Conservation Assessment
for
Ozark hellbender (Cryptobranchus alleganiensis bishopi Grobman)

Female on the left (bigger) and male on the right (smaller). Photo credit: Dr. Yue-wern Huang

USDA Forest Service, Eastern Region

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This document is undergoing peer review, comments welcome.

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This Conservation Assessment was prepared to compile the published and unpublished information on Cryptobranchus alleganiensis bishopi Grobman. It does not represent a management decision by the U.S. Forest Service. Though the best scientific information available was used and subject experts were consulted in preparation of this document, it is expected that new information will arise. In the spirit of continuous learning and adaptive management, if you have information that will assist in conserving the subject community and associated taxa, please contact the Eastern Region of the Forest Service - Threatened and Endangered Species Program at 310 Wisconsin Avenue, Suite 580 Milwaukee, Wisconsin.

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EXECUTIVE SUMMARY

The Ozark hellbender (*Cryptobranchus alleganienis bishopi*) is a large, strictly aquatic salamander endemic to streams of the Ozark plateau in southern Missouri and northern Arkansas.

The viability of the Ozark hellbender is in question. A decline in populations numbers begin in the mid 1980's and was marked by a shift in age structure. Today's hellbender populations have fewer individuals and those left in the population are of a large size, indicating poor recruitment. The population declines of the Ozark hellbender is documented in a study over a 20 period as declining by an average of approximately 70%. (Wheeler *et al*. 2003). The cause(s) for this dramatic decline in population numbers and shift in age structure is unknown.

The Ozark hellbender is a candidate species for listing under the Endangered Species Act.

ACKNOWLEDGEMENTS

This Conservation Assessment was prepared to compile the published and unpublished information on the Ozark hellbender (*Cryptobranchus alleganienis bishopi*). Much of the information contained in this document was obtained from "Status Review of Ozark Hellbender (*Cryptobranchus alleganiensis bishopi*)" by Susan O. Rogers, U.S. Fish and Wildlife Service, Conway, Arkansas. Most references cited in this document were obtained from Susan O. Rogers and from Jeff Briggler, Missouri Department of Conservation, Jefferson City, Missouri. Contributions by other authors are cited in the text or listed under contributing authors.

NOMENCLATURE AND TAXONOMY

The Ozark hellbender (*Cryptobranchus alleganiensis bishopi*) was originally designated as *C. bishopi* by Grobman (1943) from a specimen collected from the Current River in Carter County, Missouri. Due to the small amount of genetic variation possessed by the genus *Cryptobranchus* (Merkle *et al*. 1977, Shaffer and Breden 1989), Schmidt (1953) referred to the Ozark hellbender as a subspecies of the eastern hellbender, *C. alleganiensis*, and this was supported by Dundee and Dundee (1965). This designation persisted until Collins (1991) revived *C. bishopi*, due to the lack of intergradatio n between the eastern and Ozark hellbenders, which is unlikely to occur due to the allopatry of populations of these species (Dundee 1971). Although Ozark hellbenders have been shown to be distinct phenotypically (Grobman 1943, Dundee and Dundee 1965, Dundee 1971) and genetically (Routman 1993, Wagner *et al*. 1999) from eastern hellbenders, the U.S. Fish and Wildlife Service will continue the use of *C. a. bishopi*, (Rogers, 2001) which is the name currently recognized by the Center for North American Amphibians and Reptiles (Collins 1997). Although discussion continues over the taxonomic status of the Ozark hellbender, the designation of the Ozark hellbender as a species or subspecies does not affect its qualification for listing under the Endangered Species Act (87 Stat. 884, as amended: 16 U.S.C. 1531 et seq.); (Rogers, 2001).

DESCRIPTION OF SPECIES

The Ozark hellbender is a large, strictly aquatic salamander endemic to streams of the Ozark plateau in southern Missouri and northern Arkansas. Its dorso- ventrally flattened body form helps it remain immobile in the fast flowing streams it inhabits (Wagner *et al*. 1999). Hellbenders have a large keeled tail and tiny eyes. Adult Ozark hellbenders may attain total lengths of 29 - 51 cm or 11 ½ to 20 inches (Dundee and Dundee 1965, Johnson 2000). Numerous fleshy folds along the sides of the body provide surface area for respiration (Nickerson and Mays 1973a) and obscure poorly developed costal grooves (Dundee 1971). Ozark hellbenders are distinguishable from eastern hellbenders by their smaller body size, dorsal blotches, increased skin mottling, heavily pigmented lower lips, smooth surfaced lateral line system, and reduced spiracular openings (Grobman 1943, Dundee 1971, Peterson *et al*. 1983, LaClaire 1993).

LIFE HISTORY

1. Reproduction

Breeding generally occurs between September and November, with Spring River populations breeding in January (Peterson *et al*. 1983). Ozark hellbenders mate via external fertilization, and males will guard the eggs from predation by conspecifics (Nickerson and Mays 1973a). Clutch sizes vary from 138 to 450 eggs per nest (Dundee and Dundee 1965, Zug 1993), and eggs hatch after approximately 80 days (Zug 1993). Hatchlings and larvae are rarely collected during surveys, likely due to low capture efficiency and high mortality of young. Larvae and small individuals often live beneath small stones in gravel beds or shallow water habitats (Nickerson and Mays 1973a, LaClaire 1993).

2. Ecology

Typically, Ozark hellbender populations are dominated by older, large adults (Nickerson and Mays 1973a, Peterson *et al*. 1983, LaClaire 1993). Juveniles reach sexual maturity between 5 and 8 years, with males maturing at a smaller size and younger age than females. Ozark hellbenders may live 25 - 30 years in the wild (Peterson et al. 1983).

Adults are nocturnal, remaining beneath cover during the day and emerging to forage primarily on crayfish at night, although they are not entirely nocturnal (Nickerson and Mays 1973a, Noeske and Nickerson 1979, Collins 1997). Ozark hellbenders are territorial and will defend occupied cover from conspecifics (Nickerson and Mays 1973a).

3. Dispersal/Migration

Dispersal and/or migration of hellbenders appear to be limited. Nickerson and Mays (1973a) revealed that 70% of marked individuals move < 30 meters from the original site of capture. Peterson and Wilkinson (1996) study on eastern hellbenders showed that males (81 square meters) had larger average home ranges than females (28 squares meters).

4. Obligate Associations

Although there is limited information regarding obligate associations between hellbenders and other species, crayfish undoubtedly performs an important role, especially since crayfish are the primary prey item. Also, the leech (*Batracobdella cryptobranchii*) is known to only occur on

Ozark hellbenders. Although other species of leeches exist in hellbender streams, only *B. cryptobranchii* has been reported on Ozark hellbenders. Apparently, there is some type of association between *B. cryptobranchii* and Ozark hellbenders (Briggler, pers. Com.).

HABITAT

1. Range-wide

The Ozark hellbender is a benthic aquatic salamander, endemic to the Ozarks, which inhabits rocky, clear streams and rivers, usually with large shelter rocks. The species avoids water warmer than 20 C or 68 F (Nickerson and Mays, 1973a).

2. National Forests

The Mark Twain National Forest in the USA is the only National Forest where the Ozark hellbender is known to occur.

3. Site Specific

Adult Ozark hellbenders are frequently found beneath large rocks in moderately deep (< 1m), rocky, fast flowing streams in the Ozark plateau (Johnson 1987, Fobes and Wilkinson 1995, Wagner *et al*. 1999). In spring fed streams, hellbenders typically concentrate just downstream of the area where there is no temperature change throughout the year (Dundee and Dundee 1965).

DISTRIBUTION AND ABUNDANCE

1. Range-wide Distribution

Ozark hellbenders are endemic to the Black and White River drainages in Arkansas and Missouri (Johnson 2000) in portions of the Spring, White, Eleven Point, and Current Rivers and their tributaries (LaClaire 1993). Over the past 20 years populations have declined by around 70% in the Eleven Point and North Fork of the White River. The limited range of the Ozark hellbender makes it of particularly critical concern (Wheeler *et al.* 2003). The Ozark hellbender is declining throughout its range, and no populations appear to be stable (Rogers 2001). A description of the known Ozark hellbender populations follows.

a. White River System

White River - There is only one Ozark hellbender record from the main stem of the White River in Baxter County, Arkansas, in 1997 (Dr. S. Trauth, ASU, pers. com.). It is not known whether a viable population exists at this site or if the individual is a member of a relic population that was separated from the North Fork of the White River population by Norfork Reservoir. This area was surveyed during the summer 2001; however, none were found (Wheeler and Trauth 2002). It appears the Ozark hellbender may be extripated in the main stem of the White River.

