U.S. Fish and Wildlife Service

Recovery Implementation Strategy for the Missouri Distinct Population Segment of the Eastern Hellbender

(*Cryptobranchus alleganiensis alleganiensis*)

August 2024

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Prepared by the
Eastern Hellbender Missouri DPS Recovery Planning Team

for

Region 3
U.S. Fish and Wildlife Service
Bloomington, Minnesota

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EASTERN HELLBENDER MISSOURI DPS RECOVERY PLANNING TEAM

Trisha L. Crabill, Team Co-leader
Missouri Ecological Services Field Office
U.S. Fish and Wildlife Service
Columbia, Missouri

Dr. Jeffrey Briggler, Team Co-leader
Missouri Department of Conservation
Jefferson City, Missouri

Lauren Augustine[1]
Saint Louis Zoo
Saint Louis, Missouri

Theresa Davidson
Mark Twain National Forest
U.S. Department of Agriculture, Forest Service
Rolla, Missouri

Kenton Lohraff
Fort Leonard Wood
U.S. Army
Fort Leonard Wood, Missouri

Dr. Alicia Mathis
Missouri State University
Springfield, Missouri

Nate Muenks[2]
Mark Twain National Forest
U.S. Department of Agriculture, Forest Service
Rolla, Missouri

Mark D. Wanner[3]
Saint Louis Zoo
Saint Louis, Missouri

[1] Currently affiliation is the Philadelphia Zoo in Philadelphia, Pennsylvania.
[2] Currently affiliation is the Missouri Department of Conservation in Jefferson City, Missouri.
[3] Currently affiliation is the Chicago Zoological Society/Brookfield Zoo in Brookfield, Illinois.

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Actions and activities identified in this Recovery Implementation Strategy are based largely on the Hellbender Conservation Strategy: an Action Plan for the Recovery of the Ozark and Eastern Hellbender in the Ozark Highlands of Missouri and Arkansas (Briggler et al. 2010). The strategy was developed by the Ozark Hellbender Working Group, a collaborative partnership among individuals from State and Federal agencies, academia, zoos, nonprofit organizations, and other individuals interested in the conservation of the species. The Service gratefully acknowledges the members of the Ozark Hellbender Working Group for their commitment and efforts, which have played a significant role in identifying information needs and guiding conservation efforts for eastern hellbenders in Missouri. Because much of this recovery implementation strategy is based on that of the Ozark hellbender (USFWS 2021a), we also sincerely appreciate contributions of the Ozark Hellbender Recovery Planning Team.

DISCLAIMER

Recovery implementation strategies (RIS) are guiding and planning documents only, and identification of potential partners to implement recovery activities does not create legal obligations beyond existing legal requirements. Nothing in this RIS should be construed as a commitment or requirement that any Federal agency obligate or pay funds in any one fiscal year in excess of appropriations made by Congress for that fiscal year in contravention of the Anti-Deficiency Act, 31 U.S.C. 1341, or any other law or regulation.

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An electronic copy of this Recovery Implementation Strategy is available at:

https://ecos.fws.gov

Cover image courtesy Jeffrey Briggler, Missouri Department of Conservation.

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INTRODUCTION

This Recovery Implementation Strategy (RIS) specifies the activities necessary to fully implement the recovery actions outlined in the Recovery Plan for the Missouri Distinct Population Segment (DPS) of the eastern hellbender (*Cryptobranchus alleganiensis alleganiensis*) (USFWS 2024). This RIS also outlines the partners who might perform the activities and the estimated cost and schedule for implementation. This RIS will be updated as necessary to reflect changes to activities and new information, thereby maximizing implementation adaptability and flexibility.

An assessment of the biology and life history of the eastern hellbender is available in the Species Status Assessment for the Eastern Hellbender (*Cryptobranchus alleganiensis alleganiensis*) (USFWS 2018). The status and threats of the Missouri DPS are summarized in the Recovery Outline for the Missouri Distinct Population Segment of the Eastern Hellbender (USFWS 2021b). Both documents can be found at https://ecos.fws.gov. This Recovery Implementation Strategy will be updated on a routine basis as necessary.

RECOVERY ACTIONS AND ACTIVITIES NARRATIVE

The recovery actions, as specified in the recovery plan (USFWS 2024), as well as the more detailed activities identified below, are those that, based on the best available science, we believe are necessary to bring about the recovery of eastern hellbender Missouri DPS and ensure its long-term conservation. The actions apply to all three populations that comprise the eastern hellbender Missouri DPS (Niangua River, Gasconade River, and Meramec River populations). Priority 1 actions are based on currently available information that suggests those actions must be taken to prevent extinction or to prevent the DPS from declining irreversibly in the foreseeable future. Priority 2 actions are those that must be taken to prevent a significant decline in population size or habitat quality or some other significant negative impact. Priority 3 actions are all other actions necessary to provide for full recovery of the species. The assignment of priorities does not imply that some recovery actions are of low importance but recognizes that lower priority items may be deferred while higher priority items are being implemented.

The recovery activities are subject to modification as dictated by new information, changes in species status, and completion of other recovery actions and activities. Each recovery activity has been ranked for implementation according to our determination of what is most important for recovery of Missouri populations of the eastern hellbender based on its status, life history, ecology, and threats. Descriptions of each ranking category are provided below.

