural sites (GRG2011).

25. *By 2023, ensure appropriate law enforcement at X% of recreational and river access areas.*

a. Encourage timely police protection (FLBC 2008).

26. *Reduce effects (measure TBD) of incompatible recreational activities (e.g., boating, floating) by X%.*

a. Determine effects of increased boat traffic on aquatic systems of the Meramec River (MDC 2005b).

Riverbank & Channel Hardening

27. *By 2023, remove/replace hardening materials which degrade key ecological attributes of target resources from X% of hardened riverbank sites.*

a. Remove hardening material and restore the original contours of the banks and approaches when practical and as needed (MTNF 2005).

Transportation, Utility, & Service Corridors

28. *By 2023, decommission, stabilize, and restore X% of unneeded roads on public lands.*

a. Decommission unneeded roads (MTNF 2005).

b. All unneeded roads under Forest Service jurisdiction should be decommissioned (MTNF 2005).

29. *By 2023, implement Environmentally Sensitive Road Maintenance Practices and/or state BMPs at X% of dirt and gravel roads which degrade key ecological attributes of target resources.*

a. Provide cleaner, safer roadways (FLBC 2008).

30. *By 2023, implement Environmentally Sensitive Road Maintenance Practices and/or state BMPs at X% of existing low-water/ford crossings.*

31. *By 2023, implement Environmentally Sensitive Road Maintenance Practices and/or state BMPs at 100% of new low-water/ford crossings.*

a. Avoid crossing of streams; where crossing is unavoidable, temporary crossing that does not restrict flow is recommended (MDC 2000d).

b. Consider fords only where permanent roads receive low or intermittent use, and use is restricted to low-flow periods (MTNF 2005).

c. A stream crossing must include mitigating measures, which protect the channel from disturbance and the road from storm-flow (MTNF 2005).

d. Locate stream channel crossings within a stable reach and harden if needed (MTNF 2005).

e. Design roads so the runoff does not change natural hydrologic functioning of springs, seeps, fens, sinkholes, and shrub swamps (MTNF 2005).

32. *By 2023, 100% of publically owned culvert and bridge replacements follow techniques and guidelines which do not degrade key ecological attributes of target resources.*

33. *By 2023, reduce to X% (from X number/% currently) of existing utility and service line corridors which degrade key ecological attributes.*

a. Encourage addition of updated communication and internet services and corridors (FLBC 2008).

Other related objectives/strategies

- Temporary roads are prohibited within the RMZ and WPZ except at designated locations (MTNF 2005).
- Minimize stream channel crossings by temporary roads within the RMZ or WPZ (MTNF 2005).
- Whenever possible, avoid temporary road construction within or near collapsed features or losing streams (MTNF 2005).

Timber Operations

34. *By 2018, ensure that 100% of all fire management/suppression activities on public land are implemented using BMPs (e.g., MTNF guidelines) which avoid degrading key ecological attributes of target resources.*
    a. Firelines and water diversion structures must not drain directly into stream channels, sinkholes, or other specialized habitats (MTNF 2005).
    b. Mechanically constructed firelines for prescribed fires and suppression are prohibited within 1) Within 100 feet of sinkhole ponds, springs; 2) the RMZ and WPZ within 50 ft. of the channel unless necessary to protect life, structures, private property, or to maintain public and firefighter safety (MTNF 2005).
    c. Implement adequate erosion control measures (water bars, rolling dips, etc.) on all constructed firelines where necessary to reduce the amount of sediment leaving a given area (MTNF 2005).
    d. When using heavy equipment for suppression activities, cross stream channels at right angles. Stabilize and revegetate the crossing as soon as possible after the fire is controlled (MTNF 2005).
    e. Increase and improve the use of forestry Best Management Practices which protect soil and water resources (MDC 2010b).
35. *By 2023, ensure that X% of all fire management/suppression activities on private land are implemented using BMPs (MTNF guidelines) which avoid degrading key ecological attributes of target resources.*
    a. Appropriate prescribed fire in Grasshopper Hollow for HED recovery (USFWS 2001).
36. *By 2018, ensure that 100% of timber management operations on public land follow guidelines which avoid degrading key ecological attributes of target resources.*
    a. Allow timber management activities within the RMZ only to move the area towards the desired condition (MTNF 2005).
    b. Ensure all equipment used for harvesting and hauling operations is serviced outside of the RMZ and WPZ (MTNF 2005).
    c. Remove tops from drainages within the RMZ and WPZ, and avoid concentrations of tops and slash in drainages outside the RMZ and WPZ (MTNF 2005).
    d. Do not use stream channels or drainages as skid trails or temporary logging roads (MTNF 2005).
    e. Skid trails should not drain directly into roads, areas of disturbed mineral soil, sinkholes, fens, springs, or watercourses (MTNF 2005).
    f. Locate log landings outside of the WPZ and RMZ (MTNF 2005).
    g. Avoid drilling, drill pad construction, and structures within the WPZ when possible (MTNF 2005).
    h. Drilling, drill pad construction, and structures are prohibited within the RMZ (MTNF 2005).
    i. Design and implement all ground-disturbing activities to prevent or minimize soil dislocation, compaction, rapid runoff, disruption of water movement, and distribution or loss of water and soil quality (MTNF 2005).
37. *By 2018, ensure that X% of timber management operations on private land follow guidelines which avoid degrading key ecological attributes of target resources.*

Threat Abatement: General/Over-Arching

- Encourage high quality public, semi-public, and private infrastructure and services, while maintaining the natural character of the LaBarque Creek Watershed (FLBC 2008).
- Design and construct drainage features so that run-off water is spread, retained, or infiltrated below or beyond drainage features. Install drainage features at appropriate intervals to prevent erosion (MTNF 2005).
- By 2022 reduce to 45% (from 54%) the large river (exceeding 1,000 cfs avg.) sampling sites in the Southeast exceeding 0.1 ppm phosphorous concentration (SARP 2008).
- Stream channels and drainages shall not be used as travel ways for any mechanized equipment (MTNF 2005).

No Specific Existing Threat Abatement Objectives For:

- ***Climate Change; Garbage & Solid Waste; Historical Agricultural & Forestry Practices***

Maintaining/Enhancing Target Viability (Reducing Stresses)

