Fanshell
Cyprogenia stegaria

5-Year Review:
Summary and Evaluation

Photo credit: Leroy Koch (USFWS)

U.S. Fish and Wildlife Service
Southeast Region
Kentucky Ecological Services Field Office
Frankfort, Kentucky

5-YEAR REVIEW
Species reviewed: Fanshell (*Cyprogenia stegaria*)

1. GENERAL INFORMATION

A. Reviewers

Lead Region: Southeast Region, Kelly Bibb, 404-679-7132

Lead Field Office: Kentucky Ecological Services Field Office, Leroy Koch, 502-695-0468 ext. 106

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Cooperating Region: Midwest Region: Laura Ragan, 612-713-5157

Cooperating Field Offices: Midwest Region: Ohio Field Office, Angela Boyer, 614-416-8993 (ext. 22); Bloomington, Indiana Field Office, Marissa Reed, 812-334-4261; Marion, Illinois Field Office, Matt Mangan, 618-997-3344

Cooperating Region: Northeast Region: Martin Miller, 413-253-8615

Cooperating Field Offices: Northeast Region: West Virginia Field Office, Barbara Douglas, 304-636-6586 (ext. 19); Abingdon, Virginia Field Office, Jordan Richard, 276-623-1233 (ext. 26); State College, Pennsylvania Field Office, Robert Anderson, 814-234-4090

B. Methods Used to Complete the Review:

In conducting this 5-year review, we relied on available information pertaining to historical and current distribution, life history, and habitat of the fanshell, a freshwater mussel. Our sources included the final rule listing the species under the Act, the Recovery Plan, peer reviewed scientific publications, unpublished field observations by the U.S. Fish and Wildlife Service (Service), State, and other experienced biologists, unpublished survey reports, and notes and communications from other biologists or experts. We announced initiation of this review and requested information in a published *Federal Register* notice with a 60-day comment period (73 FR 43947). During this comment period, we obtained information on the status of this species from several experts. The draft 5-year review was also sent out to cooperating field offices for their review. Once all known literature and information was collected for this species, Leroy Koch, the lead recovery biologist for this species with the Kentucky Ecological Services Field Office, completed the review. Comments received were evaluated and incorporated into this final document as appropriate (see Appendix A).

C. Background

1. **Federal Register Notice citation announcing initiation of this review:** 73 FR 43947 (July 29, 2008)

2. **Species status:** The Clinch River in Tennessee and Virginia, and the Green, Licking, and Rolling Fork rivers in Kentucky contain the best remaining populations, but is sparsely distributed elsewhere. However, we have several singular populations in individual rivers that are smaller in size and susceptible to stochastic events. IUCN identifies this mussel as critically endangered.

3. **Recovery achieved:** 1 (1-25% species' recovery objectives achieved)

4. **Listing history**
   Original Listing
   FR notice: 55 FR 25591
   Date listed: June 21, 1990
   Entity listed: species
   Classification: endangered

5. **Associated rulemakings:**

   Federal Register notice: Establishment of Nonessential Experimental Population Status for 15 Freshwater Mussels, 1 Freshwater Snail, and 5 Fishes in the Lower French Broad River and in the Lower Holston River, Tennessee; 72 FR 52434.
   Date: September 13, 2007

6. **Review History:** Recovery Plan: 1991

   Each year, the Service reviews and updates listed species information for inclusion in the required Recovery Report to Congress. Through 2013, we did a recovery data call that included status recommendations of "Declining" for this mussel. We continue to show a "Declining" species status recommendation as part of our 5-year review. The most recent evaluation for this species was completed in 2016.

   A previous 5-year review for this species was noticed on November 6, 1991 (56 FR 56882). In that review, the status of many species was simultaneously evaluated with no in-depth assessment of the five factors as they pertained to the individual species. In particular, no changes were proposed for the status of the fanshell in that review.

7. **Species' Recovery Priority Number at start of review (48 FR 43098)**

5 (indicates a high degree of threat and low recovery potential)

8. **Recovery plan**
Name of plan: Recovery Plan for Fanshell, *Cyprogenia stegaria* (=*C. irrorata*)
Date issued: July 9, 1991

2. REVIEW ANALYSIS

A. Application of the 1996 Distinct Population Segment (DPS) policy

The Act defines species as including any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate wildlife. This definition limits listing DPSs to only vertebrate species of fish and wildlife. Because the species under review is an invertebrate, the DPS policy is not applicable.

B. Recovery Criteria

1. Does the species have a final, approved recovery plan containing objective, measurable criteria? Yes

2. Adequacy of recovery criteria.

a. Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat? No.

b. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)? No.

3. List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information
1991 Recovery Plan Criteria

The recovery plan provides criteria to downlist the species from endangered to threatened and for removal of the species from the Federal List of Endangered and Threatened Species.

