The Curtis' Pearlymussel
(Epioblasma florentina curtisii)

5-Year Review:
Summary and Evaluation

Epioblasma florentina curtisii, Little Black River, Missouri, 1993.
Photo by Paul McKenzie (U.S. Fish and Wildlife Service)

U.S. Fish and Wildlife Service
Columbia Missouri Field Office
Columbia, Missouri

5-YEAR REVIEW
Curtis' Pearlymussel (*Epioblasma florentina curtisii*)

TABLE OF CONTENTS

TABLE OF TABLES

5-YEAR REVIEW
The Curtis' Pearlymussel/*Epioblasma florentina curtisii*

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Regional Office: Carlita Payne, Midwest Regional Office, 612-713-5339

Lead Field Office: Andy Roberts, Columbia Missouri Field Office, 573-234-2132, ext. 110

Cooperating Field Office: Chris Davidson, Conway Arkansas Field Office, 501-513-4481

1.2 Methodology used to complete the review:

The U.S. Fish and Wildlife Service's (USFWS) Columbia, Missouri Field Office completed this review. New information considered in this review includes relevant information generated since the recovery plan for the species was written in 1986, which was the last most comprehensive review on the species since no document was prepared for the Curtis' pearlymussel (*Epioblasma florentina curtisii*) as a result of the November 6, 1991 (56 FR 56882) cursory review for all species listed before 1991. Information sources include: the recovery plan for the Curtis' pearlymussel (USFWS 1986), peer reviewed scientific publications, final unpublished reports, ongoing field survey results and information from qualified USFWS and State biologists, and the final rule listing the Curtis' pearlymussel as endangered (41 FR 21062). All literature and documents used for this review are on file at the Columbia, Missouri Field Office. All recommendations resulting from this review are the result of thoroughly reviewing all available information on this species. The notice of review was published on September 21, 2006 (71 FR 55212), with a 90-day public comment period. The notice of review requested new scientific or commercial data and information that may have a bearing on the species' classification of endangered.

1.3 Background:

1.3.1 FR Notice citation announcing initiation of this review: 71 FR 55212, (September 21, 2006)

1.3.2 Listing history

Original Listing
FR notice: 41 FR 24062
Date listed: June 14, 1976
Entity listed: subspecies
Classification: endangered

1.3.3 Associated rulemakings: No associated rulemakings have been published.

1.3.4 Review History: Curtis' pearlymussel was included in a cursory 5-year review of all species listed before January 1, 1991 (56 FR 56882) which resulted in no change in the species' listing classification of threatened. There have been no biological opinions, or other large scale analysis of this species since the recovery plan was written in 1986. Recovery data calls have been conducted annually from 2000-2009.

1.3.5 Species' Recovery Priority Number at start of 5-year review: 6 - this number indicates a subspecies with a high degree of threat and a low potential for recovery.

1.3.6 Recovery Plan

Name of plan: A recovery plan for the Curtis' pearlymussel, *Epioblasma florentina curtisi.*

Date issued: February 4, 1986, there have been no revisions.

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy

2.1.1 Is the species under review a vertebrate?

No.

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria?

No.

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

2.3.1.1 New information on the species' biology and life history:
The Curtis' pearlymussel has not been seen alive in over a decade, and therefore, no new information on its biology or life history has been generated. However, recently published reports and research on other species belonging to the genus *Epioblasma* has provided insight on the biology of the species.

The host fish used by the Curtis' pearlymussel to complete its life cycle is uncertain. Most *Epioblasma* species utilize darters or sculpin species (Yeager and Saylor 1995). The tan riffleshell (*E. f. walkeri*), the closest relative to the Curtis' pearlymussel, was found to successfully transform in the laboratory on fantail darter (*Etheostoma flabellare*), greenside darter (*E. blennioides*), redline darter (*E. rufilineatum*), snubnose darter (*E. simoterum*), and sculpin species (genus *Cottus*) (Rogers *et. al* 2001). This is consistent with Buchanan (1987), who observed glochidia resembling Curtis' pearlymussel attached to the gills of wild rainbow darters (*Etheostoma caeruleum*) in the Little Black River, Missouri. To confirm the rainbow darter as a host fish for the Curtis' pearlymussel would require laboratory transformation (to identify those fish species that support successful transformation) in addition to the field data. Other darter species may also be used by the Curtis' pearlymussel as hosts.

Current research has revealed fascinating interactions between *Epioblasma* species and their fish hosts. Freshwater mussel species use a variety of different strategies to attract fish hosts in order to facilitate the successful transfer and attachment of glochidia onto the host (Barnhart *et. al* 2008). For example, many species attract fish hosts by displaying or releasing lures resembling a food item of fish (Hartfield and Hartfield 1996, Barnhart and Roberts 1997). The method used by *Epioblasma* has only recently been discovered and has been described as "host trapping" (Barnhart *et. al* 2008). This strategy involves the female mussel capturing the host fish to forcefully infest the fish. To capture a host fish, gravid females lie at the surface of the substrate with the valves widely agape and mantle tissue exposed. When the mantle is touched by a fish (i.e., foraging darters) the mussel quickly closes and the fish is captured by the head between the valves of the shell. The female then expels glochidia directly onto the fish where some of the larvae attach to the gills. The infested fish is later released.

