

Cumberland Monkeyface
(Quadrula intermedia)

5-Year Review:
Summary and Evaluation



U.S. Fish and Wildlife Service
Southeast Region
Asheville Ecological Services Field Office
Asheville, North Carolina

† Please see Addendum 1 at the end of this, our original 5-year review, document. The Addendum provides the limited new information we have gathered for our second 5-year review for this endangered mussel that was initiated in the Federal Register (June 20, 2019; 84 FR 28850), and includes the analysis we have shared to explain the basis for continuing to recommend no change in status for this species.

5-YEAR REVIEW

Cumberland monkeyface (*Quadrula intermedia*)

I. GENERAL INFORMATION

A. Methodology used to complete the review: Public notice was given in the *Federal Register* and a 60-day comment period was opened. Pertinent status data were obtained from the Recovery Plan, published papers, unpublished reports, and experts on this species. Once all known and pertinent data was collected for this species, the status information was compiled and the review was completed by the species' recovery lead biologist in the Asheville, North Carolina, Field Office. A draft of the 5-year review was peer reviewed by three experts familiar with the species (see Appendix A). Comments received were evaluated and incorporated as appropriate.

B. Reviewers

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

Cooperating Region – Northeast Region: Mary Parkin, 617/417-3331

Lead Field Office – Asheville, North Carolina, Ecological Services: Bob Butler, 828/258-3939 Ext. 235

Cooperating Field Offices – Cookeville, Tennessee, Ecological Services: Stephanie Chance, 931/528-6481; Daphne, Alabama, Ecological Services: Jeff Powell, 251/441-5858; Abingdon, Virginia, Ecological Services: Shane Hanlon, 276/623-1233

C. Background

- 1. Federal Register Notice citation announcing initiation of this review:** September 20, 2005: 70 FR 55157
- 2. Species status:** Stable. (2010 Recovery Data Call) Between 2008 and 2009, survey work in Powell River has produced new sites for the species. While still rare and occasional in distribution, there appears to have been some recruitment over the past 15 years. Therefore, its status in Powell River appears to have improved slightly from this discovery of new sites of occurrence. The population of this species in the Duck River is currently considered significant and viable, with ample evidence of recent recruitment from qualitative and quantitative sampling in the early 2000s and quantitative sampling in late summer 2010.
- 3. Recovery achieved:** 1 (1-25% recovery objectives achieved)

4. Listing history

Original Listing

FR notice: 41 FR 24062

Date listed: June 14, 1976

Entity listed: species

Classification: endangered

5. Associated rulemakings

66 FR 32250; June 14, 2001; Establishment of Nonessential Experimental Population Status for 16 Freshwater Mussels and 1 Freshwater Snail (Anthony's Riversnail) in the Free Flowing Reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, Alabama.

66 FR 43808; August 21, 2001; correction; Establishment of Nonessential Experimental Population Status for 16 Freshwater Mussels and 1 Freshwater Snail (Anthony's Riversnail) in the Free-Flowing Reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, Alabama.

72 FR 52433; September 13, 2007; 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.

6. Review History

FWS conducted a five-year review for the Cumberland monkeyface in 1991 (56 FR 56882). In this review, the status of many species was simultaneously evaluated with no in-depth assessment of the five factors or threats as they pertain to the individual species. The notice stated that FWS was seeking any new or additional information reflecting the necessity of a change in the status of the species under review. The notice indicated that if significant data were available warranting a change in a species' classification, the Service would propose a rule to modify the species' status. No change in the mussel's listing classification was found to be warranted.

Recovery Data Call – 2010, 2009, 2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000, 1999, and 1998.

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

5c. This number indicates a high degree of threat, and a low recovery potential.

8. Recovery Plan

Name of plan: Cumberland Monkeyface Pearly Mussel (*Quadrula intermedia*) Recovery Plan (FWS 1984)
Date issued: July 9, 1984

II. REVIEW ANALYSIS

A. Application of the 1996 Distinct Population Segment (DPS) policy: Not applicable. The Cumberland monkeyface is an invertebrate and therefore not covered by the DPS policy. The other DPS questions will not be addressed further in this review.

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?** Yes
 - b. **Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria?** Yes
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.**

There are four recovery criteria listed in the Recovery Plan that must be met for delisting this mussel to be considered. They are addressed below:

1. A viable population of *Quadrula intermedia* exists in the Powell River from the backwaters of Norris Reservoir upstream to approximately PRM 130 and in the Elk River below Fayetteville, Tennessee. These two populations are dispersed throughout each river so that it is unlikely that any one event would cause the total loss of either population. *The Recovery Plan defines a viable population 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 meet this criterion will be determined as one of the recovery tasks.*

When the 1984 Recovery Plan was written, the populations in the Elk and Duck Rivers were considered to be extremely rare, and the population in the Powell River was considered to be rare but the largest and healthiest of the three known populations of this species. The Service currently considers the population of this species extirpated from the Elk River, as no live individuals or fresh dead shells

have been found there in approximately 25 years. Between 2008 and 2009, survey work in Powell River has produced new sites for the species. While still rare and occasional in distribution, there appears to have been some recruitment over the past 15 years. Increasing threats from coal mining activities imminently threaten its continued existence. However, the population of this species in the Duck River is currently considered significant and viable, with ample evidence of recent recruitment from qualitative and quantitative sampling in the early 2000s and quantitative sampling in late summer 2010. At the time the Recovery Plan was written, the Duck River population of this species was threatened by the Tennessee Valley Authority (TVA) proposed Columbia Dam project. This dam was never completed, and the river has recovered to the point where this species has expanded its population size and range in the Duck. The Service is working with researchers and natural resource managers at Virginia Polytechnic Institute and State University (VPI), Virginia Department of Game and Inland Fisheries (VDGIF), Tennessee Wildlife Resources Agency (TWRA), TVA, The Nature Conservancy (TNC), and other partners to improve the status of this species in these streams.