Downlisting Criteria

The recovery plan states the following criteria need to be achieved to reclassify the fanshell from endangered to threatened status:

1. Through protection of existing populations and through successful establishment of reintroduced populations or the discovery of additional populations, a total of nine

distinct viable populations exist. The populations shall be distributed throughout the Ohio River basin as follows: one in the upper Tennessee River system, one in the middle to lower Tennessee River system, one in the Cumberland River system, two in a Kentucky tributary to the Ohio River other than the Cumberland River, one in the Allegheny River system, one in the Muskingum or Walhonding River system, one in the Kanawha River system, and one in the Wabash River system. A viable population is defined as a reproducing population that is large enough to maintain sufficient genetic variation to enable it to evolve and respond to natural habitat changes. The number of individuals needed to reach a viable population will be determined as one of the recovery tasks.

This criterion has not been fully met; however, a portion of it has been met with viable populations occurring in the Clinch River (upper Tennessee River system), and in two rivers in Kentucky (Licking and Green). A population has also been located in the Rolling Fork River, a tributary of the Salt River which flows into the Ohio River in Kentucky (see Rolling Fork River information below in 2.3.1.2). Adult fanshells obtained from the Licking River in Kentucky, have been stocked in the lower Muskingum River in Ohio (2010), Kanawha River in West Virginia (2010), Ohio River in West Virginia (2010), Ohio River in Ohio/West Virginia (2016), and lower Tennessee River in Kentucky (2015). Monitoring of these stockings have indicated overall excellent survival (except the status is currently unknown in the lower Muskingum River); however, it is not known if any of these stockings have resulted in new recruitment. We recognize that we have good numbers and growing densities in three rivers at this point. However, we still have recovery work to do to achieve viable populations in additional streams and/or to verify the efforts in the other reaches to ensure this mussel has sufficient viable populations to ensure its representation and redundancy in its range.

2. One naturally reproduced year class exists within each of the nine populations. The year class must have been produced within five years of the downlisting date. Within one year of the downlisting date, gravid females of the species and its host fish must be present in each river.

   Although this criterion has not been fully met and is not well defined, populations in the Licking River (KY), Green River (KY), Rolling Fork River (KY) and Clinch River (TN/VA) are believed to meet this criterion.

3. Biological and ecological studies have been completed, and the recovery measures developed and implemented from these studies are beginning to be successful, as evidenced by an increase in population density and/or an increase in the length of the river reach inhabited by each of the nine populations.

   This criterion has not been met and is not well defined. However, we are making progress towards this criterion in the Clinch, Licking (e.g., increase in population), and Green Rivers.

Delisting Criteria

The recovery plan identifies delisting criteria for this endangered mussel (FWS 1991). As significant progress has not been made toward delisting, we will not restate these criteria in this five-year review. The only progress we have to provide that may apply to delisting criteria number one is provided in number one of the downlisting criteria above.

C. Updated Information and Current Species Status

1. Biology and Habitat:

New biological information for the species has been obtained since the recovery plan was completed.

New information on the species' biology and life history:

The life history details of the fanshell mussel are thought to be similar to other unionid mussel species (Parmalee and Bogan 1998). Specific life history and propagation work has been completed for the fanshell since publication of the recovery plan (Jones and Neves 2002). These researchers observed gravid females from late October to late May in the Clinch River in Tennessee. Nine host fish were identified through induced infestations of glochidia: mottled sculpin (*Cottus bairdi*), banded sculpin (*Cottus carolinae*), greenside darter (*Etheostoma blennioides*), snubnose darter (*Etheostoma simoterum*), banded darter (*Etheostoma zonale)*, tangerine darter (*Percina aurantiaca*), blotchside logperch (*Percina burtoni*), logperch (*Percina caprodes*), and Roanoke darter (*Percina roanoka*). Dr. Monte McGregor, malacolgist with the Kentucky Department of Fish and Wildlife Resources (KDFWR), identified the blackside darter (*Percina maculate*) as a host for the species, confirmed the previously mentioned logperch and greenside darter as hosts, and has transformed fanshell glochidia to juveniles using *in vitro* techniques. This process has significant potential for propagation work because it does not require the use of a host fish.

In Kentucky, Dr. McGregor has worked with the Service's Wolf Creek National Fish Hatchery to contain infested log perch in cages which were placed in Lake Cumberland in 2016. Results of this cage culture effort were not successful in transforming fanshell larvae into juveniles on host fish in 2016; however, it will be attempted again using different techniques.

Dr. McGregor was successful in propagating fanshells in a laboratory facility in 2016 using fish host and the *in vitro* methods. He successfully reared about 200 fanshells to a sub-adult stage from this effort (McGregor 2017). A portion of juveniles produced from this effort, approximately 1,000 juveniles were sent to Dr. Chris Barnhart in Missouri; however, efforts to culture these juveniles were unsuccessful (Barnhart 2017).

a. 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:

Fanshell mussels are difficult to detect, because a portion of the population can occur below the top of a stream's substrate. Therefore, population estimates must take into account the possibility that individuals are buried. Qualitative and quantitative estimates likely underestimate the number of individuals. In addition, where fanshell mussels occur in low population densities, population estimates may have large margins of error due to undetected mussels. Sparsely distributed juveniles and/or subadults, indicative of successful reproduction, are likely even more difficult to find than adults. Successful recruitment of fanshell mussel populations is difficult to detect when densities are very low and/or when survey efforts are inadequate to detect rare species. Few intensive, statistically valid surveys have been conducted on populations of this species outside of the Clinch River, Green River, Licking River, and Rolling Fork River systems. Populations with densities near or below the detection rate may not be practically assessed with quantitative techniques. Difficulty in detecting fanshell mussels can result in poorly defined information about the species' distribution and abundance in streams where the species is known to occur.