Female *Epioblasma* have several adaptations to facilitate host trapping including gaping behavior, the ability to snap shut the valves, and modified mantle tissues and/or shell structure to help clasp struggling fish. In *E. florentina*, the mantle exhibits a ridge with a spongy interior. This specialized structure (called cymapallium) is broadly expanded into mantle pads. Females have a greatly expanded shell to accommodate the cymapallium (Barnhart *et al.* 2008). Female Curtis' pearlymussel also have been observed to move to the surface and lie on their sides prior to glochdial release, but no lure or other fish host attractant is evident (Buchanan 1987).

The discovery of "host trapping" in *Epioblasma* explains the function of certain odd morphological traits and behaviors exhibited by females of the genus including modified mantle tissues, expanded posterior shell structure, gaping behavior, and the ability to snap shut the valves. This discovery also has lead to a useful innovation in artificial propagation techniques for *Epioblasma*. Before host trapping was known, glochidia extraction from brood stock was invasive. Now, the gravid female can be induced to release glochidia naturally by triggering the trapping response. This method of glochidia collection greatly increases the survival of brood stock by avoiding damage to the animal from manual glochidia extraction.

2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:

When the Curtis' pearlymussel was listed as federally endangered in 1976, it had already disappeared from the White River in Missouri where it was considered to be "abundant" in historical accounts (Utterback 1917). At the time, the only extant populations known were based on a small number of collections made during the 1960's and 1970's in the Black and Castor rivers in Missouri (Table 1). Utterback (1917) considered the species "scarce" in this portion of its range compared to the White River. Old museum records also existed for the Spring River and South Fork Spring River in Arkansas, but no other records existed for these streams (USFWS 1986) (Table 1).

In 1979, a new population was discovered in a short stretch of the Little Black River (Buchanan 1979). While it occurred in assessable numbers there, it was still relatively rare. Between 1979 and 1985, over 100 living specimens were examined in the Little Black River during the course of several studies (Buchanan 1996). It was believed that this population was stable. Surveys conducted in 1981/1982 did not find any evidence of the species in the Black River, Missouri. Therefore, the only other extant population known was a small population in the Castor River, Missouri (Buchanan 1996). The status of the South Fork Spring and Spring rivers historical populations was unknown at this time.

<u>New information since issuance of the 1986 recovery plan</u>: In 1988, monitoring results indicated that a catastrophic decline of the mussel fauna had occurred in the Little Black and Castor rivers. Additionally, no specimens of the Curtis' pearlymussel were found in the locations that were considered strongholds for the species. Overall mussel density in 1988 was estimated to be only 16.2% and 26.0% of estimates conducted in 1980/1981 in the Little Black and Castor rivers respectively. Species richness also declined between 1980 and 1988 by 22.0% and 50.0% respectively (Buchanan 1988). Further monitoring of the Little Black

River in 1992 indicated that mussels continued to decline by an average of 77 percent (from 1980/1981 to 1992), and the Curtis' pearlymussel was still not found (Buchanan 1993*a*).

In 1993, representatives of the Missouri Department of Conservation (MDC) and the USFWS found a single living male Curtis' pearlymussel after 50 person-hours of searching (Buchanan 1993*b*) and was the only specimen found in a total of 100 hours of search time (Buchanan 1996). To date, this animal remains the last of its kind ever observed live or dead in the wild. Additional searches for the Curtis' pearlymussel were conducted in 1993 and 1994 in the Little Black and Castor rivers and Cane Creek in southeast Missouri and the Strawberry and Current rivers in northeast Arkansas, but no evidence of the species was found during these searches (Sietman and Sadler 1994). A mussel survey conducted in the Little Black River in 1997 documented a near collapse of the mussel fauna and no Curtis' pearlymussel evidence of the species was found (Bruenderman *et al.* 2001).

In 1998, an amateur shell collector reported finding the Curtis' pearlymussel in the 1980's in a mussel bed in the South Fork Spring River, near Saddle, Arkansas (Frieda Shilling, amateur conchologist, St. Louis, Missouri in litt. 1998). The record cannot be confirmed with specimens, but it is consistent with a previous record from 1916 in the South Fork Spring River. This record also indicates that the species was still extant in the South Fork as recent as the 1980's, and there was a diverse mussel bed at the site. Unfortunately, a subsequent sampling trip to the site (conducted by the USFWS, MDC, and Arkansas Fish and Game Commission) failed to find any evidence of the species. Further, the area of the mussel bed was found to be disturbed by a new bridge that was constructed in 1983 (Harris *et al*. 2007).

In 2004, all mussel survey information was evaluated by a team of mussel experts within the historical range of the Curtis' pearlymussel in Missouri and Arkansas. Stream reaches that have not been surveyed or adequately surveyed were identified. Searches were then planned to target these stream reaches as well as the entire reach of the Little Black River from where the species was last known. Between 2004 and 2007, 40 sites were surveyed in southern Missouri including the Little Black, Castor, James, and Current rivers and Big, Elbow, Shoal, Cane, Turkey, Beaver, Swan, and Bull creeks (Barnhart *in prep*). A total of 56 sites were surveyed in Arkansas including the Spring, South Fork Spring, Strawberry, and Eleven Point rivers (Harris *et. al* 2007). No evidence of the Curtis' pearlymussel was found during any of these surveys. At the present time, no extant populations of the Curtis' pearlymussel are known to occur. It appears that the last remaining population of the Curtis' pearlymussel has declined in the last 20 years to the point that the species is no longer detectable unless an unknown population exists.