North Fork of the White River - In 1973, results of a mark-recapture study indicated approximately 1,150 hellbenders within 2.67 km in Ozark County, Missouri, with a density of 1/8-10 m^2 (Nickerson and Mays 1973b). Ten years later, hellbender density in a 4.6 km section of the North Fork White River in the same county remained rather high, with densities between 1/6-7 m^2 and 1/13-16 m^2 (Peterson *et al*. 1983). Individuals caught in this study represented a range of lengths (172-551 mm), with most individuals between 250 - 449 mm, indicating that reproduction was

occurring in this population. Subsequently, in a 1992 qualitative study also in Ozark County, Missouri, 122 Ozark hellbenders were caught during 49 man-hours (Ziehmer and Johnson 1992). These individuals ranged from 254 - 457 mm, and no average size was presented. Up to this point, the North Fork White River populatio n appeared to be fairly healthy (Rogers 2001). However, after reports of hellbender declines in the North Fork White River, a 1998 study of the same stretch of river censuses in 1983 (Peterson *et al*. 1983) using the same collection methods resulted in the capture of only 50 hellbenders (Wheeler *et al*. 1999). These individuals ranged in length from 200 - 507 mm, with most between 400 - 500 mm, and were on average significantly longer than those collected twenty years prior. This shift in length distribution was not a result of an increase in maximum length of individuals; instead, there were fewer individuals collected in the smaller size classes (Wheeler 1999). The collection of young individuals has become rare, indicating little recruitment. Over the past 20 years, populations in the North Fork of the White River have declined by around 70% (Wheeler *et al.* 2003). The North Fork of the White River was once considered the stronghold for the species and populations inhabiting this river were deemed stable as late as 1993 (Ziehmer and Johnson 1992, LaClaire 1993). It now appears the Ozark hellbender could become extripated in the North Fork of the White River in Missouri.

Bryant Creek - Bryant Creek is a tributary of the North Fork of the White River in Ozark County, Missouri, and flows into Norfork Reservoir. Ziehmer and Johnson (1992) expected to find Ozark hellbenders in this stream during their survey, but none were discovered after 22 man-hours. Missouri Department of Conservation (MDC) personnel, as well as fisherman, have reported observations of fairly high numbers of hellbenders in Bryant Creek during winter months (Ziehmer and Johnson 1992). A subsequent study resulted in 6 hellbenders captured from Bryant Creek (Wheeler *et al*. 1999), confirming the existence of a population in this tributary. This population is isolated from that in the North Fork of the White River by Norfork Reservoir, which could contribute to this population's apparent small size (Rogers 2001).

b. Black River System

Black River - There is no documented records of Ozark hellbenders in the Black River in Missouri, although it has not been extensively surveyed. Portions of the Black River in Missouri were surveyed in 1999, but no Ozark hellbenders were observed (Wheeler *et al*. 1999). Additional Ozark hellbender surveys are recommended for portions of the Black River near Centerville, Missouri (Briggler, pers. Com.).

Spring River - The Spring River, a tributary of the Black River, flows from Oregon County, Missouri, south to Arkansas. Large Ozark hellbender populations have been found in the Spring River near Mammoth Spring, Fulton County, Arkansas (LaClaire 1993). In the early 1980's, 370 individuals were captured during a mark-recapture study along 7 km south of Mammoth Spring (Peterson *et al*. 1988). Hellbender density at each of the two surveyed sites was fairly high (approximately 1/23 m^2 and 1/111 m^2). These individuals were considerably larger than hellbenders captured from other streams during the same time period, with 74 percent of Spring River Ozark hellbenders measuring over 450 mm total length (maximum 600 mm) (Peterson *et al*. 1988). In 1991, a longer reach (26 km) was surveyed for Ozark hellbenders, and only 20 were observed during 41 search hours of the 6 month period, at many of the same sites as Peterson (Trauth *et al*. 1992). In the following four years, an additional 33 were captured during sporadic surveys by the same researchers (Trauth and Wilhide 1997). No length information is available,

although the large sizes of the 1988 captures may be indicative of a population experiencing little recruitment. Although the recent surveys were less intensive than the previous studies, it is fairly apparent that hellbenders are scarcer in this stream (Rogers 2001).

Eleven Point River- The Eleven Point River, a tributary of the Black River, has been surveyed several times since the 1970's. Historical data provided by Peterson was analyzed by Wheeler (1999). In 1978, 87 hellbenders were captured in Oregon County, Missouri, over 3 days, yielding 29 hellbenders/day. Later, in 9 collection days from 1980 - 1982 in the same area, 314 hellbenders were captured, yielding 35 hellbenders/day. Lengths over this period ranged from 119 - 451 mm. Six years later, Peterson *et al*. (1988) captured 211 hellbenders from the Eleven Point River and estimated hellbender density to be approximately 1/20 m^2. Total lengths of these individuals ranged from approximately 120 - 450 mm, with most between 250 - 350 mm. Although it was not presented, it can be estimated that roughly 40 hellbenders were caught per day during this study (Rogers 2001). Approximately 10 years later, Wheeler (1999) captured 36 hellbenders over 4 days from Peterson *et al*.'s (1988) historical sites, for an average of 9 hellbenders per day. These hellbenders were larger than those captured previously, with total lengths of 324 - 457 mm, and there were significantly fewer individuals in the smaller size classes. It appears the population was stable until 1988 (captures of 29, 35, and roughly 40 hellbenders/day), and then dropped in 10 years to 9 hellbenders/day, and these individuals were considerably larger than those caught previously (Rogers 2001). Between the early 1980's and the late 1990's, population of Ozark hellbenders in the Eleven Point River declined by around 70% (Wheeler 2003). The Eleven Point River population shows lack of recruitment and population numbers are declining rapidly.

Current River- The Current River had not been surveyed extensively until the 1990's. Nickerson and Mays (1973a) reported an Ozark hellbender population in this stream, but no numbers were presented. In 1992, Ziehmer and Johnson (1992) found 12 Ozark hellbenders in 60 man- hours in Shannon County, Missouri, or approximately 5 hellbenders per day, using the same search day conversion as above. These individuals ranged in length from 115 mm to over 380 mm (maximum length was not reported), with most between 330 mm and 380 mm. Seven years later, 14 hellbenders were collected over 3 collection days (approximately 5 hellbenders/day), also in Shannon County, Missouri, and the individuals ranged from 375 - 515 mm, with most between 450 - 499 mm (Wheeler 1999). It appears this population is small, although not declining. However, the average size of individual has increased by nearly 100 mm, and this population shows similar lack of recruitment as other populations (Rogers 2001).

Jacks Fork- Jacks Fork, a tributary of the Current River, was surveyed for the first time in 1992 for Ozark hellbenders (Ziehmer and Johnson 1992). Four hellbenders were collected over 66 man-hours, roughly 2 hellbenders/day. The individuals were large, ranging from 330 - 430 mm. On August 12, 2003, MDC staff surveyed for hellbenders on the Jacks Fork from Alley Spring Access to Buttin Rock Access. Six locations along this reach were searched for hellbenders, including the site in which 4 hellbenders were observed in 1992 (Ziehmer and Johnson 1992). Although suitable habitat exists along this reach, no hellbenders were found (Briggler pers. Com.). It is not known if the Ozark hellbender has been extripated from the Jacks Fork; however, there appears to be that possibility.

2. National Forest Distribution

The Ozark hellbender is located within the proclamation boundary of the Willow Spring unit in the North Fork of the White River and the Doniphan-Eleven Point Ranger District in the Eleven Point River and the Current River. The 2003 Missouri Natural Heritage data base created by MDC list a total of 18 sites within the MTNF proclamation boundaries of which 15 sites are directly associated with adjacent National Forest lands. There are two sites on the North Fork of the White River, thirteen Sites on Eleven Point River, and one site on the Current River, directly associated with National Forest lands. There have been no confirmed reports in the Black River on the Poplar Bluff Ranger District; however, the Black River watershed is known to be within the historical range of this species.

RANGE WIDE STATUS

The Ozark hellbender is a candidate species for listing under the Endangered Species Act. A federal candidate species is one with sufficient information on vulnerability and status to support listing as threatened or endangered.

In the MDC "Missouri Species and Communities of Conservation Concern Checklist" dated January, 2003, the Ozark hellbender is listed as an S1 species. A numeric *"rank"* of S1 means the species is critically imperiled in the state because of extreme rarity or because of factor(s) making it especially vulnerable to extirpation from the state. On March 20, 2003, MDC elevated the Ozark hellbender *"status"* to Endangered in the "Wildlife Code of Missouri, Rules of the Conservation Commission, Administrative Office, PO Box 180, Jefferson City, MO 65102" (Rules 3, Code of State Regulations 10-4.111 Endangered Species).

The State of Arkansas, Arkansas Natural Heritage Commission, 1500 Tower Building, 323 Center Street, Little Rock, AR 72201, list the Ozark hellbender as a S1 species. A numeric *"rank"* of S1 means the species is critically imperiled in the state because of extreme rarity or because of factor(s) making it especially vulnerable to extirpation from the state. (Cindy Osborne, pers. Com.).

