Recovery Outline for the Missouri Distinct Population Segment of the Eastern Hellbender

Photo courtesy of Jeffrey Briggler

Common Name: Missouri Distinct Population Segment (DPS) of the eastern hellbender

Scientific Name: *Cryptobranchus alleganiensis alleganiensis*

Species Range: Missouri

Listing status: Endangered

Effective Listing Date: April 8, 2021

Recovery Priority Number: 3

Lead Region: Region 3

Cooperating Regions: NA

Lead Office: Missouri Ecological Services Field Office
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Lead contact: Trisha Crabill (see contact info above for Lead Office)

Purpose of the Recovery Outline

In the interim between listing and recovery plan approval, a recovery outline provides preliminary strategies for conservation that conform to the mandates of the Endangered Species Act (ESA), as amended. It organizes near-term recovery actions, provides a range-wide conservation context for U.S. Fish and Wildlife Service (USFWS) decisions, and sets the stage for recovery planning and stakeholder involvement.

Information Sources and Treatment of Uncertainties

This recovery outline is based on the best available data, including the Hellbender Conservation Strategy (Briggler et al. 2010) and the listing decision (USFWS 2021, 86 FR 13465), and recent information from species experts. Research needed to address information gaps is described in this document. For issues in which there is uncertainty associated with the conservation needs, caution will be exercised until such uncertainty can be resolved.

I. BACKGROUND

A. Life History

Eastern hellbenders are large, strictly aquatic salamanders that can grow up to 74 centimeters cm (cm)(29 inches)(in) long (Fitch 1947, Petranka 1988). Numerous fleshy folds along the sides of the body provide surface area for respiration (Dundee and Dundee 1965, Johnson 2000).

The eastern hellbender is a habitat specialist that is found in perennial, fast-flowing, cool, and highly oxygenated streams (Green 1934, Bishop 1941, Green and Pauley 1987). Eastern hellbender adults are typically found beneath large rocks (Johnson 2000) as well as bedrock crevices (Peterson 1987); while larvae and juveniles hide beneath small stones in gravel beds or under large rocks, similar to those occupied by adults (Nickerson and Mays 1973, Nickerson et al. 2003, Foster 2006).

Hellbenders are long-lived and capable of living 25 to 30 years in the wild (Peterson et al. 1983), and possibly longer (Briggler 2019, pers. comm.). Females reportedly reach sexual maturity in 7 to 8 years and males in approximately 5 years (Taber et al. 1975).

Eastern hellbender breeding generally occurs between late August and early October (Smith 1907, Bishop 1941), and males prepare nests beneath large flat rocks, within bedrock, or beneath submerged logs (Nickerson and Mays 1973). Eastern hellbenders mate via external fertilization, and males guard the fertilized eggs against predation by fish and other eastern hellbenders (Nickerson and Mays 1973). Average size of clutches varies from 138 to 450 eggs per nest (Dundee and Dundee 1965, Peterson et al. 1988), and eggs hatch in approximately 45 to 75 days (Green and Pauley 1987, Petranka 1998).

B. Distribution and Population Status

The historical and the current range of the eastern hellbender in Missouri are the same and include the: Niangua River, Gasconade River, Osage Fork of the Gasconade River, Big Piney River, Meramec River, Huzzah Creek, Courtois Creek, and Big River (Fig. 1). We consider the DPS to consist of 3 populations, with each population defined as all of the occupied rivers within a watershed flowing into the Missouri or Mississippi River (Fig. 1). Thus, the Niangua River population consists of individuals in the Niangua River; the Gasconade River population consists of individuals from the Gasconade River, Osage For of the Gasconade River, and Big Piney River; and the Meramec River population consists of individuals from the Meramec River, Huzzah Creek, Courtois Creek, and Big River (Fig. 1).