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.): No information is known regarding genetics.

2.3.1.4 Taxonomic classification or changes in nomenclature: No new taxonomic information.

2.3.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.):

The historical range of the Curtis' pearlymussel includes the White, Black, Little Black, and Castor rivers and Cane Creek in Missouri. It has been reported from the South Fork Spring River and possibly the Spring River in Arkansas (USFWS 1986). In preparing this review, some inconsistencies were found in the literature regarding collection localities of the Curtis' pearlymussel. The discussion below addresses some of these inconsistencies. Also, Table 1 was constructed to organize records reported in the literature and help clarify the range of the Curtis' pearlymussel.

In 1980, three fresh shells the Curtis' pearlymussel were reported from Arkansas from the "Spring River just above its confluence with the Black River" (Bates and Dennis 1983, Ecological Consultants, Inc. 1984). It appears that this record was erroneously referenced in the recovery plan as "Black River near the mouth of the Spring River", but the original collection is described in the Spring River proper. This record was discounted in the recovery plan because the specimens did not have shell characters similar enough to Missouri specimens (USFWS 1986). Specifically, the specimens were considered too large to be the Curtis' pearlymussel. The Spring River record is listed in Harris and Gordon (1987) and Harris and Gordon (1990) in describing the distribution of mussels in Arkansas, but its validity is not questioned. However, in a later report, Harris *et al*. (2007) suggest that the Spring River record could have been a case of mislabeled field data because the specimens depicted in the photograph resemble *E. capsaeformis*, an eastern species. With these doubts aside, the Spring River record would not be unlikely because of other localities of the species reported nearby. It also was found in the Spring River upstream from the confluence near Hardy and in the South Fork Spring River near Salem and Saddle (Table 1). If the Spring River specimens still reside in a museum, they should be further examined to confirm the species.

A record for Cane Creek, Missouri is listed in the recovery plan as collected in 1979. Another Cane Creek record for the year 1978 is discussed in Buchanan (1996). However, there only has been one record for the Curtis' pearlymussel for Cane Creek, Missouri, which was a subfossil shell collected by Ronald Oesch on April 18, 1978 (Steve McMurray, MDC, in litt. 2008).

Johnson (1978), in his account of the Curtis' pearlymussel, discusses historical records from the White and Black rivers in Missouri. However, the accompanying map in the publication depicts a record in the St. Francis River in Missouri. This is assumed to be a mapping error because 1) no records from the St. Francis River are discussed in the text, 2) the map does not show the Black River collections that are discussed in the text, and 3) the Black River is in close proximity to the St. Francis River making it easy to misplace points on the map. On the other hand, this location seems plausible. A population existed in the Castor River as recent as 1980 (Bates and Dennis 1983, Ecological Specialists, Inc. 1984) and was a tributary to the St. Francis River before it was diverted into the Mississippi River. Also, the St. Francis River historically supported a diverse freshwater mussel fauna (Hutson and Barnhart 2004). If the St. Francis River locality is correct, today it is located near the mouth of the old Castor River confluence at the approximate location of Lake Wappapello, and thus has been destroyed.

2.3.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):

The Curtis' pearlymussel requires good water quality and occurs in shallow stable riffles and runs. The species is limited to stream segments that are transitional between headwater and lowland streams reaches (USFWS 1986). In the White, Black, St. Francis, and Castor rivers, these transitional stream reaches either have been inundated by major reservoirs, affected by altered flows from reservoir releases, or destroyed by channelization (USFWS 1986). The recent population declines and continued lack of mussels found during recent surveys indicate that habitat conditions in the Little Black River are not currently conducive to freshwater mussels (Bruenderman *et al*. 2001). While this stream appears to still have suitable physical habitat in some areas, unidentified threats continue to suppress the mussel fauna there. Only subfossil shells of the Curtis' pearlymussel have been documented in Cane Creek (USFWS 1986), and the freshwater mussel fauna was found to be very limited (Buchanan 1996). Further, no suitable habitat or mussel shells of any kind were found in 2004 (Christian Hutson, Southwest Missouri State University, in litt. 2004). Of the historical populations, only the Spring River and South Fork Spring River support diverse mussel faunas and presumably provide suitable habitat for the Curtis' pearlymussel. However, it is unknown what reaches of these streams might be transitional between headwater and lowland habitats.

2.3.1.7 Other: N/A

2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range:

Habitat alteration has been the principal threat to the Curtis' pearlymussel throughout its historical range (USFWS 1986). Flowing water and a stable substrate are two important basic habitat requirements of the species. Stream impoundments, gravel dredging, and channelization have completely eliminated these basic habitat components in several streams including the White, Castor, and Black, rivers. The largest population in the White River was eliminated by the construction of reservoirs including Lake Tanycomo and Table Rock, Bull Shoals, and Beaver reservoirs (USFWS 1986). The Castor River was channelized and diverted into the Mississippi River in 1913 (Norman 1994). This eliminated most of this stream entirely and cut it off from the St. Francis River Basin. The Black River populations have been affected by gravel dredging and are currently greatly affected by the operation of Clearwater Reservoir upstream (USFWS 1986). If there was a population in the St. Francis River (listed by Johnson 1986), it is now the location of Lake Wappapello. Today, no major impoundments or channelization projects are proposed within the historical range of the Curtis' pearlymussel, but gravel dredging is an ongoing activity.