Contamated Sediments

38. *By 2023, stabilize and restore X% (or X acres if total affected acreage is known) of heavy metal contaminated floodplain and wetland areas.*
    a. Removal or stabilization of contaminants from wetlands, floodplains, and riparian corridors where not fully addressed by EPA or other agency (wetland/floodplain/riparian) (NRDAR 2013).
    b. Implementation of source control and water conservation projects (Groundwater) (NRDAR 2013).
    c. Remediate/remove/reduce contaminated sediments directly from the Big River floodplain (URS 2012).
    d. Stabilization of soils that represent residual injury in contaminated floodplains (WQ/Aquatic) (NRDAR 2013).
39. *By 2023, stabilize and restore X% (or X acres/feet/miles if total affected acres/feet/miles is known) of heavy metal contaminated riparian areas/streambanks.*
    a. Restoration of mine drainage seeps or mine waste adjacent to waterways (WQ/Aquatic) (NRDAR 2013).
    b. Stabilization of contaminated or eroding stream banks (WQ/Aquatic) (NRDAR 2013).
40. *By 2023, stabilize X% (or X feet/miles if total affected feet/miles is known) of in-stream channel reaches with heavy metal contamination.*
    a. Remediate/remove/reduce contaminated sediments directly from the Big River in-stream channel (URS 2012).
41. *By 2023, BMPs are implemented at X% all known sinkholes, cave entrances, and springs which are susceptible to heavy metal contamination.*
    a. Prevent sinkhole and groundwater contamination (DCWA 2011).
    b. Prohibit surface-disturbing mineral activities within 100 feet of the edge of a cave entrance, spring, seep, fen, sinkhole, or shrub swamp (MTNF 2005).
    c. Closure of voids that allow contamination to enter groundwater directly (Groundwater) (NRDAR 2013).
42. *By 2023, X% (or X acres if total acreage is known) of priority floodplain and wetland areas are permanently protected via land protection actions (e.g., purchases, easements).*
43. *By 2023, X% (or X acres if total acreage is known) of priority riparian areas are permanently protected via land protection actions (e.g., purchases, easements).*
    a. Land protection/mitigation in vicinity of contaminated river reaches in the Big River (URS 2012).
44. *By 2023, X% (or X acres if total acreage is known) of priority groundwater recharge areas are permanently protected via land protection (e.g., purchases, easements) and/or establishment of protection zones.*
    a. Protection of recharge areas/establishment of groundwater protection zones (Groundwater) (NRDAR 2013).

Other related objectives/strategies

- Surface water protection and enhancement projects that will improve water quality and provide habitat for biological resources (WQ/Aquatic) (NRDAR 2013).
- Groundwater protection and enhancement projects that will improve groundwater quality for drinking water and provide habitat for biological resources (Groundwater) (NRDAR 2013).
- Other projects that serve to reestablish natural characteristics that have been eliminated would be utilized, as appropriate (Groundwater) (NRDAR 2013).

Excessive Suspended & Bedded Sediments

45. *By 2023, reduce the number of stream miles impaired by excessive suspended and bedded sediments by X unit/% (from X unit/% currently).*
    a. Reduce the number of stream miles impaired by excess sediment (SARP 2008).
46. *By 2023, stabilize/restore X unit/% (from X unit/%) of unstable/eroding streambanks in the target area.*
    a. Stabilize ten miles or more of stream reaches (MTNF 2005).
    b. Reduce the risk of stream bank erosion, sedimentation, and flooding from a one year or greater storm event (DCWA 2011).
    c. Decrease sedimentation and provide bank stabilization and improved riparian buffers for hellbenders (per MDC 2000d).

47. By 2023, stabilize/restore X unit/% (from X unit/%) of roads which contribute to excessive suspended and bedded sediments in the target area.

Other related objectives/strategies

- Reduce sediment inputs through BMPs to the Big River (URS 2012).
- Erosion and sediment controls should be strictly implemented, monitored and maintained for the duration of the project (MDC 2000d), (MDC 2000a).
- Practices that control erosion and prevent the delivery of sediment to the aquatic system will prove beneficial to this species (MDC 2010a).

Altered Riparian Corridor

48. By 2023, increase non-urban/non-agricultural riparian corridor habitats (e.g., forested) to X% (from X% currently) within 100 feet of rivers and streams throughout the Meramec River Basin.

a. By 2022, ensure that adequate non-urban/non-agricultural riparian buffer habitats exist on at least 85% (from 77% nationally; i.e., 23% of the lands within 100 feet of the waters' edge along streams nationwide were either farmlands or urban development in the early 1990s) of the lands within 100 feet of rivers and streams in the Southeast by 2022 (SARP 2008).

b. Reforest 50–100-foot buffer areas and limit livestock watering areas along streams to improve aquatic habitat for mussels (Hinck et al. 2012).

c. Establishment or protection of injured riparian corridors with native species (WQ/Aquatic) (NRDAR 2013).

d. Conserve riparian corridors (land within 100' of streams) (FLBC 2008).

e. Maintain a vegetated riparian buffer of 100 feet along streams and rivers to prevent erosion and excessive siltation (MDC 2000e), (MDC 2000d).

f. Restoring and protecting existing riparian habitats, especially in the headwaters, may help reduce erosion and sedimentation and protect mussel populations in the Meramec River basin (Hinck et al. 2012).

g. Maintain, expand, and restore riparian corridors, enhance watershed management, improve in-stream habitat, and reduce streambank erosion throughout the watershed (MDC 1999).

h. Maintain or improve wooded riparian corridors to protect stream habitat (MDC 2005a)

i. Riparian restoration along losing streams (Groundwater) (NRDAR 2013).

j. Maintain, expand, and restore riparian corridors, enhance watershed management, improve in-stream habitat, and reduce streambank erosion throughout the basin (MDC 1998).

49. By 2023, increase forested riparian corridor habitats of at least 200 feet (or X-feet) from streams and rivers to X% (or X % currently) on public lands managed for conservation.

a. 200 foot-wide stream buffers on each side of permanent "blue line" streams, and 100 foot-wide stream buffers on each side of intermittent "blue line" streams are automatically considered Forest Opportunity Area (MDC 2010b).

50. By 2023, stabilize and restore X% (or X units) of degraded riparian corridor habitats on existing public property and facilities.

a. Continue to Implement the Best Management Practices to Restore Riparian Habitat (Hinck et al. 2011).

51. By 2023, stabilize and restore X% (or X units) of degraded riparian corridor habitats on existing private properties.

a. Create and maintain 150 acres of intact riparian corridors/buffers on private land and complete 2228 feet of stream bank stabilization on public land by 2015 (MDC 2013b).

52. By 2023, ensure that BMPs which protect riparian corridor habitats are implemented on 100% of all new construction or major renovations on public property and facilities.

a. When possible, avoid cutting trees that are anchoring the banks of all drainages, including those that are not within the RMZ or WPZ. If these trees must be cut, the stump and root system should be left in place and intact whenever possible (MTNF 2005).

b. Within 25 feet of a WPZ stream channel: Do not cut trees, unless necessary to move the area towards the desired condition or to facilitate designated crossings; and do not operate mechanized equipment, except at designated skid trail locations (MTNF 2005)

c. Maintain a canopy closure of 50-100% on all permanent streams less than 25 feet wide, where possible (MTNF 2005).

d. Establish a buffer zone of 100 feet in radius from the outside edge of springs and locate new trails within these buffer zones at least 100 feet from the feature's edge (MTNF 2005).

53. *By 2023, ensure that BMPs which protect riparian corridor habitats are implemented on X% of all new construction or major renovations on private property.*

a. Provide adequate stream buffer zones (or stream riparian corridor) to reduce erosion and sedimentation to enable streams to carry large volumes of water associated with heavy rains without damage to property (DCWA 2011).

Altered Floodplains & Wetlands

54. *By 2023, increase non-urban/non-agricultural floodplain and wetland habitats (e.g., forested) to X% (from X% currently) throughout the Meramec River Basin.*

a. Restore 100 acres of bottomland forest and 2 wetland sites on public land and secure funds to successfully meet all demand for bottomland forest, mesic forest, and wetland restoration projects on private land by 2015 (MDC 2013b).

b. Restore and actively manage at least 25,000 acres of bottomland forests by 2013 to meet multiple objectives—flood control, sediment and nutrient capture, carbon sequestration and more (UMWP 2009).

c. Restoration of floodplain forests (WQ/Aquatic) (NRDAR 2013).

d. Re-establishment of wetland, floodplain, and riparian corridor plants and other native vegetation (wetland/floodplain/riparian) (NRDAR 2013).