Tier 1: An activity that is of high importance and/or urgency.

Tier 2: An activity that is of moderate importance and/or urgency.

Tier 3: An activity that is of lower importance and/or urgency.

Because situations change over time, assigned tier numbers must be considered in the context of past and potential future actions at all sites. Assigning tier numbers does not imply that some recovery activities are of low importance; instead, it implies that those activities may be deferred while higher priority recovery activities are being implemented. Therefore, the tier assignments are intended to guide, not to constrain, the allocation of limited conservation resources. In addition, some recovery activities may be assigned tier numbers different than those assigned to the action they detail (e.g., Priority 1 action, Tier 2 activity). This is because implementation of individual activities may be of lower importance and/or urgency than that of implementing the action in its entirety.

The timing and order in which activities are implemented may also be affected by the availability of funding, landowner permission, and the extent of information required to formulate an appropriate management activity to address the threat. Some threats may require specific research in order to inform management activities, whereas others can be addressed based on the current information available (for example, control of unauthorized recreational activities in occupied habitat).

Although this list of activities will likely change during the process of implementing activities, we recommend the following activities as a comprehensive list using all available methods to lead to recovery of the eastern hellbender in Missouri.

1. **Propagate eastern hellbenders in captivity to augment declining, wild populations. (Priority 1)**

   Until the factors contributing to population declines of the eastern hellbender Missouri DPS can be more definitively identified, the establishment of a successful captive breeding program is necessary. Once the causes contributing to the rapid population declines are identified, and the negative impact factors reversed, captive-bred stock may be used to augment populations in suitable habitat. Propagated individuals can also be used for research investigating causes of population declines.

   1-1. Collect eastern hellbender eggs from the wild in Missouri and head-start hatchlings at propagation facilities to augment and/or reestablish wild populations. Artificial boxes may be used to increase the number of nests found. (Tier 1)

1-2. Continue to breed individuals naturally[1] in captivity using indoor and outdoor raceways to augment wild populations using propagated young. This will be accomplished through implementation of the propagation plan (Briggler et al. 2020), developed in accordance with the USFWS controlled propagation policy (65 FR 56916). Captive breeding will involve collecting from and/or rotating brood stock within the Niangua River, Gasconade River[2], and Meramec River populations as needed for the long-term propagation of eastern hellbenders[3]. Rotating brood stock from each river is needed to maintain genetic diversity and to replace senescing individuals or those that have died. (Tier 1)

1-3. Construct outdoor raceways and associated life support systems (equipment that supports survival in captivity). (Tier 2)

1-4. Address health issues in adult captive hellbenders. (Tier 2)

1-5. Develop artificial fertilization and cryopreservation techniques to maintain or increase genetic diversity and for genetic banking. These techniques may include the use of assisted reproduction techniques (hormone injections) to stimulate egg and sperm production. (Tier 3)

2. Monitor populations to assess long-term trends. (Priority 1)

An understanding of the current status of eastern hellbender Missouri DPS populations is needed for conservation efforts to be successful. By estimating population sizes in each occupied river and assessing long-term trends, current threats to populations can be identified, the impacts of threats assessed, and appropriate conservation efforts implemented where they will be most effective. Because various researchers have and will likely continue to contribute to monitoring, these data should be standardized to allow for comparisons over time and among sites. Monitoring can also be used to assess success of augmentations.

2-1. Monitor populations at a frequency that allows assessment of population trends but minimizes impacts to habitat from the surveys (approximately every 10 years). Protocols are implemented to prevent disease transmission and minimize habitat disturbance. Surveys also may include some form of qualitative assessment of habitat. (Tier 2)

[1] Allowing individuals to breed on their own without the use of hormones.
[2] Includes individuals from the Big Piney River.
[3] Rotation of brood stock would be within, not among populations.

2-2. Conduct environmental DNA (eDNA) surveys in the Big River, Huzzah Creek, Courtois Creek, and Osage Fork of the Gasconade River to refine the range of the eastern hellbender in Missouri. (Tier 3)

2-3. Conduct standardized surveys within the Big River, Huzzah Creek, Courtois Creek, and Osage Fork of the Gasconade River at sites with positive eDNA results. (Tier 3)

2-4. Conduct a new Population Viability Analysis (PVA) and/or Population Habitat Viability Analysis (PHVA). A PHVA was conducted in 2006 (Briggler et al. 2007); however, new information is available that would influence the projections. By developing new PHVAs or PVAs, population trends may be assessed and the most influential life stages and threats identified. This activity would include determining some of the parameter inputs, such as population structure, age classes, sex ratios, fecundity, recruitment, survivorship data. (Tier 3)

2-5. Investigate non-invasive techniques to monitor populations. This activity would focus on investigating additional methods to detect individuals that do not involve flipping rocks, such as using dive lights or environmental DNA (eDNA). (Tier 3)

3. Using a watershed approach, protect and improve habitat and water quality, which may include land acquisition, conservation easements, and conservation actions and practices on private and public land. (Priority 1)

The permeable skin of hellbenders makes them particularly sensitive to physical and chemical contaminants in the environment. Sedimentation, nutrient influx, inorganic and organic chemicals, and physical disturbance to the habitat can all negatively affect hellbenders and their health. Reducing or eliminating physical inputs (such as sedimentation) and chemical inputs (such as nutrients, metals, and pharmaceuticals) into rivers and streams is needed to protect and/or improve the water quality (physico-chemical parameters) in waterways containing Missouri populations of the eastern hellbender.