All streams with currently known fanshell mussel populations are listed below, and all occur within the Ohio River basin. There is no indication this species' distribution has changed substantially since the recovery plan was completed.

Ohio River Basin

Tennessee River System

Clinch River

The following status update of fanshell mussels in the Clinch River in Virginia and Tennessee was provided by Jess Jones, U.S. Fish and Wildlife Service, Blacksburg, Virginia (Jones 2017). The Clinch River fanshell population occupies a reach from river mile 159 at Grissom Island, Tennessee, upstream to river mile 213 at Clinchport, Virginia (Jones et al. 2015; Ahlstedt et al. 2016). The species is present at numerous localized gravel shoals (>20) within this reach, typically occurring at a site density of less than 0.1 per square meter. Quantitative sampling from 2004 to 2014 (Jones et al. 2015) documented juvenile recruitment, revealing a cohort structure comprised of juveniles (1 to 4 yrs.), young adults (5 to 15 yrs.), and older adults (16 to 25+ yrs.). Quantitative sampling from 1979 to 2004 further demonstrated that a similar density and cohort structure has been maintained within this river reach over a 25-year period (Ahlstedt et al. 2016). Therefore, the population continues to recruit and maintain itself at a similar density over the last 30 years. As long as water quality and habitat conditions are maintained in the river, this population should continue to exist at such levels.

Tennessee River (mainstem)
The fanshell is considered extremely rare in the Tennessee River mainstem and its current status is likely limited to individuals that are of such low density as to be undetectable by typical survey efforts. Although he has not conducted mussel surveys specifically for the fanshell mussel, Mr. Jeff Garner, Alabama's state malacologist, provided information regarding this species' status in the Tennessee River in Alabama, and believes that this species is apparently extant in the riverine reach of the Tennessee River just downstream of Wilson Dam in northwestern Alabama (Williams, et al. 2008). He found a single live individual during 389.5 hours of dive time in Pickwick Reservoir (including the Wilson Dam tailwater area). Mr. Garner also indicated that no fanshells were observed in 146 hours of sampling in Wheeler Reservoir, including the Guntersville Dam tailwaters, the most likely place to find it in Alabama outside of the Wilson Dam tailwaters. Downstream of Pickwick Landing Dam, a population of this species likely still occurs; however, very little specific searching has been done for the fanshell since the recovery plan was completed in 1991.

The fanshell is rarely encountered during routine mussel sampling in the Tennessee River downstream of Pickwick Landing Dam (river mile 206) to Swallow Bluff Island (river mile 170). One to two individuals are collected every few years in this area. In 2008, divers logged about 34 hours of dive time in this portion of the river and observed one live fanshell (Hubbs 2017).

In 2012, Dr. Monte McGregor (KDFWR) stocked 100 adult fanshells into the lower Tennessee River downstream of Kentucky Lock and Dam. Monitoring of this stocking has indicated high survival and gravid females; however, no evidence of juveniles has been observed (McGregor 2017)

Cumberland River System

Cumberland River
The following information is from Don Hubbs of the Tennessee Wildlife Resources Agency (TWRA), who has surveyed portions of the Cumberland River that are most likely to contain fanshells.

TWRA has spent considerable effort surveying portions of the Cumberland River to track commercial mussel stocks and monitor endangered mussel occurrences over the past 25 years. During June 2011 to August 2012, 10 trips were made to the Cumberland River in the upper reach of Old Hickory Reservoir located between Carthage and Lebanon, and one trip was made to the lower Cumberland River upstream of Clarksville (Mile 135-140) where mussel recruitment occurs among reservoir tolerant species, but not for the fanshell. A total of 81 hours of time (7.4 hours/day) was accumulated by TWRA divers searching for mussels at 34 sites within areas that historically supported a diverse mussel fauna. These 34 sites are among the best physical habitat left in the main stem Cumberland River where the fanshell would most likely remain, however persistent cold water discharges from Wolf Creek, Dale Hollow, and Center Hill dams

for over 50 years have nearly eliminated the entire mussel fauna, including most common and commercially valuable mussels (Hubbs 2017).