2. Through reestablishments and/or by discoveries of new populations, viable populations exist in two additional rivers. Each of these rivers will contain a viable population that is distributed such that a single event would be unlikely to eliminate *Q. intermedia* from the river system. (If the Duck River Columbia Dam project is not completed and a viable population of the species exists in the Duck River, only one additional viable population will be needed to meet this criterion.)

As mentioned above, this species is included in an NEP designation for 16 mussels and 1 snail in the free-flowing reach of the Tennessee River below Wilson Dam in Colbert and Lauderdale Counties, Alabama and in an NEP designation for 15 Freshwater mussels, 1 Freshwater snail, and 5 Fishes in the Lower French Broad River and in the Lower Holston River, Tennessee. Although some individuals of other listed mussels have been reintroduced into these NEPs over the past several years, no individuals of this species have been reintroduced at these locations.

3. The species and its habitat are protected from present and foreseeable human-related and natural threats that may interfere with the survival of any of the populations.

Some limited progress has been made regarding this criterion; however, we do not anticipate meeting this criterion in the near future. We are working with VPI, VDGIF, TWRA, TVA, TNC, and other partners to improve the status of this species in these streams. In the Duck River, TVA's Reservoir Release Improvement (RRI) program, initiated in 1991, led to the improvement of dissolved oxygen (DO) levels from Normandy Dam in 1994-95. The DO concentration improved from 1 to over 7 in the summer-fall after soaker hoses

were installed to improve aeration of discharged tailwaters. Further, increased minimum flow releases have also increased near-bank stream habitat, which has proven to be the best habitat for juvenile mussels. In the Powell and Duck Rivers, we have ongoing projects that are intended to repair and restore stream banks, riparian areas, and instream habitats. These efforts have provided protection for several miles of stream bank in these watersheds. In the Duck River, the State of Tennessee (TWRA/TDEC) now owns and manages the TVA lands that would have encompassed the reservoir footprint of the now defunct Columbia Dam. This parcel includes 32 river miles and approximately 12,800 acres.

4. Noticeable improvements in coal-related problems and substrate quality have occurred in the Powell River, and no increase in coal-related siltation occurs in the Clinch River.

The Southwest Virginia Field Office of the Service is working with partners and coal mining interests to better protect the Powell River population of this species from mining activities. At the present time, there are no noticeable improvements in coal-related problems and substrate quality in the Powell River. In fact, mining activities appear to be increasing in the entire Clinch River drainage which imminently threatens this mussel's continued existence in the Powell River. This is manifest in more frequent release of polluted water into the river from coal washing facilities in the headwaters. With the increasing need for energy sources and the emphasis towards expanding mining activities, we do not foresee a reverse of this trend in the near future. In fact, a new coal-fired power plant is under construction in the upper Clinch River in Virginia (B. Evans, FWS, personal communication, 2011). The Virginia legislature has passed a resolution mandating the sole usage of Virginia coal for this facility, which is planned to consume 2 million tons per year. Some improvement in conditions in the Tennessee portion of the stream may indicate that habitat conditions are improving in the lower reaches of the free-flowing Powell River.

C. Updated Information and Current Species Status

1. Biology and Habitat

Reproductive Biology: Some life history research has been conducted at VPI since the Recovery Plan was written. This species is a short-term brooder. Host fishes may include the Tennessee shiner, streamline chub, and blotched chub. Gravid females are found in May and June, and are very prone to aborting glochidia when disturbed. Propagation efforts on this species are still in their infancy. Research on *Quadrula* species and other short-term brooders, which are being conducted at various propagation facilities, should increase our level of knowledge and aid significantly in the species' recovery.

Age and Growth: Thin-sectioned fresh dead shells collected during a 2008-09 Powell River survey ranged in age from 7-35 years (mean = 23

years) (Johnson et al. 2010b). Growth was rapid the first 14 years then slowed considerably. Since most mussels tend to divert early energy reserves to growth, this pattern indicates that the species may be late maturing.

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:

Duck River, Tennessee: Systematic surveys have been conducted on the Duck River over the past 30 years by TVA and other biologists (Ahlstedt 1981, 1991; Jenkinson 1988; Hubbs and Jones 2000). From 2000-2003, 112 sites were surveyed throughout the watershed of the Duck River (Ahlstedt et al. 2004). Status information gathered on *Quadrula intermedia* clearly indicates that this population has increased and its range has expanded in the Duck over the past 20 years. Nineteen individuals were found live during qualitative sampling at 11 sites in a 22-mile reach of river downstream from Lillard Mill Dam. This represents a seven-fold increase in numbers compared to TVA sampling conducted in 1988 and an expansion of its range in the river from 16 to 22 miles. In September 2010, six sites were selected for intensive quantitative surveys involving quadrat sampling (80, 0.25 m² quadrats per site) (D.W. Hubbs, TWRA, pers. comm. 2011). A total of 43 individuals were found at three sites. There was evidence of recent recruitment over both recent sampling periods (early 2000s and 2010) and the population is considered viable.

The Duck River population of this species has clearly become the best rangewide and represents the last functional population remaining. TVA's RRI program has led to the improvement of DO levels from Normandy Dam since the mid-1990s. Researchers have credited TVA to a large degree for the improvement of this species' status since aeration and DO levels were increased in their reservoir release.

