

**U.S. Fish and Wildlife Service**

**Ozark Hellbender**  
*(Cryptobranchus alleganiensis bishopi)*

**5-Year Review**



Photo credit: Jeffrey Briggler, Missouri Department of Conservation

U.S. Fish and Wildlife Service  
Midwest Region

Missouri Ecological Services Field Office  
Columbia, Missouri

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## 1. INTRODUCTION

The U.S. Fish and Wildlife Service (Service) is required by section 4(c)(2) of the Endangered Species Act (Act) to conduct a status review of each listed species at least once every 5 years. Based on the outcome of the 5-year review, we recommend whether the species should: 1) be removed from the list of endangered and threatened species; 2) be changed in status from endangered to threatened; 3) be changed in status from threatened to endangered; or 4) remain unchanged in its current status. If we recommend a change in listing status based on the results of the 5-year review, a separate rulemaking process must be conducted to implement the recommendation.

We must use the best scientific and commercial information available when we conduct a 5-year review. Therefore, we published a Federal Register notice on April 25, 2019 requesting any new information since the Ozark hellbender's listing (84 FR 17420). Two comments were received following the Federal Register notice, and additional comments were received during an Ozark Hellbender Recovery Planning team meeting on August 19-20, 2019.

This 5-year review was primarily written by the Missouri Ecological Services Field Office with contributions and review by cooperating field and regional offices and members of the Ozark Hellbender Recovery Planning Team.

## 2. BACKGROUND

Scientific and Common Name:	Ozark hellbender ( <i>Cryptobranchus alleganiensis bishopi</i> )
Listing Classification:	Endangered
Listing History:	76 FR 61956; November 7, 2011
Critical Habitat:	None Designated
Other Associated Rules:	Inclusion in Appendix III of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (76 FR 61978; April 3, 2012)
Recovery Planning:	Recovery Outline for the Ozark Hellbender ( <i>Cryptobranchus alleganiensis bishopi</i> )(USFWS 2012)
Recovery Priority number:	3
Lead Agency, Region:	Midwest Region, U.S. Fish & Wildlife Service
Lead Field Office:	Missouri Ecological Services Field Office (Columbia, MO)
Contact Information:	Trisha Crabill; 573-234-5016; Trisha_Crabill@fws.gov
Cooperating Field Offices:	Arkansas Ecological Services Field Office (Conway, AR)
Cooperating Regional Offices:	Southeast Regional Office (Atlanta, GA)

### 3. REVIEW ANALYSIS

In accordance with section 4(c)(2) of the Endangered Species Act of 1973, as amended (Act), the purpose of a 5-year review is to assess each threatened species and endangered species to determine whether its status has changed and it should be classified differently or removed from the Lists of Threatened and Endangered Wildlife and Plants. The Service most recently evaluated the biology and status of the Ozark hellbender when developing a Biological Report to inform the Draft Recovery Plan. The Biological Report was peer-reviewed by members of the Ozark Hellbender Recovery Planning Team in August 2019 and then updated to inform this 5-year review. Please refer to the Biological Report for the Ozark Hellbender (*Cryptobranchus alleganiensis bishopi*)(USFWS 2020) for a complete review of the species' status (including biology, population trends, and habitat), threats, and recovery actions.

### 4. NEW INFORMATION SINCE THE TIME OF LISTING

Below is a summary of the Ozark hellbender's current status and new information since the species was listed.

#### **Species Description and Life History**

Within the last several years, observations of Ozark hellbender larvae in the wild and in captivity have increased our understanding of larval movement and ecology. Observations of larvae under nest rocks in the wild indicate that larvae leave the nest primarily in late winter through early April when many predators are less active and that larvae appear to orient and move upstream (Briggler 2019a, pers. comm.). The timing of when larvae leave the nest may depend on the availability of food resources in the nest, which in turn may be influenced by the size of the nest rock or bedrock cavity (Briggler 2019b, pers. comm.). Larvae also tend to bury into gravel, both under nest rocks in the wild (Briggler 2015, pers. comm.) and in captivity (Wanner 2015, pers. comm.). Staff at the Saint Louis Zoo also have observed captive Ozark hellbender larvae swimming in the water column at night and under low light conditions (Wanner 2015, pers. comm.). Swimming in the water column could facilitate dispersal downstream if the larvae are carried downstream in the current.

#### **Taxonomy**

Results of genetic studies indicate that within the Ozark hellbender, there are a minimum of 3 genetic lineages: 1) North Fork White River/Bryant Creek<sup>1</sup>, 2) Spring River, and 3) Eleven Point River/Current River (Sabatino and Routman 2009, Crowhurst et al. 2011, Tonione et al. 2011). Ozark hellbender populations in the Eleven Point and Current rivers cluster together genetically (Sabatino and Routman 2009, Crowhurst et al. 2011, Tonione et al. 2011). However, populations in these 2 rivers exhibit substantial genetic differentiation and are geographically isolated from each other, thus potentially constituting 2 separate genetic lineages (Crowhurst et al. 2011). In addition, results of Hime et al. (2017) indicate that the

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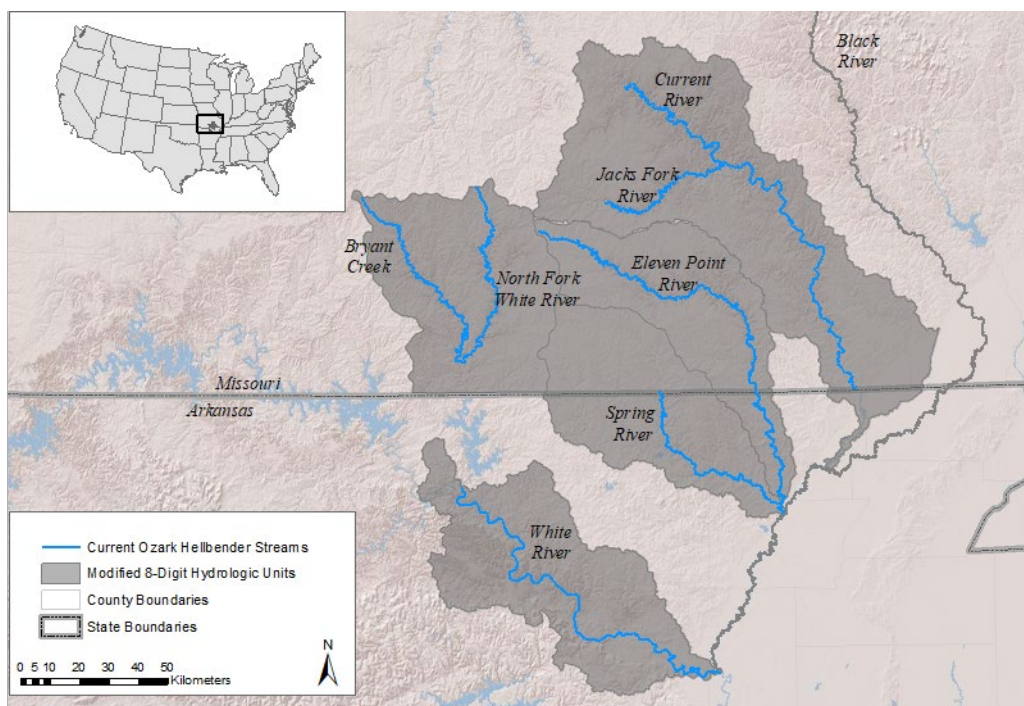
<sup>1</sup> Though no individuals from the White River mainstem were included in the genetics studies, we presume that any hellbenders present within the White River mainstem are genetically similar to those in Bryant Creek and the North Fork White River given the North Fork White River is a tributary of the White River.