Surveys of historical sites indicate that abundance in Missouri eastern hellbender populations has declined by at least 80 percent (Wheeler et al. 2003), and no population is considered stable. In 2006, the total number of eastern hellbender individuals in Missouri in the wild was estimated to be approximately 600 individuals (Briggler et al. 2007). In both 2014 and 2019, the total number of individuals was estimated to be 1,065 (Briggler 2014, pers. comm.; Briggler 2019, pers. comm.). Though the estimated total number of individuals increased from 2006 to 2014, this increase reflects a better understanding of the number of animals likely present, rather than an actual increase in the total number of individuals in the wild (Briggler 2014, pers. comm.) In addition to reduced abundance, it appears that there has been and continues to be a shift in age class structure to older individuals and a reduction in recruitment (Wheeler et al. 2003).

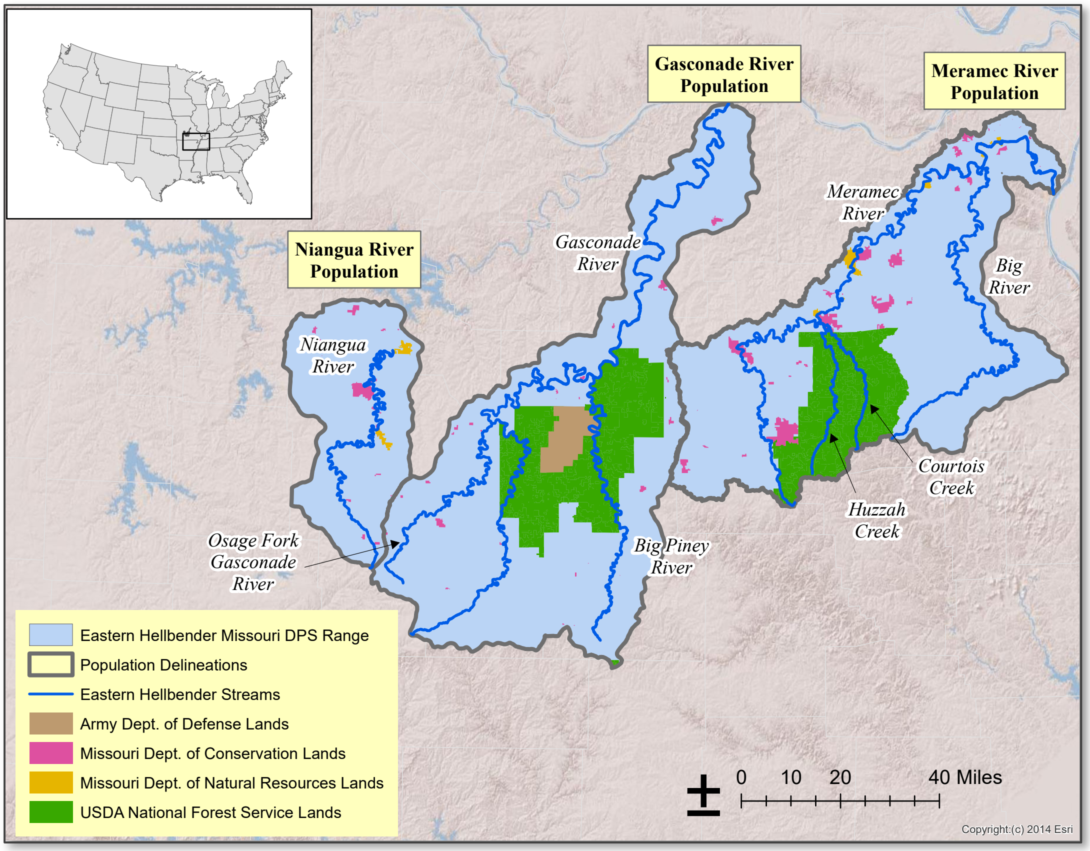

Figure 1. Range-wide distribution of the eastern hellbender in Missouri and surrounding public lands. Rivers in which the eastern hellbender DPS is thought to occur include the Niangua River, Gasconade River, Osage Fork of the Gasconade River, Big Piney River, Meramec River, Huzzah Creek, Courtois Creek, and the Big River.

C. Landownership

Federal – Major Federal lands within the current distribution of the eastern hellbender include the Mark Twain National Forest (U.S.D.A. Forest Service) and Fort Leonard Wood (U.S. Army Department of Defense)(Fig. 1).