Powell River, Virginia and Tennessee: The *Quadrula intermedia* population in the Powell River has steadily declined over the past 30 years. At the time the Recovery Plan was written, this population was considered the best of the three remaining populations of this species. Every approximately five years since 1979, quantitative (quadrats) and qualitative mussel sampling has been conducted on the Powell River (Ahlstedt and Brown 1980, Ahlstedt and Tuberville 1997, Ahlstedt et al. 2005). During the sampling regime in 2004, four live specimens were found at four sites, two in Virginia and two in Tennessee. All four specimens were found during the qualitative portion of the sampling effort (i.e., no specimens were found in quadrats), so no density information was available in 2004. In 1999, this species occurred at densities of from 0.01-0.02/foot square at three sites across both states. Densities have decreased

by about half or more since quantitative data has become available, making this rare species even rarer. During 2008-09 sampling, 68 individuals were collected from 12 of 23 sites surveyed (Johnson et al. 2010a, b). Some new sites of occurrence were located. Individuals less than 10 years of age were located in a single 0.5 mile reach.

The species currently occupies a 62-mile reach of river. The upstream limit of distribution appears to have shrunk a few miles since 1990, but overall the reach of occurrence has expanded by about 2.5 miles since that time (Johnson et al. 2010a, b). Overall, its range in the river and overall status appears to have remained relatively constant since 1980s (Johnson et al. 2010b). However, overall mussel populations appear to have improved in recent years in the Tennessee portion of the river (Johnson et al. 2010a). Despite these improvements, evidence of recent recruitment remains largely lacking for the species in the Powell River.

Elk River, Tennessee: During a 120-mile TVA float survey of the Elk River in 1980, one live and five fresh dead specimens of this species were collected from five sites (Ahlstedt 1983). These records are thought to represent the last time an extant population of this species was verified in this stream. Recent sampling between 1990 and 2005 has not located any live specimens or even fresh dead shells of this species (FWS 1999, Ahlstedt et al. 2006). Regional mussel experts now consider *Quadrula intermedia* extirpated from the Elk River.

b. Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):

No information is currently known concerning population genetics.

c. Taxonomic classification or changes in nomenclature:

A recent work suggests that the genus of this species be changed to *Theliderma* (Cummings and Graf 2010). However, until the American Malacological Union considers whether the use of this genus is valid, we continue to retain it in the well known genus *Quadrula*.

d. Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range:

The Elk River, one of the three populations known at the time the Recovery Plan was published (1984), is now considered extirpated. The species is currently restricted to approximately 62 miles of the Powell River, representing a 2.5-mile increase of linear range since 1990, and 22 miles of the Duck River, representing a 6-mile increase in linear range since 1988. Although NEPs have been established in different river

drainages to establish it and several other endangered mussels, no individuals of *Quadrula intermedia* have been reintroduced into these stream reaches to date.

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

This species requires relatively clean substrates and flowing water in shallow shoal habitats for survival. Coal mining activities in the upper Powell River drainage may increase and collectively are increasing concerns to this species since these activities contribute sedimentation, coal fines, and associated contaminants (e.g., polycyclic aromatic hydrocarbons, heavy metals) to the substrate occupied by this species.

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

a. Present or threatened destruction, modification or curtailment of its habitat or range: The Recovery Plan listed impoundment, siltation, and pollution as the “major causes” for the decline of this species. The Elk River population is now considered extirpated due primarily to altered flow conditions below Tims Ford Dam. Impacts include cold-water releases and detrimental hydropeaking flows that have destabilized banks and the stream channel, thus reducing mussel habitat primarily in the middle reaches and secondarily in the lower reaches of Elk River. Increasing demands for water withdrawal, particularly from municipalities, threatens this species in the Duck River. Coal mining is increasing in the Powell River drainage and is anticipated to continue increasing into the foreseeable future. A new coal-fired power plant that will use 2 million tons per year of Virginia coal is under construction on the upper Clinch River in Virginia. The Service and its partners, (e.g., VDGIF, TWRA, TVA, TNC) are working on improving stream habitat conditions in the Duck and Powell Rivers through various funding sources that serve to improve stream bank and riparian habitats. In the mid-1990s, TVA started making ecologically beneficial changes in seasonal discharges from Normandy Dam in the Duck River headwaters that have contributed to increases in DO concentrations and improved habitat conditions downstream. Increased minimum flows have also increased near-bank stream habitat, which has proven to be the best habitat for juvenile mussels. This improvement in nursery habitat has resulted in increases in the populations of numerous species of mussels in the Duck River, including *Quadrula intermedia*. Sampling evidence from the summer of 2010 indicates that this species and others continue to benefit from current regulated flows.

b. Overutilization for commercial, recreational, scientific, or educational purposes: The overutilization for commercial, recreational, scientific or educational purposes was not specifically considered to be a limiting factor in the Recovery Plan. We have no new information to indicate that this has changed.

c. Disease or predation: We have no new information on disease or predation that would indicate either is a limiting factor.

d. Inadequacy of existing regulatory mechanisms: The inadequacy of existing regulatory mechanisms was not specifically considered to be a limiting factor in the Recovery Plan. *Quadrula intermedia* is listed as endangered by the states of Tennessee and Virginia and considered extirpated but with conservation efforts underway in Alabama. Though these designations prohibit the collection of the species without a valid state collecting permit, they do not provide any protection to the species from other forms of take, or offer any regulatory protection to its habitat.