Ohio River System

Ohio River (mainstem)
There are recent (since 2000) records of live fanshell mussels from the mainstem Ohio River where it borders West Virginia and Ohio, specifically the Belleville and Racine pools. Fanshells are rarely observed in these pools, but a small population still persists based on these recent detections. One live individual was observed in the Belleville Pool at Neal Island in 1994, and one live individual was observed at Muskingum Island in 2009 that was estimated to be 8 to 10 years old. The Belleville Pool was significantly impacted in 1999 due to a chemical spill that killed most or all mussels within the area impacted, and further impacted in 2005 by loss of pool (lowered 16 feet at the dam) when several barges blocked the gates open.

Restoration efforts have been ongoing within the Belleville pool since 2007. In 2010, 200 fanshells from the Licking River in Kentucky were used to augment the population at Muskingum Island. Muskingum Island is located just upstream of the area impacted by the 1999 spill. These fanshells have shown good survival over the past 6 years. Unstocked fanshells are more frequently encountered throughout the pool from just downstream of Willow Island (2 in 2012), along the Ohio shoreline near Buckley Island (1 in 2011), and in the backchannel of Buckley Island (1 in 2016). Live fanshells have also been collected along the right descending bank near Muskingum Island (1 in 2009, 1 in 2011, and 2 in 2015). Naturally recruited fanshells continue to be collected during survey efforts at Muskingum Island. In 2012, the first naturally recruited fanshell was detected within the area impacted by the 1999 spill, near old Lock 18. In 2014, another naturally recruited fanshell was observed at the head of Neal Island, which is also within the area impacted by the 1999 spill.

The last live fanshell observed within the Racine pool was observed in 2002. Only one survey has been conducted at this location (just downstream of the Belleville Dam) since 2004, and no fanshells were observed.

In 2016, 99 fanshells from the Licking River in Kentucky were established within the Greenup Pool of the Ohio River at river mile 284. This site will be monitored over the next several years to determine survival (Clayton 2017); and, if it is successful, additional individuals will be added.

The species may occur elsewhere in the Ohio River; however, more extensive and thorough mussel surveys are needed to determine the species' status in the Ohio River mainstem.

Kanawha River
The fanshell is extant in the upper two-thirds of the Marmet Pool of the Kanawha River in West Virginia. Two live individuals were observed in 2006 between Glasgow and

Watson's Island. This population may be expanding, based on the observation of 13 individuals that were found during a salvage effort associated with a pipeline project at Pratt in 2013, including a <12mm juvenile. Extant populations of fanshells continue into the upper reaches of the Kanawha River from the head of London Pool (7 individuals in 2014, juvenile in 2016) upstream to Kanawha Falls. The low density population at Kanawha Falls was augmented in 2010 with 203 individuals from the Licking River in Kentucky. Additionally, naturally recruited individuals continue to be observed within the Kanawha River. Six newly recruited individuals were observed during monitoring of this site in 2010, and two additional untagged fanshells were observed within the monitoring area in 2015, indicating that recruitment continues. Monitoring of the augmented population continues to show good survival (Clayton 2017).

Licking River

The Licking River harbors the healthiest population of fanshell mussels in Kentucky based on densities and year classes. The fanshell's range within the Licking River extends from Kenton and Campbell Counties, near the mouth of the river in northern Kentucky, upstream to the Clay Wildlife Management Area in Nicholas County, Kentucky, a distance of approximately 75 river miles. There are multiple sites within the Licking River where recruitment is occurring, as evidenced by the presence of multiple size classes and juveniles at these sites. During quantitative sampling in the Licking River, fanshell densities have ranged from 0.1 to 3 mussels per square meter. The best recruitment and highest densities tend to occur in the downstream sections of the Licking River, where the population appears to be increasing. At one site, the density of fanshells in 2007 was about 1 per square meter, and, in 2016, that same site had increased to a density of 3 fanshells per square meter. At another site in the Licking River, every year class was represented, indicating successful recruitment on an annual basis (McGregor 2017).

Rolling Fork River (tributary to Salt River)

The Rolling Fork River supports at least one reproducing population of fanshell mussels, but its range in the Rolling Fork River appears to be restricted to Nelson County, Kentucky, where individuals can be found in a few locations over a distance of approximately 9 miles. During quantitative sampling in 2007 at one location, multiple size classes and juveniles were located, and densities were determined to be 0.55 mussels per square meter. In 2013, densities were 0.9 fanshells per square meter at that same site (McGregor 2017).

Green River

The Green River in Kentucky supports what is considered to be a healthy, reproducing population of fanshells based on densities and year classes present. The fanshell's range within the Green River extends from near the mouth of the Barren River upstream to Green River Lake, a distance of approximately 60 miles. Obvious recruitment, as evidenced by multiple size classes and juveniles, has been observed at several sites. Dr. Monte McGregor (KDFWR) has recently conducted quantitative and qualitative surveys at selected sites in the river. Fanshell mussel densities ranged from 0.05 to 0.6

mussels per square meter at the survey locations. Within the Green River, fanshells populations are considered to be recruiting, stable and/or increasing. Fanshell populations appear to be doing their best in the free flowing portions of the Green River (McGregor 2017).