Ozark hellbender should be elevated to full species status. However, no proposed changes have been submitted for publication, and the Service will continue to use the nomenclature *C. a. bishopi* for the Ozark hellbender, which is the taxonomy currently recognized by the Committee on Standard English and Scientific Names (Crother et al. 2017).

### **Distribution**

Due to the difficulty in detecting hellbenders in some habitats (areas with large boulders or with bedrock crevices), we consider the current range to include streams in which any hellbenders have been captured within 30 years. Thus, at the time of this 5-year review, we consider the current range of the Ozark hellbender to be the same as it was at the time of listing: Bryant Creek, the North Fork White River, the lower portion of the White River mainstem, the Spring River, the Eleven Point River, Jacks Fork River, and the Current River (Fig. 1). Though the Black River is presumed to be part of the Ozark hellbender’s historical range, no additional hellbenders have been captured during surveys (Wheeler et al. 1999, Briggler 2008a, pers. comm.) and habitat no longer appears suitable (Briggler 2008a, pers. comm.; Irwin 2008, pers. comm.).

In early November 2019 environmental DNA (eDNA) sampling was conducted in Missouri in the Black River and the Warm Fork of the Spring River (a tributary to the Spring River in Missouri) to determine if Ozark hellbenders are present and results are forthcoming (Crabill 2019b, pers. comm.). If results indicate that Ozark hellbenders may be present, surveys will be conducted and/or additional eDNA sampling will be conducted to determine if the species’ current range should be modified.



**Figure 1. Streams in which the Ozark hellbender likely or possibly still occurs. Individuals occur in discrete habitat patches, rather than throughout the entirety of streams.**

**Status of Populations**

The following is a brief description of the current status of each Ozark hellbender population, including population sizes estimated in 2006, 2014, and 2019 (Table 1). Because genetic analyses indicate that there is gene flow between individuals in the North Fork White River and Bryant Creek (Crowhurst et al. 2011), there is a combined population estimate for these rivers. Though genetic data are lacking for the Jacks Fork River, we presume there is or was gene flow with individuals in the Current River. Thus, there is also a combined population estimate for Ozark hellbenders in the Current and Jacks Fork rivers.

**Table 1. Ozark hellbender population size estimates from 2006 (Briggler et al. 2007), 2014 (Briggler 2014, pers. comm.), and 2019 (Briggler 2019c, pers. comm.; Irwin 2020b, pers. comm.). Estimated population sizes for 2014 and 2019 pertain only to wild adults and do not include larvae, subadults, or introduced animals.**

River	Estimated Population Size in 2006	Estimated Population Size in 2014	Estimated Population Size in 2019
White River mainstem	Not estimated	Not estimated	Not estimated
North Fork White River/Bryant Creek	200	580 <sup>2</sup>	305 <sup>3</sup>
Black River	Not estimated	NA	NA
Spring River	10	Not estimated	Not estimated
Eleven Point River	300 <sup>4</sup>	180 <sup>5</sup>	250 <sup>6</sup>
Current River/Jacks Fork River	80	360 <sup>7</sup>	360 <sup>8</sup>
<b>Total</b>	<b>590</b>	<b>1120</b>	<b>915</b>

<sup>2</sup> The estimated number of individuals in the North Fork White River is 550; while the estimated number in Bryant Creek is less than or equal to 30

<sup>3</sup> The estimated number of individuals in the North Fork White River is 275; while the estimated number in Bryant Creek is less than or equal to 30. The reduction in the estimated population size of the North Fork White River is due to the severe impacts from flooding in 2017.

<sup>4</sup> Includes both Missouri and Arkansas.

<sup>5</sup> Does not include individuals from Arkansas.

<sup>6</sup> The estimated number of individuals in the Eleven Point River in Missouri is 150; while the estimated number in the Eleven Point River in Arkansas is approximately 100.

<sup>7</sup> The estimated number of individuals in the Current River is 350; while the estimated number in the Jacks Fork River is less than or equal to 10.

<sup>8</sup> The estimated number of individuals in the Current River is 350; while the estimated number in the Jacks Fork River is less than or equal to 10.

**White River (mainstem)** - Since the listing there have been no new records of Ozark hellbenders from the White River mainstem, but there have been tentative detections of eDNA from the river (Irwin 2019b, pers. comm.). Additional eDNA testing is scheduled for autumn of 2020 (Irwin 2019c, pers. comm.) and will hopefully provide a better understanding of the species' presence or absence in the White River. Until this additional sampling is conducted, it is unknown if a viable population exists in this river or if previous reports represent individuals of a relic population within the White River and North Fork White River system present prior to construction of the hydroelectric dams.

**North Fork White River** - Population monitoring conducted by the Missouri Department of Conservation indicates that this population is continuing to experience a decline (Bodinof et al. 2012c, Bodinof Jachowski et al. 2012). Although fertilized egg clutches are typically found every year in nest boxes and natural nests, the collection of young individuals continues to be rare, indicating that there is little recruitment. In addition, extreme flooding occurred in the spring of 2017, resulting in record flooding (over a 500-year flood)(Heimann et al. 2018) that significantly impacted Ozark hellbender habitat (Briggler 2018). Both the substrate and riparian zone of the North Fork White River were heavily damaged from the flooding (Briggler 2018), and two adults were found dead on the riverbank (MDC 2018). In some locations, massive movement of rocks occurred on the river bottom, resulting in deposition of piles of rocks at the downstream end of each site (Briggler 2018). Following the flood there has been a substantial reduction in the number of nests located, and all of the artificial nest boxes were lost (Briggler 2019b, pers. comm.). Due to the severe impacts from the flooding, the population of Ozark hellbenders in the North Fork White River may have been reduced by over 50% (Briggler 2018). At the time of listing the population size of the North Fork White River and Bryant Creek was estimated to be 200 individuals (Table 1)(Briggler et al. 2007).