3-1. Conduct a comprehensive threats analysis for each priority watershed (the Niangua River, Gasconade River, Big Piney, and Meramec River watersheds) and identify and prioritize areas experiencing excessive sedimentation and other nutrient/chemical inputs. (Tier 1)

3-2. Reduce or eliminate sediment runoff from the comprehensive network of unpaved public and private roads and stream crossings by creating a more environmentally and economically sustainable road network through education, outreach, and project funding. (Tier 1)

3-3. Reduce or eliminate sediment runoff from other land use activities by using landowner incentive programs, education, and outreach to help implement best management practices. (Tier 1)

3-4. Restore or improve instream habitat and habitat adjacent to streams (riparian areas) using landowner incentive programs to help implement conservation measures or practices such as stabilizing/restoring stream banks, providing alternative water sources for livestock, and maintaining and restoring forested buffer strips along streams within hellbender watersheds. Areas identified in activity 3-1 should be prioritized. (Tier 1)

3-5. Enhance hellbender habitat with natural rock or nest boxes where needed to maintain source populations. (Tier 1)

3-6. Inventory unpaved roads to identify areas of sediment input. (Tier 2)

3-7. Determine other sources of sediment (such as agriculture, silviculture, unforested eroding stream banks) and potential adverse effects to habitat from human activities (such as recreational uses, public access, stream crossings, gravel mining, cattle grazing, riparian habitat conversion, horse trails, and stream bed scour). (Tier 2)

3-8. Acquire fee title or conservation easements on riparian tracts within watersheds from willing landowners, focusing on priority areas. (Tier 2)

3-9. In streams with large amounts of sediment transport, construct sediment traps or basins to intercept sediment and prevent it from moving downstream and degrading hellbender habitat. (Tier 2)

3-10. Reduce sedimentation through other measures, such as streambank and streambed stabilization. (Tier 2)

3-11. Use existing demonstration areas for stream restoration techniques that reduce sedimentation (such as vegetative revetments[1] and natural stream channel design) to increase landowner awareness of conservation opportunities. (Tier 3)

3-12. Utilize watershed alliance groups to promote conservation programs and to contribute to cost-share programs via funding and/or labor. (Tier 3)

[1] Revetments are a passive structure that protects against erosion.

4. Identify, prioritize, and conduct other research to enhance the conservation and recovery of eastern hellbenders in Missouri. (Priority 1)

Many factors have been suggested as contributing to the decline of hellbenders, yet direct causes remain unknown. Continued research is needed to definitively determine factors contributing to the declines so that they can be eliminated or ameliorated.

4-1. To determine if predation by non-native species or stocked species is contributing to population declines, conduct an additional study investigating the palatability of larval hellbenders to native and non-native species[1] (such as feeding trials or assessing stomach contents of fish). (Tier 2)

4-2. To determine if predation by non-native species or stocked species is contributing to population declines, evaluate the behavior response of larval eastern hellbenders to native and non-native fish (possibly looking at both eggs/young from trout and non-trout zones). Some work has already been conducted (Gall 2008). While not conclusive, results indicate that larval hellbenders do not recognize non-native fish as predators. If behavioral results indicate that eastern hellbenders are susceptible, then predator recognition should be investigated. (Tier 2)

4-3. To determine if predation by non-native species or stocked species is contributing to population declines, examine survivorship of larval eastern hellbenders exposed to native and non-native predators in artificial environments and, if possible, in the wild. This activity could also include investigating the behavior of larvae to assess predation risks (such as observing nocturnal behavior and substrate studies) or by stomach analyses of the fish. (Tier 2)

4-4. Investigate how instream bed load movement (such as cobble, gravel, sand, silt) and suspended sediment influence hellbender habitat. (Tier 2)

4-5. If instream bed load movement is found to influence hellbender habitat, identify sources leading to exacerbated or unnatural instream bed load movement (such as instream gravel mining and eroding stream banks). (Tier 2)

4-6. Investigate the life history of larval hellbenders to better understand what factor(s) may be causing the limited recruitment observed in the wild. This will involve identifying microhabitat characteristics, developing sampling techniques[2] (if detectability of

[1] Such as rainbow trout, brown trout, walleye, striped bass, and other relevant species.

[2] Such as underwater cameras.

released animals continues to be small), conducting radio telemetry studies to determine movement of juveniles, investigating movement patterns, and determining survivorship, if feasible. (Tier 2)

4-7. Evaluate movement and habitat use of captive-reared hellbenders after release. (Tier 2)

4-8. Collect information on abnormalities in wild hellbenders and assess patterns or trends. (Tier 3)

4-9. Examine sperm viability in wild populations. Although some work has already been conducted (Unger 2003, Crabill and Briggler, unpublished data), additional data are needed from some of the rivers. Evaluating sperm health may also be used to assess reproductive health of released captive-reared individuals. (Tier 3)

4-10. Collect and summarize existing water quality data from prioritized eastern hellbender streams in Missouri (such as those with high abundance) and if deemed necessary, initiate water quality analyses and monitoring programs for all prioritized streams. (Tier 3)