The Ozark hellbender is ranked a G3G4T3Q (13Aug2001) in NatureServe Explorer: An online encyclopedia of life [web application]. 2002. Version 1.6 . Arlington, Virginia, USA: NatureServe. Available: http://www.natureserve.org/explorer. (Accessed: May 30, 2003). G3 means the species is rare or uncommon, or in a restricted range, or vulnerable to extinction throughout its range because of specific factors. G4 means the species is widespread, abundant and apparently secure. T3Q is a subspecies rank and means the subspecies is rare or uncommon, or in a restricted range, or vulnerable to extinction throughout its range because of specific factors and questionable taxonomy. It should be noted NatureServe ranked the species on 13 August 2001. An up-to-date ranking by NatureServe is expected.

POPULATION BIOLOGY AND VIABILITY

The viability of the Ozark hellbender is in question. The population declines of the Ozark hellbender is documented in a study over a 20 period as declining by an average of approximately 70%. This decline begins in the mid 1980's. The decline is marked by a shift in density and age

structure. Hellbender populations have fewer individuals and those left in the population are of a large size, indicating poor recruitment (Wheeler *et al*. 2003).

POTENTIAL THREATS

1. Present or Threatened Risks to Habitat

The decline of the Ozark hellbender in the White and Black River systems in Missouri and Arkansas is likely the result of habitat degradation. Although the precise cause of hellbender declines remains unknown, habitat degradation is the most frequent cause of lotic faunal declines (Allan and Flecker 1993). Hellbenders are habitat specialists that depend on constant levels of dissolved oxygen, temperature, and flow (Williams *et al*. 1981). Therefore, even minor alterations to stream habitat could be detrimental to hellbender populations. Impoundments, water quality, and den site disturbance appear to have degraded habitat for hellbenders (Williams *et al*. 1981, La Claire 1993).

Impoundments impact stream habitat in many ways. When a dam is built on a freeflowing stream, riffle and run habitats in the area impounded by the dam are converted to open water. Temperature and dissolved oxygen levels are changed by the lotic conditions of the water (Allan 1995). Because hellbenders are habitat specialists, they cannot tolerate a wide range of habitat conditions. Hellbenders depend upon highly vascularized lateral skin folds for respiration; therefore, lakes and reservoirs are unsuitable habitats for Ozark hellbenders, as these areas have lower oxygen levels (Williams *et al*. 1981, LaClaire 1993) than their fast flowing, cool water, highly oxygenated stream habitat. Impoundments on inhabited streams create unsuitable habitat for hellbenders and are impediments to movement between populations.

Norfork dam was constructed on the North Fork of the White River in 1944 and has isolated Ozark hellbender populations north and south of Norfork Reservoir. Ozark hellbender populations in Bryant Creek and the North Fork of the White River in Missouri are now isolated from Ozark hellbender populations on the main stem of the White River in Arkansas. Additionally, populations downstream of Norfork dam were likely extirpated due to hypolimnetic releases from the reservoir. These releases are much cooler than normal stream temperatures, and the water typically is depleted of oxygen. In addition, tailwaters experience extreme water level fluctuations and scouring for many miles downstream which likely jeopardize hellbender populations.

Items which have the potential to cause water quality problems in watersheds with Ozark hellbender populations include: large numbers of livestock in riparian zones for extended periods of time, private septic system failure, increased nutrients from municipal sewage treatment facilities, improper sand and gravel removal, indiscriminate land clearing, road construction and maintenance, and pesticide or fertilizer runoff from fields. (Wilkerson, 2003).

Livestock in riparian zones and improper sewage treatment can result in periodic high fecal colifo rm levels and nutrient loading. A portion of the Jacks Fork, a major tributary of the Current River, is currently included on the 303d list due to high fecal coliform counts which periodically exceed state standards for whole-body contact recreation indicating the presence of excessive organic wastes (MDNR 1994 and USGS 2001c). Gravel dredging and poor land use practices such as indiscriminate land clearing can cause significant soil erosion, sediment deposition, and

degradation of in-steam habitat (Miller & Wilkerson, 2000). Roads can cause marginally stable slopes to fail, and they can capture surface runoff and channel it directly into streams resulting in increased sediment deposition(Allan 1995). The USGS identified nine pesticides in its National Synthesis Project water quality sampling for pesticide compounds within the Current River Watershed (Wilkerson, 2003).

The Krast features within the Ozark watersheds acts as a direct link to the ground water system. Activities as described above pose a threat to the quality of the water in the many spring discharge sites, where the Ozark hellbender is located. These cold water spring discharges (approx. 58 degrees F) provide the needed water temperatures for the Ozark hellbenders. Poor water quality at spring discharges may be causing the decline of the Ozark hellbender; however, there are no qualitative analysis indicating this is the case.

Habitat disturbance may be affecting hellbender success in several rivers. Recreation use (canoeing, fishing, & gigging) is common in many of the rivers inhabited by the Ozark hellbender, including the Spring, Current, and North Fork White Rivers. It has been speculated that the disturbance of den sites by contact with canoes may kill or cripple the Ozark hellbender by smashing the animal (Nickerson & Mays, 1973a). In addition, some larger rocks have been removed in order to prevent canoe damage and this may have destroyed highly suitable hellbender den sites (Nickerson and Mays 1973a, Wheeler *et al*. 1999).

2. Overutilization

Anecdotal reports indicate that Ozark hellbenders have been collected for commercial and scientific purposes (Trauth *et al*. 1992). Commercial and non-commercial collections are currently illegal in both Missouri and Arkansas, but hellbenders may be collected with a permit from the appropriate state agency. In 1992, a gentleman from Alabama confessed to illegally collecting 100 or more hellbenders from the North Fork of the White River in the mid 1980's to sell to the pet trade. Also, hellbenders are susceptible to anglers, gigging for suckers. Over the years, gigged hellbenders have been found throughout the range of hellbenders in Missouri (Briggler pers. Com.). Because the species is long lived and does not reproduce until approximately age 7, the removal of even a few individuals from a population that is experiencing declines can impact the recruitment potential of that population (Rogers, 2001).

3. Disease or predation.

The majority of hellbenders captured in the past few years have an alarming number of abnormalities; mainly the absence of toes with exposed flesh (Trauth pers. Com.). Although the causes of these abnormalities are unknown, some type of disease might be involved.

Within their natural range, most aquatic plants and animals are kept in check by the powerful forces of competition, predation, and disease. If moved to new regions, however, these aquatic species may be freed from their normal biological and physical constraints, and spread unfettered. They displace native aquatic plants and animals, disrupt ecological processes, upset the stability of ecosystems, and can permanently change our natural landscapes.

In the past decade, numerous publications have indicated the ne gative impacts that non-native trout have on native species with the majority of the work focusing on amphibian assemblages in

mountain lakes (Bradford 1989, Bradford et al. 1993, Brana 1996, Frank and Dunlap 1999, Knapp and Mathews 2000). Although there has not been any direct evident of the effects of trout on hellbenders; other species of salamanders have been impacted by trout (Tyler et al. 1998a and 1998b, Rundio and Olson 2003). Salamanders have developed the ability to respond (fright response) to chemical cues of known predators. Recent evidence by Unger (2003) indicates that hellbender larvae from Missouri do not show a fright response to chemical cues by trout. Thus, indicating that larvae hellbenders would not adjust their behavior to trout and therefore, trout could decrease the survival of hellbender larvae. Since trout and hellbender habitats overlap in Missouri and Arkansas, further investigation is warranted.

4. The inadequacy of existing regulatory mechanisms.

The states of Arkansas and Missouri prohibit the taking of Ozark hellbenders for any purpose without a state collecting permit. However, enforcement of this permit requirement is difficult. Additionally, state regulations do not protect hellbenders from other threats.

Existing authorities available to protect riverine ecosystems, such as the Clean Water Act (CWA), administered by the Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers, may not have been fully used to prevent instream activities and the resulting habitat degradation. This may have contributed to the general habitat degradation apparent in riverine ecosystems and loss of populations of aquatic species in the southeast. Although the Ozark hellbender coexists with other federally listed species throughout parts of its range, listing under the Endangered Species Act wo uld provide additional protection, as the threats to hellbenders and the other endangered species are not identical. Federal permits would be required to take the species, and federal agencies would be required to consult with the Service when activities they fund, authorize, or carry out may adversely affect Ozark hellbenders (Rogers, 2001).

5. Other natural or manmade factors affecting its continued existence.

Certain population characteristics of Ozark hellbenders cause the species to be fairly vulnerable to extirpations and extinction. The Ozark hellbender, having specialized habitat requirements, is extremely vulnerable to environmental perturbations. When populations are small, they are less likely to rebound following these perturbations. In addition, Ozark hellbenders exhibit very low genetic diversity (Merkle *et al*. 1977, Wagner *et al*. 1999). This genetic uniformity is consistent with habitat specialization (Nevo 1978, Wagner *et al*. 1999). Ozark hellbenders have adapted to a relatively constant environment, and therefore several structural, behavioral, and physiological specializations have resulted (Williams *et al*. 1981). These specializations, in combination with the stable environment, seem to have resulted in very low levels of genetic dive rsity (Wagner *et al*. 1999). This has been exacerbated with the fragmentation of populations by impoundments, habitat degradation, and other impediments to dispersal. Without the level of interchange the hellbender experienced historically, many small, isolated populations do not receive the influx of new genetic material that once occurred. As the populations decrease in size, genetic diversity is lost and inbreeding can occur, which may result in decreased fitness, and the loss of genetic heterozygosity can result in a significantly increased risk of extinction in localized natural populations (Saccheri *et al*. 1998). With fragmentation, local extinctions cannot be repopulated (Rogers, 2001).