In 2014, the population size was estimated to be 580 individuals (Briggler 2014), and the current estimated population size for these rivers is 305 individuals (Table 1)(Briggler 2019c, pers. comm.). The increase in estimated population size from 2006 to 2014 does not necessarily reflect an actual increase in the population size, but rather a better understanding of the number of animals likely present because limited information was available in 2006 regarding the size of populations (Briggler 2014, pers. comm.).

**Bryant Creek** - Ozark hellbenders in Bryant Creek continue to be somewhat isolated from those in the North Fork White River by the Norfork Reservoir, which could contribute to this population's apparent small size due to habitat fragmentation. Bryant Creek also has warmer temperatures and greater extremes in temperature than the North Fork White River due to less spring influence (Bodinof Jachowski et al. 2012). However, genetic analyses indicate that there is some movement of hellbenders between the two streams (Crowhurst et al. 2011), and a small number of individuals (6 or less) continue to be captured in Bryant Creek (Briggler 2019c, pers. comm.). The reason for low abundance in Bryant Creek remains unclear, and the population is currently not considered to be viable on its own (Briggler 2008b, pers. comm.).

At the time of listing the population size of the North Fork White River and Bryant Creek was estimated to be 200 individuals (Table 1)(Briggler et al. 2007). The population size was estimated to be 580 individuals in 2014 (Briggler 2014, pers. comm.), and the current estimated population size for these rivers is 305 individuals (Table 1)(Briggler 2019c, pers. comm.). As noted above, the increase in estimated population size from 2006 to 2014 does not necessarily reflect an actual increase in the population size, but rather a better understanding of the number of animals likely present because limited information was available in 2006 regarding the size of populations (Briggler 2014, pers. comm.).

***Black River*** - There have been no new records of Ozark hellbenders in the Black River since the time of listing, and we do not consider it to be part of the species' current range given that only one record exists from an individual captured in 1978 in Arkansas. However, eDNA sampling was conducted in early November 2019 in the upper portion of Reynolds County in Missouri and results are forthcoming (Crabill 2019b, pers. comm.).

***Spring River*** - No Ozark hellbenders have been observed in the Spring River since the time of listing (Irwin 2014, pers. comm.). The last surveys were conducted in 2005-2006 and resulted in the capture of only 5 individuals (Trauth et al. 2007). Two of the animals captured were found in a stressed condition with no apparent injuries and died shortly after capture (Irwin 2020b, pers. comm.). Although no surveys have been conducted since 2006 in the Spring River, the Arkansas Game and Fish Commission considers the population in this river functionally extirpated based on the low number of animals found in 2005-2006 and the poor health of individuals that were captured. However, eDNA sampling is scheduled to be conducted in 2020 (Irwin 2019c, pers. comm.) and will hopefully provide more information about the status of this population.

***Eleven Point River*** - Ozark hellbenders continue to be consistently found during surveys in the Eleven Point River in Missouri and Arkansas. Fertilized egg clutches are also consistently found in artificial nest boxes in Missouri and young appear to be hatching successfully (Briggler 2019b, pers. comm.). However, the collection of young individuals continues to be rare (Briggler 2019b, pers. comm.), indicating that there is little recruitment. At the time of listing the population size of the Eleven Point River in Missouri and Arkansas was estimated to be 300 individuals (Table 1)(Briggler et al. 2007). The estimated population size in Missouri was estimated to be 180 individuals in 2014 (Briggler 2014, pers. comm.), and the current estimated population size for the river in both Missouri and Arkansas is 250 individuals (Table 1)(Briggler 2019c, pers. comm.; Irwin 2020a, pers. comm.). The slight increase in estimated population size in 2014 does not necessarily reflect an actual increase in the population size. Rather the increase likely represents a better understanding of the number of animals likely present because limited information was available in 2006 regarding the size of populations (Briggler 2014, pers. comm.).

***Current River*** - Similar to the Eleven Point River, Ozark hellbenders and fertilized egg clutches continue to be consistently found during surveys in the Current River, and young appear to be successfully hatching (Briggler 2019b, pers. comm.). As with all of the other

Ozark hellbender populations, however, the collection of young individuals continues to be rare (Briggler 2019b, pers. comm.), indicating that there is little recruitment. At the time of listing the population size of the Current River and Jacks Fork River population was estimated to be 80 individuals (Table 1)(Briggler et al. 2007). In 2014 the population size was estimated to be 360 individuals, and the current estimated population size for these rivers has not changed (Table 1)(Briggler 2019c, pers. comm.). Though there appears to be a considerable increase in the population size from 2006 to 2014, the increase does not necessarily reflect an actual increase in the population size. Rather, the increase likely represents a better understanding of the number of animals likely present because limited information was available in 2006 regarding the size of populations (Briggler 2014, pers. comm.).

***Jacks Fork River-*** Despite a survey of all suitable Ozark hellbender habitat in the Jacks Fork River by the Missouri Department of Conservation and the National Park Service's Ozark National Scenic Riverways, Ozark hellbenders have not been captured or observed in the Jacks Fork River since 2007. Given the difficulty in finding hellbenders when there are few individuals present, we presume that there may be a small number of Ozark hellbenders remaining in the Jacks Fork River. Water samples were collected in early November 2019 for eDNA sampling and results are currently pending (Crabill 2019b, pers. comm.). At the time of listing the population size of the Current River and Jacks Fork River population was estimated to be 80 individuals (Table 1)(Briggler et al. 2007). In 2014 the population size was estimated to be 360 individuals, and the current estimated population size for these rivers has not changed (Table 1)(Briggler 2019c, pers. comm.). As noted above, the considerable increase in the estimated population size does not necessarily reflect an actual increase in the population size, but rather a better understanding of the number of animals likely present (Briggler 2014, pers. comm.).

Ozark hellbender populations are continuing to senesce and the exact cause of the limited recruitment in the wild continues to be unclear. In collaboration with the Missouri Department of Conservation, the Service evaluated Ozark hellbender sperm health in individuals from the North Fork White, Eleven Point, and Current rivers from 2010-2016 (Crabill and Briggler 2016, unpublished data). Results to date indicate that sperm health is high, as evidenced by high motility rates, viability rates, and sperm concentration (Crabill and Briggler 2016, unpublished data). Based on this information, it appears that sperm health is not a primary factor affecting recruitment. Methods to find nests in the wild have improved and numerous Ozark hellbender nests are typically located each year (Briggler 2018, pers. comm.). Results of nest monitoring indicates that egg-hatching rates are high (Briggler 2018, pers. comm.), in turn indicating that successful fertilization is occurring. Though sample sizes are relatively low, there also does not appear to be high mortality during the subsequent weeks while larvae remain in the nest (Briggler 2018, pers. comm.). Combined with the data on sperm health, it appears the factor(s) affecting recruitment occur after larvae leave the nest.