55. *By 2023, restore X% (or X units) of degraded floodplains and wetlands in the target area*

a. Decrease altered floodplain (MDC 2005a).

b. Restoration of floodplain forests (wetland/floodplain/riparian) (NRDAR 2013).

c. Ecological enhancement of response activities performed by the EPA or other agency (wetland/floodplain/riparian) (NRDAR 2013).

d. Other projects that serve to reestablish natural characteristics that have been eliminated would be utilized, as appropriate (wetland/floodplain/riparian) (NRDAR 2013).

e. Wetland, floodplain, and riparian corridor reestablishment and enhancement projects that will improve water quality and provide habitat for biological resources (NRDAR 2013).

f. Protect floodplains (FLBC 2008).

g. Identify willing landowners located in the floodplain for voluntary purchase/sale and permanent removal from development (DCWA 2011).

h. Protect and improve 900 acres of wetlands (MTNF 2005).

i. Restore 100 acres of bottomland forest and 2 wetland sites on public land and secure funds to successfully meet all demand for bottomland forest, mesic forest, and wetland restoration projects on private land by 2015 (MDC 2013b).

j. Restore and actively manage at least 25,000 acres of bottomland forests by 2013 to meet multiple objectives—flood control, sediment and nutrient capture, carbon sequestration and more (UMWP 2009).

k. Riparian Forests and Wetlands: Maintain existing riparian forests and wetlands, and re-forest priority riparian areas and wetlands which have been converted from forest to non-forest use (MDC 2010b).

l. Protect and restore the limited wetland habitat within the Meramec River watershed, particularly palustrine wetlands that function as fish nursery areas and areas containing significant clusters of palustrine wetlands (MDC 1998).

56. *By 2023, reduce the annual rate of floodplain and wetland alteration/conversion in the target area to X% (from X% currently).*

a. By 2022, reduce the number of acres of altered freshwater wetlands drained or converted through development annually in the Southeast by 30% (SARP 2008).

See "Contaminated Sediments" for related objectives

In-Stream Habitat Modification

57. *By 2023, stabilize, restore, and enhance in-stream habitat of X% (of X unit/% known or identified) of stream and river reaches with degraded key ecological attributes using techniques which maximize ecological benefit.*

    a. By 2022 improve the physical habitat of reaches in streams and rivers containing structural improvements in the Southeast (This would not include downstream affected areas.) (SARP 2008).

    b. Improve aquatic habitat to maintain or improve aquatic biodiversity (MDC 1997)

    c. Increase loading in 3 miles or more in a stream or river to 100 to 300 pieces of large woody material (LWM) per stream mile (MTNF 2005).

    d. Design aquatic habitat enhancement structures using natural appearing materials and placement to mimic the appearance and function of natural habitat features (MTNF 2005).

    e. Habitat enhancement in degraded reaches to improve hellbender viability (per MDC 2000d).

    f. Provide for sufficient shade and large woody material recruitment to meet WPZ objectives when developing silvicultural prescriptions (i.e., keep trees for LWM and stream structures) (MTNF 2005).

Altered Stream Geomorphology

58. *By 2023, restore stream geomorphology of X% (from X% known) of altered stream and river reaches with degraded key ecological attributes) using techniques which maximize stream stability and ecological benefit.*

    a. Natural stream channel design/restoration of channelized streams (WQ/Aquatic) (NRDAR 2013).

    b. Utilize best available technology to improve channel protection and function (DCWA 2011).

    c. By 2022 decrease miles of streams destroyed or converted by permitted construction into unnatural drainage systems annually in the Southeast by 30%.(SARP 2008).

    d. Reduce stream channel instability, soil erosion, and sedimentation as well as maintain and improve riparian corridors (MDC 1997).

    e. Decrease altered stream channel (MDC 2005a).

    f. Maintain and improve the natural stream physical stability and reduce stream widening and bank erosion (DCWA 2011).

    g. Conserve streambanks (FLBC 2008).

    h. Ecological enhancement of response activities performed by the EPA or other agency (WQ/Aquatic) (NRDAR 2013).

59. *By 2023, reduce the annual rate and distribution of stream channel alteration in the target area to X% (from X% currently).*

    a. Prohibit permanent stream channelization on National Forest System lands (MTNF 2005).

    b. Streams within the watershed will meet state standards for water quality (MDC 1999).

    c. Streams within the basin will meet state standards for water quality (MDC 1998).

    d. By 2022 restore at least 10% of impaired segments/areas in the Southeast to non-impaired status per the EPA 303(d) list (SARP 2008).

Altered Connectivity

60. *By 2023, restore up- and downstream access to X miles of streams and rivers by effectively removing barriers to aquatic organism passage in the Meramec River Basin.*

    a. By 2022 restore fish access to 1,000 miles of rivers and streams by effectively removing barriers to fish passage in the Southeast (SARP 2008).

    b. Improve stream crossings (FLBC 2008).

61. *By 2023, replace X% (of X% known) of culverts and bridges which alter up- and downstream connectivity with culverts, bridges, or other structures which provide stability and ecological function and do not degrade key ecological attributes.*

    a. Maintain stable channel configurations, native local substrates, and native vegetation; Carry expected storm flows; and provide passage for aquatic and semi-aquatic organisms (i.e., fish, crayfish, shellfish, salamanders, and turtles) (MTNF 2005).

    b. Design crossings to allow passage of large woody material, bed load and floating debris, when possible. (MTNF 2005).

62. *By 2023, increase/restore floodplain and wetland connectivity to X% (of X units/% known) in stream and river reaches in the Meramec River Basin.*

   a. Re-establishment of interconnections between surface water and injured wetland, floodplains, and riparian corridors (wetland/floodplain/riparian) (NRDAR 2013).

Altered Hydrology

63. *By 2023, increase the percentage of urban/suburban natural area patches 10-100 acres in size in the project area to X% (from X% currently).*

   a. By 2022 increase the percentage of urban/suburban natural area patches 10-100 acres in size in the Southeast to 35% (from 30%).(SARP 2008).

64. *By 2023, reduce water withdrawals from agricultural sources by X%.*

   a. By 2022 reduce freshwater withdrawals from all sources, using withdrawal in 1980 as an index of 1.00, to an index of 0.90 (113.0 bgd) (SARP 2008).

65. *By 2023, reduce water withdrawals from urban/suburban sources by X%.*

66. *By 2023, restore hydrology in X% of areas with altered hydrology which degrade key ecological attributes using techniques which maximize ecological benefit.*

   a. Restore local hydrology by eliminating old drainage ditches or other water diversionary structures when possible if such activities would not result in a loss of habitat (MTNF 2005).

   b. Restore areas with affected hydrology for HED recovery (USFWS 2001).

   c. Design hydrologic control structures to mimic as much as possible the appearance and function of natural habitat features in the RMZ and WPZ (MTNF 2005).

   d. Restoration of above habitats with techniques such as restoring hydrology or by controlling invasive species and woody brush invasion (MDC 2010a).

   e. By 2022, reduce the percentage of rivers in the Southeast that have experienced more than 75% change in high or low flows or more than a 60-day change in timing of flows since the 1940s to 58% (SARP 2008).