Other threats to the Curtis' pearlymussel have been described that are generally caused by poor land use. These include water quality degradation, sedimentation, and increased nutrient loading (USFWS 1986, Bruenderman *et al*. 2001). These threats are still ongoing today throughout the range of the species. The cause of the decline of the last known population in the Little Black River remains unknown, but water quality degradation and head-cutting (channel degradation) were suspected as the main cause (Bruenderman *et al*. 2001).

Recently a new threat has been identified for freshwater mussels related to water quality. While mussel biologists generally agree that contaminants are partially responsible for the decline of mussels (e.g., Havlik and Marking 1987, Bogan 1993, The National Native Mussel Conservation Committee 1998), few contaminants have been tested for their toxicity to mussels. However, recent studies indicate that mussels are among the most sensitive organisms to ammonia (Augspurger *et al*. 2003, Wang *et al*. 2007*a*, Wang *et al*. 2007*b*), which is a common pollutant. These studies have suggested that the current numeric water quality criteria for ammonia supported by the U.S. Environmental Protection Agency (EPA) may not be protective of early life stages of freshwater mussels. Ammonia is a degradation product of nitrogenous organic matter and is associated with municipal wastewater treatment plants, industrial wastes, and run off from agricultural areas including animal wastes and nitrogenous fertilizers (Goudreau *et al*. 1993). These sources are nearly ubiquitous throughout the historical range of the Curtis' pearlymussel in Missouri and Arkansas.

<u>Conservation measures</u>: The protection of riparian areas is identified as a delisting criterion as well as a high priority recovery action in the recovery plan

for the Curtis pearlymussel (USFWS 1986). In 1988, the Mudpuppy Conservation Area was purchased by the MDC. This 1,404 acre area was purchased to protect the Curtis' pearlymussel and its habitat. The area surrounds the last known extant sites for the species in the Little Black River and serves to help protect aquatic habitat in this 3.5-mile reach (MDC 2007). Additionally, the 3.5 mile reach of the Little Black River in the Mudpuppy Conservation Area was designated an outstanding resource water by the Missouri Department of Natural Resources (MDC 2007). These designated areas require more stringent water quality standards for various activities regulated under the Clean Water Act that may affect aquatic resources. However, these two measures have proven to be ineffective in protecting the species.

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes: There is no past or present demand for the Curtis' pearlymussel for any commercial, recreation, or educational purposes. This species was collected, under the appropriate permits, in the 1980's as part of surveys, monitoring, and life history studies. The majority of those collected specimens were returned to the population.

2.3.2.3 Disease or predation: No disease or predation on the Curtis' pearlymussel has been documented. Predation on freshwater mussels from raccoons, muskrats, and river otters is common, particularly during dry periods when low water levels allow easier access to mussel beds.

2.3.2.4 Inadequacy of existing regulatory mechanisms: As described in section 2.3.2.1, recent studies indicate that EPA's national water quality standards may not be protective of early life stages of freshwater mussels for acute and chronic ammonia (Augspurger *et al*. 2003, Wang *et al*. 2007*a*, Wang *et al*. 2007*b*). This has implications throughout the range of the Curtis' pearlymussel as ammonia is a common pollutant.

Currently, the Curtis' pearlymussel is considered state endangered in Missouri, and with this status the species is extended protection under the State Wildlife Code (3 CSR 10-4.111). In Arkansas it is listed as a Species of Greatest Conservation Need (SGCN) in the Arkansas Wildlife Action Plan (AWAP) (Anderson 2006). Inclusion on the SGCN list does not confer any special or regulatory status, but these species are addressed by the AWAP where threats and conservation measures identified for the species.

2.3.2.5 Other natural or manmade factors affecting its continued existence: Significant flooding may have contributed to the decline of the Curtis' pearlymussel at least one site in the Little Black River (Buchanan 1993*a*). In December, 1982, flooding occurred, of unprecedented magnitude, throughout the Little Black River basin. The flooding was estimated to be larger than the estimated 100 year flood (USGS 1987). Subsequent monitoring indicated the habitat had been significantly altered (loss of substrate stability) in a ¾ mile stretch that encompassed one extant Curtis' pearlymussel site. Likewise, a significant decline in the mussel fauna was documented at this site after this flooding (Buchanan 1993*a*). Negative effects of major flooding also have been documented in other mussel populations where channel alterations destroyed habitat and individual animals (Hastie *et al.* 2001, Oliver *et al.* 2008).

Drought is another natural factor that can have devastating effects on freshwater mussels because of their inability to escape adverse environmental conditions. Riffle species like the Curtis' pearlymussel are particularly vulnerable to drought because they typically live in shallow water. Low water also allows raccoons and other small mammals that prey on mussels to gain easy access to mussel beds, thus increasing predation. Flow data are only available for the Little Black River from 1980-1986, 2007, and 2008. Of these years, stream flow was lowest in 1980 and 1981, both years prior to the 1982 flood (Table 2). Other periods of low flow (below 40 cubic feet per second) occurred in August and September of 1983 and 2007 (Table 2). Drought, as well as extreme flooding may have contributed to the decline of the Curtis' pearlymussel population in the Little Black River.