A large percentage of captured individuals continue to exhibit severe physical abnormalities, such as necrotic limbs, missing digits, and swollen toe pads (Briggler 2019b, pers. comm.). Although the prevalence and severity of abnormalities in Ozark hellbenders appeared to be

increasing in 2007, often to a level that the animals were near death (Briggler 2007, pers. comm.), by 2015 the prevalence and severity of physical abnormalities showed no increase (Briggler 2016). Subsequent sampling indicates that there has not been a continued increase in the percentage of individuals exhibiting abnormalities (Briggler 2019c, pers. comm.). However, the number of individuals captured since 2015 has been small since there has not been standardized surveys or intensive sampling to collect individuals for scientific studies. Thus, we cannot conclude definitively that there has not been a change in the percentage of individuals exhibiting physical abnormalities. The exact cause of these physical abnormalities on Ozark hellbenders is still yet to be determined. However, the current belief continues to be that secondary bacterial and fungal infections are contributing factors (Briggler 2019b, pers. comm.; Wanner 2019, pers. comm.). While these pathogens likely naturally occur on the animals, it appears that some unknown factor is increasing the hellbenders' susceptibility to these infections. Because *Bd* (amphibian chytrid fungus) can cause an increase in some pathogens (Jani and Briggs 2014; Federici et al. 2015; Walke et al. 2015), it is postulated that *Bd* may play a role in development of the abnormalities (Hernández-Gómez et al. 2018).

#### Threats Affecting the Species

We refer to factors negatively influencing the Ozark hellbender's viability as threats. As noted above, a complete description of known and presumed threats to the Ozark hellbender is provided in the Biological Report (USFWS 2020).

***The present or threatened destruction, modification, or curtailment of its habitat or range (Factor A)*** – The construction of a series of impoundments on the portion of the White River likely extirpated any populations that may have been present in the upper portion of the White River. Hellbender habitat was lost in the vicinity of reservoirs created from the dams and the suitability of habitat in tail-water zones below the dams was reduced. There also are ongoing effects from the impoundments to the North Fork White River and Bryant Creek population. These effects include increased sedimentation upstream of the Norfork Reservoir following flood events (Briggler 2011b, pers. comm.; Crabill 2011, pers. obs.), increased predation pressure above the reservoir from large predatory fish (Roberts 2011, pers. comm.; Anonymous. 2010, pers. comm.), and reduced gene flow between the North Fork White River and Bryant Creek due to the unsuitability of habitat for hellbenders separating the two streams (Briggler 2019a). In the White River mainstem, there are 3 lock and dams in the vicinity of Ozark hellbender records, and these dams continue to fragment hellbender habitat and block the flow of immigration and emigration among any sites that may still be occupied (Dodd 1997). If any Ozark hellbenders are still present in the Spring River, the dams at the upper end of the river likely also impede hellbender movement among habitat patches.

Sedimentation continues to be one of the primary factors affecting Ozark hellbender populations. As noted above, the Norfork Reservoir causes sedimentation towards the lower end of the North Fork White River following flood events. However, there are many other sources of sedimentation throughout the species' range. These sources include legacy effects from historical timber clearing, gravel dredging that does not follow appropriate Best Management Practices (BMPs) and alters stream hydrology, poor

land use practices (indiscriminate land clearing, allowing livestock in riparian areas for long periods of time), current timber harvests that do not implement appropriate BMPs, and gravel/unpaved roads (Miller and Wilkerson 2000, Miller and Wilkerson 2001, Wilkerson 2003).

Excessive sediment can fill interstitial spaces between substrate particles (i.e., sand, gravel, and cobble), reducing suitable habitat for hellbender larvae and subadults (FISRWG 1998) as well as hellbender prey. Excessive sediment also can cover the stream bottom, degrading suitable habitat for adults and suffocating eggs. In severe cases, sedimentation can even cause stream bottoms<sup>9</sup> to become embedded, and when habitat patches are completely lost due to sedimentation, the movement of individuals and colonization of new habitat can be impeded (Routman 1993). Increased sediment can also increase suspended particle loads, which can cause water temperatures to increase, and cause more particles to absorb heat, thereby reducing dissolved oxygen levels (Allan and Castillo 2007). In addition, various chemicals, such as pesticides, bind to silt particles and become suspended in the water column when flushed into a stream (Widenfalk 2002). The hellbender's permeable skin can allow direct exposure to these chemicals, which can be toxic (Wheeler et al. 1999).

Sedimentation continues to affect each of the extant Ozark hellbender populations (Briggler 2019b, pers. comm.; Irwin 2019b, pers. comm.). With the exception of the area upstream of Norfolk Reservoir that has a lake influence, Ozark hellbender habitat in the North Fork White River and Bryant Creek has not been substantially impacted by sedimentation (Briggler 2019c, pers. comm.). However, as indicated above, the record flooding in 2017 resulted in major mobilization of the substrate and deposited large amounts of sediment in some areas (Briggler 2019c, pers. comm.). Hellbender habitat at the lower end of the Eleven Point River has also experienced considerable degradation due to sedimentation, particularly in Arkansas. Additional information is needed on the extent of sedimentation in Ozark hellbender streams and the extent of the impact it may have on the species survival and reproduction.

Impaired water quality continues to be a concern in Ozark hellbender streams. Portions of the Eleven Point River and Current River are currently included in the Environmental Protection Agency (EPA) list of impaired streams for atmospheric deposition of mercury (MDNR 2002-2018), and the Eleven Point River in Arkansas was on the list from 2008-2010 for low dissolved oxygen (ADEQ 2008, 2010). Part of the Jacks Fork River was listed as impaired from 1998-2004 due to fecal coliform (MDNR 1998-2004), and portions of the Spring River have been listed for increased temperature (from 2008-2011) and for siltation (2008-2010)(ADEQ 2008, 2010). A portion of the Spring River was recently added to the list again in 2018 for increased temperature (ADEQ 2018). Other pollutants such as nitrogen, phosphorus, estrogenic compounds, and pharmaceuticals were discussed in the Ozark hellbender's final listing rule. We are not aware of substantial changes in land use, recreation, water quality standards, the National Pollutant Discharge Elimination System (NPDES) permit program, or other activities that would

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<sup>9</sup> The stream bottoms consist of large substrate features such as cobble, rocks, and boulders.

cause a reduction in these pollutants in Ozark hellbender streams. Thus, we expect that exposure to these chemicals is similar to what was described in the final rule. A compilation of available water quality data is needed, as is a thorough evaluation of how each of the pollutants may affect Ozark hellbenders.