Many of the activities that pose a significant threat to the surviving populations of the *Quadrula intermedia* and its habitat are not subject to the regulations of section 7 of the Endangered Species Act (Act) (i.e., they do not have any federal involvement—no federal permits, authorization, or funding associated with the activity—and therefore no requirement for consultation with the Service if they may adversely affect federally-listed species). Accordingly, most of these activities occur without any coordination with the Service and are reviewed and regulated, if any review/regulation takes place, only by state and local regulatory agencies/governments for compliance with any applicable state and local regulations/ordinances¹. Neither of the states nor the local governments with jurisdictions within the watersheds of streams supporting populations of the Cumberland monkeyface currently have regulations/ordinances that are adequate to protect the species from the effects of residential and commercial development activities; private, county, and state road construction, maintenance, and runoff; agriculture and forestry activities, etc. (e.g., loss of riparian buffers, adequate stormwater controls to protect the stream hydrographs and to control non-point source pollution, etc.). Accordingly, many of the activities occurring in the watersheds of streams supporting the *Quadrula intermedia* continue to impact or contribute to impacts to the species and/or limit the species recovery; or, pose a significant threat to the species and its recovery.

Also, while we have had success through section 7 of the Act in eliminating or reducing impacts to *Quadrula intermedia* and its habitat from some federal activities (activities subject to section 7 of the Act, or activities that are authorized/permitted, funded, or carried out by federal agencies), we have not been successful in eliminating all of the adverse effects from all of these activities. Several of these activities have adversely affected the species, at least

¹ Unless it can be proven: (1) in a federal court of law that violation of section 9 of the Act, which prohibits the “take” of federally listed species, or other federal regulation, has occurred as a result of the activity; or, (2) that violation of section 9 will occur and a permit pursuant to section 10(a)(1)(B) of the Act is required. However, under the former scenario impact(s) to the species has(have) already occurred or is(are) occurring, and the later requires notification of the Service of the impending activity.

in the short-term, and/or affected or are limiting recovery².

e. Other natural or manmade factors affecting its continued existence: Rare species with small, highly disjunct populations like *Quadrula intermedia* may suffer various threats from inherently small population size. These threats are associated primarily with isolation and the deleterious effects of genetics (summarized in FWS 2004).

D. Synthesis

Primary threats to the species remain similar to what they were in 1976 when this species was listed as endangered in the *Federal Register* and to what they were in 1984 when the Recovery Plan was written. Coal mining activities appear to be increasing in southwestern Virginia, where a new coal-fired power plant is under construction on the upper Clinch River. There have been no significant improvements regarding these threats, and coal mining is considered to be an increasing threat to the Powell River population. Since the 1984 Recovery Plan was published, the Elk River population has become extirpated, but the Duck River population has expanded significantly and become more abundant. Although a few new sites of occurrence in the Powell River were recently discovered, the viability status of this population continues to be questionable with little evidence of recent recruitment. The Duck River population is considered viable with evidence of recent recruitment. Considering the overall poor quality of the Powell River population, the Duck River is the only sound population remaining of this species. Some life history research has been conducted. Additional research will increase our level of knowledge for this species and aid significantly in its recovery.

In summary, three populations were considered extant at the time the Recovery Plan was published (1984). Since the mid-1980s, the Elk River population has become extirpated. The Powell River population, despite a few newly discovered localities of occurrence, remains at depressed levels and is imminently threatened by increasing coal mining activities. The Duck River population has expanded its range and become more widespread and abundant with evidence of recent recruitment but is limited to a 22-river mile reach. If the Powell River population is lost, this species will become restricted to a linear population in the Duck River that is highly susceptible to a stochastic event, such as a chemical spill or extreme drought. All of the surviving populations continue to be threatened by many of the same factors identified at the time of listing and the Recovery Plan which contributed to the loss and decline of the species throughout significant portions of its historical range as well as continuing threats to surviving populations (e.g., habitat fragmentation, loss, and alteration resulting from impoundments;

² Section 7 (a)(2) of the Act requires federal agencies to ensure that their activities do not “jeopardize the continued existence” of federally-listed species or “destroy or adversely modify designated critical habitat”; however, it does not prohibit federal activities that adversely affect the species, its habitat, or designated critical habitat if these affects fall below the jeopardy and/or destruction/adverse modification of critical habitat thresholds.

stochasticity; operation of hydroelectric dams; instream mining; wastewater discharges; water withdrawal; and the runoff of silt and other pollutants from ground disturbance activities). In view of this status summary, the Service believes *Quadrula intermedia* continues to meet the definition of endangered.

III. RESULTS

A. Recommended Classification:

 x No change is needed

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

- Conduct life history research and confirm fish hosts.
- Develop propagation technology.
- Reintroduce viable populations in other streams within the historical range (e.g., Clinch, Nolichucky, South Fork Holston, upper Holston, Paint Rock, and Tennessee Rivers below Wilson Dam (and possibly lower French Broad/Holston and Elk Rivers if thermal, DO, and flow regimes are corrected) that have suitable habitat and water quality conditions, through propagation of juveniles and/or release of infected host fishes.
- Augment and expand extant populations (primarily the Duck River) through propagation of juveniles and/or release of infected host fishes.
- Determine viability of the Powell River population.
- Reassess status and viability of currently known population in the Duck River in approximately five years.
- Determine the degree of threat (especially coal mining in the Powell River and water withdrawals in the Duck River) to each stream in which this species occurs.
- The experience from increased minimum flows, aeration improvements, and subsequent DO level increases in the Duck River from Normandy Dam tailwater discharges proves that fairly simple measures can be implemented at TVA dams to improve habitat for mussels. With that in mind:
 - Continue to evaluate TVA's flow releases from other reservoirs (e.g., Tims Ford Dam, Elk River) to explore ways to further improve habitat conditions to potentially reintroduce the species in those rivers.
 - Continue to evaluate TVA's flow releases from Normandy Dam and explore ways to further improve habitat conditions in the Duck River to benefit the species.