Invasive Species

See "Invasive Species" Threats

Maintaining/Enhancing (Reducing Stresses): General/Over-Arching

- Maintain and improve water quality and quantity in watershed related to a one year storm event or less (DCWA 2011).
- Ensure that basin streams meet state water quality standards (MDC 1997).
- Development/ Best Management Practices (EWG 2012).
- Improve water quality (MDC 2005b).
- Sustain or improve water quantity and quality (MDC 2005a).
- Protect and enhance aquatic biodiversity (MDC 2005a).
- Protect and enhance terrestrial biodiversity (MDC 2005a).
- Maintain healthy aquatic community integrity (MDC 2005a).
- Conserve the forested landscape, aquatic resources, numerous natural communities and species of conservation concern (MDC 2005b).
- Protect and restore existing mussel and native fish populations (MDC 2005b).
- Maintain populations of native non-game fishes and aquatic invertebrates at or above present levels throughout the basin (MDC 1998).
- Improve water quality for drinking water, and to protect and restore existing mussel and native fish populations (MDC 2013b).
- To protect and improve the water quality in tributary streams of the Meramec River so that all designated uses are fully supported in the tributaries and the Meramec main stem (EWG 2012).

- Tree Preservation (EWG 2012).
- Protect and maintain the known populations and their associated terrestrial and aquatic habitat (USFWS 2001).
- Carry out cooperative regulatory and voluntary projects using existing programs to protect the species and habitat, restore degraded habitat, and improve surface lands in occupied watersheds (USFWS 2010).
- Implement Missouri BMPs for hellbenders (per MDC 2000d).
- Achieve measurable habitat conservation results through strategic actions of Fish Habitat Partnerships that improve ecological condition, restore natural processes, or prevent the decline of intact and healthy systems leading to better fish habitat conditions and increased fishing opportunities (NFHAP 2012).
- Incorporate best management practices in sustainable design into greenway projects (GRG2011).
- Enhance and maintain natural communities in greenways through design and construction practices (GRG2011).
- Protect natural communities and scenic values (STL 2003).
- Protect WQ (STL 2003).
- Other projects that serve to reestablish natural characteristics that have been eliminated would be utilized, as appropriate (WQ/Aquatic) (NRDAR 2013).
- Ecological enhancement of response activities performed by the EPA or other agency (Groundwater) (NRDAR 2013).

Land Protection Category

- Land Protection (Easements, Purchases, Stream Buffer Ordinances) (EWG 2012).
- Improve permanent watershed land protection by increasing public lands through land purchase, easements, leases and/or other devices from willing landowners (FLBC 2008).
- Permanently conserve watershed integrity through best management practices and permanent land protection tools (easement, acquisition or other special practices) (MDC 2005a).
- Partner with other organizations to conserve environmentally sensitive lands, improve water and air quality and reduce flooding in existing greenways (GRG2011).

No Specific Existing Maintaining/Enhancing (Reducing Stresses) Objectives for:

- ***Organic pollution; Chemical pollution***

Other

Freshwater Mussel Target Objectives

67. *By 2023, ensure no loss of sensitive freshwater mussel species within at all known collection localities.*
    a. Maintain populations of native non-game fishes and aquatic invertebrates at or above present levels throughout the watershed (MDC 1999).
68. *By 2023, sensitive freshwater mussel species increase in population size by X% at all known collection localities.*
    a. Propagation and re-stocking of T&E, game, and non-game aquatic species (WQ/Aquatic) (NRDAR 2013).
69. *By 2023, sensitive freshwater mussel species expand current distribution by X% (versus X known localities) in target areas.*

Other related objectives/strategies

- Propagation and re-stocking of T&E, game, and non-game wetland species (wetland/floodplain/riparian) (NRDAR 2013).
- Propagation and re-stocking of T&E species, and other karst dwelling species (Groundwater) (NRDAR 2013).

Sport Fishery Objectives (Not Included as a Specific Target in the Plan but Related to Potential Conservation Strategies)

70. *By 2023, ensure stable cool-water sport fish (e.g., SMB, rock bass) populations which require no hatchery enhancement in the target area.*

    a. Manage cool-water streams to achieve self-sustaining smallmouth bass, goggle eye, and other naturally reproducing aquatic populations or other populations maintained by releases of hatchery-reared fish (MTNF 2005).

    b. Evaluate, maintain, and where feasible, improve sport fish populations, with primary emphasis on smallmouth bass, largemouth bass, spotted bass and rock bass (MDC 1999).

    c. Evaluate, maintain, and where feasible, improve sport fish populations, with primary emphasis on smallmouth bass, largemouth bass, spotted bass and rock bass (MDC 1999).

    d. Evaluate, maintain, and where feasible, improve sport fish populations, with primary emphasis on smallmouth bass, largemouth bass, brown trout, rainbow trout, and rock bass (MDC 1998).

71. *By 2023, ensure stable warm-water sport fish (e.g., LMB, bluegill) populations which require no hatchery enhancement in the target area*

    a. Manage warm-water streams to achieve a self-sustaining largemouth bass, bluegill, and other naturally reproducing aquatic populations (MTNF 2005).

    b. Improve or maintain sport fish populations (MDC 1997).

Outreach/Education/Stakeholder Engagement

Urban/Suburban

72. *By 2018, develop outreach materials outlining aquatic conservation, stewardship, and BMPs in urban/suburban watersheds and distribute to key (non-conservation) user groups (e.g., industry, politicians). By 2023, develop formal partnerships with at least one user group and implement at least two conservation projects.*

    a. Encourage appropriate maintenance and repair of septic systems (BCWP 2008).

    b. Promote a public stewardship of the River Ring (GRG2011).

    c. Encourage intelligent use of chemical fertilizers, pesticides, herbicides, proper use of detergents and proper ways to handle yard waste (BCWP 2008).

    d. Engage residential property owners in managing stormwater (71% of land is privately owned).

    e. Engage single party residential property owners in managing stormwater (DCWA 2011).

    f. Educate homeowners regarding the importance of reducing homeowner leaf litter entering streams (DCWA 2011).

    g. To educate citizens about non-point source pollution and strategies to reduce runoff, and to inspire individual action to provide solutions on privately owned land both to protect healthy streams and improve degraded streams (EWG 2012).

    h. Engage residents in tree inventory, tree maintenance, and tree planting efforts (DCWA 2011).

    i. Where development occurs, promote designs that conserves watershed natural resources, community character and a sense of place (FLBC 2008).

    j. Engage residents and other stakeholders as partners in conserving the watershed (MDC 2005a).

    k. Identify and involve additional stakeholders (FLBC 2008).

    l. Support involvement of watershed landowners in watershed conservation plan implementation activities (FLBC 2008).

    m. Expand outreach for watershed families and property owners to increase awareness of watershed natural resources and interest in stewardship (FLBC 2008).

    n. Outreach to communities re: watershed conservation (TPL 2010).

    o. Increase community awareness (FLBC 2008).

    p. Encourage area convention and tourism organizations to include greenway facilities in marketing materials (GRG2011).

    q. Develop strategies to assist commercial property owners to engage as responsible watershed stakeholders (DCWA 2011).