Ozark hellbenders do not reproduce until approximately 7 years of age. Declines being observed presently may be the result of activities that occurred years earlier. Because juvenile hellbenders

are rarely observed, it takes many years to detect population trends. The lack of recruitment in most all Ozark hellbender populations is a significant sign that little reproduction has occurred in these populations for several years. Delayed reproduction, when paired with a long life span, can disguise declines until they become fairly severe (Rogers, 2001).

The present distribution and status of Ozark hellbender populations in the White and Black River systems in Arkansas and Missouri may be demonstrating the characteristics mentioned above. Genetic studies have demonstrated repeatedly very low genetic diversity in hellbender populations, which may be a factor in the decline of the species. The current combination of population fragmentation and habitat degradation may prohibit this species from recovering without the intervention of conservation measures designed to facilitate hellbender recovery (Rogers, 2001).

SUMMARY OF LAND OWNERSHIP & EXISTING HABITAT PROTECTION

Ownership of water

In most Missouri river systems, the water belongs to the people of the State of Missouri and therefore is property of the State. The State Legislature passed laws which empowered the Department of Natural Resources (DNR) and Missouri Department of Conservation (MDC) to manage waters within the State for the people of the State.

Ownership of aquatic wildlife

The State Legislature passed laws which empowered MDC to manage wildlife and fish population within the State for the people of the State. The wildlife code of Missouri (www.state.mo.us) list those animals (both terrestrial and aquatic) yo u may take. If an animal is not listed, it may not be taken.

Per the "2003-2004 Arkansas Hunting and Guide book" up to six individual of a species that is neither hunted or trap may be kept per household if taken by hand from the wild so long as they are not birds, bats, ornate box turtles, alligator snapping turtles, hellbenders, cave-dwelling creatures or endangered species, page 24 (federal listed species page 26). Therefore, hellbenders are protected under Arkansas State regulations (Cindy Osborne, pers. Com.) and may not be taken.

Ownership of land

Approximately 80 percent of the land within the watershed of the Ozark hellbender is in private ownership, with the remaining 20 percent in Federal or State ownership (Rogers, 2001).

Habitat protection

Except for the Eleven Point River, public lands total a small percentage within those watersheds where the Ozark hellbender is located. Therefore, during the next decade, private landowners will determine land uses on the vast majority of these watersheds. Current land uses on private ownerships include homes, pastures, forest, and small businesses. Private lands are a mixture of open pastures, developed areas, and some forest. Past trends on private land are toward an increase in fescue pastures and developed areas. Private woodlands are being heavily harvested, since timber prices are relatively high. If these trends continue, it is likely that there will be less forest on private ownerships at the end of this decade, and more openland or developed land.

Forested riparian along streams play a major role in maintaining water quality and stream bank stability.

On National Forest lands, special habitats (glades, springs, seeps, fens, wetlands, riparian corridors, bottomland hardwood forest, caves, and sinkholes) are protected and managed as needed to maintain the unique qualities of these areas, including the Ozark hellbender.

SUMMARY OF EXISTING MANAGEMENT ACTIVITIES (MTNF)

North Fork of White River (Feakes pers. Com.).

- The North Fork Recreation Area, including a day use area with a boat launch and picnic facilities and a campground, is located adjacent to the North Fork of the White River. With an overnight camping fee of $8/site/night, and a day use parking fee of $2/vehicle/day, these recreation areas have total revenue of about $6,000-$6,500/year.
- This recreation area is an important launch site for canoes by outfitters and persons who have their own canoes. It is estimated that over 6,000 canoes/year are launched from this site by outfitters. There are no current estimates of privately launched canoes available.
- Recent improvements to this recreation area include replacement of the toilet in the day use area in 2003. Future improvements include replacement of toilets in the campground with 2 accessible toilets, and repaving of the road and campground spurs.
- The campground has previously been operated by a concessionaire, but is currently being operated by the Forest Service. It will be offered again for concession in the near future.
- Eighteen miles of this river, from the northern district proclamation boundary south 18 miles, is a 5d study river determined to be eligible for consideration as a recreation river under the Wild & Scenic Rivers Act, and is currently being managed under Rx 6.3. See Appendix C of the Land Management Plan for more details.

Eleven Point (Feakes pers. Com.).

- Most recreational use of the river is for canoeing and for fishing; other major recreational activities within the scenic river corridor include hiking, hunting, and camping.
- Dispersed camping occurs at some of the boat launches, (such as Riverton and Turner South), the float camps, and on gravel bars and other undeveloped locations along the river.
- Motorized watercrafts are limited to 25hp from the Narrows at Hwy 142 to the Hwy 99 bridge at Thomasville.
- Estimated that almost 85% of the canoe use is by outfitted recreationists. In 2001, 4 outfitters reported launching 3382 canoes, with 6,353 floating in those canoes.
- Main trails in this corridor are the Ele ven Point River section of the Ozark Trail, the McCormack-Greer Trail, and the Greer Spring Trail.
- Irish Wilderness borders the Eleven Point Scenic River corridor for about 7 miles.
- Greer Crossing, the only developed campground within the Scenic River Corridor, has 19 campsites, and has had annual receipts of $5,500 - $6,500 each of the last 5 years. Camping fee is $8/night, (50% discount for golden Age or Golden Access).
- Dispersed camping occurs at some of the boat launches, (such as Riverton and Turner South), the float camps, and on gravel bars and other undeveloped locations along the river.

- Recent reconstruction includes replacement of vault toilets at Riverton East and West, Turner South, Cane Bluff, and Greer.
- Access points at Greer, Riverton, Hwy 142, Thomasville, & Cane Bluff are being reconstructed under contract in 2003-2004. Reconstruction includes replacement of deteriorated tie walls, steps, ripraps and boat launches with concrete structures.
- Future reconstruction work planned within the next five years includes reconstruction of facilities at six primitive float camps, (including replacement of walls, steps and toilets), and possible redesign and reconstruction at Whitten, Boze Mill, and Morgan Spring and possible trail construction and reconstruction at Morgan Spring and Greer Spring.
- We do not anticipate river use increasing by more than 10% over the next 5 years, even with the newly rehabilitated.

Lower Current River (Feakes pers. Com.).

- Float Camp, Deer Leap and Bay Nothing are the 3 primary access points to the Lower Current River, (between the Ozark National Scenic Riverways and the City of Doniphan). Float Camp and Deer Leap both have campgrounds and day use areas that are operated by a concessionaire. With an overnight camping fee of $8/site/night, and a day use parking fee of $2/vehicle/day, these recreation areas have total revenue of about $9,000/year. Dunrovin is a minor access point that has a pavilion for day use, and has no charge for parking or other use.
- The two outfitters that operate on this portion of the river offer tubes, canoes and rafts, and provided floating opportunities for almost 5,800 people in 2001. Over 55% of theses floaters used tubes, approximately 29% of these people used rafts for their float, and just over 15% of them canoed. Very few craft are rented outside of the Memorial Day to Labor Day summer season, and most of the ones that are rented outside this period are rafts. The most common float trip is from Deer Leap to Doniphan.
- Recent improvements along this section of river include reconstruction of the toilets at Float Camp and Bay Nothing, and dredging of material around the boat launches at Deer Leap and Bay Nothing.
- Flooding has repeatedly damaged the campground at Deer Leap, and washed out sections of the road and launch areas. There are no plans to make further investments in the Deer Leap recreation area, and the paved road is being converted to gravel. We will continue to provide a launch site for boats, canoes and tubes within the Float Camp/Deer Leap location.
- The Forest is considering removal of facilities at Dunrovin within the next few years.