V. REFERENCES -

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Personal Communications:

- B. Evans, FWS, Abingdon, Virginia
D.W. Hubbs, TWRA, Camden, Tennessee

APPENDIX A: Summary of peer review for the 5-year review of Cumberland monkeyface (*Quadrula intermedia*)

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Cumberland monkeyface (*Quadrula intermedia*)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

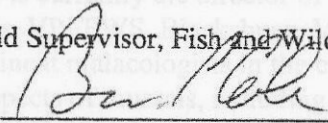
 x No change is needed

Review Conducted By: Bob Butler, Asheville Ecological Services Field Office

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve



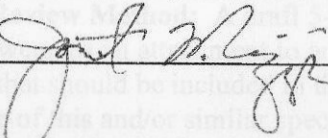
Date

6/22/11

REGIONAL OFFICE APPROVAL:

Lead Regional Director, Fish and Wildlife Service

Approve



Date

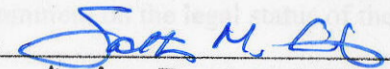
7/5/11

Cooperating Regional Director, Fish and Wildlife Service

Concur

Do Not Concur

Signature



Date

7/28/11

Acting Regional Director

APPENDIX A: Summary of peer review for the 5-year review of Cumberland monkeyface (*Quadrula intermedia*)

Peer Reviewers:

Steve Ahlstedt, U.S. Geological Survey, Knoxville, Tennessee, retired (865/545-4140). Mr. Ahlstedt has conducted survey and other research on mussels for 35 years and is generally considered the most knowledgeable malacologists in the Tennessee River system. He is the senior author of many of the studies cited in this document and although retired, continues to be involved in many aspects of mussel conservation.

Paul Johnson, Aquatic Biodiversity Conservation Center (AABC), Alabama Department of Conservation and Natural Resources, Marion, Alabama (334/683-5069). Dr. Johnson is an all-round expert of mussels who has been conducting research studies and status surveys for 20 years. He is currently the director of the AABC.

Jess Jones, VPI/FWS, Blacksburg, Virginia (540/231-2266). Dr. Jones has emerged as one of the preeminent malacologists in the country today, with a stellar publication record spanning various aspects of mussels, including reproductive and conservation biology, population demographics, genetics, propagation technology, taxonomy, and status surveys. Virtually all of his endeavors have centered on the Tennessee River system and its diverse mussel fauna. He is currently a faculty member at VPI and director of their culture facility (the Freshwater Mollusk Conservation Center), as well as a biologist for the Virginia Field Office of the FWS.

A. Peer Review Method: A draft 5-year review of *Quadrula intermedia* was sent to each of the peer reviewers, as an attachment to an email, requesting their review and any other changes or additions that should be included in the document. All three reviewers have extensive knowledge of this and/or similar species.

B. Peer Review Charge: Reviewers were charged with providing a review of the document including any other comments and/or additions appropriate to include. Reviewers were not asked to comment on the legal status of the species.

C. Summary of Peer Review Comments/Report: The reviewers recognized the imperiled status of the species and generally agreed with the data and conclusions of the draft review.

D. Response to Peer Review: Very few substantial comments were received. Minor edits were generally incorporated into the draft document where appropriate.

5-YEAR REVIEW OF CUMBERLAND MONKEYFACE
(Quadrula intermedia)

Addendum 1. Summary of new information obtained since the 2011 5-year review.

I. GENERAL INFORMATION

A. Methodology used to complete the review

The *Federal Register* notice announcing the initiation of this 5-year review was published on June 20, 2019 (84 FR 28850). No comments were received during the 60-day public comment period following this notice. However, the US Fish and Wildlife Service (Service) did receive additional information about the species, from biologists familiar with the species, in response to requests for specific information.

Only updated information is presented below. Internal review was conducted by one member of the Service's South Atlantic-Gulf Region, and one member of the Service's North Atlantic-Appalachian Region. Additionally, the Service conducted independent peer review on new information (Appendix A). The Service sought review from four knowledgeable experts on this species and its habitats, we received comments from three peer reviewers. Comments have been addressed and incorporated into this addendum as appropriate and necessary.

B. Reviewers

Lead Region: South Atlantic-Gulf Region, Atlanta, GA; Carrie Straight; (404) 679-7226; carrie_straight@fws.gov

Lead Field Office: Asheville Ecological Services, Andrew Henderson, (828) 258-3939 Ext. 42227; andrew_henderson@fws.gov

Cooperating Regional Office: North Atlantic-Appalachian Region, Hadley, MA: Martin Miller (413) 253-8615; martin_miller@fws.gov

Cooperating Field Offices:

Southwestern Virginia Ecological Services: Rose Agbalog, (276) 623-1233 ext. 25; rose_agbalog@fws.gov;

Tennessee Ecological Services: Anthony Ford, (931) 525-4982; anthony_ford@fws.gov

C. Background

- 1. Federal Register Notice citation announcing initiation of this review:** 84 FR 28850; June 20, 2019.
- 2. Species Status:** Declining (2019 Recovery Data Call). The Cumberland monkeyface historically occurred throughout the Tennessee River drainage in the states of Alabama, Tennessee, and Virginia. It is currently limited to two isolated populations: the Powell River near the Virginia-Tennessee border, and the Duck River in central Tennessee. Since 2011, survey work in the Powell and Duck rivers has not uncovered new occurrences of the species,

and it displays an increasing level of rarity, with no recent documentation of recruitment in the Powell River population. Based on limited information, the Powell River population appears to have declined since the last 5-year review completed in 2011, while the Duck River population appears to be stable.