Though habitat disturbance from rock flipping may impact some Ozark hellbenders, we do not consider it to currently be a major factor affecting the populations. However, there could be substantial impacts to reproduction if nest rocks are targeted or disturbed. There was major disturbance to the habitat in the North Fork White River as a result of severe flooding in 2017, and this is discussed under ***Other natural or manmade factors affecting its continued existence (Factor E)***.

***Overutilization for commercial, recreational, scientific, or educational purposes (Factor B)*** - The unauthorized collection of Ozark hellbenders for commercial sale in the pet trade continues to be a threat, as is people recreationally looking for hellbenders. Flipping large rocks without proper training can injure or kill hellbenders and can also result in damage to their habitat if the sediment seal around the rock is disturbed. The Missouri Department of Conservation has documented on 2 occasions disturbance to Ozark hellbender sites that indicated that the habitat patches had been searched for hellbenders (Briggler 2011, Briggler 2014). However, it is unclear if the purpose was to collect Ozark hellbenders for the pet trade or just to see them in the wild.

Though recreational fishing and gigging were discussed in the Ozark hellbender final rule, they are not currently considered to be among the primary threats to the species.

***Disease or predation (Factor C)*** - Amphibian chytrid fungus (*Bd*) continues to be present in Ozark hellbender populations. However, prevalence of the fungus does not appear to be increasing (Briggler 2019c, pers. comm.), and the specific effects of *Bd* infection on Ozark hellbenders remains unclear. The belief among species experts remains the same as it was at the time of listing - that the *Bd* pathogen may cause some hellbenders to be more susceptible to other infections, including those responsible for lesions and appendage loss, but that there may be additional unknown factors underlying the increased vulnerability. Because *Bd* can cause an increase in some pathogens (Jani and Briggs 2014; Federici et al. 2015; Walke et al. 2015), it is postulated that *Bd* may play a role in development of the severe abnormalities observed on many Ozark hellbenders (Hernández-Gómez et al. 2018).

There is new information about when Ozark hellbenders may have first been exposed to the fungus. Bodinof et al. (2011) evaluated the occurrence of *Bd* in tissue samples from Ozark hellbender museum specimens collected from Missouri between 1896 and 1969. They confirmed *Bd* in 6.9% of the 102 Ozark hellbender specimens evaluated and in specimens collected as early as 1969 (Bodinof et al. 2011). With both Ozark and eastern hellbenders, *Bd*-positive individuals were collected and deposited in collections prior to or during the period when hellbender populations in Missouri declined (Bodinof et al. 2011). These results indicate that *Bd* could have contributed to the population declines that occurred throughout the Ozark hellbender's range between the 1970s and 1990s.

Ranaviruses are an emerging group of pathogens affecting amphibians worldwide. They can cause disease in fish, reptiles, and other amphibians (Marschang and Miller 2012) and are often virulent, causing systemic infections in amphibians (Daszak et al. 1999). Amphibian larvae seem to be the developmental stage most susceptible to ranaviruses (Daszak et al. 1999), with physical characteristics of infections in larval stages including skin hemorrhages, ulcers, and bloating (Marschang and Miller 2012). Overt signs of infection may not be exhibited in juvenile and adult stages (Daszak et al. 1999), but when present typically include skin abnormalities (e.g., sloughing, hemorrhaging) and sometimes necrosis (tissue death) of digits and limbs (Cunningham et al. 1996, Jancovich et al. 1997).

Though broad-scale Ranavirus outbreaks have not been documented among Ozark or eastern hellbenders, Ranavirus has been detected in several eastern hellbender populations. Since 2010, 84 Ozark hellbenders in Missouri have been tested for Ranavirus using internal cloacal and buccal swabs and external swabs of skin hemorrhages and ulcers (Briggler 2020a, pers. comm.). The testing yielded no positive results, as did results of the 47 eastern hellbenders tested in Missouri (Briggler 2020a, pers. comm.). Testing in Arkansas indicates that the pathogen may be present (Miller et al. 2016), however, there is some uncertainty regarding the results given the number of times samples needed to be amplified before Ranavirus DNA could be detected (Crabill 2017, pers. comm.). The role that Ranavirus may play in declines of Ozark hellbenders, and the threat it poses to this species, is unclear.

*Batrachochytrium salamandrivorans* (*Bsal*) is another fungal pathogen that has recently emerged. The fungus invaded Europe from Asia around 2010 and is responsible for causing mass die-offs of fire salamanders (*Salamandra salamandra*) in northern Europe (Martel et al. 2014, Fisher 2017). Given extensive unregulated trade and the recent discovery of *Bsal* in amphibians, there is concern about the introduction of a novel pathogen causing extirpations of naive salamander populations in North America (Yap et al. 2017). While we still do not have a clear understanding of all of the salamander species that will be susceptible to *Bsal*, there is concern that Ozark hellbenders could be impacted. The Ozark Highlands are within an area identified as having a medium risk of introduction of *Bsal* based on proximity to areas with a high volume of amphibian trade (Richgels et al. 2016). Since *Bsal* can be transmitted via environmentally-resistant zoospores and encysted spores that can float at the water-air interface (Stegen et al. 2017) in addition to direct contact, it is expected to spread readily in stream environments. The Missouri Department of Conservation has been testing Ozark and eastern hellbenders for *Bsal* and so far all samples have been negative (95 individuals were tested).

There is no new information regarding predation by native or non-native predators.

***The inadequacy of existing regulatory mechanisms (Factor D)*** - The only new information regarding the inadequacy of existing regulatory mechanisms pertains to the rate of implementation and effectiveness of Best Management Practices (BMPs) during timber harvests. In the final listing rule for the Ozark hellbender, it was stated that timber

harvest and associated activities (construction and increased use of unpaved roads, skid trails, and fire breaks) are prominent in many areas within the range of the Ozark hellbender and increase terrestrial erosion and sedimentation into streams. It was also stated that peak stream flows often rise in watersheds with timber harvesting activities, due in part to compacted soils resulting from construction of roads and landings (where products are sorted and loaded for transportation) and vegetation removal (Allan and Castillo 2007, Box and Mossa 1999). According to information we received during the public comment period from the National Council for Air and Stream Improvement, Inc. (NCASI) forestry BMPs are implemented at high rates nationally and when implemented, reduce, if not eliminate effects of forest management on water quality. However, implementation of BMPs is required only for forest landowners and mills that are certified under forest certification standards (NCASI 2019). At this time, we are unable to determine the amount of timber harvest within the range of the Ozark hellbender that occurs under this certification and thus implements BMPs.