Global climate change poses a new potential threat to the Curtis' pearlymussel. Current climate change predictions for the Midwest indicate warmer air temperatures, more intense precipitation events, and increased summer drying [U.S. Global Change Research Program (GCRP) 2009]. These changes are likely to have complex and unpredictable effects upon freshwater biota, but some potential impacts related to extreme low and high water events and overall temperature changes to mussel populations are intuitive. Increased occurrence of both major flood events and drought in the Midwest would affect any remaining populations of the Curtis' pearlymussel as discussed above. Additionally, the human response to drought would be increased water withdraw from streams for crop irrigation, and thus, would further decrease water levels in streams intensifying the effects of drought.

Water temperatures would increase in Midwestern streams with the predicted increases in air temperatures (GCRP 2009). More periods of drought would intensify this effect within streams and smaller streams in particular. Because freshwater mussels are ectotherms (body temperature depends on the environment), their physiological processes and reproductive success are constrained and controlled by water temperature. Mussels appear to have varying temperature optima, which strongly influences filtration rates, excretion rates and other processes (Sponner and Vaughn 2008). Therefore, increased water temperatures would be expected to cause changes in the distribution and abundance of species and local extirpations could occur. Species would be expected to respond differently to climate change, and therefore, it is uncertain whether changes in water temperature would affect the Curtis' pearlymussel. The species is limited to relatively cool upper reaches of small Ozark streams. This distribution suggests that it or its host fish would be sensitive to increased water temperatures.

Ficke et al. (2005) described the general potential effects of climate change on freshwater fish populations world-wide. Overall, the distribution of fish species is expected to change including range shifts and local extirpations. Because freshwater mussels are entirely dependant upon a fish host for successful reproduction and dispersal, any changes in local fish populations would also affect freshwater mussel populations. Therefore, mussel populations will reflect local extirpations or decreases in abundance of fish species. Species such as the Curtis' pearlymussel that have one or small number of suitable fish host species would be more likely to be affected with changes in the fish community.

As the climate may change, species across the United States are expected to undergo large shifts in range (GCRP 2009). With increases in air temperature, the range of some species may gradually shift northward to stay within their optimal temperature. However, species like the Curtis' pearlymussel, with limited and highly fragmented suitable habitat and populations, may have a more difficult time adjusting their ranges or may not be able to respond to changing conditions at all. All streams within the range of the Curtis' pearlymussel flow south from southern Missouri into Arkansas and eventually flow into the Mississippi River. Given this drainage pattern, a gradual shift in the range of the species northward to a cooler climate would not be possible for the species. Populations would first have to shift a considerable distance to the south before beginning to migrate north to more suitable habitat. Dispersal of mussel populations into more suitable regions of the country via fish hosts could be possible. Mussel populations are sometimes capable of traveling long distances while attached to their fish hosts. However, the Curtis' pearlymussel is dependant upon darters for dispersal, a relatively localized fish species not known to travel or migrate long distances.

2.3 Synthesis

Since the recovery plan was written in 1986, the Curtis' pearlymussel has further declined to the point that it is no longer detectable where known populations occurred in accessible numbers (i.e., Little Black, Black, Castor rivers in Missouri and the South Fork Spring River in Arkansas). Because of this decline and the continued presence of threats in these streams, the species still meets the definition of endangered. While the species has not been seen since 1993, it should not be considered extinct because suitable habitat still exists and not enough time has gone by since its disappearance. The Curtis' pearlymussel occurred in a wide range of streams within the Ozarks, and an unknown population could exist in a stream with no prior records of the species. Further, the species could possibly be found where it has been collected in the past because of its small size and cryptic nature. With improved habitat, particularly in water quality, freshwater mussel communities have been known to rebound quickly and species that have not been seen in decades reappear (Ahlstedt *et al.* 2004). If this would hold true for the Little Black River and other Curtis' pearlymusssel streams, the species may still have a chance of being relocated when improvements are accomplished.

3.0 RESULTS

3.1 Recommended Classification:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist (*Indicate reasons for delisting per 50 CFR 424.11):*
 ____ *Extinction*
 ____ *Recovery*
 ____ *Original data for classification in error*
_X_ No change is needed

3.2 New Recovery Priority Number: No Change

Brief Rationale: Based on the available information, we do not believe any change is necessary to the recovery priority number because the species remains a subspecies with a high degree of threat and a low potential for recovery.

3.3 Listing and Reclassification Priority Number: Not Applicable

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

After considering all new information on the Curtis' pearlymussel, we recommend the initiation of the following actions before the next 5-year review:

1. Conduct a threats analysis of the Little Black River watershed to identify potential threats that could be contributing to the decline and continued suppression of this once diverse freshwater mussel fauna. Emphasis should be placed on identifying contaminants and potential sources of water quality degradation. This should involve bioassays using new techniques involving monitoring the survival of caged juvenile mussels (Barnhart 2006). In particular, ammonia needs to be monitored at least over the course of a year to determine temporal and spatial distribution of this pollutant in the Little Black River. If the primary stressor can be identified, removing that threat could allow the mussel fauna to begin to recover, and possibly the Curtis' pearlymussel could return to assessable numbers.

2. Because the Curtis' pearlymussel has not been found in several years, searches should continue of any remaining habitat that has not been surveyed within its historical range in Missouri and Arkansas.