PAST AND CURRENT CONSERVATION ACTIVITIES

1. The Ozark Hellbender Working Group

The Ozark Hellbender Working Group met February 14, 2003, in West Plain, Missouri. This group has been in existence since September 2001 and has been working cooperatively for hellbender conservation since then, although individual members have been working for hellbenders for years, if not decades, prior to that. The minutes of this meeting can be found in the Appendix. At this meeting the following committees were established:

Captive Care and Head Start Protocol (or simply Propagation Protocol?)
Chair: Tom Johnson
Members: Dewayne French, Ron Goellner, Richard Shelton

Conservation Planning
Chair: Susan Rogers
Members: Amy Salveter

Monitoring and Data Compilation
Jeff Briggler, Kelly Irwin

Outreach and Education
Chair: Amy Smith
Members: Jeff Briggler, Theresa Davidson, Jason Elrod, Dewayne French, Yue-wern Huang, Tom Johnson, Amy Salveter, Ben Wheeler

Research
No members yet- if no volunteers soon, Susan will come up with research priorities for review and comment by the group

Watershed Protection
Chair: Kelly Irwin
Members: Al Christian, Lisa Irwin, Susan Rogers

2. Conservation strategy

The Fish and Wildlife Service is working on the development of a conservation plan for the Ozark hellbender. The Mark Twain National Forest is working on "Forest Plan Revision". It is expected the Forest Plan revision will incorporate protection measures for the Ozark hellbender

RESEARCH AND MONITORING

The Ozark Hellbender Working Group is developing a standard monitoring protocol for the Ozark hellbender, as well as research priorities.

There are at least three Universities doing research and monitoring of the Ozark hellbender, Arkansas State University (ASU), Southwest Missouri State University (SMSU) and University of Missouri – Rolla (UM-Rolla). A summary from the three universities known to be doing studies follow:

1. ASU (report by Ben Wheeler and Stan Trauth)

a. Existing Surveys, Monitoring, and Research

All rivers known to harbor Ozark hellbenders are found in the Black (Current, Jack's Fork of the Current, Eleven Point) and White (North Fork of the White River and Bryant Creek) river systems. Although the Ozark hellbender can be found in both systems in Missouri, populations have only been confirmed in the Eleven Point and Spring rivers in the Black River system in Arkansas.

The Spring River population was studied extensively in the 1980s (Peterson 1985; Peterson et al. 1988; 1989a; 1989b). Peterson et al. (1988) reported finding 340 hellbenders from 1980-1982, within two locations in the upper Spring River. A decade later Trauth et al. (1992) was only able

to find 20 large adult hellbenders. Trauth et al. (1992) searched 10 sites, including the two historical locations. This was the first report of declines in the Ozark hellbender populations.

Hellbender populations have long been known in the Eleven Point River, MO (Nickerson and Mays 1973); however, it was not until the Spring River decline prompted a survey of other Arkansas waters, that hellbenders were found in the Eleven Point River, AR (Trauth et al. 1993). Since then ASU has continued survey efforts in the Eleven Point River (in Arkansas) and has found several locations harboring hellbenders. The populations in these areas are similar to those described in Missouri (Wheeler et al. 2003), with the greatest portion of the population being large adults.

ASU recent research has focused on the following: 1) characterizing the abnormalities found in the Ozark hellbender, 2) continuing survey efforts in new areas of potential hellbender streams and investigating reports of hellbender sightings, and 3) establishing a captive propagation program of the Ozark hellbender at the Mammoth Spring National Fish Hatchery.

b. Survey Protocol

The hellbender water in Arkansas differs from that found elsewhere in the range of the hellbender, in that the waters tend to be deeper, more silt- laden, and have a lower visibility. The survey protocol we utilize is a combination of those used by other researchers. We survey both new locations and historical sites. Hellbenders are located by turning large rocks, logs, and other cover objects. In areas of extremely large rocks, a log peavy is used to aid in the lifting of rocks. We occasionally conduct nocturnal searches with waterproof flashlights. Scuba gear is used to aid in search efforts.

All animals collected are measured for total length, snout-vent length (to the anterior margin of the vent). Sex is determined during the breeding season. Hellbenders are also PIT tagged (AVID), and a genetic sample is taken from the dorsal portion of the tail. Captured animals are the n immediately released.

Sample sites chosen are loosely based on the habitat description given in Fobes (1995). ASU routinely sample sites that are slower, siltier, and deeper.

c. Research Priorities

Currently ASU is focusing research efforts on the following: 1) an analysis of hellbender habitat at the landscape scale, 2) an analysis of male hellbender movements before, during, and after the breeding season using radio telemetry, 3) an analysis of the nesting chamber microhabitat, 4) a continuance of mo nitoring selected known hellbender populations, and 5) a continuance of captive propagation efforts.

2. SMSU (report by Alicia Mathis)

a. Existing Surveys, Monitoring, and Research

Extensive population surveys were conducted in 1998-1999 for *C. a. alleganiensis* (Big Piney River, Gasconade River, Niangua River) and *C. a. bishopi* (Elelven Point River, North Fork of White River) in Missouri. When compared to historical data from the 1970's and 1980's, all

populations showed dramatic decreases in numbers (75-85%) and a disproportionate decline in the proportion of young (small) individuals. These data have been published (Wheeler et al. 2003. Biological Conservation 109:151-156).

Because the 1998-1999 surveys revealed an apparent problem with recruitment of young individuals, current research is focusing on examining reproductive health of both sub-species in these declining populations. SMSU is examining two major reproductive indicators: (1) quality of sperm production, and (2) survival and growth of eggs and larvae. Our approach is to compare data for the declining populations with data for hellbenders from populations of *C. a.alleganiensis* from the eastern United States that appear to be more stable. There apparently are no healthy populations of *C. a. bishopi*. We also have made a few unsuccessful attempts at artificial insemination and captive breeding.

b. Survey Protocol

SMSU survey protocol is to re-visit sites that have historically contained hellbenders. We sample by wading/snorkeling and turning large rocks. Specific sampling sites are selected using the criteria established by Fobes (1995, unpublished master's thesis, SMSU) – areas that are 1-2 meters deep with rocky bottoms and swift currents. Hellbenders are caught by hand, weighed, measured for total length, and evaluated for reproductive status (whether males have swollen cloacae and whether females are gravid). For SMSU current research, SMSU stripped milt from males for quantification of sperm health parameters. SMSU collected a few naturally produced clutches of eggs, transported them to the laboratory in Springfield, and monitored development of eggs and larvae.

c. Research Priorities

SMSU current priority is completing the comparison of populations (declining versus healthy) with respect to sperm health and growth of embryos and larvae. Captive rearing of larvae has been successful, and SMSU believes future research in this area could be productive for conservation efforts. In addition, in a behavioral experiment, SMSU preliminary data indicate that failure of larvae to recognize the danger imposed by introduced fish predators is potentially a serious problem for Missouri hellbenders. SMSU believes future study of larval behavior, including studies of captive larvae with a possible goal toward predator-recognition training, should be a priority.

3. UM-Rolla (report by Yue -wern Huang)

a. Existing Surveys, Monitoring, and Research

A recent survey on the Ozark hellbender (*Cryptobranchus alleganiensis bishopi*) in Missouri rivers in comparison with data from the 70's and 80's indicates 1) the size of the hellbender populations appears to have decreased, and 2) a disproportionate decline in the proportion of small individuals (Wheeler et al. 2003. Biological Conservation 109:151-156).

Because of the population decline, recruitment problems, and population aging, the research conducted at the University of Missouri – Rolla has focused on assessing possible factors that contribute to population decline. Currently we are examining 1) overall water quality, 2) biomarkers for exposure to endocrine disruptors, and 3) health condition of the Ozark hellbenders

with hematology. Since the populations in Missouri are not "healthy", the populations of the eastern hellbenders in Georgia and South Carolina are used to establish the baseline data for comparison.

b. Survey Protocol

UM-Rolla conducts monthly surveys in the White River and Eleven Point River. Twenty-four hour composite water samples are collected and analyzed for pesticides, herbicides, and domestic chemicals using a gas chromatography/mass spectrometry or a liquid chromatography/mass spectrometry. This chemical analysis is to identify chemicals that possess endocrine disrupting activity leading to perturbation of reproductive functions.

The overall water quality is determined on-site with grab samples to test the levels of nitrogen, phosphorus, and twenty other parameters. We suspect that high levels of nitrogen and phosphorus may increase the possibility of egg infestation leading to reduced fecundity.

Blood samples from animals are analyzed for altered hormone levels and vitellogenin levels, an indication of endocrine disruption. A comparative hematology study is underway to evaluate health conditions of the hellbenders. All of these above analyses can be used for long term population monitoring.

c. Research Priorities

UM-Rolla began our water analysis March 2003, and blood collections and analyses will begin in June 2003. UM-Rolla does not have conclusive data yet; but by the end of CY 2003 UM-Rolla expects to generate some data which will lead us to narrow down our scope and focus on prime suspects contributing to population decline.