Barren River (tributary to Green River)
Recent observations of fanshell mussels from the Barren River are restricted to an area downstream of Lock and Dam No. 1 near Greencastle and below Bowling Green, Kentucky. This species may still be extant in the Barren River; however, only relic individuals have been recorded over the last several years, most recently in 2008.

Wabash River System

Mr. Brant Fisher, Indiana Department of Natural Resources, provided the following information as to the current status of the species in Indiana in the Wabash River system (Fisher 2017).

East Fork White River
The fanshell still occurs in the East Fork White River from Williams Dam, Lawrence County, downstream to the confluence of the West Fork and East Fork White Rivers, Pike/Daviess/Knox counties. The highest concentrations of the species occur from Williams Dam downstream to Hindustan Falls, Martin County. Although this population is extant, fanshells are not abundant. Fanshells observed in middens over the last 15 years average about 12 years of age.

Tippecanoe River
This population is similar to those found in the East Fork White River. They are regularly observed but never in large numbers. Evidence suggests that they are still reproducing to some extent, with one five-year old individual observed in 2008.

Wabash River
The fanshell is rare in the mainstem Wabash River and likely not reproducing, based on only old individuals observed. One live individual was found in 1988 in Wabash County, Indiana, and another live individual was found in 2004 in Carroll County. It is possible that the Tippecanoe River population is contributing individuals to the Wabash River.

Muskingum River system

Muskingum River (mainstem)
The fanshell is considered to be extant in the lower reaches of the Muskingum River in Morgan and Washington Counties, Ohio (Hoggarth 1993, Watters 2017) with occasional observations of juveniles and adults suggesting recruitment. Only relic and subfossil individuals have been observed in the Walhonding River and Killbuck Creek (Hoggarth 1994).

In 2010, about 200 adult fanshell were stocked in the lower Muskingum River just below Devola Dam a couple of miles upstream of the Ohio River. The current status of this stocking is unknown but it is thought that they are likely still present there, since stocked fanshell mussels have done well at all other locations (Watters 2017).

Allegheny River system

Allegheny River (mainstem)
The fanshell mussel is currently considered extirpated in the Allegheny River and other portions of Pennsylvania; however, there is a need for additional survey work in Pennsylvania to examine areas either not surveyed or inadequately surveyed, since other species presumed extirpated have been recently documented (Anderson 2017).

Summary
In summary, the best populations of the fanshell mussel occur in the Licking, Green, and Rolling Fork rivers in Kentucky, and in the Clinch River in Tennessee and Virginia. These populations are considered healthy with evidence of recruitment over several years or even decades, with multiple year classes present. The Rolling Fork River population adds one more known reproducing population since the recovery plan was written, but it is a relatively small population compared to the Licking River, Green River, and Clinch River populations. Other locations (e.g., East Fork White, Tippecanoe, Kanawha, Ohio Rivers, etc.) appear to have small and restricted, extant populations with limited evidence of recruitment. Additional survey efforts need to be conducted in portions of its historic range to better assess its current status.

b. Genetics, genetic variation, or trends in genetic variation:

Dr. Jess Jones (USFWS at Virginia Tech) conducted a genetic characterization of extant populations of the fanshell mussel in the Clinch River, Tennessee, and the Green, Licking, and Rolling Fork Rivers, Kentucky (Jones *et al.* 2008). These results have provided some recommendations on management of these populations. Based on phylogenetic analyses of mitochondrial DNA sequences, and analyses of variation of nuclear DNA microsatellite loci, individuals from the Green, Licking, and Rolling Fork rivers showed low divergence, and the Clinch River population showed moderate divergence from the Green, Licking and Rolling Fork populations. The close similarity between fanshells from the Green, Licking, and Rolling Fork rivers may allow unconstrained exchange of individuals within the Ohio River basin. Regarding the Clinch River fanshell population, it could be treated as a separate management unit; however, any uniqueness of the Clinch River population is based on the absence of a second mtDNA lineage rather than the possession of a unique population-specific genetic attribute. The population can, therefore, not be regarded as a unique evolutionary unit and exclusion of the population from an overall metapopulation management strategy for fanshell mussels is not justifiable.

In the past, there has been questions regarding the status of *Cyprogenia stegaria* as a distinct species from *Cyprogrenia aberti*, which occurs west of the Mississippi River.

However, recent research by Roe and Chong (2014) examined genetic diversity in the genus *Cyprogenia* and determined that there are three distinct populations or groups of *Cyprogenia*, and recognized three evolutionary lineages within the genus. *Cyprogenia* that are found west of the Mississippi River within the range of the western fanshell, *C. aberti*, appears to form two distinct lineages, one restricted to the Ozark region and the other in the Ouachita region (Roe and Chong 2014); and, this report supports considering the fanshell, *C. stegaria*, as a distinct entity, occurring east of the Mississippi River and occupying tributaries of the Ohio River basin.

c. Taxonomic classification or changes in nomenclature:

There has been no change in the classification or nomenclature of this species since it was listed (ITIS 2017).

d. Spatial distribution, trends in spatial distribution, or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.):

The fanshell mussel is now sparsely distributed within most of its highly restricted range. Except for populations in the Green, Licking, Rolling Fork, and Clinch Rivers, known populations represent remnants within the historical range of this species. It is unlikely fanshell populations are experiencing any genetic exchange between the different river populations, except possibly in locations where mussels have been transplanted from the Licking River.