- 3. Review History:** The Service finalized a 5-year review for the Cumberland monkeyface in 2011. The review recommended the species remain classified as endangered due to narrow range, known threats, and inadequate understanding of needed management (Service 2011).

II. REVIEW ANALYSIS

B. Recovery Criteria

- 1. Does the species have a final, approved recovery plan containing objective, measurable criteria?** Yes. However, no downlisting criteria have been developed.
- 2. List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information:**

There are four recovery criteria listed in the Recovery Plan that must be met for delisting this mussel to be considered. They are addressed individually below. Down-listing criteria were not included in the Recovery Plan.

*Criterion 1. A viable population of *Quadrula intermedia* exists in the Powell River from the backwaters of Norris Reservoir upstream to approximately PRM 130 and in the Elk River below Fayetteville, Tennessee. These two populations are dispersed throughout each river so that it is unlikely that any one event would cause the total loss of either population. The Recovery Plan defines a viable population as a reproducing population that is large enough to maintain sufficient genetic variation to enable it to evolve and respond to natural habitat changes.*

This criterion has not been met. The population in the Powell River is considered rare and sporadic, with continued imminent threats from coal mining activities in the watershed (Zipper et al. 2016). As a result, the long-term viability of the population in the Powell River is uncertain. The Service currently considers the population of this species extirpated from the Elk River, as no live individuals or fresh dead shells have been found in the Elk River in approximately 35 years (Service 2011).

*Criterion 2. Through reestablishments and/or by discoveries of new populations, viable populations exist in two additional rivers. Each of these rivers will contain a viable population that is distributed such that a single event would be unlikely to eliminate *Q. intermedia* from the river system. (If the Duck River Columbia Dam project is not completed and a viable population of the species exists in the Duck River, only one additional viable population will be needed to meet this criterion.)*

At the time the Recovery Plan was written, the Duck River population was threatened by the Tennessee Valley Authority's (TVA) proposed Columbia Dam project, but the dam was never completed. The population of Cumberland monkeyface in the Duck River, Tennessee, occurs in approximately 22 linear miles (35.4 kilometers [km]), and remains vulnerable to stochastic events. There have been no re-establishments or discoveries of new populations. This criterion has not been met.

The Virginia Department of Wildlife Resources' (VDWR) Aquatic Wildlife Conservation Center (AWCC) is working to evaluate host fish suitability and identify methods for holding and caring for this species, as well as other closely-related and co-occurring federally protected mussels, thus providing valuable information on culture techniques as well as captive care protocols. To date, the AWCC has reared 4 individuals to 4.5 months of age and 2 mm in length out of 180 metamorphosed individuals, using blotched chub and streamline chub as hosts (T. Lane pers. comm. 2020). If AWCC is able to improve on this success, it may help facilitate reestablishment of populations in an additional river.

Criterion 3. The species and its habitat are protected from present and foreseeable human-related and natural threats that may interfere with the survival of any of the populations.

The threats described in the recovery plan have not been abated. The decline of this species is primarily due to anthropogenic causes, such as impoundments, resource extraction, channelization, pollution, sedimentation, development, and other factors. The species and its habitats continue to be affected by excessive sediment, nutrients, and pollution primarily resulting from nonpoint-source loading from land-use practices. Other impacts stem from the extraction and processing of coal. The species' restricted range and low population levels increase its vulnerability to stochastic events and the deleterious effects of small population size and genetic isolation.

The Service continues to work with VDWR, Tennessee Wildlife Resources Agency (TWRA), TVA, and non-governmental organizations (NGOs) to improve habitats and species status in the Duck and Powell rivers. There are ongoing projects to stabilize stream banks and restore riparian areas; however, multiple human-related threats remain to these populations such as dams, agriculture, and mining. Therefore, this criterion has not been met.

Criterion 4. Noticeable improvements in coal-related problems and substrate quality have occurred in the Powell River, and no increase in coal-related siltation occurs in the Clinch River.

Although there have been some localized improvements since the recovery plan was finalized, coal-related problems and poor substrate quality still persist in the Powell River. Coal extraction and processing continue to negatively impact the Powell and Clinch River watersheds, and pre-Surface Mining Control and Reclamation Act (SMCRA) mine features continue to contribute to poor water quality and effects to aquatic organisms.

The Southwest Virginia Field Office of the Service is working with partners and coal mining interests to better protect the Powell River population of this species from mining activities, though at present there are no documented improvements in coal-related water quality problems and substrate quality. We do not foresee a reversal of this trend in the near future. This criterion has not been met.

C. Updated Information and Current Species Status

1. Biology and Habitat

- a. Abundance, population trends:** The recovery plan recognized three populations of Cumberland monkeyface; however, there was no estimation of population sizes (Service 1984). The population in the Elk River, Tennessee, is extirpated (Service 2011).

Therefore, currently there are only two remaining populations, one in the Powell River, Virginia and Tennessee, and one in the Duck River, Tennessee.