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2. Review Requests

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Susan Rogers	U.S. Fish and Wildlife Service	susan_rogers@fws.gov

APPENDIX

1. Ozark Hellbender Working Group

Meeting Minutes, February 14, 2003, Missouri Department of Conservation, West Plains, MO

Attendees

Kelly Irwin, AGFC
Lisa Irwin, FWS
Dewayne French, FWS
Richard Shelton, FWS
Amy Salveter, FWS
Amy Smith, MDC
Don Smith, MDC
Victoria Grant, NPS
Ron Goellner, St. Louis Zoo
Karen Goellner, MDC
Tom Johnson, MDC retired
Stan Trauth, ASU
Ben Wheeler, ASU
Al Christian, ASU
Alicia Mathis, SMSU
Shem Unger, SMSU
Yue-wern Huang, UMR
Dirac Twidwell, UMR
Jason Elrod, UMR
Theresa Davidson, FWS
Larry Furniss, USFS
Rhonda Rimer, MDC
Mary Palmer, MDC
Jeff Briggler, MDC
Susan Rogers, FWS

The Ozark hellbender working group met to discuss preliminary results from the last field season and other issues. The meeting opened with Jeff Briggler discussing activities in Missouri since the last meeting. Missouri Department of Conservation (MDC) has listed both subspecies as endangered in the state, which will become effective on March 20, 2003. MDC will be filming an outdoor show on hellbenders, and Jeff will contact members of the group about participating in this show.

Kelly Irwin reported that there have been no real changes in activities in Arkansas regarding hellbenders. He was able to secure funding for the Arkansas portion of Al Christian's hellbender habitat study.

Jason Elrod and Yue-wern Huang discussed the previous field season and gave an overview of their work to date. They are having trouble finding a definitive method to determine the sex of the animals without laparoscopy, which requires surgery. Ultrasound did not prove to be useful.

Alicia Mathis and Shem Unger provided an overview of their work to date. They have had varying success with eggs and larval hellbenders. They were successful in producing larvae from eggs from three streams, and they currently have a number of larvae from each. Studies are being conducted to determine if predator responses are learned or innate, which will help guide augmentation and reintroduction efforts in the future. Hellbenders held at Mammoth Spring NFH deposited eggs in the raceway but none were fertilized. A similar phenomenon occurred with hellbenders ASU had held in the raceway.
From ASU: Stan Trauth reported that there will be three publications this upcoming year regarding

his hellbender work. Ben Wheeler discussed the feasibility of using radio transmitters. The animals have quickly learned to escape from collars, so they are looking into other types of transmitters. Al Christian reported that work will begin soon on the Arkansas habitat work. They will look at the habit at in streams with historical hellbender records, current hellbender records, and no hellbender records, and they will characterize the physical habitat in each.

Ron Goellner discussed the St. Louis Zoo's Field Research for Conservation program, which can provide money to projects that are related to one of their areas of focus. Projects related to hellbenders are eligible.

After lunch, roundtable discussions began. The group discussed the disposition of the larvae that are currently at SMSU. Once Alicia's studies are completed, she will not be able to keep the animals in the facilities that they require. Larvae from North Carolina will be returned, but the fate of the remaining animals is currently undecided due to various concerns. Returning the animals may be risky as they may not be suitable for the wild- predator avoidance and foraging behaviors may reduce survivability. Alicia's studies will answer some of these questions, but others remain. Ron is interested in holding some to determine their requirements and potentially start a captive program. Tom Johnson suggested forming a committee to select parameters necessary for captivity and disposition. Volunteers for this committee include Tom, Ron, Richard Shelton, and Dewayne French. They will have a draft plan ready for the group in May.

Jeff and Kelly discussed forming a repository for PIT tag information. Concerns were raised regarding what data to provide and if it will be available to the public, but all involved were willing to compile their information so that any animals found in the future with a PIT tag can be easily traced. Jeff and Kelly will work together to determine what data fields will be necessary for this database.

Amy Salveter discussed outreach needs for the species. The group agreed that much outreach is necessary both to prevent intentional killing of the animals and to raise public awareness. Various methods were discussed, as well as various funding avenues for completing projects. A committee was formed to tackle these issues and develop an outreach plan. Members of this committee include Amy Salveter, Amy Smith, Jeff, Tom, Yue-wern, Dwayne, Ben, and Jason.

Susan Rogers discussed where the Ozark hellbender falls in priority for listing by the Fish and Wildlife Service. As populations have continued to drop and other populations that were thought to be stable, it may be necessary to revise its current priority (6) to the next higher level (3). Additional information regarding population trends was requested, and Susan will assimilate this information and present it to the group at the September 2003 meeting. The next chance to revise the priority number is in January 2004 when information is collected for the next Candidate Notice of Review in the Federal Register.

Kelly discussed selecting priority watersheds on which to focus habitat restoration efforts, such as Stream Team, Partners for Wildlife, and EQIP, among others. Outreach efforts will greatly facilitate restoration actions, as well.
Susan brought up development of a conservation plan for the Ozark hellbender, and the plans that the committees develop will be sections of this plan. The group seemed to agree to this, although

discussion led elsewhere. This will be discussed again at the September meeting.

Jeff discussed the problem of rock weirs being installed on caving banks- many questions were raised as to whether this helps or harms hellbender habitat. Hopefully, Al's habitat project will help to answer some of these questions.

It was decided that meetings will be held every 6 months, at least until the committees have developed plans and the group is moving in a unified direction.

Jason asked the group for suggestions for sexing the animals. Laparoscopy was not ruled out, and he will continue to investigate options.

Stan asked that members of the group present at the national hellbender meeting in Georgia in August.

Tom provided a summary of hellbender work over the years, and he was very pleased and the work that has been accomplished and the direction that we are heading.

2. FWS Status Review by Susan O. Rogers

Status Review
of
Ozark Hellbender (*Cryptobranchus alleganiensis bishopi*)

by
Susan O. Rogers
U.S. Fish and Wildlife Service
Conway, AR

BIOLOGICAL INFORMATION:

Taxonomy

The Ozark he llbender (*Cryptobranchus alleganiensis bishopi*) was originally designated as *C. bishopi* by Grobman (1943) from a specimen collected from the Current River in Carter County, Missouri. Due to the small amount of genetic variation possessed by the genus *Cryptobranchus* (Merkle *et al*. 1977, Shaffer and Breden 1989), Schmidt (1953) referred to the Ozark hellbender as a subspecies of the eastern hellbender, *C. alleganiensis*, and this was supported by Dundee and Dundee (1965). This designation persisted until Collins (1991) revived *C. bishopi*, due to the lack of intergradation between the eastern and Ozark hellbenders, which is unlikely to occur due to the allopatry of populations of these species (Dundee 1971). Although Ozark hellbenders have been shown to be distinct phenotypically (Grobman 1943, Dundee and Dundee 1965, Dundee 1971) and genetically (Routman 1993, Wagner *et al*. 1999) from eastern hellbenders, the U.S. Fish and Wildlife Service will continue the use of *C. a. bishopi*, which is the name currently recognized by the Center for North American Amphibians and Reptiles (Collins 1997). Although discussion continues over the taxonomic status of the Ozark hellbender, the designation of the Ozark hellbender as a species or subspecies does not affect its qualification for listing under the Endangered Species Act (87 Stat. 884, as amended: 16 U.S.C. 1531 et seq.).

Description

The Ozark hellbender is large, strictly aquatic salamander endemic to streams of the Ozark plateau in southern Missouri and northern Arkansas. Its dorso- ventrally flattened body form helps it remain immobile in the fast flowing streams it inhabits (Wagner *et al*. 1999). Hellbenders have a large keeled tail and tiny eyes. Adult Ozark hellbenders may attain total lengths of 29 - 57 cm (Dundee and Dundee 1965, Johnson 1987). Numerous fleshy folds along the sides of the body provide surface area for respiration (Nickerson and Mays 1973a) and obscure poorly developed costal grooves (Dundee 1971). Ozark hellbenders are distinguishable from eastern hellbenders by their smaller body size, dorsal blotches, increased skin mottling, heavily pigmented lower lips, smooth surfaced lateral line system, and reduced spiracular openings (Grobman 1943, Dundee 1971, Peterson *et al*. 1983, LaClaire 1993).

Ecology and Habitat

Adult Ozark hellbenders are frequently found beneath large rocks in moderately deep (< 1m), rocky, fast flowing streams in the Ozark plateau (Johnson 1987, Fobes and Wilkinson 1995, Wagner *et al*. 1999). In spring fed streams, hellbenders typically concentrate just downstream of the area where there is no temperature change throughout the year (Dundee and Dundee 1965). Adults are nocturnal, remaining beneath cover during the day and emerging to forage primarily on crayfish at night, although they are not entirely nocturnal (Nickerson and Mays 1973a, Noeske and Nickerson 1979, Collins 1997). Ozark hellbenders are territorial and will defend occupied cover from conspecifics (Nickerson and Mays 1973a). This species migrates little, with one tagging study revealing that 70 percent of marked individuals moved less than 30 meters from the site of original capture (Nickerson and Mays 1973b).

Typically, Ozark hellbender populations are dominated by older, large adults (Nickerson and Mays 1973a, Peterson *et al*. 1983, LaClaire 1993). Juveniles reach sexual maturity between 5 and 8 years, with males maturing at a smaller size and younger age than females. Ozark hellbenders may live 25 - 30 years in the wild (Peterson et al. 1983).