***Other natural or manmade factors affecting its continued existence (Factor E)*** - In the final listing rule, one of the threats listed under Factor E was that Ozark hellbenders have small, isolated populations. This threat is being managed, at least in part, through captive propagation and augmentation efforts. As described later under **Conservation Measures**, 7,038 Ozark hellbender larvae and juveniles have been released back to date, with 2,357 individuals released into the North Fork White River, 1,451 in Bryant Creek, 1,820 in the Eleven Point River (in both states), and 1,410 in the Current River (Briggler 2019c, pers. comm.). These efforts are helping to bolster the populations and increase connectivity among occupied sites. The efforts are also helping to address another threat identified under Factor E: the limited recruitment observed in the wild. However, the cause behind the reduced recruitment in the wild still needs to be determined to address the threat.

Recent climate models provide a better idea of likely changes in climate. According to the National Oceanic and Atmospheric Administration's global climate models, increased flooding along rivers and streams is predicted to continue in Missouri, and extreme precipitation events are predicted to increase in Arkansas over the next 80 years (NOAA NCEI 2016a, NOAA NCEI 2016b). If these events result in extreme flooding, they will likely cause substantial disturbance to and mobilization of the substrate, similar to the effects observed on the North Fork White River following the extreme flooding in 2017. This disturbance can directly injure or kill Ozark hellbenders if they are dislodged from their cover rocks and swept downstream in the current. The mobilization of substrate can also impact hellbenders if their cover rocks are buried in gravel or transferred downstream, as were boulders during the 2017 flood on the North Fork White River (Briggler 2018). The flood events are expected to be even greater if substantial forest clearing occurs due to a synergistic effect between land cover and climate change on stream discharge (Hu et al. 2005).

In both Arkansas and Missouri, the global climate models predict that higher temperatures in the future will result in a greater intensity of droughts (NOAA NCEI 2016a, NOAA NCEI 2016b). A greater intensity of droughts will decrease groundwater levels (Schindler 2001) and significantly reduce annual stream base flows (Moore et al.

1997, Hu et al. 2005). The drought conditions and prolonged low flows associated with climate change may favor the establishment and spread of nonnative species (Rahel and Olden 2008). Invasion by nonnative plant species could impact the quality of hellbender habitat; whereas invasion by nonnative animals could create competition for resources. If the higher temperatures predicted by the global climate models are high enough to result in interrupted stream flows, it could cause direct mortality to hellbenders from desiccation and reduced fitness and reproduction due to stress, decreased prey availability, and lower dissolved oxygen. Reduced stream flow may also increase impacts to the stream substrate during flooding because woody debris carried in the stream flow will be lower in the stream channel and more likely to disturb the substrate (Briggler 2020b, pers. comm.).

Because Ozark hellbender streams are spring-fed, their temperatures are influenced by subsurface groundwater temperature. Though groundwater temperature exhibits less seasonal variability than surface water temperature (Constantz 1998, O’Driscoll and DeWalle 2006, Tague et al., 2007), groundwater temperature is still influenced by atmospheric temperatures and is expected to increase with increasing atmospheric temperatures (Menberg et al. 2014; Kurylyk et al. 2015). Changes to stream temperature of spring-fed streams are difficult to predict due to the complex interactions that influence groundwater temperature. However, if the predicted increase in atmospheric temperature substantially increases temperatures of Ozark hellbender streams, the fitness of individuals will be affected. If the health of hellbenders is already compromised by other environmental stressors, elevated water temperatures could increase susceptibility to bacterial and fungal infections (Wanner 2011, pers. comm.). Conversely, an increase in stream temperature may reduce the prevalence of *Bd* since the fungus thrives at cooler temperatures such as those in Ozark streams (Briggler 2020b, pers. comm.).

Though not evaluated in the final rule, the effect of electrofishing on Ozark hellbenders has recently been investigated (Morrison 2019). Electrofishing is conducted by various agencies to sample fish, and in the past has been conducted at Ozark hellbender sites. In 2011, the Missouri Department of Conservation began avoiding Ozark hellbender sites where a large number of animals occurred or where reproduction had been documented as a precautionary measure (Briggler 2013, pers. comm.). For the same reason, the Arkansas Game and Fish Commission discontinued electrofishing over Ozark hellbender sites in 2012 (Irwin 2019a, pers. comm.). Results of the electrofishing study indicate that hellbenders are exposed to the electrical field, react to the exposure, and in one instance, experienced a physical injury in the form of a broken vertebra (Morrison 2019). Based on these results, additional measures have been implemented by the Missouri Department of Conservation to further protect Ozark hellbenders when conducting electrofishing in streams occupied by the species (Crabill 2019a, pers. comm.). It is unknown if electrofishing had contributed to Ozark hellbender population declines.

### **Conservation Measures**

The following conservation efforts have either been conducted since the Ozark hellbender’s listing or are currently being conducted.

**Population Monitoring** - The Arkansas Game and Fish Commission and Missouri Department of Conservation continue to conduct regular surveys to monitor Ozark hellbender populations and assess the overall health of animals. The survey protocol implemented by Missouri Department of Conservation in 2009 allows for calculating detection rates and projecting population trends (Calfee et al. 2009). Since 2009, monitoring in Missouri has shifted from every 3 years to every 10 years for each river to minimize disturbance to habitat and individuals (Briggler 2019b, pers. comm.). The frequency of monitoring Ozark hellbenders in the Eleven Point River in Arkansas has also been reduced for the same reason (Irwin 2019b, pers. comm.). Population monitoring by both State agencies also includes checking nest boxes for individuals and eggs and in some instances, monitoring larvae when nests are found. Methods to find nests in the wild have improved and numerous Ozark hellbender nests are typically located each year (Briggler 2018, pers. comm.). In addition to monitoring population abundance and occupancy, the Service and the Missouri Department of Conservation evaluated sperm health of Ozark hellbenders from 2010-2016. Results indicate that Ozark hellbenders in the North Fork White, Eleven Point, and Current rivers have healthy sperm and that poor sperm health is not a factor contributing to population declines. Additional partners assisting with population monitoring include the National Park Service's Ozark National Scenic Riverways, the U.S.D.A. Forest Service's Mark Twain National Forest, and the Service.

**Captive Propagation** - In 2011, Ozark hellbenders successfully bred in captivity at the Saint Louis Zoo (Ettling et al. 2013). Since then, adults from the North Fork White River, Eleven Point River, and Current River have all bred at the Saint Louis Zoo, resulting in successfully fertilized eggs. As of result of captive breeding, collecting eggs from the wild, and subsequent head-starting, approximately 7,038 Ozark hellbender larvae and juveniles have been released, with 2,357 individuals released into the North Fork White River, 1,451 in Bryant Creek, 1,820 in the Eleven Point River (in both states), and 1,410 in the Current River (Briggler 2019c, pers. comm.).