Powell River, Virginia and Tennessee: When the Recovery Plan was written, the Powell River population was considered the best of the three remaining populations (Service 1984). It remains the largest in terms of extent, inhabiting approximately 100 river km (62 miles) of the Powell River (Johnson et al. 2010). A comprehensive survey of the Powell River was conducted in 2008-2009 (Johnson et al. 2010; Johnson 2011; Johnson et al. 2012). Abundance information from that survey was incorporated into the previous 5-year review for the Cumberland monkeyface (Service 2011).

Limited information on the Powell River population has been gathered since 2009. Since our 2011 review, the Service is aware of qualitative and quantitative (quadrat) surveys for freshwater mussels conducted in the Powell River by various entities. However, these efforts have not specifically targeted the Cumberland monkeyface and did not detect the species (Phipps et al. 2018; Phipps 2019). While recruitment in the Powell River population was documented at one site in 2008-2009 (upper and lower Brooks Bridge shoals; Johnson et al. 2012), more recent quantitative and qualitative surveys at these sites did not detect any live individuals. As a result, there has been no documentation of recruitment or multiple age classes present in the Powell River population since 2009.

The only survey efforts targeting the Cumberland monkeyface in the Powell River since 2011 were conducted by VDWR, who collected six live individuals at four different sites in qualitative searches (78 person-hours) for fish host and captive culture studies in 2018 and 2019. Of these six live individuals, three were found from a single shoal (Bales Ford). This recent survey points to the increasing rarity of the species, as it yielded a cumulative total of only 0.08 mussels/person-hour and 0.02 mussels/site, despite targeted sampling. Additionally, four individuals were collected in a bridge crossing survey within the known range in 2012 (Ostby and Beaty 2012). With such limited occurrence information it is difficult to make inferences on the current status of the population, but the decline of freshwater mussel abundance and distribution in the Powell River is well documented through quantitative and qualitative mussel sampling approximately every five years from 1979-2010 (Ahlstedt et al. 2016). This declining trend is expected to continue based on recent surveys and observations.

Mussel surveys in the Powell River have generally documented variable but overall low densities of the Cumberland monkeyface at several sites (0-0.4/m²) indicating low abundance, sporadic occurrence, and persistent vulnerability to extirpation (Johnson et al. 2010; Ahlstedt et al. 2016). Previous surveys have observed the Cumberland monkeyface inhabiting a 96.6-km reach of the Powell River between km 232.7 and 136.1 (Wolcott and Neves 1994). The 2008-2009 survey collected the species between km 129.4 to 229.8. Therefore, the most recent available information on the occupied reach in the Powell River indicates the upstream boundary for the distribution of Cumberland monkeyface has decreased by 2.9 km, but the downstream boundary has expanded by approximately 3.8 km (Johnson et al. 2010).

Water quality has not substantially improved in the Powell River drainage over the last decade, and the mussel decline is attributed to a variety of factors, including degraded

water and sediment quality associated with current and legacy land use activities, including coal mining (Zipper et al. 2016). Habitat quality in the Powell River is adversely affected by increased levels of contaminants, including dissolved solids, trace metals, and polycyclic aromatic hydrocarbons, which in turn can limit mussel survival and reproduction (Diamond et al. 2002; Soucek et al. 2003). Threats to the Cumberland monkeyface continue as a result of historic and ongoing impacts due to mining activities, particularly in the headwaters of the Powell River drainage.

Duck River, Tennessee: Survey information indicates that this population increased in abundance and extent between 1980 and 2010, but there is no indication since 2010 that the species is expanding its range in the river. It remains the largest population in terms of abundance, despite still being considered rare within the Duck River (Ahlstedt et al. 2017; Service 2011). The extent of the Cumberland monkeyface in the Duck River is estimated to be 35.4 river km (22 miles) (Service 2011). Quantitative surveys conducted by TWRA at six sites in the Duck River in 2010, 2015, and 2020 indicate that Cumberland monkeyface is present in low density at three sites (TWRA 2016, Jason Wisniewski pers. comm. 2020) and absent from the other three.

Three of six sites surveyed by TWRA (Lillard's Mill, Venable Springs, and Hooper Island) contained Cumberland monkeyface in the 2010, 2015, and 2020 surveys. While recruitment (indicated by individuals less than 25 millimeters [mm] total length present in the surveys) was documented at two sites in 2010, there was a reduction from 43 total individuals in 2010 to 19 total individuals in 2015 (TWRA 2011; TWRA 2016). Additionally, the smallest individual encountered in 2015 was 42 mm total length (approximate age 4 years), indicating a potential lack of recently recruited individuals. In 2020, out of 16 total individuals observed, none were less than 25 mm in length; however, one individual encountered at Hooper Island was 29 mm. All other individuals encountered during 2020 were between 39-62 mm (mean = 45 mm), indicating a lack of younger age classes represented in the survey.

At Lillard's Mill, Cumberland monkeyface density was 0.10 individuals/m² in the 2010 survey, 0.15 individuals/m² in 2015, and 0.09 individuals/m² in 2020. At Venable Spring, density was 0.50 individuals/m², 0.35 individuals/m², and 0.19 individuals/m², in 2010, 2015 and 2020, respectively. At Hooper Island, density was 1.55 individuals/m², 0.45 individuals/m², and 0.46 individuals/m², in 2010, 2015 and 2020, respectively (J. Wisniewski pers. comm. 2020).

These survey results are highly variable, but indicate the species can still be detected in low abundances consistently within the known range in the Duck River. However, potential declines in Cumberland monkeyface abundance have been observed at Venable Spring and Hooper Island. Inconsistent survey results at these three sites may be a reflection of small sample sizes and survey methods, therefore, our ability to make strong inferences about population status and trends across the occupied reach of the Duck River is limited. Three other TWRA sites sampled in 2010, 2015, and 2020, upstream and downstream of sites where the species was collected, failed to produce Cumberland monkeyface. The survey data does give assurance that the species is still present in the river, but the small, linear area of occupation is cause for concern, as it is highly susceptible to a single stochastic event.