Breeding generally occurs between September and November, with Spring River populations breeding in January (Peterson *et al*. 1983). Ozark hellbenders mate via external fertilization, and males will guard the eggs from predation by conspecifics (Nickerson and Mays 1973a). Clutch sizes vary from 138 to 450 eggs per nest (Dundee and Dundee 1965, Zug 1993), and eggs hatch after approximately 80 days (Zug 1993). Hatchlings and larvae are collected rarely during surveys, likely due to low capture efficiency and high mortality of young. Larvae and small individuals often live beneath small stones in gravel beds or shallow water habitats (Nickerson and Mays 1973a, LaClaire 1993).

DISTRIBUTION:

Ozark hellbenders are endemic to the Black and White River drainages in Arkansas and Missouri (Johnson 1987) in portions of the Spring, White, Eleven Point, and Current Rivers and their tributaries (LaClaire 1993). This species is declining throughout its range, and no populations appear to be stable. A description of the known Ozark hellbender populations follows.

White River System

White River- There is only one Ozark hellbender record from the main stem of the White River in Baxter County, Arkansas, in 1997 (Dr. S. Trauth, ASU, pers. com.). It is not known whether a viable population exists at this site or the individual is a member of a relic population that was separated from the North Fork White River population by Norfork reservoir. This area is scheduled to be surveyed during summer 2001.

North Fork White River- The North Fork White River historically has contained considerable populations. In 1973, results of a mark-recapture study indicated approximately 1,150 hellbenders within 2.67 km in Ozark County, Missouri, with a density of 1/8-10 m^2 (Nickerson and Mays 1973b). Ten years later, hellbender density in a 4.6 km section of the North Fork White River in the same county remained rather high, with densities between 1/6-7 m^2 and 1/13-16 m^2 (Peterson *et al*. 1983). Individuals caught in this study represented a range of lengths (172-551 mm), with most individuals between 250 - 449 mm, indicating that reproduction was occurring in this population. Subsequently, in a 1992 qualitative study also in Ozark County, Missouri, 122 Ozark hellbenders were caught during 49 man- hours (Ziehmer and Johnson 1992). These individuals ranged from 254 - 457 mm, and no average size was presented. Up to this point, the North Fork White River population appeared to be fairly healthy. However, after reports of hellbender declines in the North Fork White River, a 1998 study of the same stretch of river censussed in 1983 (Peterson *et al*. 1983) using the same collection methods resulted in the capture of only 50 hellbenders (Wheeler *et al*. 1999). These individuals ranged in length from 200 - 507 mm, with most between 400 - 500 mm, and were on average significantly longer than those collected twenty years prior (Wheeler 1999). This shift in length distribution was not a result of an increase in maximum length of individuals; instead, there were fewer individuals collected in the smaller size classes.

In order to compare results between these qualitative and quantitative studies, Wheeler *et al*. (1999) converted historical hellbender collections (Peterson *et al*. 1983) to numbers of individuals caught per day. In addition, the other studies that were not included in that conversion have been converted here. Those conversions calculated in this status review use one search day as 8 hours of searching by 3 people. Although this search day may be an underestimate of actual effort, a conservative estimate of effort will result in a conservative estimate of hellbender declines. Therefore, 17 years ago, approximately 51 hellbenders were caught per sampling day (Peterson *et al*. 1983). In 1992, 60 hellbenders/day were caught (Ziehmer and Johnson 1992), and in 1998, 16 hellbenders/day were caught (Wheeler 1999). A decline in the North Fork White River is evident, although it cannot yet be quantified.

The North Fork White River had been considered the stronghold of the species, and the populations inhabiting this river were deemed stable (Ziehmer and Johnson 1992, LaClaire 1993). However, these populations now appear to be experiencing declines similar to those in other streams. The collection of young ind ividuals has become rare, indicating little recruitment. In species such as the Ozark hellbender, which are long lived and mature at a relatively late age, detecting declines related to recruitment can take many years, as recruitment under healthy population conditions is typically low. This slow decline appears to be occurring in the North Fork White River, although quantitative studies are needed for confirmation.

Bryant Creek- Bryant Creek is a tributary of the North Fork White River in Ozark County, Missouri, and flows into Norfork Reservoir. Ziehmer and Johnson (1992) expected to find Ozark hellbenders in this stream during their survey, but none were discovered after 22 man- hours. Missouri Department of Conservation (MDC) personnel, as well as fisherman, have reported observations of fairly high numbers of hellbenders in Bryant Creek during winter months (Ziehmer and Johnson 1992). A subsequent study resulted in 6 hellbenders captured from Bryant Creek (Wheeler *et al*. 1999), confirming the existence of a population in this tributary. This population is isolated from that in the North Fork White River by Norfork reservoir, which could contribute to this population's apparent small size.

Black River System

Black River- There are no documented records of Ozark hellbenders in the Black River, although it has not been extensively surveyed. Portions of the Black River in Missouri were surveyed in 1999, but no Ozark hellbenders were observed (Wheeler *et al*. 1999). The Black River is presumed to be part of the historical range of the species, and hellbenders presently occur in several tributaries (Trauth *et al*. 1992).

Spring River- The Spring River, a tributary of the Black River, flows from Oregon County, Missouri, south to Arkansas. Large Ozark hellbender populations have been found in the Spring River near Mammoth Spring, Fulton County, Arkansas (LaClaire 1993). In the early 1980's, 370 individuals were captured during a mark-recapture study along 7 km south of Mammoth Spring (Peterson *et al*. 1988). Hellbender density at each of the two surveyed sites was fairly high (approximately 1/23 m^2 and 1/111 m^2). These individuals were considerably larger than hellbenders captured from other streams during the same time period, with 74 percent of Spring River Ozark hellbenders measuring over 450 mm total length (maximum 600 mm) (Peterson *et al*. 1988). In 1991, a longer reach (26 km) was surveyed for Ozark hellbenders, and only 20 were observed during 41 search hours of the 6 month period, at many of the same sites as Peterson (Trauth *et al*. 1992). In the following four years, an additional 33 were captured during sporadic surveys by the same researchers (Trauth and Wilhide 1997). No length information is available, although the large sizes of the 1988 captures may be indicative of a population experiencing little recruitment. Although the recent surveys were less intensive than the previous studies, it is fairly apparent that hellbenders are much more scarce in this stream.

Eleven Point River- The Eleven Point River, a tributary of the Black River, has been surveyed several times since the 1970's. Historical data provided by Peterson was analyzed by Wheeler (1999). In 1978, 87 hellbenders were captured in Oregon County, Missouri, over 3 days, yielding 29 hellbenders/day. Later, in 9 collection days from 1980 - 1982 in the same area, 314 hellbenders were captured, yielding 35 hellbenders/day. Lengths over this period ranged from 119 - 451 mm. Six years later, Peterson *et al*. (1988) captured 211 hellbenders from the Eleven Point River and estimated hellbender density to be approximately 1/20 m^2. Total lengths of these individuals ranged from approximately 120 - 450 mm, with most between 250

- 350 mm. Although it was not presented, it can be estimated that roughly 40 hellbenders were caught per day during this study. Approximately 10 years later, Wheeler (1999) captured 36 hellbenders over 4 days from Peterson *et al*.'s (1988) historical sites, for an average of 9 hellbenders/day. These hellbenders were larger than those captured previously, with total lengths of 324 - 457 mm, and there were significantly fewer individuals in the smaller size classes. In summary, the population appeared stable until 1988 (captures of 29, 35, and roughly 40 hellbenders/day), and then dropped in 10 years to 9 hellbenders/day, and these individuals were considerably larger than those caught previously. Therefore, in the Eleven Point River, similar declines and lack of recruitment are evident as in other streams.

Current River- The Current River had not been surveyed extensively until the 1990's. Nickerson and Mays (1973a) reported a large population in this stream, but no numbers were presented. In 1992, Ziehmer and Johnson (1992) found 12 Ozark hellbenders in 60 man-hours in Shannon County, Missouri, or approximately 5 hellbenders/day, using the same search day conversion as above. These individuals ranged in length from 115 mm to over 380 mm (maximum length was not reported), with most between 330 mm and 380 mm. Seven years later, 14 hellbenders were collected over 3 collection days (approximately 5 hellbenders/day), also in Shannon County, Missouri, and the individuals ranged from 375 - 515 mm, with most between 450 - 499 mm (Wheeler 1999). It appears that this population is small, although not declining. However, the average size of individual has increased by nearly 100 mm, and this population shows similar lack of recruitment as other populations.

Jacks Fork- Jacks Fork, a tributary of the Current River, was surveyed for the first time in 1992 for Ozark hellbenders (Ziehmer and Johnson 1992). Four hellbenders were collected over 66 man- hours, roughly 2 hellbenders/day. The individuals were large, ranging from 330 - 430 mm. There have been no subsequent investigations of Jacks Fork, so no conclusions may be drawn about population trends in this stream.