State – Major State lands within the current distribution of the eastern hellbender include several Missouri Department of Conservation lands (Barclay, Indian Trail, Lead Mine, Huzzah, Woodson K. Memorial, Pea Ridge, Little Indian Creek, and Meramec conservation areas) and Missouri Department of Natural Resources lands (Meramec, Onondaga Cave, and Bennett Springs state parks)(Fig. 1).

Most of the remaining area within the eastern hellbender's range in Missouri is in private ownership and managed primarily for crop production, livestock operations, or timber harvest.

D. Threats to the Species

The primary threats to the Missouri DPS of the eastern hellbender are habitat loss and degradation from sedimentation and degraded water quality, over collection, disease, and potential predation by non-native fish. Presented below is a brief description of the threats, classified according to the five listing/delisting factors identified in section 4 of the Endangered Species Act ("Act"; 16 USC 1531 et seq.). Additional information, including a description of all potential threats, may be found in the final rule (76 FR 13465).

1) **The present or threatened destruction, modification, or curtailment of its habitat or range (Factor A) -** Habitat degradation from sedimentation and reduced water quality, is caused by multiple factors (human and livestock wastes, agricultural runoff, mine waste, unpaved roads, activities related to timber harvest, riparian forest clearing, etc.) and poses a significant threat to the eastern hellbender in Missouri. Increased siltation can affect eastern hellbenders by potentially suffocating eggs, eliminating suitable habitat for all life stages, reducing dissolved oxygen levels, and reducing prey populations. Increased nitrate levels, along with other contaminants from agricultural runoff and increased urbanization, have been detected in eastern hellbender streams (Petersen et al. 1998) and may be negatively affecting survivorship and/or reproduction. Additional information is needed on the presence of chemical pollutants such as endocrine disruptors and pharmaceuticals and their impacts on eastern hellbenders.

2) **Overutilization for commercial, recreational, scientific, or educational purposes (Factor B) -** Anecdotal reports and published information indicate that eastern hellbenders have been extensively collected for commercial and scientific purposes (Swanson 1948, Dodd 1977, Peterson 1985, Ingersol et al. 1991). Measures to reduce the threat of collection have been implemented by State agencies, but the unauthorized collection of eastern hellbenders for commercial sale in the pet trade continues to be a threat, especially with declining numbers.

3) **Disease or predation (Factor C) -** Chytridiomycosis is a highly infectious amphibian disease caused by the pathogen *Batrachochytrium dendrobatidis* (*Bd*, or amphibian chytrid fungus), and has been demonstrated to infect and kill all life stages of an increasing number of amphibian species worldwide (Berger et al. 1998). With the exception of those rivers in which only small numbers of hellbenders have been captured (Osage Fork of the Gasconade River, Huzzah Creek, Courtois Creek, and Big River), the fungus has been detected in all currently occupied eastern hellbender rivers (Briggler et al. 2008, Bodinof et al. 2011, Briggler 2020, pers. comm.). However, the prevalence is lower than that in Ozark hellbender rivers with only 3-8% of hellbenders testing positive for the fungus (Briggler 2016).

   Non-native trout (e.g., rainbow and brown trout) are stocked in several of the rivers that historically and currently contain eastern hellbenders. Predation of eastern hellbender larvae by non-native trout and other piscivorous fish possibly contributes to the decline of eastern hellbender populations (Gall and Mathis 2010a; Gall and Mathis 2010b). Stocking of predatory fish is an ongoing threat, particularly if stocking numbers increase in eastern hellbender streams.

4) **The inadequacy of existing regulatory mechanisms (Factor D) -** Several factors contributing to degradation of water quality remain outside government regulatory authority. Ongoing gravel mining in eastern hellbender streams is no longer regulated by the U.S. Army Corps of Engineers under section 404 of the Clean Water Act unless there is placement of fill back into the streams; while State agencies only regulate commercial gravel mining and not mining for personal use or for county or municipal governments. Gravel mining can cause stream instability when the scouring process leads to degradation of the streambed or when excessive sediment deposition results in aggradation (the process of building up a streambed grade or level by deposition of sediment). These modifications to the stream channel can alter habitat conditions that provide space, cover, shelter, and sites for breeding, reproduction, and growth of offspring for the eastern hellbender.