Agriculture

73. *By 2018, develop outreach materials outlining aquatic conservation, stewardship, and BMPs in agricultural watersheds and distribute to key (non-conservation) user groups (e.g., farmers). By 2023, develop formal partnerships with at least two user groups and implement at least four conservation projects.*

    a. Build awareness of the Fishes and Farmers Partnership's beliefs, intentions, and capabilities (FFP 2012).

    b. Identify priority farmer/landowner needs (i.e. profitability, fertility) at the local scale, and begin providing technical and organizational assistance to meet those needs (FFP 2012).

    c. Establish one new farmer-led project in each of the five Upper Mississippi River Basin states before the end of 2012 (FFP 2012).

    d. Develop effective communications and reporting strategies to support active conservation projects (FFP 2012).

    e. Identify priority farmer/landowner needs (i.e. profitability, fertility) at the local scale, and begin providing technical and organizational assistance to meet those needs (FFP 2012).

    f. Engage farmers and agricultural institutions in the business of the Fishers and Farmers Partnership (FFP 2012).

74. *By 2018, triple the number (or X%, from X number currently) of farmers and other private land owners with riparian ownership in the Woodlands for Wildlife Partnership (Middle Meramec Conservation Opportunity Area) and implement five conservation projects. By 2023, ensure participation from X% of farmers and other private land owners with riparian ownership in the Woodlands for Wildlife Partnership (Middle Meramec Conservation Opportunity Area) and implement 15 conservation projects.*

    a. Develop a landowner advisory committee by March 1st, 2010, and have at least one landowner workshop and one landowner tour specifically for key landowners each year until 2015 (MDC 2013b).

75. *By 2018, triple the number (or X%, from X number currently) of farmers and other private land owners with riparian ownership in the Lower Bourbeuse River Landowner Partnership (Lower Bourbeuse Conservation Opportunity Area) and implement five conservation projects. By 2023, ensure participation from X% of farmers and other private land owners with riparian ownership in the Lower Bourbeuse River Landowner Partnership (Lower Bourbeuse Conservation Opportunity Area) and implement 15 conservation projects.*

Recreation

76. *By 2018, develop outreach materials outlining aquatic conservation, stewardship and BMPs and distribute to key (non-conservation) recreation user groups (e.g., canoe outfitters, fishing groups). By 2023, develop formal partnerships with at least one user group and implement at least two conservation projects.*

    a. Educate recreational users regarding effects of habitat disturbance (Briggler et al. 2007)

    b. Inform anglers about impacts on hellbenders from releasing bait (disease transmission, habitat and prey competition) (Briggler et al. 2007).

    c. Collaborate in education and outreach activities that promote outdoor participation and appreciation of nature (GRG2011).

    d. Inform the public about the types, amounts and quality of recreation available on Big River and tributary streams (MDC 1997).

    e. Provide stream-oriented activities (MDC 1997).

    f. Increase the general public's awareness of stream recreational opportunities, local stream resources, and good watershed and stream management practices (MDC 1999).

    g. Increase the general public´s awareness of stream recreational opportunities, local stream resources, and good watershed and stream management practices (MDC 1998).

    h. Public outreach and education targeting anglers and public at large re: habitat, predator effects of nonindigenous species, pet trade, etc. for hellbenders (per MDC 2000d).

    i. Broaden the community of support for fish habitat conservation by increasing fishing opportunities, fostering the participation of local communities – especially young people – in conservation activities, and raising public awareness of the role healthy fish habitats play in the quality of life and economic well-being of local communities (NFHAP 2012).

    j. Communicate the conservation outcomes produced collectively by Fish Habitat Partnerships, as well as new opportunities and voluntary approaches for conserving fish habitat, to the public and conservation partners (NFHAP 2012).

Other Related Objectives/Strategies

- Understanding the conservation community – the GCPO geography easily has more than 225 federal, state, university, and non-governmental organizations that have conservation delivery or related missions. The conservation community of the GCPO is complex, with multiple, and overlapping missions, priorities, and governance structures. The GCPO LCC will seek to untangle this web of competing and overlapping institutions, and develop a communications database, platforms and strategies that) effectively communicate our priorities to our partners and stakeholders (GCPO LCC 2013).
- Reaching out to other sectors that affect the landscape - long-term sustainability of resources constitutes common ground for collaboration with community planners, resource-based industries and others. Long-term success will also require outreach to actors on the landscape who may not share conservation goals, but who have the power to influence land use decisions. To effectively target our conservation outreach, we will improve our understanding of how and by whom conservation decisions are made across the landscape and incorporate human dimensions and social sciences into our communications program (GCPO LCC 2013).
- Informing the people of our region - to achieve long-term goals across a huge landscape where private landownership predominates, we will need the acceptance, if not the active support, of the people living there. GCPO LCC communications will include techniques to assess public attitudes and educate key audiences about landscape scale conservation (GCPO LCC 2013).
- Educate the public on the value of healthy stream ecosystems and encourage advocacy on behalf of basin streams (MDC 1997).
- Initiate educational and public outreach actions to heighten awareness of the scaleshell as an endangered species and solicit help with recovery actions (USFWS 2010).
- Develop education and awareness programs for river health (URS 2012).
- Develop stewardship programs for rivers/tribs/floodplain (URS 2012).
- Identify stakeholders within priority watersheds and develop a comprehensive outreach program (Briggler et al. 2007).
- Inspire local landowners and river users to value and protect the hellbender (Briggler et al. 2007).
- Natural Resources and Environmental Stewardship Education (STL 2003).
- Determine existing riparian corridors and educate landowners on the benefit of maintaining and/or establishing riparian corridors (BCWP 2008).
- Riparian landowners should be helped to understand the importance of good stream stewardship and where to obtain technical assistance for sound stream habitat improvement and good watershed management (MDC 1999).
- Riparian landowners on third-order and larger streams will understand the importance of good stream stewardship and where to obtain technical assistance for sound stream habitat improvement and good watershed management (MDC 1998).
- Support greenway/trail development along riparian corridors (DCWA 2011).
- Determine existing riparian corridors and educate landowners on the benefit of maintaining and/or establishing riparian corridors (BCWP 2008).
- Support annual citizen engagement projects in the watershed (DCWA 2011).
- Promote practices that support conservation goals and enhance a sense of place (FLBC 2008).

Outcomes of Specific Conservation Actions

77. *By 2023, X% of land owners (specific?) with +10 acres have conservation management plans.*
    a. For the 292 landowners in the project area who own more than 10 acres, double (to 4.2%) the statewide average who have Forest Management Plans and who have received advice (to 15.4%) from the state forest agency by 2015 (MDC 2013b).