3. Identify any areas outside of its known historical range that may have suitable transitional habitat and supporting an undiscovered population, and survey these areas if they have not been surveyed adequately.

4. If a population is discovered the following actions may be appropriate:
    a. Confirmation of host fish
    b. Artificial propagation and augmentation of existing population
    c. Reintroduction of the species into suitable historical habitat
    d. Further surveys to determine extent of the population
    e. Analysis of watershed where the population is found to determine what threats may be affecting the population
    f. Update the recovery plan

5.0 REFERENCES

Ahlstedt S.A., J.R. Powell, R.S. Butler, M.T. Fagg, D.W. Hubbs, S.F. Novak, S.R. Palmer, and P.D. Johnson. 2004. Historical and current examination of freshwater mussels (Bivalvia: Margaritiferidae, Unionidae) in the Duck River basin Tennessee. Report to Tennessee Wildlife Resource Agency 213 pp.

Anderson, J.E. (Ed) 2006. Arkansas Wildlife Action Plan. Arkansas Game and Fish Commission, Little Rock, Arkansas. 2028 pp.

Augspurger, T., A.E. Keller, M.C. Black, W.G. Cope, F.J. Dwyer. 2003. Water quality guidance for protection of freshwater mussels (unionidae) from ammonia exposure. Environmental Toxicology and Chemistry 22(11):2569-2575.

Barnhart, M. C. 2006. Propagation and restoration of mussel species of concern. Endangered Species Grant Interim Report, Grant No. E-1-42. 42 pp.

Barnhart, M. C., W. R. Haag & W. N. Roston. 2008. Adaptations to host infection and larval parasitism in the Unionoida. J. N. Amer. Benthol. Soc. 27(2): 370-394.

Barnhart, M. C. and A.D. Roberts. 1997. Reproduction and fish hosts of unionids from the Ozark Uplifts. *In*: K. S. Cummings, A. C. Buchanan and L. M. Koch, eds. Conservation and management of freshwater mussels II. Proceedings of a UMRCC symposium, 16-18 October 1995, St. Louis, Missouri. Upper Mississippi River Conservation Committee, Rock Island, Illinois.

Bates, J.M. and S.D. Dennis. 1983. Mussel (naiad) survey--St. Francis, White, and Cache rivers Arkansas and Missouri. Final Report prepared for U.S. Army Corps of Engineers, Memphis District, Contract No. DACW66-78-C-0147. 89 pp + Appendices.

Bogan, A.E. 1993. Freshwater bivalve extinctions (Mollusca: Unionoida): A search for causes. American Zoologist 33:599-609.

Bruenderman, S.A., J.S. Faiman, and A.C. Buchanan. 2001. Survey for the Curtis Pearlymussel, *Epioblasma florentina curtisii* (Utterback 1914) and other mussel species in Little Black River, Missouri. Report prepared for the U.S. Fish and Wildlife Service, Whipple Federal Building, 1 Federal Drive, Fort Snelling, Minnesota 55111-4056. 72 pp.

Buchanan, A.C. 1979. Mussels (Naiades) of the Little Black River Basin in Missouri and Arkansas. United States Department of Agriculture, Soil Conservation Service, Columbia, Missouri. 69 pp.

Buchanan, A.C. 1987. Aspects of the life history of the Curtis' pearly mussel, *Epioblasma florentina curtisi* (Utterback 1915). Missouri Department of Conservation. 21 pp.

Buchanan, A.C. 1988. Densities of the Curtis' pearlymussel and other naiads at selected sites in Little Black and Castor rivers, Missouri. Missouri Department of Conservation. 14 pp.

Buchanan, A.C. 1993*a*. Densities of the Curtis' pearlymussel and other naiads at selected sites in Little Black and Castor rivers, Missouri. Missouri Department of Conservation. 11 pp.

Buchanan, A.C. 1993*b*. The status of the Curtis pearly mussel, *Epioblasma florentina curtisi* in Missouri. Missouri Department of Conservation. 6 pp.

Buchanan, A.C. 1996. Distribution of Naiades in Select Streams in Southeastern Missouri, A survey conducted during 1981-1982. Missouri Department of Conservation, Jefferson City, Missouri. 79 pp.

Ecological Consultants, Inc. 1984. Handbook of the mussels of the St. Francis, White, and Cache Rivers, Arkansas and Missouri. Supplement to the Final Report February 1, 1984. Prepared for the U.S. Army Corps of Engineers, Memphis District. Contract no. DACW66-78-C-0147. 62 pp. + Appendices.

Ficke, A. A., C. A. Myrick, and L. J. Hansen. 2005. Potential impacts of global climate change on freshwater fishes. World Wide Fund for Nature, Gland, Switzerland.

Goudreau, S., R. J. Neves, and R. J. Sheehan. 1993. Effects of wastewater treatment plant effluents on freshwater mollusks in the upper Clinch River, Virginia, U.S.A. Hydrobiologia 252(3):211-230.

Harris, J.L. and M.E. Gordon. 1987. Distribution and status of rare and endangered mussels (Mollusca: Margaritiferidae, Unionidae) in Arkansas. Proceedings Arkansas Academy of Science 41:49-56.

Harris J.L., and M.E. Gordon. 1990. Arkansas Mussels. Arkansas Game and Fish Commission, Little Rock, AR. 32pp.