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

This species is endemic to the Ohio River system and found in flowing water and stable substrate which contains a relatively firm and clean gravel, sand, and silt mixture. Fanshell mussels are often associated with other riverine mussel species that also prefer this type of habitat.

The Kentucky Chapter of The Nature Conservancy (TNC) has been working in recent years to improve land practices and stream conditions in the Green River Basin. The Nature Conservancy recognizes the mussel fauna, especially the G1-G3 mussel species (as identified by NatureServe) such as the fanshell, as conservation targets in the Green River. The Nature Conservancy's conservation action plan (CAP) includes comprehensive strategies intended to abate threats to freshwater mussel viability by improving water quality, habitat quality, and river flows for mussels. Actions implemented over the past 10 years include a change in flow releases at the Green River Lake Dam to mimic natural flows in the river and the Conservation Reserve Enhancement Program, resulting in the enrollment of nearly 100,000 acres of agricultural land along the upper Green into riparian buffers and sediment capturing prairie fields. The Nature Conservancy's land acquisitions and conservation easements have permanently protected over 35 miles of stream banks on the Green River and

major tributaries. Improvements in habitat conditions in the Licking River Basin have also been initiated by TNC in order to benefit fanshell mussels.

2. **Five-Factor Analysis**

The recovery plan identified several likely factors responsible for the decline of fanshell mussel populations: impoundments, navigation projects, pollution, and habitat alterations such as gravel and sand dredging that directly affected the species and reduced or eliminated its fish host (USFWS 1991). In addition, fanshell populations are all likely isolated from each other, restricting the natural interchange of genetic material between populations. The small size of many of the populations likely contributes to a reduction of genetic variability within populations.

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

Ongoing threats to the fanshell include water quality degradation from point and non-point sources, particularly in tributaries that have limited capability to dilute and assimilate sewage, agricultural runoff, and other pollutants. In addition, the species is affected by hydrologic and water quality alterations resulting from the operation of impoundments. The presence of impoundments may have ameliorated the effects of downstream siltation on fanshells, but these structures also control river discharges and the many environmental parameters influenced by discharge, which may profoundly affect the ability of these populations to occupy or successfully reproduce in downstream habitats.

A variety of instream activities (e.g., sand and gravel dredging, road construction, etc.) continue to threaten fanshell populations. Protecting these populations from the direct physical disturbance of such activities depends on accurately identifying the location of the populations. The indirect effects of altering the streambed configuration may cause changes in previously suitable habitat.

Coal, oil, and natural gas resources are present in some of the watersheds known to support fanshell mussels. Exploration and extraction of these resources can result in increased siltation, an altered hydrograph, and degraded water quality.

Land-based development including residential and agricultural activities near streams often results in loss of riparian habitat, increased stormwater runoff due to increased impervious surfaces, increased sedimentation due to loss of streamside vegetation, and subsequent degradation of streambanks.

b. Overutilization for commercial, recreational, scientific, or education purposes:
The fanshell mussel is not commercially valuable, but it was noted in the recovery plan this species may be included in commercial harvests (USFWS 1991). The fanshell is more likely to occur in harvests from brailing than diving, since brailing is relatively indiscriminate with regard to the mussel species taken. This threat may have diminished in recent years since brailing is on the decline in the Tennessee River

downstream of Pickwick Landing Dam. Overutilization for recreational, scientific, or educational purposes was not considered to be a limiting factor in the recovery plan. We have no new information to indicate this has changed. Currently, the only known individuals of fanshell mussels in captivity are located at the Center for Mollusk Conservation facility operated by the Kentucky Department of Fish and Wildlife Resources in Frankfort, Kentucky.

c. Disease or predation:
This species has a number of predators including muskrats, raccoons, otters, molluscivorous fish, and some invertebrates. Such predation could locally reduce populations of fanshell mussel, but the overall impact of this threat on the species is not known. It is unknown if disease is having an impact on the fanshell. The black carp (*Mylopharyngodon piceus*), a species of Asian carp that is known to predate on snails and mussels, has been recently recorded in the lower Ohio River. This new threat to the fanshell is most likely to impact juveniles and small adults, creating additional obstacles to the species recovery. It remains unknown if the black carp will be a significant predator to the fanshell; and, how extensive the spread of the black carp will be in the Ohio River basin. It has the potential to impact all or only a portion of the fanshell population.

d. Inadequacy of existing regulatory mechanisms:
Coal, oil, and gas resources are present in a number of the basins (e.g., Green River, Barren River, Clinch River) where fanshell mussels occur, and extraction of these resources is considered a continuing threat. Although these resource extraction activities generally occur away from the river, extensive road and pipeline networks are required to access sites. These road networks frequently cross or occur near tributaries, contributing sediment to the receiving waterway. In addition, the construction and operation of wells may result in the discharge of brine. Point source discharges are typically regulated; however, non-point inputs such as silt and other contaminants may not be sufficiently regulated.