<u>**Socioeconomic**</u>

78. *By 2018, develop and distribute unified "conservation marketing" or other techniques and outreach materials that defines the economic benefits of conservation and are incorporated with future outreach materials.*
    a. Employ "conservation marketing" techniques to understand customer needs and values in order to develop products and services that they need, want, and trust, and which produce a "conservation profit". Teaming with local landowners to create "win/win" programs that meet landowners' needs and values through products and services can help incentivize landowners create and maintain plant and animal communities for future generations to enjoy (MDC 2013b)

b. Expand the economic benefits of conservation (FLBC 2008)

c. Collaborate and partner with public and private entities to implement greenway projects that serve as economic catalysts for increased property values and tax revenues (GRG2011)

d. Partner with economic development organizations and real estate agents to market greenways as a neighborhood and community assets (GRG2011)

e. Enhancement of Quality of Life and Regional Economic Competitiveness (STL 2003)

<u>**Policy & Legislation**</u>

79. *By 2023, establish basin- or statewide policies or statutory laws that ensure that no nonindigenous/invasive aquatic species are established in the Meramec River Basin*

    a. Monitoring and controlling invasive species should be considered when developing strategies to protect mussel diversity and density in the basin (Hinck et al. 2012)

80. *By 2023, establish basin- or statewide policies or statutory laws that reduce the impacts of in-stream, riparian, and/or floodplain construction*

    a. Formulate guidelines for river access construction and bridge placement (Briggler et al. 2007)

    b. Encourage building requirements for stream crossings (bridges) (BCWP 2008)

    c. Prohibit various activities (see plan, pg. 2-3) within the Riparian Management Zone (RMZ) (MTNF 2005)

    d. Prohibit various activities (see plan, pg. 2-4) within the Watercourse Protection Zone (WPZ) (MTNF 2005)

    e. Restrict equipment operation within the WPZ and RMZ to designated crossings or other approved locations (MTNF 2005)

    f. Allow equipment operation within the RMZ only at designated crossings or other approved locations (MTNF 2005)

81. *By 2023, establish basin- or statewide policies or statutory laws that reduce Threats or enhance key ecological attributes of target resources (refine foe a specific threat).*

    a. Seek legislation in each state regarding issues such as collecting hellbenders and dumping bait. Some states in the eastern part of the range have live bait regulation that allow hellbenders to be collected legally. Hellbenders need to be removed from the list for bait collection (Briggler et al. 2007).

    b. Protect Water Quality in Greater Biodiversity Areas as a Matter of Public Policy (Hinck et al. 2011).

    c. Lobby for new environmental laws to improve water quality (Briggler et al. 2007).

    d. Upgrade the protection status of hellbenders and prevent illegal collecting (Briggler et al. 2007).

    e. Federally list the Ozark hellbender and petition for listing the Eastern hellbender as a federally threatened or endangered species (Briggler et al. 2007).

82. *By 2023, ensure that aquatic conservation strategies are required in X% municipal planning, zoning, and ordinances affecting target areas.*

    a. Develop a multifunctional database outlining watershed's high-quality natural communities and sensitive areas which would be accessible to developers and county government for use in site planning (FLBC 2008).

    b. Share information on model set-back ordinances (DCWA 2011).

    c. Incorporate responsible water resource management practices in local planning efforts (TPL 2010).

    d. Support the development of municipal planning and zoning efforts (many objectives under this) (DCWA 2011).

    e. Support the development of municipal planning and zoning efforts that may include a combination of incentives, ordinances, removal of barriers and/or case study implementation (DCWA 2011).

    f. New Development Approaches (EWG 2012).

    g. To provide a framework for planning so that local government officials, along with state and federal agencies and non-governmental organizations can work together to solve non-point source problems in the lower Meramec River watershed (EWG 2012).

83. *By 2023, establish basin- or statewide policies or statutory laws that reduce or eliminate the practice or impacts of in-stream gravel mining and/or reaming*

Acquisition of Project Resources

Funding

84. *By 2018, develop a strategy to support long-term funding mechanisms for conservation in the Meramec River Basin.*

    a. Find private funding sources (MDC 2005a).

    b. By 2013, we have resources available to assist in the restoration and management of bottomland forests (UMWP 2009).

    c. Fundraise for watershed management (TPL 2010).

    d. Investigate funding opportunities (FLBC 2008).

    e. Investigate funding opportunities (FLBC 2008).

    f. Identify and create alternative funding strategies for capital projects and long-term sustainability of greenway infrastructure (GRG2011).

Conservation Practices

85. *By 2018, develop a consensus of conservation approaches (e.g., BMPs, restoration techniques) among all partners (federal, state, local, NGO, academic, stakeholder) for implementing conservation actions and ensuring maximum benefit to target resources.*

    a. Establish a consensus set of national conservation strategies as a framework to guide future actions and investment by the Fish Habitat Partnerships by 2013 (NFHAP 2012).

    b. Encourage environmentally sensitive practices at a site scale (FLBC 2008).

    c. Encourage environmentally sensitive practices at a landscape scale (FLBC 2008).

    d. Consider the balance between adverse and beneficial practices when determining the overall effect of a conservation practice (MDC 2010a).

    e. Encourage land management and conservation practices that maintain watershed integrity (FLBC 2008).

Conservation Planning and Coordination

86. *By 2023, develop a strategy for unifying non-conservation user groups for long-term, sustainable conservation in the Meramec River Basin.*

87. *By 2018, establish a Meramec River Basin Project Coordinator for unifying activities of all conservation partners throughout the basin.*

    a. Develop comprehensive watershed conservation plans and agreements (Briggler et al. 2007).

    b. Coordinate watershed conservation plan implementation (FLBC 2008).

    c. Strengthen partnership and coordination between local, state, and federal agencies, NGO's, and other partners to work together on common water quality and forestry concerns (UMWP 2009).

    d. Use watershed planning in the LaBarque Creek Watershed as a model for watershed planning in Jefferson County and throughout the Meramec Basin (MDC 2005a).

    e. Coordination with Watershed Partnerships and Plans Strategies: Utilize and promote watershed basin partnerships and plans which incorporate tree and forest strategies to benefit water quality and quantity (MDC 2010b).

    f. Form effective permanent work teams (FFP 2012).

    g. Create a Middle Meramec partnership (MDC 2005b).

APPENDIX G: RESEARCH-BASED ACTIONS

We compiled and analyzed over 40 federal, regional, state, local, academic, and stakeholder conservation plans, policies, and publications relevant to aquatic resources in the Meramec River Basin. We extracted over 64 research-based actions (which often overlapped) for conserving aquatic resources in the Meramec River Basin.