SUMMARY OF FACTORS AFFECTING THE SPECIES:

A. The present or threatened destruction, modification, or curtailment of its habitat or range.

The decline of the Ozark hellbender in the White and Black River systems in Missouri and Arkansas is likely the result of habitat degradation. Although the precise cause of hellbender declines remains unknown, habitat degradation is the most frequent cause of lotic faunal declines (Allan and Flecker 1993). Hellbenders are habitat specialists that depend on constant levels of dissolved oxygen, temperature, and flow (Williams *et al*. 1981). Therefore, even minor alterations to stream habitat could be detrimental to hellbender populations. In particular

impoundments, gravel mining, siltation, and den site disturbance appear to have degraded habitat for hellbenders (Williams *et al*. 1981, La Claire 1993).

Impoundments impact stream habitat in many ways. When a dam is built on a freeflowing stream, riffle and run habitats in the area impounded by the dam are converted to open water. Temperature and dissolved oxygen levels are changed by the lotic conditions of the water (Allan 1995). Because hellbenders are habitat specialists, they cannot tolerate a wide range of habitat conditions. Hellbenders depend upon highly vascularized lateral skin folds for respiration; therefore, lakes and reservoirs are unsuitable habitats for Ozark hellbenders, as these areas have lower oxygen levels (Williams *et al*. 1981, LaClaire 1993) than their fast flowing, cool water, highly oxygenated stream habitat. Impoundments on inhabited streams create unsuitable habitat for hellbenders and are impediments to movement between populations.

Norfork dam was constructed on the North Fork White River in 1944 and has isolated Ozark hellbender populations in Jacks Fork, Bryant Creek, and the White River from those in the North Fork White River. Additionally, populations downstream of Norfork dam were extirpated due to hypolimnetic releases from the reservoir. These releases are much cooler than normal stream temperatures, and the water typically is depleted of oxygen. In addition, tailwaters experience extreme water level fluctuations and scouring for many miles downstream which likely jeopardize hellbender populations.

Gravel mining has occurred in many southeastern streams and could contribute to Ozark hellbender habitat loss. Dredging results in stream instability both up and downstream of the dredged portion (Neves *et al*. 1997, Box and Mossa 1999). Head cutting, in which the increase in transport capacity of a dredged stream causes severe erosion and degradation upstream, can result in extensive bank erosion, sloughing, and increased turbidity levels (Allan 1995). Reaches downstream of the dredged portion often experience aggradation as the sediment transport capacity of the stream is reduced (Box and Mossa 1999). These activities can disturb den sites in dredged areas, and the associated siltation can affect den sites for miles downstream. In addition, these effects may alter crayfish populations, which are the primary prey species for Ozark hellbenders. Gravel dredging is widespread in the White and Black River systems in southern Missouri and northern Arkansas (LaClaire 1993). Modifications of stream channels associated with gravel mining, as well as the removal of small stones and chert that are important microhabitat for larvae and subadults, may contribute to the decline of Ozark hellbenders in these systems. However, the Service has no data at this time that indicate the Ozark hellbender has declined in areas of gravel mining activity.

Silt and sediment runoff from land use activities in the area may have contributed to habitat degradation. Timber harvesting is prominent in many areas, and roads probably have the most detrimental effect on water quality. Roads can cause marginally stable slopes to fail, and they can capture surface runoff and channel it

directly into streams (Allan 1995). In addition, erosion from roads can contribute more sediment than the land harvested for timber (Box and Mossa 1999). Peak streamflows often rise in watersheds with timber harvesting activities, due in part to compacted soils resulting from roads, landings, and vegetation removal (Allan 1995, Box and Mossa 1999). The cumulative effects of timber harvest on sedimentation rates can last for many years, even after harvest practices have ceased in the area (Frissell 1997).

Habitat disturbance may be affecting hellbender success in several rivers. Canoeing and fishing are common in many of the rivers inhabited by the Ozark hellbender, including the Spring, Current, and North Fork White Rivers. Although no data are available that support this assertion, it has been speculated that the disturbance of den sites by contact with canoes may lead to the abandonment of those sites. In addition, some larger rocks have been removed in order to prevent canoe damage (Nickerson and Mays 1973a, Wheeler *et al*. 1999). These large rocks are often highly suitable hellbender den sites.

B. Overutilization for commercial, recreational, scientific, or educational purposes.

Anecdotal reports indicate that Ozark hellbenders have been collected for commercial and scientific purposes (Trauth *et al*. 1992). Commercial collections are currently illegal in both Missouri and Arkansas, but hellbenders may be collected with a permit from the appropriate state. The Service lacks data to document these reports, but it is likely that overcollection is a threat to already imperiled populations. Because the species is long lived and does not reproduce until approximately age 7, the removal of even a few individuals from a population that is experiencing declines can impact the recruitment potential of that population. Presently, collecting levels appear reduced (LaClaire 1993), but collecting could become more of a threat as populations continue to decline.

C. Disease or predation.

The occurrence of disease is virtually unknown in Ozark hellbender populations and has been studied little. Although hellbenders are occasionally preyed upon by large fish, turtles, and water snakes, this is rare and likely does not occur after hellbenders reach 380 mm (Nickerson and Mays 1973a, Peterson *et al*. 1983). It is unlikely an otherwise healthy population would be threatened by this level of predation. No evidence has been presented that would indicate that disease or predation are serious threats.

D. The inadequacy of existing regulatory mechanisms.

The states of Arkansas and Missouri prohibit the taking of Ozark hellbenders for any purpose without a state collecting permit. However, enforcement of this permit requirement is difficult. Additionally, state regulations do not protect hellbenders from other threats.

Existing authorities available to protect riverine ecosystems, such as the Clean Water Act (CWA), administered by the Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers, may not have been fully used to prevent instream activities and the resulting habitat degradation. This may have contributed to the general habitat degradation apparent in riverine ecosystems and loss of populations of aquatic species in the southeast. Although the Ozark hellbender coexists with other federally listed species throughout parts of its range, listing under the Endangered Species Act would provide additional protection, as the threats to hellbenders and the other endangered species are not identical. Federal permits would be required to take the species, and federal agencies would be required to consult with the Service when activities they fund, authorize, or carry out may adversely affect Ozark hellbenders.

E. Other natural or manmade factors affecting its continued existence.

Certain population characteristics of Ozark hellbenders cause the species to be fairly vulnerable to extirpations and extinction. The Ozark hellbender, having specialized habitat requirements, is extremely vulnerable to environmental perturbations. When populations are small, they are less likely to rebound following these perturbations. In addition, Ozark hellbenders exhibit very low genetic diversity (Merkle *et al*. 1977, Wagner *et al*. 1999). This genetic uniformity is consistent with habitat specialization (Nevo 1978, Wagner *et al*. 1999). Ozark hellbenders have adapted to a relatively constant environment, and therefore several structural, behavioral, and physiological specializations have resulted (Williams *et al*. 1981). These specializations, in combination with the stable environment, seems to have resulted in very low levels of genetic diversity (Wagner *et al*. 1999). This has been exacerbated with the fragmentation of populations by impoundments, habitat degradation, and other impediments to dispersal. Without the level of interchange the hellbender experienced historically, many small, isolated populations do not receive the influx of new genetic material that once occurred. As the populations decrease in size, genetic diversity is lost and inbreeding can occur, which may result in decreased fitness, and the loss of genetic heterozygosity can result in a significantly increased risk of extinction in localized natural populations (Saccheri *et al*. 1998). With fragmentation, local extinctions cannot be repopulated.

Ozark hellbenders do not reproduce until approximately 7 years of age. Declines being observed presently may be the result of activities that occurred years earlier. Because juvenile hellbenders are rarely observed, it takes many years to detect population trends. The lack of recruitment in most all Ozark hellbender populations is a significant sign that little reproduction has occurred in these populations for several years. Delayed reproduction, when paired with a long life span, can disguise declines until they become fairly severe.

The present distribution and status of Ozark hellbender populations in the White and Black River systems in Arkansas and Missouri may be demonstrating the characteristics mentioned above. Genetic studies have demonstrated repeatedly very low genetic diversity in hellbender populations, which may be a factor in the decline of the species. The current combination of population fragmentation and habitat degradation may prohibit this species from recovering witho ut the intervention of conservation measures designed to facilitate hellbender recovery.

RECOMMENDATION:

The Service has the data to document population declines and imminent threats to the Ozark hellbender. It is our conclusion that the Ozark hellbender warrants the protection of the Endangered Species Act. This status review does not address the eastern hellbender, *Cryptobranchus alleganiensis*.

LAND OWNERSHIP: Approximately 80 percent of the land within the range of the Ozark hellbender is in private ownership, with the remaining 20 percent federally owned (Mark Twain National Forest).

PRELISTING:

No conservation agreements have been developed for the Ozark hellbender. However, the state of Arkansas has identified the need for conservation of this species and has erected signs throughout its range in Arkansas alerting recreationists to their presence. The Service, U.S. Geological Survey, and Arkansas Game and Fish Commission have funded surveys to fill in unsurveyed gaps in Arkansas and Missouri, and work is being done at Mammoth Springs National Fish Hatchery to examine potential refugia as well as life history characteristics.

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