Point source discharges, though regulated, may still adversely affect the fanshell mussel. Freshwater mussels appear to exhibit more sensitivity to some pollutants than organisms typically used in toxicity testing. As a result, some of the water quality criteria established by the U.S. Environmental Protection Agency to protect aquatic life may not be protective of mussels. For example, Augspurger *et al.* (2003) found that the current EPA numeric criteria for ammonia may not protect mussels. Consequently, sewage treatment plants that comply with their ammonia effluent limits may still be discharging water that is toxic to mussels. Few substances have been tested for their toxicity to mussels and none on fanshell mussels. "Safe" concentrations of regulated pollutants for this species are not yet known.

Agricultural, suburban, and urban land uses continue to expand in many watersheds within the current range of the species. Land use changes alter runoff patterns and flow in this species habitat, and the consequences of such changes to these remaining populations are not known. Few regulatory mechanisms exist to address land use

changes that may indirectly affect stream habitats far from the source of disturbance. Protection for this species in the states where it occurs usually involves limiting take, and environmental review due to its listing.

e. Other natural or manmade factors affecting its continued existence:
Zebra mussels have continued to spread in North American waterways since their accidental introduction in the 1980s. Large zebra mussel populations in Lake St. Clair, the Detroit River, and Lake Erie appear to have eliminated most native mussels from the colonized areas, although the species may persist in refugia where habitat is less suitable for zebra mussels. Zebra mussel populations in the Ohio River could possibly be negatively impacting fanshell mussel populations. Zebra mussels could also influence recovery actions to benefit this species by limiting locations in which to establish new populations and/or impacting newly established populations.

There are likely many currently unidentified threats to the fanshell that could result in local extirpations. Enigmatic declines have been documented in several streams in Kentucky (e.g. Horselick Creek, Marsh Creek) where strong mussel populations were previously documented but recent surveys have found near total extirpation of listed and common mussel species. Testing of the water and stream sediments have not identified a likely culprit for these die-offs. These declines are a serious concern. We have documented similar enigmatic declines in other freshwater mussels in the southeast with no ultimate resolution found yet. We expect to continue to monitor the situation.

D. Synthesis -

Extant populations of the fanshell mussel currently exist in portions of the Muskingum, Kanawha, Ohio, Wabash, East Fork White, Tippecanoe, Tennessee, Green, Licking, and Rolling Fork rivers in Indiana, Kentucky, Ohio, Tennessee, Virginia, and West Virginia. Each of these populations is susceptible to single, catastrophic events. This includes both natural stochastic events, such as floods, and anthropogenic events, such as toxic spills. The Clinch River in Tennessee and Virginia, and the Green, Licking, and Rolling Fork rivers in Kentucky contain the best remaining populations. Fanshell mussel life history and genetic evaluations have been completed since the recovery plan was written. The close similarity between fanshells from the Green, Licking, and Rolling Fork rivers may allow unconstrained exchange of individuals within the Ohio River drainage. While uniqueness was identified in the Clinch River population, treating it as a separate management unit cannot be justified at this time, since its uniqueness is based on the absence of a second mtDNA lineage rather than the possession of a unique population-specific genetic attribute.

Although specific events can be cited as causing negative impacts to the fanshell mussel, in many cases, diverse freshwater mussel populations persist where fanshell mussels do not. This species may be more sensitive to environmental change than other mussel species, and/or life history traits may make recovery from a disturbance less likely than with other mussels.

Fanshell mussels do exist in large numbers in specific locations (e.g. Licking, Green and Clinch Rivers) such that adult mussels can be translocated to implement recovery actions described in

the recovery plan (e.g., reintroduce species back into historic habitat and augment populations). Also, enough adults currently exist for utilization in propagation facilities to produce juvenile mussels for recovery actions. Future enhancement and trans-locations of individuals could be accomplished through juvenile or adult introductions.

The fanshell mussel should remain listed as *endangered* because the species has declined in portions of its historic range, and threats have not been ameliorated or reduced to a point where downlisting would be possible. Numerous threats persist for fanshell mussel populations including invasive species, habitat alteration, land-use changes, and point and non-point source pollution, and new threats have appeared. Zebra mussels are currently present in much of the Ohio River system where fanshells will need to be established if the species is to recover. It remains to be seen as to how this infestation may affect the survival and recovery of the fanshell in infected waterways. In addition, the black carp (Mylopharyngodon piceus), a species of Asian carp that is known to predate on snails and mussels, has been recently recorded in the lower Ohio River. This new threat to the fanshell is most likely to impact juveniles and small adults, creating additional obstacles to the species recovery. The environmental sensitivity of this species is still poorly known, so it is possible that previously unidentified activities could cause a precipitous decline of one or more of the remaining populations. Before we consider downlisting, we need to develop and protect viable populations in several more streams, enough to maintain genetic diversity in this species range, to ensure redundancy to protect against catastrophes and enigmatic declines, etc, and to ensure resiliency against remaining threats like habitat alteration and pollution.