Biological

1. Identify suitable reintroduction sites and restore habitat in those areas. (USFWS 2010)
2. Conduct water quality studies to understand effects on Scaleshell mussels. (USFWS 2010)
3. Monitor and assess aquatic populations and communities for biodiversity. (MDC 1997)
4. A survey of the waterways in the project area should be conducted by a trained biologist in order to identify occurring populations of this species.(MDC 2000b), (MDC 2000c), (MDC 2000e), (MDC 2000f), (MDC 2000g), (MDC 2000h)
5. Inventory aquatic invertebrates. (MDC 2005a)
6. Inventory terrestrial natural communities (including invasive and exotic species). (MDC 2005a)
7. If suitable habitat is present, conduct specific biological surveys to determine the presence or absence of threatened, endangered or rare mussel species prior to initiating work. (MTNF 2005)
8. Determine the impact of predator populations on local populations, and, if necessary, implement local predator control measures. (USFWS 2010)
9. Conduct Further Analyses of Historical Mussel Distribution, Land Use, and Water-Quality and Ecotox Data, including fish and fisheries data, to better understand impacts of Threats to mussels (Hinck et al. 2011)
10. Conduct Landscape Scale Modeling to Predict Mussel Distributions, including designated refugia, site-specific WQ criteria, and other anti-degradation policies or designated uses (Hinck et al. 2011)
11. Derive Risk-based Guidance Values for Mussel Protection for ecotoxins (Hinck et al. 2011)
12. Basic research on demographics, behavioral, and population trends and causative factors for hellbenders. (Mayasich et al. 2003)
13. Research and implement captive breeding efforts to reintroduce hellbenders and improve wild population viability. (MDC 2000d)
14. Build a baseline of diseases found in wild hellbender populations. (Briggler et al. 2007)
15. Determine possible impacts of predation by native and non-native fishes and native mammals. (Briggler et al. 2007)
16. Conduct a comprehensive threat analysis incorporating stakeholder involvement/comments, GIS analysis, modeling and, where needed, field measurements. (Briggler et al. 2007)
17. Survey for additional populations and to monitor known populations to detect population trends (USFWS 2001)
18. Develop reintroduction and augmentation and captive husbandry protocols and techniques. (Briggler et al. 2007)
19. Support research into other potential threats related to public use and recreation such as disease in the bait industry, competition/predation from released bait, and effects of noise from recreational vehicles. (Briggler et al. 2007)
20. Collect eggs from Eastern populations of hellbenders for research and from Midwest hellbender populations (Ozark and Eastern Hellbenders) to head-start for release. (Briggler et al. 2007)
21. Produce animals for captive assurance colonies to maintain genetic diversity, for experimental release and reintroduction where appropriate, and for research purposes. (Briggler et al. 2007)
22. Investigate possibility of establishing "semi-natural" outdoor breeding facilities for hellbenders within their range. (Briggler et al. 2007)
23. Conduct various L-H and captive breeding research on hellbenders. (Briggler et al. 2007)
24. Develop a post-mortem/protocol/pathology network. (Briggler et al. 2007)

Habitat-Based

25. Identify and inventory spring, cave and karst features and species. (MDC 2005b)
26. Identify and inventory all glade, woodland and fen communities. (MDC 2005b)

27. Inventory recharge zones and sources of point-source pollution that negatively affect aquatic resources. (MDC 2005b)

28. Monitor and analyze data related to fluvial geomorphology, water quality, terrestrial landscape condition, road crossings, floodplain function, conservation target condition and management, land ownership. (FLBC 2008)

29. Measure and correlate sediment deposition rates to hellbender demographics from a wide range of streams (impacted to pristine). (Briggler et al. 2007)

30. Prepare a Belews Creek Floodplain Study (BCWP 2008)

Hydrology and Water Quality

31. Develop appropriate methods and standards to test water quality and quantity. (MDC 2005a)

32. Use models to determine stormwater and sediment control needs for individual homes and subdivisions (existing and planned). (MDC 2005a)

33. Investigate the effects of septic systems, lagoons, roads and bridges on stream health; develop best management practices. (MDC 2005a)

34. Evaluate stormwater runoff and its effect on the watershed (BCWP 2008)

35. Research hydrology to better understand water quality and quantity needs and protection for HED recovery (USFWS 2001)

36. More studies are needed to determine the extent to which water quality is a limiting factor (for freshwater mussels) (Hinck et al. 2012)

37. Monitor ammonia, copper, zinc, lead, certain pesticides, pharmaceuticals, and personal care products to protect mussels in the Meramec Basin (Hinck et al. 2012)

38. Initiate intensive water quality analysis and monitoring program on all prioritized hellbender streams. (Briggler et al. 2007)

39. Using surrogate species, determine acute and chronic toxicity of heavy metals, organophosphates, ammonia, etc. to various life stages (eggs, larvae, and adults) of hellbenders. (Briggler et al. 2007)

40. Determine the effects of endocrine disrupters on hellbender eggs, larvae, and adults. (Briggler et al. 2007)

41. Support ongoing and new research on the effects of introduced hormones on the health and immune systems of hellbenders in streams. (Briggler et al. 2007)

Monitoring and Management

42. Monitoring landscape change – the GCPO LCC will develop innovative solutions to monitoring landscape changes within the GCPO geography, through improved geospatial processes and methodologies. Landscape change will be monitored on an ongoing and regular basis, to provide partners with the most up to date information possible. (GCPO LCC 2013)

43. Analyze/assess both existing conditions and effectiveness of management measures. (DCWA 2011)

44. Develop a comprehensive, consensus-based, best management practices manual for hellbenders. (Briggler et al. 2007)

45. A voice for monitoring - to promote the feedback loop of adaptive management, which encourages the design of management projects as assumption-based research, the GCPO LCC will advocate and support the need for outcome-based monitoring of on-the-ground project results as well as landscape scale monitoring of changing conditions. (GCPO LCC 2013)

46. Standardize and unify monitoring/research efforts/methods. (Briggler et al. 2007)

47. Develop single- and multiple-project monitoring designs and methods to measure success at both project and basin scales. (FFP 2012)

48. Monitoring capacity – we will lead and facilitate a collaborative monitoring approach, working with our partners to develop explicit landscape monitoring objectives, share monitoring procedures and increase efficiencies among our various organizations working across the landscape. (GCPO LCC 2013)

49. Implement monitoring studies to assess effects of wastewater treatment plants and areas of suspected nonpoint source pollution on mussel beds (Hinck et al. 2011)

50. Increased monitoring and survey of hellbenders. (Mayasich et al. 2003)

51. Standardize survey methodology for conducting meta-population studies and long-term monitoring of life history and population demography, and conduct baseline studies. (Briggler et al. 2007)

Socioeconomic

52. Measure the social, environmental and economic impact of greenway development in the River Ring. (GRG2011)
53. Identify and involve additional stakeholders. (FLBC 2008)
54. Cultural resources – the GCPO LCC will identify and define cultural landscapes within our geography that are historically or culturally significant, and develop appropriate scientific processes to ensure their sustainability in the 21st century. (GCPO LCC 2013)
55. Ecosystem Services – the GCPO LCC will develop appropriate metrics that establish the values people place on ecosystem services provided by healthy natural and cultural landscapes in the GCPO geography. (GCPO LCC 2013)
56. Private lands – the GCPO LCC will develop appropriate means and strategies for achieving conservation by working with private landowners on private lands, focusing on agricultural, forest industry, and nonindustrial forestlands. Initiatives will be strategically designed to provide sustainable and functional systems and landscapes within the GCPO region. (GCPO LCC 2013)
57. Non-conservation sector – the GCPO LCC will work with non-conservation sectors (such as, highway planning departments, community planners, marine shipping and fisheries interests, developers, energy development community) to develop appropriate and targeted conservation delivery strategies to facilitate the development, restoration, and maintenance of functional systems and landscapes within the GCPO geography. (GCPO LCC 2013)
58. Conduct stakeholder surveys. (MDC 2005a)
59. Consolidate existing data from multiple partners. (MDC 2005b)

General/Over-Arching Research

60. Acquire specific additional knowledge of the basin's streams, fish habitats, and agricultural dynamics to support spatial strategies designed effect basin improvements most rapidly. (FFP 2012)
61. Fill gaps in the National Fish Habitat Assessment and its associated database to empower strategic conservation action supported by broadly available scientific information, and integrate socio-economic data in the analysis to improve people's lives in a manner consistent with fish habitat conservation goals. (NFHAP 2012)
62. Natural resources – the GCPO LCC will define the amount, configuration and condition of functional terrestrial, aquatic, subterranean, and marine ecosystems to meet the needs of the full suite of flora and fauna that are representative of and reliant on those ecosystems. (GCPO LCC 2013)
63. Expand and improve watershed modeling efforts. (DCWA 2011)
64. Continue and refine watershed monitoring efforts. (DCWA 2011)

APPENDIX H: ACRONYMS AND GLOSSARY

Appendix H. Acronyms and Glossary

A

B

BMP -– Best Management Practice

C

CAP -– Conservation Action Plan (TNC 2007).