4-11. Compare water quality between streams containing healthier hellbender populations (those with higher abundance and physical health) to less healthy populations. (Tier 3)

4-12. Investigate endocrine disrupters and the presence of other contaminants using hellbender blood, tissue and/or water. (Tier 3)

4-13. Determine acute and chronic toxicity of water quality parameters (such as heavy metals and ammonia) to all eastern hellbender life stages. (Tier 3)

4-14. Collect blood samples from previously marked and examined animals to document changes in blood chemistry over time (such as reproductive hormones and heavy metals). (Tier 3)

4-15. Identify sources of funding to implement recovery activities, using the recovery plan to prioritize activities. (Tier 3)

5. Monitor and address emerging diseases and other stressors that affect the health of individuals. (Priority 2)

The exact effects of amphibian chytrid fungus on individuals remains unknown, but infected individuals of other amphibian species have experienced decreased growth rates and reduced

survivability. Thus, additional research is needed to better understand how to minimize impacts from the disease.

5-1. Determine lethality of amphibian chytrid fungus (*Bd*) to larvae and juveniles to determine if it is contributing to the low recruitment observed in the wild. (Tier 1)

5-2. Test for amphibian chytrid fungus in captive and wild hellbenders. Monitoring is important to assess prevalence of the fungus in wild populations and to manage an outbreak in captivity should one occur. Testing captive-released animals will provide insight on susceptible age classes, infection rates, and if necessary, verify infected individuals are not released into wild populations. (Tier 2)

5-3. Investigate the possibility of immunizing or inoculating hellbenders to amphibian chytrid fungus using dead zoospores. If effective, this could increase the survivorship of released captive-reared individuals. The importance of this activity will be influenced by results of activity 5-1 (determining lethality). However, activity 5-1 need not be completed prior to initiating activity 5-3 because there is already evidence of substantial effects to juveniles from amphibian chytrid fungus. The priority of this activity may be elevated if it is determined that amphibian chytrid fungus is reducing survivorship of young in the wild. (Tier 2)

5-4. Screen and test for other pathogens in captive and wild populations (such as *Ranavirus, Batrachochytrium salamandrivoran*). New pathogens continue to emerge; thus, if new and detrimental pathogens are found, the priority of this activity may be elevated. (Tier 2)

5-5. Investigate the potential transmission of diseases to eastern hellbender populations via hatcheries, bait industry, fish stocking, and other sources and implement appropriate measures to prevent disease transmission. Disinfection techniques for processing eastern hellbenders should be modified as appropriate. (Tier 2)

5-6. Continue to identify and compare bacteria and fungi found in captive and wild individuals, possibly using gene sequencing. Hellbenders propagated in captivity may not harbor beneficial bacteria and fungi occurring on wild hellbenders. Propagated individuals may also be more susceptible to non-beneficial bacteria or fungi if released without prior exposure. (Tier 2)

5-7. Utilize new technology and/or methods as they become available to determine impacts of diseases on hellbenders. (Tier 3)

6. Maintain or enhance protections through policy, regulation, and enforcement (such as preventing illegal collection and minimizing impacts to individuals and their habitats). (Priority 2)

Hellbenders require a number of protections, such as preventing illegal collection and avoiding or minimizing impacts to individuals and their habitat. Many of these protections can be accomplished as part of consultation under section 7 of the Endangered Species Act.

6-1. Avoid, minimize, and/or mitigate construction projects that may have adverse effects on eastern hellbenders in Missouri, such as river access locations, bridge placement and renovations, and weirs. (Tier 1)

6-2. Maintain a network of individuals to watch and report illegal collecting activities (much of the network has already been developed). (Tier 2)

6-3. Continue to refrain from disclosing site-specific locality information in publications or other sources that could facilitate illegal collection or harassment of animals (flipping hellbender rocks can disturb habitat and/or injure animals). (Tier 2)

6-4. To minimize the risk of illegal collection, avoid development of new river accesses near important hellbender sites, such as those with a large number of hellbenders. (Tier 2)

6-5. Avoid construction of new reservoirs or lakes in eastern hellbender streams in Missouri. Construction of new reservoirs or lakes makes hellbender habitat unsuitable in areas inundated with water as well in tail-water zones downstream of the dams (due to extreme temperature fluctuations and lower dissolved oxygen when water is released). The impoundments also affect upstream hellbender habitat by increasing sedimentation during periods of heavy rainwater backs up upstream of the impoundment. (Tier 2)

6-6. For both existing and proposed water withdrawals, consider impacts to hellbender streams and avoid or minimize impacts since withdrawal of ground and surface water can affect the base-flow of streams, particularly in the late summer. (Tier 2)

6-7. When dams are removed, consider impacts to hellbenders and implement conservation measures to minimize or avoid impacts. Potential impacts include release of sediment upstream of dams onto downstream hellbender sites and increased depredation from native and non-native fish that may occur downstream of dams. (Tier 2)

6-8. Consider manipulation of water levels in reservoirs or lakes downstream of hellbender sites. Increased water levels can lower stream flow velocities at upstream sites, resulting in increased sediment deposition over hellbender habitat. (Tier 2).