3. RESULTS

Recommended Classification: Endangered; no change is needed.

4. RECOMMENDATIONS FOR FUTURE ACTIONS

Recommendation: Revise the recovery plan.

A species status assessment should be prepared to evaluate the species' status under the ESA and to help inform recovery planning prior to development of the next five year review. The fanshell recovery plan is over 25 years old and in need of revision. A revised plan will assist all partners, including State agency partners, in planning watershed and ecosystem recovery actions to help recover this mussel and its habitat.

Recommendations for specific recovery actions:

The following recovery actions should be made a priority over the next five years:

1) Conduct additional surveys of known populations to monitor their status and viability.

2) Conduct propagation and culture of juveniles to a suitable stocking size. This would facilitate the propagation and culture of the species and help inform site selection to restore

populations in other rivers. Captive holding of fanshell mussels may provide additional options for the species' recovery and re-establishment into historical habitat.

3) Continue to develop and utilize 'in-vitro' transformation of larvae to provide juveniles for establishing new populations.

4) Determine sensitivity of each life stage to selected contaminants that are likely to be found in streams in which the species currently resides and determine contaminant levels at potential augmentation and reintroduction sites, including the assessment of interstitial water quality.

5) An assessment of habitat should be completed to identify sites where fanshell mussel augmentation and re-establishment can be achieved.

6) Identify and map threats and stressors within each river ecosystem that may affect the fanshell mussel and its host fish at known sites of occurrence, and at potential augmentation and reintroduction sites.

7) Age and growth analyses should be conducted to determine mean age-at-length and longevity of the species in remaining reproducing populations. This would help state and federal agencies and other stakeholders to understand the recruitment rates needed to sustain viable populations.

8) Development of a geospatial database, containing site specific information for each population that should include, but is not limited to:

    a. Occupied stream length
    b. Assessment of population vulnerability
    c. Survey results, including evidence of recruitments and survey dates
    d. Habitat conditions including limiting factors
    e. Opportunities for range expansion

9) Sites suitable for reintroduction efforts should be identified.

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U.S. FISH AND WILDLIFE SERVICE

5-YEAR REVIEW of fanshell (*Cyprogenia stegaria*)

Current classification: Endangered

Recommendation resulting from the 5-Year review: Retain endangered classification. No change in status is recommended.

Review conducted by: Leroy Koch, Kentucky Ecological Services Field Office, Frankfort, Kentucky

FIELD OFFICE APPROVAL

Kentucky Office Field Supervisor, U.S. Fish and Wildlife Service

Approve VIRGIL ANDREWS Digitally signed by VIRGIL ANDREWS Date: 2019.06.17 12:08:34 -04'00' Date June 17, 2019

REGIONAL OFFICE APPROVAL

The Regional Director or the Assistant Regional Director, if authority has been delegated to the Assistant Regional Director, must sign all 5-year reviews.

Lead Regional Director, U.S. Fish and Wildlife Service

Approve Frank Acting ARD-ES Date 7/8/2019

REGIONAL CONCURRENCE

for **Cooperating Northeast Regional Director, U.S. Fish and Wildlife Service**

X Concur ___ Do Not Concur

Signature Kyle J Hartman Acting ARD-Ecological Services Date 6-21-19

Cooperating Midwest Regional Director, U.S. Fish and Wildlife Service

X Concur ___ Do Not Concur

Signature [signature] Date July 3, 2019

APPENDIX A: Summary of peer review for the 5-year review of fanshell *(Cyprogenia stegaria)*

Reviewers: Steve Ahlstedt, retired U.S. Geological Survey biologist, Dr. Monte McGregor, Kentucky Department of Fish and Wildlife Resources, Mr. Don Hubbs, Tennessee Wildlife Resources Agency, and review by Mr. Jess Jones (with FWS)

A. Peer Review Method:
A draft review of the fanshell mussel was sent to each of the reviewers requesting their review and any other comments or additions they felt were appropriate to include in the document. All reviewers have extensive knowledge of this species and have worked with the species in field conditions.

B. Peer Review Charge:
Peer reviewers were asked to evaluate the 5-year review and provide any comments, edits or suggestions/additions on the data and information in this document. Peer reviewers were not asked to comment on the status recommendation.

C. Summary of Peer Review Comments/Report:
Peer reviews were verbal and/or by email with responses placed in the record. All reviewers thought the information in the draft 5-year review for fanshell provided to them was accurate. They did provide some additional references and recommendations that were incorporated into the 5-year review as appropriate.

D. Response to Peer Review:
All comments and suggested edits were carefully considered and incorporated where deemed appropriate in the final draft of the 5 year review. Comments were generally in agreement with our assessment on population status and other information contained in the document. No major concerns were raised.