   Best Management Practices (BMPs) have been developed for timber harvest activities and address the construction of logging decks, increased use of unpaved roads, improperly designed and maintained roads, skid trails, riparian areas, and fire breaks. BMPs help reduce impacts to aquatic resources from erosion and sedimentation; however, implementation is not mandatory. There are also no laws or regulations that preclude the wholesale removal of riparian forest buffers, livestock from grazing in riparian corridors, or livestock from directly accessing streams and rivers, which increases sedimentation and nitrification of streams.

5) **Other natural or manmade factors affecting its continued existence (Factor E) –** According to global climate models, increased flooding along rivers and streams is predicted to continue in Missouri (NOAA NCEI 2016). If these events result in extreme flooding, they will likely cause substantial disturbance to and mobilization of the substrate, which can directly injure or kill individuals as well as smother habitat. The global climate models also predict a greater intensity of droughts in Missouri (NOAA NCEI 2016), which will decrease groundwater levels and reduce annual stream flows, which could cause mortality to hellbenders from desiccation and reduced fitness and reproduction due to stress, decreased prey availability, and lower dissolved oxygen.

   The small size and isolation of eastern hellbender populations, potential loss of genetic diversity, and reduced recruitment also could exacerbate other factors negatively affecting the subspecies and increase the risk of extinction. Effects from some threats also may interact synergistically to enhance effects from other factors (*e.g.*, compromised health from water quality or increased predation risks from exposure to various pathogens).

E. Past and Current Conservation Efforts

The Ozark Hellbender Working Group (Briggler et al. 2010) was formed in 2001 and is composed of individuals from Federal and State agencies, academia, zoos, nonprofit organizations, and other individuals interested in the conservation of the subspecies. The group has played a significant role in identifying information needs and guiding conservation efforts for both Ozark and eastern hellbenders, which includes the development of a comprehensive conservation strategy (Briggler et al. 2010). Below is a list of conservation measures which have been undertaken to date; for more on these efforts see Appendix A. For a comprehensive list of measures, see the Hellbender Conservation Strategy (Briggler et al. 2010).

- Population monitoring (*ongoing*)
- Captive propagation (*ongoing*)
- Augmenting Habitat (*ongoing*)
- Protecting populations and habitat (*ongoing*)
- Disease Assessment and Treatment (*ongoing*)
- Other Efforts

F. Recovery Priority Number

The eastern hellbender is assigned a recovery priority number of 3 on a scale of 1C (highest) to 18 (lowest; the "C" indicates the potential for conflict with human economic activities). The ranking is based on a high degree of threat, high potential for recovery, and taxonomic status as a subspecies (USFWS 1983a, b).

The magnitude of threat is currently high given continued population declines, spread of amphibian chytrid fungus, potential predation by non-native fish, and reduced recruitment and population size in the wild.

Recovery potential is considered high because most of the potential threats can ultimately be managed or abated. These threats include habitat degradation from sedimentation, degraded water quality; unauthorized collection; and potential predation by non-native predators. A threat that may not be possible to manage is amphibian chytrid fungus because there is currently no known method to control the fungus in the wild. Recovery potential is also considered high because approximately 814 eastern hellbender larvae/juveniles are currently being reared in captivity. These individuals will be used to augment wild populations and investigate potential threats contributing to population declines.

We do not presently anticipate implementation of recovery actions to conflict with construction or other forms of economic activity.

II. INTERIM RECOVERY PROGRAM

A. Interim Recovery Strategy

Abundance in eastern hellbender populations in Missouri have declined over 80 percent since the 1970s (Wheeler et al. 2003). Limited recruitment is observed in wild populations and roughly 1,065 individuals are estimated to remain in the wild (Briggler 2019, pers. comm.). Although extensive work has been done to help conserve the eastern hellbender and better understand potential threats, population declines continue and the exact cause(s) of the declines remains unclear. The captive propagation program, however, is helping to stabilize the populations until threats are more definitively identified and managed.