6-9. Collaborate with fisheries biologists to avoid electro-fishing in core eastern hellbender areas and implement other conservation measures as needed. Conservation measures will be based on results of research. (Tier 2)

6-10. Encourage more stringent enforcement of regulations related to illegal collection (see activity 7-5 for training recommendations). (Tier 3)

6-11. Collect and archive information regarding the demand for hellbenders. (Tier 3)

6-12. If research indicates non-native or stocked fish are contributing to population declines of the eastern hellbender Missouri DPS, implement conservation actions to minimize or prevent impacts. The priority may be elevated if research indicates there is a determinable impact. (Tier 3)

7. Initiate educational and public outreach activities to heighten awareness of the hellbender and solicit help with recovery activities. (Priority 3)

Informing people about the eastern hellbender may spark an interest in conservation efforts such as stream cleanups and enrollment in landowner incentive programs to protect riparian zones. For agency personnel, outreach can provide information on avenues for habitat protection and restoration, requirements for permits, and ways to reduce habitat disturbance during stream-side projects.

7-1. Update fact sheet about the eastern hellbender in Missouri, which includes basic information about the species, recovery efforts, and habitat management guidelines for landowners. (Tier 3)

7-2. Develop partnerships with the Farm Service Agency (FSA) and the Natural Resources Conservation Service (NRCS) to engage landowners through Farm Bill programs to implement practices that will benefit eastern hellbenders in Missouri. (Tier 3)

7-3. Compile all relevant best management practices for hellbenders from existing guidelines and add other specific practices not already identified that will protect riparian habitat, improve water quality, minimize sedimentation, and protect the species during breeding. (Tier 3)

7-4. Develop a strategy for outreach efforts and incentives to improve habitat quality. Implementing range-wide habitat improvements will require a coordinated strategy to inform landowners of benefits of implementing practices and inform agency personnel administering practices. Create positive public relations with landowners by acknowledging those that have contributed to conservation efforts and by providing information on the benefits of conservation practices that contribute to watershed improvement (such as articles in farm, ranching, and rural electric cooperative magazines). (Tier 3)

7-5. Conduct training that benefits the eastern hellbender or its habitat such as grazing workshops, road design and maintenance Best Management Practices (BMPs), and training pertaining to law enforcement (identification of animals, types of suspicious activity, hellbender trafficking and correspondence, and watershed protection). (Tier 3)

IMPLEMENTATION SCHEDULE

The following **Implementation Schedule** outlines recovery activities and their prioritization (**Table 1**). The schedule also provides an estimated timetable and cost of performing activities, as well as potential partners to either fund or carry out activities.

Potential partners are those parties that may have authority, responsibility, or expressed interest to implement a specific recovery activity. The listing of a potential partner in the Implementation Schedule does not require the identified party to implement or procure funding for the activity(s). However, parties willing to participate may benefit by being able to show in their budgets that their funding request is for a recovery action or activity identified in an approved recovery plan or RIS and is, therefore, considered a necessary action for the overall coordinated effort to recover the Missouri DPS of the eastern hellbender. Also, section 7(a)(1) of the Endangered Species Act directs all Federal agencies to utilize their authorities in furtherance of the purposes of the Endangered Species Act by carrying out programs for the conservation of endangered and threatened species. Cost estimates are provided for the first 15 years and detailed for the first 5 years of the recovery period, though full recovery is expected to take 45 years.

The Implementation Schedule will be reviewed periodically and revised as appropriate to reflect knowledge gained, accomplishments met, potential future funding constraints encountered (such as lack of funding, changing management priorities), and consequent refinements to near-term activities and priorities.

Key to Implementation Schedule

Priority 1: An activity that must be taken to prevent extinction or to prevent a species from declining irreversibly.

Priority 2: An activity that must be taken to prevent a significant decline of the species' population/habitat quality, or some other significant negative impact short of extinction.

Priority 3: All other activities necessary to provide for full recovery of the species.

Key to Suggested Partners

DOD	Department of Defense
FERC	Federal Energy Regulatory Commission
FSA	Farm Service Agency
MDC	Missouri Department of Conservation
MoDNR	Missouri Department of Natural Resources
MoDOT	Missouri Department of Transportation
NGO	Non-governmental Organization
NRCS	Natural Resources Conservation Service
OHWG	Ozark Hellbender Working Group
STLZ	Saint Louis Zoo
TNC	The Nature Conservancy
UNIV	University (To Be Determined)
USACE	U.S. Army Corps of Engineers
USDA FS	U.S. Department of Agriculture, U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

We expect that this list will not be static through time and that additional partnering agencies/organizations will be identified as specific recovery activities are implemented.

Table 1. Implementation Schedule with the activity number, description, and duration as well as suggested recovery partners and the cost estimate in thousands of dollars for the first 15 years of implementation. Suggested recovery partners are listed in alphabetical order, and asterisks (*) indicate the primary partner(s) implementing the activity (where applicable).