Though the long-term success of the propagation efforts has yet to be determined, propagated individuals have successfully bred at the Saint Louis Zoo (Briggler 2019c, pers. comm.), indicating that propagated individuals in the wild have the ability to also successfully reproduce. In addition, it appears that after being released to the wild, head-started Ozark hellbenders have annual survivorship comparable to that of hellbender born in the wild (Bodinof et al. 2012b).

Augmenting the populations will allow the continued persistence of the Ozark hellbender, at least in the near term. Bolstering the populations also will provide additional time as well as individuals to use for research to better understand and address the factor(s) contributing to population declines. In addition, collecting eggs from the wild and rearing the larvae results in higher survivorship rates than in the wild, which will help to maintain genetic diversity while identifying and addressing population declines. Propagation efforts for the Ozark hellbender have been guided by an interagency propagation, augmentation, and reintroduction plan (Briggler et al. 2012) and are a collaborative effort led by the Saint Louis Zoo and Missouri Department of Conservation with assistance

from the Arkansas Game and Fish Commission, Ozark National Scenic Riverways, Mark Twain National Forest, and the Service.

***Artificial Nest Boxes*** - Artificial nest boxes were developed by Briggler and Ackerson (2012) to provide nesting habitat for hellbenders in the wild and to also provide an efficient way to collect eggs for captive rearing. For the same reasons, the nest boxes are used in the captive breeding program. The nest boxes have substantially increased the number of egg clutches found in the wild and have also reduced the amount of habitat disturbance to find and collect them. To date, 9 nest boxes have been augmented into the North Fork River, 98 have been placed in the Eleven Point River in Missouri and Arkansas, and 34 have been placed into the Current River (Briggler 2019c, pers. comm.; Irwin 2020a, pers. comm.).

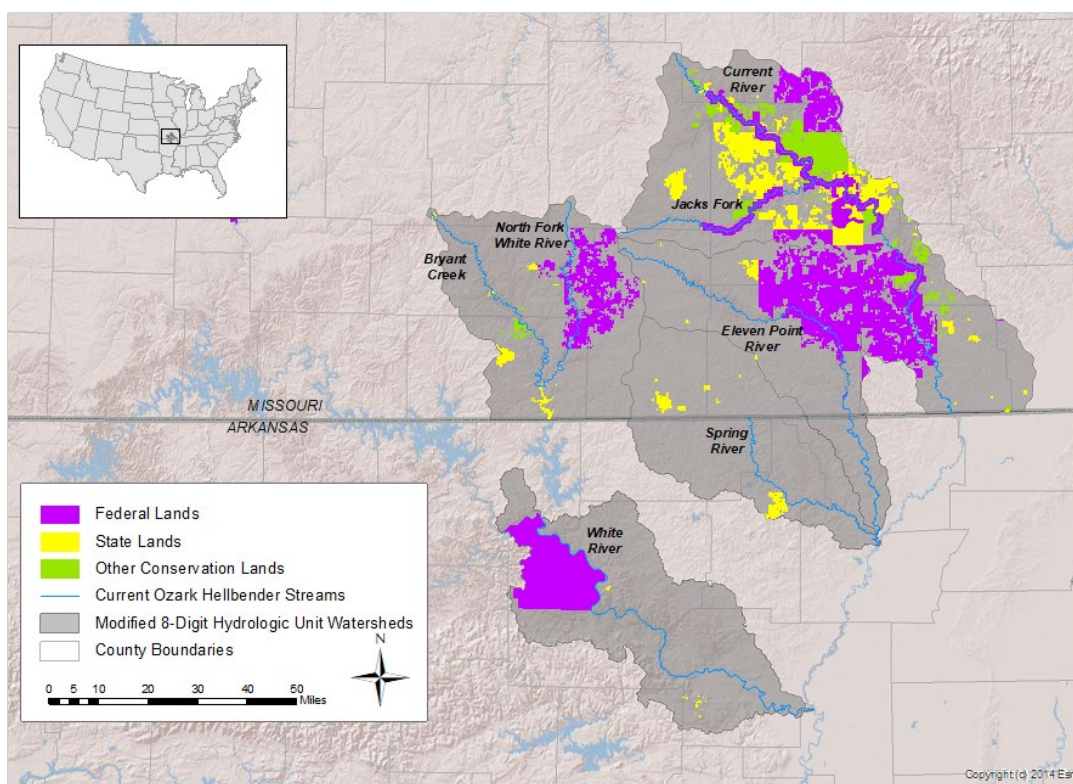
***Protecting Populations and Habitat*** - The Missouri Department of Conservation, Arkansas Game and Fish Commission, and the Service continue to review projects potentially affecting Ozark hellbenders and make recommendations to minimize or mitigate for adverse effects. The Service reviews proposed projects having a Federal nexus (i.e., authorized, funded, or carried out by a Federal agency) under section 7 of the Endangered Species Act and. Since the listing the Service has reviewed 776 projects within the range of the Ozark hellbender, including 5 consultations for which incidental take was authorized<sup>10</sup>. The state agencies often review projects with no Federal nexus. BMPs were developed by Missouri Department of Conservation and include specific recommendations for activities occurring in or near Ozark hellbender streams. To protect populations from illegal collection, disclosure of specific locations of Ozark hellbender sites continues to be limited and law enforcement and private landowners monitor sites for suspicious activity. Involved partners include the Missouri Department of Conservation, Arkansas Game and Fish Commission, Ozark National Scenic Riverways, Mark Twain National Forest, the Service, and U.S. Army Corps of Engineers.

***Disease Assessment and Treatment*** - Due to the prevalence and severity of physical abnormalities found in Ozark hellbender populations, considerable effort continues to be focused on understanding the cause of these abnormalities as well as other diseases that may be compromising animal health. External microorganisms associated with injured or necrotic tissue have been identified (Nickerson et al. 2011, Hernández-Gómez et al. 2017), and extensive necropsies and screenings have been performed on affected individuals. Recent and ongoing monitoring surveys incorporate sampling protocols for testing of fungal, bacterial, and viral pathogens; and museum specimens have been histologically examined to determine when the fungus first occurred in the populations (Bodinof et al. 2011). Involved partners include the Missouri Department of Conservation, Arkansas Game and Fish Commission, Saint Louis Zoo, the Service, and University of Tennessee.

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<sup>10</sup> The 5 projects include removal of a dam, a bridge repair project, a bridge replacement project, and issuance of recovery permits under section 10 of the Act to the Missouri Department of Conservation and Arkansas Game and Fish Commission to conduct captive breeding and head-starting activities.