The interim recovery vision for the eastern hellbender Missouri DPS is to have at least two healthy, resilient populations. Because the Niangua River and Meramec River populations cluster together genetically (Crowhurst et al. 2011), a healthy population is needed in at least one of these watersheds, as well as the Gasconade River watershed to guard against catastrophic events and to preserve adaptive potential. For a population to be healthy and resilient, it would have sufficient recruitment to maintain a sustaining population with size class histograms resembling those from surveys conducted in the 1970s[1]. A healthy population also would have an adequate number and distribution of occupied habitat patches to allow the population to be resilient to stochastic and catastrophic events, to maintain genetic diversity, and to provide for natural re-establishment if a patch is extirpated.

Initial recovery efforts should focus on further investigating potential causes of declines while continuing to stabilize populations using the captive propagation and head-starting program. Long-term recovery efforts should focus on improving water quality, reducing sediment and gravel input, and addressing any other threats found to contribute to declines. Impacts to avoid are those that could 1) result in mortality or injury to eastern hellbenders, 2) reduce reproduction or recruitment of young into populations, 3) increase stress to remaining individuals in the wild, or 4) alter habitat such that survival or reproduction is reduced. Especially critical is the protection of eastern hellbender sites where reproduction is known to still occur or which contain larger numbers of hellbenders.

B. Preliminary Recovery Actions

Below are the primary actions that are anticipated, including ongoing conservation measures identified under Past and Current Conservation Efforts and described in Appendix A.

1) Propagate eastern hellbenders in captivity to augment declining, wild populations.
2) Monitor population status to assess long-term trends.
3) Augment habitat to improve the availability of refugia and nesting habitat.

[1] As reported by Prosen (1999).

4) Protect populations and habitat by reviewing projects that could cause impacts and by refraining from disclosing specific locations of hellbenders to protect against illegal collection. Land protection may also occur through land acquisition, conservation easements, or other such programs, if appropriate.
5) Investigate diseases to minimize or prevent impacts to eastern hellbenders.
6) Investigate potential water quality issues to identify and address areas of concern.
7) Reduce sediment and gravel input into rivers to improve habitat
8) Conduct other research as needed to identify or address population declines.

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Citation

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Appendix A. Conservation Efforts to Date

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There have been a number of conservation efforts aimed at conserving the eastern hellbender (C*ryptobranchus alleganiensis alleganiensis*) in Missouri, including, but not limited to, monitoring the status of populations, establishing a captive propagation program, augmenting habitat, protecting populations and habitat, assessing diseases and effective treatment, and various research efforts. This document lists and summarizes conservation efforts already taken or underway. Additional information on the threats to these species can be found in the final listing rule (USFWS 2020).

Captive Propagation (*ongoing*)

The captive propagation program was initiated in 2001 for Ozark hellbenders. However, eastern hellbenders were not collected from the wild for captive breeding until 2014 when adults were collected from the Meramec River and transferred to the Saint Louis Zoo (Briggler 2020, pers. comm.). Until 2011, breeding attempts with both Ozark and eastern hellbenders were unsuccessful despite the deposition of eggs in multiple years by Ozark hellbender females in the indoor raceway. Though Ozark hellbenders bred in captivity at the Saint Louis Zoo in 2011, eastern hellbenders have yet to breed successfully in captivity. In addition to captive breeding, egg clutches also have been collected from the wild for hatching and head-starting. To date, eggs have been collected from the Niangua, Gasconade, and Big Piney rivers and approximately 1,386 larvae and juveniles have been reared at the Saint Louis Zoo and Shepherd of the Hills Hatchery (MDC) and released back into the wild (Briggler 2020, pers. comm.). An additional 814 larvae and juveniles are currently being reared for release (Briggler 2020, pers. comm.). Head-starting eastern hellbenders from eggs collected from the wild and from captive breeding will help bolster populations by maintaining genetic diversity, significantly increasing survivorship rates of young, and by effectively augmenting more individuals into the population than would have otherwise normally survived. Propagation of eastern hellbenders has been a collaborative effort primarily between the Saint Louis Zoo, MDC, and USDA Mark Twain National Forest.