Activity Number	Activity Description	Tier Number	Duration	Suggested Partners	Estimated Cost of First 15 Years	Comments
1-1.	Collect eggs from the wild in Missouri and head-start at propagation facilities to augment and/or reestablish wild populations using propagated young.	1	Ongoing	MDC STLZ	1,800	Total cost estimate is based on 15 years of augmenting populations to reach carrying capacity. This time may change based on survivorship in the wild.
1-2.	Continue to breed individuals naturally in captivity using indoor and outdoor raceways to augment wild populations using propagated young.	1	Ongoing	MDC STLZ	1,830	Total cost estimate based on 15 years of augmenting populations to reach carrying capacity. This time may change based on survivorship in the wild.
1-3.	Construct outdoor raceways and associated life support systems (equipment that supports survival in captivity).	2	2 yrs	MDC* MTNF STLZ* USFWS	300	
1-4.	Address health issues in adult captive hellbenders.	2	Ongoing	STLZ	75	Costs include a portion of veterinary salary. Total cost estimate is based on 15 years of augmenting populations to reach carrying capacity. This time may change based on survivorship in the wild.

Activity Number	Activity Description	Tier Number	Duration	Suggested Partners	Estimated Cost of First 15 Years	Comments
1-5.	Develop artificial fertilization and cryopreservation techniques.	3	Ongoing	MDC STLZ USFWS	32	Already underway. Total cost estimate is based on 15 years of augmenting populations via artificial fertilization (if applicable) and/or storing genetic samples.
2-1.	Monitor populations at a frequency that allows assessment of population trends but minimizes impacts to habitat from the surveys.	2	Ongoing	DOD MDC* STLZ USDA FS USFWS	465	Standardized surveys on eastern hellbender streams are conducted every 10 years for three consecutive years, followed by 2 years of other misc. monitoring. This monitoring would likely continue beyond 15 years.
2-2.	Conduct eDNA surveys in the Big River, Huzzah Creek, Courtois Creek, and Osage Fork of the Gasconade River.	3	3 yrs	MDC* STLZ USDA FS USFWS*	54	Cost estimate includes supply costs, cost of processing samples, and staff time to collect samples.
2-3.	Conduct standardized surveys within the Big River, Huzzah Creek, Courtois Creek, and Osage Fork of the Gasconade River at sites with positive eDNA results.	3	3 yrs	MDC	18	
2-4.	Conduct Population Viability Analysis (PVA) and/or Population Habitat Viability Analysis (PHVA).	3	1 yr	MDC USFWS*	30	A PVA was developed in 2006, but inputs need to be updated. The PVA should be updated every 7-8 years to evaluate

Activity Number	Activity Description	Tier Number	Duration	Suggested Partners	Estimated Cost of First 15 Years	Comments
						population trajectories given estimates for population sizes and demographic rates.
2-5.	Investigate non-invasive techniques to monitor populations.	3	2 yrs	DOD MDC USDA FS USFWS	100	
3-1.	Conduct a comprehensive threats analysis for each priority watershed (the Niangua River, Gasconade River, and Meramec River watersheds).	1	3 yrs	MDC NGO USFWS	450	
3-2.	Reduce or eliminate sediment runoff from the comprehensive network of unpaved public and private roads and stream crossings by creating a more environmentally and economically sustainable road network through education, outreach, and project funding.	1	Ongoing	FSA MDC NGO NRCS USFWS	300	Costs are a general estimate since they since they will depend on results of activity 3.1. Implementation will likely be ongoing and sporadic because it will depend on landowner opportunities.
3-3.	Reduce or eliminate sediment runoff from other land use activities by using landowner incentive programs, education, and outreach to help implement best management practices.	1	Ongoing	DOD FSA MDC NGO NRCS USDA FS USFWS	3,000	Costs are a general estimate since they since they will depend on results of activity 3-1 and landowner opportunities. Implementation will likely be ongoing.

Activity Number	Activity Description	Tier Number	Duration	Suggested Partners	Estimated Cost of First 15 Years	Comments
3-4.	Restore or improve instream habitat and habitat adjacent to streams (riparian areas).	1	Ongoing	DOD MDC NGO NRCS USDA FS USFWS	2,250	Costs are a general estimate since they will depend on activities 3-6 and 3-7 and landowner opportunities. Implementation will likely be ongoing. This activity could be accomplished using Habitat Restoration Teams[1].
3-5.	Enhance hellbender habitat with natural rock or nest boxes where needed to maintain source populations.	1	Ongoing	DOD MDC* USDA FS USFWS	175	
3-6.	Inventory unpaved roads to identify areas of sediment input.	2	3 yrs	DOD MDC NGO USDA FS USFWS	75	
3-7.	Determine other sources of sediment (such as agriculture, silviculture, unforested eroding stream banks) and potential adverse effects to habitat from human activities (such as recreational uses, public access, stream crossings,	2	3 yrs	DOD MDC NGO NRCS USDA FS USFWS	891	

[1] Habitat Restoration Teams are teams of habitat specialists that treat invasive species, expand prescribed burning fire activity, and diversify native habitats in prioritized regional landscapes within Missouri. The teams represent a partnership among the MDC; Pheasants Forever, Inc.; Quail Forever; and Shaw Nature Reserve.