Harris, J.L., J.L. Farris, and A.D. Christian. 2007. Status of *Epioblasma florentina curtisii* (Frierson and Utterback 1916), Curtis Pearlymussel, in Arkansas. Final Report to the U.S. Fish and Wildlife Service. 37 pp + Appendices.

Hartfield, P. and E. Hartfield. 1996. Observations on the conglutinates of *Ptychobranchus greeni* (Conrad, 1834) (Mollusca: Bivalvia: Unionidae). American Midland Naturalist 135:370-375.

Hastie, L.C., P.J. Boon, M.R. Young, and S. Way. 2001. The effects of a major flood on an endangered freshwater mussel population. Biological Conservation 98:107-115.

Havlik, M. and L.L. Marking. 1987. Effects of contaminants on naiad mollusks (Unionidae): A review. U.S. Fish and Wildlife Series, Research Publication 164:1-20.

Hutson, C. and M. C. Barnhart. 2004. A survey of endangered and special concern mussel species in the Sac, Pomme de Terre, St. Francis and Black rivers in Southeastern Missouri, 2001-2003. Final report. Missouri Department of Conservation, Endangered Species Grant No. E-1-36. 369 pp.

Johnson, R.I. 1978. Systematics and zoogeography of Plagiola (=Dysnomia =Epioblasma), an almost extinct genus of mussels (Bivalvia: Unionidae) from middle North America. Bulletin of the Museum of Comparative Zoology 148:239-320.

Missouri Department of Conservation (MDC). 2007. Mudpuppy Conservation Area Action Plan. Missouri Department of Conservation, Jefferson City, Missouri. 12 pp.

Norman, D.E. 1994. Headwater Diversion Channel Watershed Inventory and assessment. Missouri Department of Conservation, Jefferson City, Missouri.

Oliver, L.R., R. Seed and B. Reynolds. 2008. The effect of high flow events on mussels (*Mytilus edulis*) in the Conwy estuary, North Wales, UK, Hydrobiologia 606 (2008), pp. 117–127.

Rogers, S.O., B.T. Watson, and R.J. Neves. 2001. Life history and population biology of the endangered tan riffleshell (*Epioblasma florentina walkeri*) (Bivalvia: Unionidae). Journal of the North American Benthological Society. 20:582–594

Sietmann, B.E. and J.L. Sadler. 1994. Survey of Curtis pearl mussel (*Epioblasma florentina curtisi*) in Southeast Missouri and Northeast Arkansas. Missouri Department of Conservation, Columbia, Missouri. 14 pp.

Spooner, Daniel E. and Caryn C. Vaughn. 2008. A trait-based approach to species' roles in stream ecosystems: climate change, community structure, and material cycling. Oecologia 158:307-317.

The National Native Mussel Conservation Committee. 1998. National strategy for the conservation of native freshwater mussels. Journal of Shellfish Research 17(5): 1419-1428.

United States Fish and Wildlife Service (USFWS). 1986. Curtis' pearly mussel recovery plan. U.S. Fish and Wildlife Service, Twin Cities, Minnesota. 92 pp.

United States Geological Survey (USGS). 1987. Surface-water hydrology of the Little Black River Basin, Missouri and Arkansas, before water-land improvement practices. Water –Resources Investigations Report No. 87-4076. United States Geological Survey, Rolla, Missouri. 372 pp.

United States Global Change Research Program (GCRP). 2009. Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press.

Utterback, W.I. 1915. The Naiads of Missouri. American Midland Naturalist 4(3-8): 200.

Utterback, W.I. 1917. Naiad geography of Missouri. American Midland Naturalist 5(1): 26-30.

Wang, N, Ingersoll C.G., Greer I.E., Hardesty D.K., Ivey C.D., Kunz J.L., Brumbaugh W.G., Dwyer F.J., Roberts A.D., Augspurger T., Kane C.M., Neves R.J., Barnhart M.C. 2007*a*. Chronic toxicity of copper and ammonia to juvenile freshwater mussels (unionidae). Environmental Toxicology and Chemistry 26(10): 2048-2056.

Wang, N, Ingersoll C.G., Hardesty D.K., Ivey C.D., Kunz J.L., May T.W., Dwyer F.J., Roberts A.D., Augspurger T., Kane C.M., Neves R.J., Barnhart M.C. 2007*b*. Acute toxicity of copper, ammonia, and chlorine to glochidia and juveniles of freshwater mussels (unionidae). Environmental Toxicology and Chemistry 26(10): 2036-2047.

Yeager, B.L. and C.F. Saylor. 1995. Fish hosts for four species of freshwater mussels (Pelecypoda: Unionidae) in the Upper Tennessee River Drainage. American Midland Naturalist 133:1-6.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of the Curtis' Pearlymussel (*Epioblasma florentina curtisii*)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review
____ **Downlist to Threatened**
____ **Uplist to Endangered**
____ **Delist**
__x__ **No change is needed**

Appropriate Recovery Priority Number: 6

Review Conducted By: Andrew Roberts

FIELD OFFICE APPROVAL:
Lead Field Supervisor, Fish and Wildlife Service

Approve Charles M. Wooley Date 1/8/2010

REGIONAL OFFICE APPROVAL:
Assistant Regional Director, Ecological Services, Fish and Wildlife Service, Midwest Region

Approve Lynn M. Lewis Date 2/10/2010

Cooperating Acting **Regional Director, Fish and Wildlife Service, Southeast Region**

Signature Aaron L Valenta Date 3-2-10

Table 1. Known records of the Curtis' pearlymussel (*Epioblasma florentina curtisii*) reported in the literature.