Population Monitoring (*ongoing*)

The severe decline in eastern hellbender populations was first recognized in the late 1990s (Prosen 1998, Wheeler et al. 2003). Subsequently, the Missouri Department of Conservation (MDC) began conducting regular surveys to monitor populations and assess the overall health of animals. Currently, the MDC surveys each Ozark Hellbender river in Missouri on a 10-year rotation. The survey protocol implemented by the MDC allows for calculating detection rates, estimating population sizes, and projecting population trends. In addition, suitable habitat has been mapped throughout all occupied steams. Involved partners include the MDC, USDA Mark Twain National Forest, DOD Fort Leonard Wood, and USFWS.

Augmenting Nesting and Cover Habitat (*ongoing*)

Artificial nest boxes were developed by Briggler and Ackerson (2012) to provide nesting habitat for hellbenders and to also provide an efficient way to collect eggs for captive rearing. For the same reasons, the nest boxes are also used in the captive breeding program. Though eastern hellbender eggs are not found in the wild in nest boxes as frequently as those of Ozark hellbenders, eastern hellbenders frequently use the nest boxes for cover. To date, 8 nest boxes have been augmented into the Niangua River, 8 have been placed in the Gasconade River, and 8 have been placed into the Big Piney River (Briggler 2019, pers. comm.). Slab rock has also been placed into some eastern hellbenders streams to augment non-nesting habitat.

Protecting Populations and Habitat (*ongoing*)

Prior to the eastern hellbender being federally listed as endangered, many agencies and other project proponents have voluntarily coordinated with the USFWS and MDC to minimize or mitigate for adverse effects to eastern hellbenders from project activities. Best Management Practices (BMPs) were developed by the MDC and include specific recommendations for activities occurring in or near eastern hellbender streams. To protect populations from illegal collection, disclosure of specific locations of eastern hellbender sites is limited, and law enforcement and private landowners monitor sites for suspicious activity. Involved partners include the MDC, USFWS, USDA Mark Twain National Forest, DOD Fort Leonard Wood, and the DOD Army Corps of Engineers.

Disease Assessment and Treatment (*ongoing*)

Recent and ongoing monitoring surveys incorporate sampling protocols for testing of fungal, bacterial, and viral pathogens. Museum specimens have been histologically examined to determine when the amphibian chytrid fungus first occurred in the populations (Bodinof et al. 2011), and methods to treat captive individuals infected with amphibian chytrid fungus also have been explored, with heat treatment methods proving most successful (Junge 2012). Additionally, the bacterial microbiomes hellbenders have been evaluated to determine if captivity induces changes in skin microbiota that could influence reintroduction efforts (Hernández-Gómez et al. 2018a) and if hellbenders have genetic traits that influences their skin microbial communities (Hernández-Gómez et al. 2018b). Involved partners include the MDC, Saint Louis Zoo, and Purdue University.

Other Efforts

While extensive research has also been done elsewhere in the eastern hellbender's range, the following is a list of the numerous efforts that have focused on understanding the causes underlying eastern hellbender declines in Missouri or addressing its potential threats: assessing the sperm quality of wild and captive individuals (Unger et al. 2013; Crabill and Briggler 2016, unpublished data); monitoring survivorship, hematology, and movement patterns of released captive-reared individuals (Huang et al. 2010, Bodinof et al. 2012a, Bodinof et al. 2012b); examining reproductive hormones and heavy metal levels (Huang et al. 2010); adding both Ozark and eastern subspecies of hellbenders to the Appendix III list for the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)(USFWS 2011), preparing outreach materials, developing a Population and Habitat Viability Analysis (Briggler et al. 2007), and multiple genetic studies investigating genetic variability and population structure among rivers (Sabatino and Routman 2009, Crowhurst et al. 2011, Tonione et al. 2011, Feist et al. 2014, Hime 2017). Involved partners include various individuals from Federal and State agencies, academia, zoos, and nonprofit organizations.

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