Activity Number	Activity Description	Tier Number	Duration	Suggested Partners	Estimated Cost of First 15 Years	Comments
	gravel mining, cattle grazing, riparian habitat conversion, horse trails, and stream bed scour).					
3-8.	Acquire fee title or conservation easements on riparian tracts within watersheds from willing landowners, focusing on priority areas identified by activities 3-6 and 3-7.	2	Ongoing	DOD MDC NGO NRCS USDA FS USFWS	15,000	Costs are a general estimate since they will depend on activities 3-6 and 3-7 and landowner opportunities. Implementation will likely be ongoing.
3-9.	Where appropriate, construct sediment traps or basins to prevent sediment from moving downstream and degrading hellbender habitat.	2	3 yr	DOD MDC NGO USDA FS USFWS	600	Cost estimate includes 3 sediment traps.
3-10.	Reduce sedimentation through other measures such as streambank and streambed stabilization.	2	Ongoing	DOD MDC NGO NRCS USDA FS	1,950	Costs are a general estimate since they will depend on landowner opportunities.
3-11.	Use existing demonstration areas for stream restoration techniques (such as vegetative revetments and natural stream channel design) to increase landowner awareness of conservation opportunities.	3	Ongoing	MDC NGO NRCS USDA FS	15	Estimated costs include staff time to outreach to landowners and visit sites.
3-12.	Utilize watershed alliance groups to promote conservation programs and	3	Ongoing	NGO[1] OHWG	0	Costs negligible.

[1] NGOs may include Conservation Opportunity Area (COA) groups. COAs are geographic areas of significant conservation potential throughout the state.

Activity Number	Activity Description	Tier Number	Duration	Suggested Partners	Estimated Cost of First 15 Years	Comments
	to contribute to cost-share programs via funding and/or labor.					
5-1.	Conduct an additional study investigating the palatability of larval hellbenders to native and non-native species (such as feeding trials or assessing stomach contents of fish).	2	2 yrs	MDC* STLZ* UNIV* USDA FS USFWS	40	Some work already done indirectly.
5-2.	Evaluate the behavioral response of larval eastern hellbenders to native and non-native fish.	2	2 yrs	MDC* STLZ* UNIV* USDA FS USFWS	40	Some work already done.
5-3.	Examine survivorship of larval hellbenders exposed to native and non-native predators in artificial environments and if possible, in the wild.	2	2 yrs	MDC* STLZ* UNIV* USDA FS USFWS	20	
5-4.	Investigate how instream bed load movement and suspended sediment influence hellbender habitat.	2	2 yrs	UNIV* USDA FS USFWS USGS*	200	
5-5.	If instream bed load movement is found to influence hellbender habitat, identify sources leading to exacerbated or unnatural instream	2	2 yrs	MDC NGO TNC* USFWS	400	

Activity Number	Activity Description	Tier Number	Duration	Suggested Partners	Estimated Cost of First 15 Years	Comments
	bed load movement (such as instream gravel mining and eroding stream banks).					
5-6.	Investigate the life history of larval hellbenders to better understand what factor(s) may be causing the limited recruitment observed in the wild.	2	2 yrs	MDC STLZ UNIV	200	
5-7.	Evaluate movement and habitat use of captive-reared hellbenders after release.	3	2 yrs	DOD MDC USFWS		
5-8.	Collect information on abnormalities in wild hellbenders and assess patterns or trends.	3	Ongoing	MDC	6	Data collected as part of monitoring surveys (see activity 2-1). Costs include staff time every 10 years to assess trends.
5-9.	Examine sperm viability in wild populations.	3	Ongoing	MDC USFWS	45	Already underway. Health assessments of wild populations will likely be conducted for an additional one year, after which, assessments of released propagated individuals will be assessed.
5-10.	Collect and summarize existing water quality data from prioritized streams and, if deemed necessary, initiate water quality analyses and a	3	3 yrs	STLZ* USFWS	30	Some work already done.

Activity Number	Activity Description	Tier Number	Duration	Suggested Partners	Estimated Cost of First 15 Years	Comments
	monitoring program for all prioritized streams.					
5-11.	Compare water quality between streams containing healthier populations and those containing unhealthy populations.	3	1	MDC STLZ USFWS	10	Some work already done.
5-12.	Investigate endocrine disrupters and the presence of other contaminants, using hellbender blood, tissue and/or water.	3	3 yrs	MDC STLZ UNIV USDA FS USFWS	250	Some work already done.
5-13.	Determine acute and chronic toxicity of water quality parameters (such as heavy metals, and ammonia) to all eastern hellbender life stages.	3	2 yrs	MDC UNIV* USFWS USGS	200	
5-14.	Collect blood samples from previously tagged and examined animals to document changes in blood chemistry over time.	3	Ongoing	MDC* STLZ	75	Some assessments already done.
5-15.	Identify sources of funding to implement recovery activities, using the Recovery Implementation Strategy to prioritize activities.	3	Ongoing	DOD MDC STLZ USDA FS USFWS	2	Costs include staff time.

Activity Number	Activity Description	Tier Number	Duration	Suggested Partners	Estimated Cost of First 15 Years	Comments
5-1.	Determine lethality of *Bd* to larvae and juveniles.	1	2 yrs	MDC* STLZ* UNIV* USFWS	140	
5-2.	Test for amphibian chytrid fungus in captive and wild hellbenders.	2	Ongoing	MDC STLZ	120	
5-3.	Investigate the possibility of immunizing/inoculating hellbenders to *Bd*.	2	2 yrs	MDC* STLZ* UNIV* USFWS	30	
5-4.	Screen and test for other pathogens in captive and wild populations (such as *Ranavirus*, *Bsal*).	2	Ongoing	MDC STLZ	60	
5-5.	Investigate the potential transmission of diseases to hellbender populations, such as from hatcheries, bait industry, and fish stocking, and implement appropriate measures to prevent disease transmission.	2	2 yrs	MDC STLZ USFWS	6	
5-6.	Continue to identify and compare bacteria and fungi found in captive and wild individuals.	2	2 yrs	MDC STLZ UNIV	60	Some work has already been done and more is currently underway.
5-7.	Utilize new technology/methods as they become available to determine impacts of diseases on hellbenders.	3	TBD	MDC STLZ UNIV	90	Costs are a general estimate since the new technology/methods cannot be anticipated.