Stream	Locality	State	Collection Date	Number of Specimens	Condition of Specimens and Notes	Reference
White River	Near Hollister	MO	Early 1900's	Unspecified, considered "abundant in White River" by Utterback (1917)	Unknown, presumably collected live	Utterback 1915
	Near Forsyth	MO	Early 1900's	Unspecified	Unknown, presumably collected live	Johnson 1978
Little Black River	Near Doniphan	MO	1979	3	Collected live at 3 sites, first known collections	Buchanan 1979
	Near Doniphan	MO	1979-1985	Over 100 specimens examined	Male and female specimens collected at four sites during the course of several studies	Buchanan 1996
	Near Doniphan	MO	1993	1	**Last specimen observed in the wild live or dead**, live male, estimated 10 years old, collected after 50 hours of search time (Buchanan 1993) and the only specimen found during 100 hours of search time (Buchanan 1996)	Buchanan 1993
Cane Creek	Near Poplar Bluff	MO	1978	1	Subfossil shell	Buchanan 1996
Black River	Unknown	MO	Early 1900's	Unspecified, considered "scarce" by Utterback (1915)	Unknown, presumably collected live	Utterback 1915
	Between Williamsville and Poplar Bluff	MO	1964	"Collected in small numbers"	Unknown, presumably collected live	Johnson 1978
	Near Markham Spring	MO	1960's	Unspecified	Unknown, presumably collected live	Buchanan 1996
	At Williamsville,	MO	1960's	Unspecified	Unknown, presumably collected live	Buchanan 1996
	At Hendrickson	MO	1960's	Unspecified	Unknown, presumably collected live	Buchanan 1996
	Near Markham Spring	MO	1971	Unspecified	"Fresh shell"	Buchanan 1996

Table 1 continued. Known records of *Epioblasma florentina curtisii* reported in the literature.

Stream	Locality	State	Collection Date	Number of Specimens	Condition of Specimens and Notes	Reference
Black River con't	Near Williamsville	MO	1981/1982	Unspecified	Sub-fossil shells	Buchanan 1996
St. Francis River	Near present day Wappapello dam	MO	Unknown	Unspecified	Unknown. This record is probably an error on distribution map.	Johnson 1978
Castor River	Near Zalma	MO	1971-1978	Multiple specimens	Living and fresh-dead	USFWS 1986, Buchanan 1996
	"Upper Castor"	MO	1980	1	Recently dead	Bates and Dennis (1983), Ecological Specialists, Inc. (1984)
South Fork Spring River	Near Salem	AR	1916	Unspecified, presumably multiple specimens	Unknown, presumably collected live	USFWS 1986, Harris and Gordon 1987
	Near Saddle	AR	1980's	Unspecified	Unknown, presumably collected live	Frieda Shilling, *in. litt.* 1998
Spring River	Hardy	AR	Pre 1938	5	Live	Harris *et. al*. 2007
	Hardy	AR	Unknown	1	Unknown. Old museum record.	Harris *et. al*. 2007
	Above confluence with Black River	AR	1980	3	Recently dead (2 females, 1 male), identification of specimens uncertain. Collection discounted in USFWS 1986, listed in Gordon (1987) and Harris and Gordon (1990), identification considered questionable by Harris *et al*. (2007)	Bates and Dennis (1983), Ecological Specialists, Inc. (1984)

Table 2. Monthly averages in flow on the Little Black River, U.S. Geological Survey Data (http://waterdata.usgs.gov)

USGS 07068510 Little Black River below Fairdealing, MO
Butler County, Missouri
Hydrologic Unit Code 11010008
Latitude 36°37'54", Longitude 90°34'31" NAD27
Drainage area 194 square miles
Gage datum 295.18 feet above sea level NGVD29

00060, Discharge, cubic feet per second,												
YEAR	Monthly mean in cfs (Calculation Period: 1980-06-01 -> 2008-09-30) Period-of-record for statistical calculation restricted by user											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1980						52.0	42.4	42.1	37.4	43.1	55.6	57.6
1981	50.5	115.4	113.3	83.7	185.2	145.2	80.6	47.0	33.5	35.6	67.2	70.6
1982	744.1	514.5	406.8	228.7	270.1	67.4	54.4	370.8	81.7	118.6	248.5	1,761
1983	127.7	97.4	104.5	497.4	419.7	76.6	46.4	40.8	31.9	52.2	460.7	485.9
1984	110.2	296.1	401.0	414.3	224.5	64.7	52.8	46.2	41.2	314.8	703.6	752.8
1985	396.9	450.9	682.5	513.8	447.0	106.1	59.3	57.1	56.7	64.1	341.0	228.2
1986	80.0	336.3	283.9	496.7	384.0	313.3	53.1	57.4	50.4	80.7		
2007				344.1	615.4	71.4	51.1	31.5	37.5	51.1	51.0	358.2
2008	173.4	499.3	1,574	1,427	338.0	68.1	47.1	39.1	56.2			
Mean of monthly Discharge	240	330	509	501	360	107	54	81	47	95	275	531
** No Incomplete data have been used for statistical calculation												