CMP -– Conservation Measures Partnership (CMP 2014).

Condition – A class of Key Ecological Attribute that is a measure of the biological composition, structure, and biotic interactions that characterize the occurrence of a Target (TNC 2007).

Contribution – For ranking a Threat, the expected contribution of a Threat (i.e., the source of stress), acting alone, to the full expression of a given Stress under current circumstances (i.e., given the continuation of the existing management/conservation situation) (TNC 2007).

Critical Threats – Threats that are the most problematic. Most often, Very High and High-rated Threats based on Threat rating criteria of their impact on the focal targets (TNC 2007).

Current Status – In a Viability analysis, an assessment of the current "health" of a target as expressed through the most recent measurement or rating of an indicator for a Key Ecological Attribute of the target (TNC 2007).

D

Desired Future Status – In a Viability analysis, a measurement or rating of an indicator for a Key Ecological Attribute that describes the level of viability/integrity that the project intends to achieve. Generally equivalent to a project goal (TNC 2007).

Direct Threat – See "Threat".

E

F

Focal Conservation Target – See "Target"

G

H

I

Indicator – Measurable entities related to a specific information need (for example, the status of a Key Ecological Attribute, change in a Threat, or progress towards an Objective). A good indicator meets the criteria of being measurable, precise and consistent, sensitive, timely, and technically feasible. Institutionally, the most effective indicators will also be cost-effective, partner-based, and publicly relevant (TNC 2007).

Indirect Threats – In a Situation Analysis, the contributing or underlying factors identified in an analysis of the project situation that are responsible for or the drivers of direct Threats. Often an entry point for conservation actions. For example, "poor logging policies" may be an underlying factor responsible for the Threat "Timber Operations".

Irreversibility – For ranking a Threat, the degree to which the effects of a Threat (i.e., the source of stress) can be restored (TNC 2007).

J

K

KEA – See "Key Ecological Attribute".

Key Ecological Attribute (KEA) – Aspects of a target´s biology or ecology that, if missing or altered, would lead to the loss of that Target over time. As such, KEAs define the target´s viability or integrity. More technically, the most critical components of biological composition, structure, interactions and processes, environmental regimes, and landscape configuration that sustain a target´s viability or ecological integrity over space and time (TNC 2007).

L

Landscape context – A class of Key Ecological Attribute that is an assessment of a Target´s environment, including (1) ecological processes and regimes that maintain the Target's occurrence such as flooding, fire regimes and many other kinds of natural disturbance; and (2) connectivity, such as species Target having access to habitats and resources or the ability to respond to environmental change through dispersal or migration (TNC 2007).

M

MDC -– Missouri Department of Conservation.

MDNR -– Missouri Department of Natural Resources.

MODOT -– Missouri Department of Transportation

N

NGO -– Non-government organization.

NRCS -– U.S. Natural Resources Conservation Service (U.S. Department of Agriculture).

NRDAR -– Natural Resources Damage Assessment and Restoration (U.S. Department of Interior).

O

Objectives – Specific and measurable statements of what you hope to achieve within your project. Objectives follow the S.M.A.R.T criteria of being specific, measurable, achievable, relevant, and time-limited (TNC 2007)

Opportunities – In a Situation Analysis, the contributing factors that potentially have a positive effect on targets, either directly or indirectly, and are often an entry point for conservation actions. For example, "demand for excellent fishing opportunities" may positively affect riverine targets.

Overall Threat Rank – The combined rankings of a single threat across all targets.

Overall Threat Status for the Project – A single rating describing the combination of all 'Overall Threat Ranks" and "Overall Threat Status for Targets"

Overall Threat Status for Each Target) – The combined rankings of all threats for a single target.

P

Project Scope – The place where the biodiversity of interest to the project is located. The project scope of the Meramec River Conservation Action Plan includes all rivers, streams, creeks, and associated riparian and floodplain habitats of the Meramec River Basin, which encompass the range of connected environments used by aquatic species and communities and the threats affecting those ecosystems.

Project Vision – A general summary of the desired state or ultimate condition of the project area or scope that a project is working to achieve. The vision of the Meramec River Conservation Action Plan

Q

R

RM -– River mile.

S

SABs -– Suspended and bedded sediments (USEPA 2003)

Severity – For ranking a Stress, the level of damage to a target by a stress that can reasonably be expected within 10 years under current circumstances (i.e., given the continuation of the existing situation) (TNC 2007).

Scope (Project) – See "**Project Scope**".

Scope (Stress) – For ranking a Stress, most commonly defined spatially as the geographic scope of impact of a stress on a target at the site that can reasonably be expected within 10 years under current circumstances (i.e., given the continuation of the existing situation) (TNC 2007).

Source of Stress – See "Threat"

Size – A class of Key Ecological Attribute that is a measure of the area or abundance of the conservation Target´s occurrence (TNC 2007).

S.M.A.R.T. -– Objectives that are specific, measurable, achievable, relevant, and time-limited (TNC 2007). See "Objectives".

Strategic Action – A broad or general course of action undertaken needed to help reach one or more of the project's objectives.

Stresses – Impaired aspects of Targets that result directly or indirectly from human activities (e.g., low population size, reduced extent of forest system; reduced river flows; increased sedimentation; lowered groundwater table level). Generally equivalent to degraded Key Ecological Attributes (e.g., habitat loss) (TNC 2007).

T

Target – A limited suite of species, ecological communities, or ecological systems that are chosen to represent and encompass the biodiversity found in your project area (TNC 2007). There are eight targets identified in the Meramec River Conservation Action Plan, including the Lower Meramec River Drainage, Middle Meramec River Drainage, Upper Meramec River Drainage, Bourbeuse River Drainage, Big River Drainage, Huzzah Creek and Courtois Creek River Drainage, LaBarque Creek River Drainage, and Freshwater Mussels.

Threat – The proximate activities or processes that directly have caused, are causing, or may cause a Stress(es) and thus the impairment, degradation, and/or destruction of Targets (e.g., logging). Also known as the "Source of Stress" or "Direct Threat". Also see "Critical Threats" (TNC2007).

TNC -– The Nature Conservancy

U

USEPA -– U.S. Environmental Protection Agency

USGS -– U.S. Geological Survey

USFS -– U.S. Forest Service

USFWS -– U.S. Fish and Wildlife Service

V

Viability – The status or "health" of a population of a conservation target. Viability indicates the ability of a focal conservation target to withstand or recover from most natural or anthropogenic disturbances and persist sustainably or over long time periods (TNC 2007).

Viability Analysis – An assessment of a Target to determine how to measure its "health" over time, including how to identify how the Target is doing currently and what a "healthy state" might look like in the future (TNC 2007).

Vision – See "**Project Vision**"

W

X

Y

Z