Activity Number	Activity Description	Tier Number	Duration	Suggested Partners	Estimated Cost of First 15 Years	Comments
						Assessments will likely be conducted every few years.
6-1.	Avoid, minimize, and/or mitigate construction projects that may have adverse effects on eastern hellbenders in Missouri.	1	Ongoing	All Federal Agencies	300	Costs are a general estimate as future projects cannot be anticipated.
6-2.	Maintain a network of individuals to watch and report illegal collecting activities.	3	Ongoing	MDC	15	Costs include staff time. Much of the network has already been developed but will need to be maintained and redeveloped when landowners change.
6-3.	Continue to refrain from disclosing site-specific locality information in publications or other sources that could facilitate illegal collection or harassment of animals.	2	Ongoing	DOD MDC MoDOT USACE USDA FS USFWS	0	Costs are negligible. Any other entity having access to data for research projects or other purposes should refrain from disclosing locality data.
6-4.	To minimize the risk of illegal collection, avoid development of new river accesses near important hellbender sites.	2	Ongoing	MDC MoDOT USACE USDA FS	0	Costs beyond staff time (for coordination and evaluation) are negligible.
6-5.	Avoid construction of new reservoirs or lakes in eastern hellbender streams in Missouri.	2	Ongoing	FERC USACE	3	Costs include staff time to coordinate w/ project proponents. Proposal of new reservoirs/lakes is uncommon and not expected to occur more than once in 15 years.

Activity Number	Activity Description	Tier Number	Duration	Suggested Partners	Estimated Cost of First 15 Years	Comments
6-6.	For both existing and proposed water withdrawals, consider impacts to hellbender streams and avoid or minimize impacts.	2	Ongoing	DOD MDC MoDNR USFWS	6	Costs include staff time to coordinate w/ project proponents. Proposal of new water withdrawals is fairly uncommon and not expected to occur more than twice in 15 years.
6-7.	When dams are removed, consider impacts to hellbenders and implement conservation measures to minimize or avoid impacts.	3	Ongoing	FERC MDC USACE USFWS	600	Costs include staff time for evaluation and coordination and implementation of conservation measures to minimize or avoid impacts. The costs are a general estimate since dam removal will be based on opportunities.
6-8.	Consider manipulation of water levels in reservoirs or lakes upstream or downstream of hellbender sites.	2	Ongoing	FERC MDC USACE USFWS	100	Costs include staff time for considering impacts and costs of implementing conservation measures to minimize or avoid impacts. Costs are general estimates since future projects cannot be anticipated.
6-9.	Collaborate with fisheries biologists to avoid electro-fishing in core eastern hellbender areas.	2	Ongoing	MDC USDA FS USFWS	45	Costs include staff time for coordination and costs of alternative survey techniques, where appropriate.

Activity Number	Activity Description	Tier Number	Duration	Suggested Partners	Estimated Cost of First 15 Years	Comments
6-10.	Encourage more stringent enforcement of regulations related to illegal collection.	3	Ongoing	MDC USFWS	6	Costs include staff time for coordination.
6-11.	Collect and archive information regarding the demand for hellbenders.	3	Ongoing	MDC USFWS	3	Costs include staff time. Implementation will occur opportunistically as information becomes available (estimate includes once every 5 years).
6-12.	If research indicates non-native or stocked fish are contributing to population declines of the eastern hellbender Missouri DPS, implement conservation actions to minimize or prevent impacts.	3	TBD	MDC USDA FS USFWS	150	Costs are general estimates since implementation and costs of the conservation measures will depend on results of activities 4-1, 4-2, and 4-3.
7-1.	Update fact sheet about the eastern hellbender in Missouri,	3	Ongoing	MDC* STLZ USDA FS USFWS	4	Costs include staff time. The fact sheet will likely be updated twice every 15 years.
7-2.	Develop partnerships with the FSA and NRCS to engage landowners through Farm Bill programs to implement practices which will benefit eastern hellbenders in Missouri.	3	Ongoing	MDC USDA FS USFWS	3	Costs include staff time.
7-3.	Compile all relevant best management practices for	3	1 yr	MDC USDA FS	1	Costs include staff time.

Activity Number	Activity Description	Tier Number	Duration	Suggested Partners	Estimated Cost of First 15 Years	Comments
	hellbenders and add other specific practices not already identified that will protect riparian habitat, improve water quality, minimize sedimentation, and protect the species during breeding.					
7-4.	Develop a strategy to outreach efforts and incentives to improve habitat quality.	3	1 yr	MDC NRCS TNC* USDA FS* USFWS*	2	Costs include staff time.
7-5.	Conduct relevant training that benefits the eastern hellbender or its habitat.	3	Ongoing	MDC NGO NRCS USDA FS USFWS	45	Some training already being conducted with law enforcement.

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