**Public Land Ownership** - Approximately 19% of the Ozark hellbender range is currently in public ownership, with the primary public landowners being the U.S.D.A. Forest Service, National Park Service’s Ozark National Scenic Riverways, Missouri Department of Conservation, and Arkansas Game and Fish Commission (Fig 2). Another 3% of the species’ range is owned by conservation organizations (The Nature Conservancy, L-A-D Foundation, and Ozark Land Trust), which we refer to as “Conservation Lands” (Fig. 2). Ozark hellbenders benefit from public and conservation lands because these organizations implement management practices that reduce the input of sedimentation and other contaminants into streams, especially when the lands are immediately adjacent to streams. In addition, representatives from the U.S.D.A. Forest Service and National Park Service’s Ozark National Scenic Riverways are very active in Ozark hellbender recovery efforts.



**Figure 2. Public and other conservation lands within watersheds of presumed Ozark hellbender streams.**

**Other Efforts** - Numerous studies other than those that have already been discussed in this 5-year review have focused on understanding the causes underlying Ozark hellbender declines or addressing potential threats since the listing. These include evaluating movement patterns of released captive-reared individuals (Bodinof et al. 2012a), assessing hematology (Huang et al. 2010), evaluating the effects of electrofishing on various hellbender life stages (Morrison 2019), developing methods to determine sex of an individual using genetic data (Hime et al. 2019), examining reproductive hormones

and heavy metal levels (Huang et al. 2010), assessing breeding behavior to assist with propagation efforts (Settle et al. 2018), and multiple genetic studies (Crowhust et al. 2011, Tonione et al. 2011, Feist et al. 2014).

### **Synthesis**

Population monitoring indicates that Ozark hellbender populations are continuing to decline, with an estimated 915 adults remaining in the wild. The Spring River population is now considered functionally extirpated, and the North Fork White River population, once considered the stronghold of the species, was severely impacted by record flooding in 2017. The populations are continuing to senesce with the collection of young individuals still rare compared to historical samples, indicating that there is little recruitment occurring in the wild. In addition, a large percentage of captured individuals continue to exhibit severe physical abnormalities, such as necrotic limbs, missing digits, and swollen toe pads, although the rates no longer appear to be increasing.

The exact cause of population declines continues to be unclear. However, the primary threats believed to currently contribute to population declines are habitat degradation and disease. Habitat throughout the Ozark hellbender's range is degraded to varying extents due to sedimentation, with the degradation particularly pronounced in the Eleven Point River in Arkansas. The sources of sedimentation include legacy effects from historical timber clearing, gravel dredging that does not follow appropriate BMPs and alters stream hydrology, poor land use practices (indiscriminate land clearing, allowing livestock in riparian areas for long periods of time), current timber harvests that do not implement appropriate BMPs, and gravel/unpaved roads. The sedimentation reduces suitable habitat for all life stages of the Ozark hellbender, increases water temperature, reduces dissolved oxygen, and increases exposure to pollutants. Amphibian chytrid fungus (*Bd*) continues to be present in all Ozark hellbender populations and the belief among species experts remains the same as it was at the time of listing - that the *Bd* pathogen may cause some hellbenders to be more susceptible to other infections, including those responsible for lesions and appendage loss, but that additional unknown factors are underlying the increased vulnerability. To date, Ranaviruses have not been definitively documented in any Ozark hellbender populations.

Though recruitment continues to be limited in the wild, we hope that the populations are being temporarily stabilized by augmentation efforts. Over 7,000 Ozark hellbender larvae and juveniles have been released to date, and nests are consistently found in the wild, allowing for the removal of eggs for head-starting. In addition, Ozark hellbenders now breed successfully in captivity at the Saint Louis Zoo. However, the number of released individuals that are recaptured is small and the success of augmentation efforts remains unknown. Because many of the released individuals are young juveniles, we hope that as they reach larger sizes and their detection rates increase, that a higher proportion are recaptured. Even with success of the augmentation program, however, the threats will need to be identified and addressed for the Ozark hellbender to recover.

A recovery plan and implementation schedule have been drafted for the Ozark hellbender and are currently undergoing internal review.

## 5. REVIEW RESULTS

Recommended Classification: No Change Needed

Recovery Priority Number: No Change Needed

Rationale: We do not recommend a change in classification because populations of the Ozark hellbender are still threatened with extinction. One of the four populations at the time of listing (the Spring River) is considered functionally extirpated, and the remaining 3 populations are continuing to decline. Recruitment in the wild appears to still be very limited, and a high proportion of individuals captured continue to exhibit severe physical abnormalities (necrotic toes, feet, and in limbs). Though efforts to augment populations continue, the success of these efforts remains unclear since few released animals have been recaptured to date. In addition, the exact cause(s) of population declines continues to be unclear.

## 6. RECOMMENDATIONS FOR FUTURE ACTIONS

Below are the recommended future actions for the next 5 years:

- Finalize the recovery plan.
- Stabilize populations until factor(s) causing the declines can be better understood by continuing to augment populations with head-started individuals from captive breeding and from eggs collected from the wild.
- Continue to augment nesting habitat with artificial nest boxes.
- Continue to monitor populations while minimizing disturbance to habitat and individuals. This includes evaluations of abundance, size class distributions (to determine if populations are continuing to senesce), health (extent and severity of physical abnormalities), and number of captured individuals that were head-started.
- Conduct follow-up surveys or additional eDNA sampling if Ozark hellbender eDNA is detected in water samples collected from the Jacks Fork River, Black River, White River, or Warm Fork Spring River.
- Conduct another population viability analysis.
- Continue to test for amphibian chytrid fungus, ranaviruses, and any other emerging pathogens.
- Collect and summarize existing water quality data from prioritized streams and, if deemed necessary, initiate water quality analyses and monitoring program for all prioritized streams.

- Initiate a study to further investigate amphibian chytrid fungus. This may include inoculation of head-started young before being released, additional treatment options, and/or an evaluation of what life stages are most vulnerable to the fungus (to determine if the fungus is one of the primary factors contributing to population declines).
- Reduce sedimentation entering streams by working with Federal agencies through the section 7 consultation process and with private landowners through existing landowner incentive programs.
- Pursue funding for one or more watershed assessments to identify areas contributing the highest amount of sediment (eroding streambanks, gravel roads, etc.).
- Continue to investigate potential factors contributing to declines by 1) determining if amphibian chytrid fungus causes high mortality during metamorphosis, 2) investigating depth of substrate mobilized during flood events to determine if larvae may be injured during these events, 3) investigating any other potential factors that may be discovered.

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## 8. APPROVAL

Approve \_\_\_\_\_ Date \_\_\_\_\_  
Lead Field Supervisor, Missouri Ecological Services Field Office

Approve \_\_\_\_\_ Date \_\_\_\_\_  
Lead Assistant Regional Director, Great Lakes Region