The Duck River in Tennessee is under substantial threats associated with rapid urban development, land use changes, incompatible agricultural practices, wastewater management, water supply practices, and resource extraction activities (US Army Corps of Engineers [Corps], 2018). Further, many developed communities in the watershed are experiencing periodic flooding which is only expected to worsen as development continues. The watershed's aquatic life is experiencing stress from increased development, hydraulic regime changes, and declining suitable habitats (Corps 2018).

- b. Genetics, genetic variation, or trends in genetic variation:** No information is currently known concerning population genetics for the Cumberland monkeyface; however, a PhD student at Virginia Tech has begun collecting genetic data necessary to analyze population structure and the overall genetic viability of this species.
- c. Taxonomic classification or changes in nomenclature:** Cummings and Graf (2010) conducted a taxonomic review and recommended resurrection of the genus name *Theliderma*, which was later accepted (Williams et al. 2017). Further phylogenetic review conducted by Lopez-Lima et al. (2019) provided a consistent recommendation, recognizing *Theliderma intermedia* as the appropriate scientific name of the Cumberland monkeyface. However, the Service currently recognizes the Cumberland monkeyface as *Quadrula intermedia*, as it is listed as such under the Endangered Species Act.
- d. Spatial distribution, trends in spatial distribution:** The Elk River population, one of the three populations known in 1984 at the time the Recovery Plan was published, is now considered extirpated (Service 2011). The species is currently restricted to approximately 100 river km (62 miles) of the Powell River, and 35.4 river km (22 miles) of the Duck River. No increases or decreases in linear range have been documented in either river since 2010.

This species is included in a non-essential experimental population (NEP) designation for 16 mussels and one snail in the free-flowing reach of the Tennessee River below Wilson Dam in Colbert and Lauderdale Counties, Alabama (66 FR 43808). It is also included in a NEP designation for 15 freshwater mussels, one freshwater snail, and five fishes in the Lower French Broad River and in the Lower Holston River, Tennessee (72 FR 52433). Thermal, dissolved oxygen (DO), and flow regimes in the lower French Broad and Holston rivers continue to affect habitat and water quality conditions for the Cumberland monkeyface and its host fishes, thereby limiting reintroduction potential within the NEP (Layzer and Scott 2006; Parmalee and Faust 2006). Although some individuals of other listed mussels have been reintroduced into these NEPs, no individuals of the Cumberland monkeyface have been reintroduced in these locations, and due to limiting water quality and habitat factors other species have not been successfully reestablished.

- e. Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):** This species requires relatively clean substrates and flowing water in shallow shoal habitats for survival, and abundant host fishes. Coal mining activities in the upper Powell River drainage have remained consistent and may increase, and are a concern for this species since these activities contribute sedimentation, coal fines, and associated contaminants (e.g., polycyclic aromatic hydrocarbons, heavy metals, and other ions) to substrates and water quality where the species occurs.

Water quality degradation in the Duck River stems predominantly from agriculture; including riparian buffer alteration, bank erosion, sedimentation, nutrient loading, low DO, and land management. However, this population of Cumberland monkeyface is also threatened by development encroaching from the City of Nashville and nearby smaller urban areas (TWRA 2016). Water supply problems are controversial because high quality and quantity water flows are essential for both supporting rare aquatic species and meeting the basin's growing municipal water demands (Corps 2018). Currently, water withdrawals for irrigation are a threat to Duck River mussel populations, but municipal water needs are anticipated to increase (Corps 2018). Agricultural activities, effects from existing impoundments, and development are currently the greatest threats to this population.

2. Five Factor Analysis (threats, conservation measures, and regulatory mechanisms)

- a. **Present or threatened destruction, modification or curtailment of its habitat or range:** The Recovery Plan lists impoundment, siltation, and pollution as the major causes for the decline of this species. All of these stressors have had increased effects on the species since the last 5-year review completed in 2011. Increasing water supply demands, particularly from municipalities, threatens this species in the Duck River. Coal mining is anticipated to continue in the Powell River drainage into the foreseeable future. The Service and its partners, (e.g., VDWR, TWRA, TVA, and NGOs such as The Nature Conservancy) are working on improving stream habitat conditions in the Duck and Powell rivers through various funding sources to improve stream bank and riparian habitats. In the mid-1990s, TVA started making ecologically beneficial changes in seasonal discharges from Normandy Dam upstream in the Duck River that have contributed to increases in DO concentrations and improved localized habitat conditions downstream (TWRA 2016). However, these improvements have yet to result in a consistently observed increase in density or extent of the Cumberland monkeyface in the Duck River.
- b. **Overutilization for commercial, recreational, scientific, or educational purposes:** The overutilization for commercial, recreational, scientific or educational purposes was not specifically considered to be a limiting factor in the Recovery Plan. We have no new information to indicate that this has changed.
- c. **Disease or predation:** The Cumberland monkeyface Recovery Plan does not specifically discuss disease or predation as limiting factors for this species (Service 1984). The previous five-year review for the Cumberland monkeyface stated that virtually nothing is known regarding mussel diseases, but disease has long been suspected as a cause of mussel declines (Service 2011). This assertion remains true, particularly concerning die-off events (Neves 1987; Haag 2019). Recent research in the Clinch River suggests that mussels involved with an ongoing mussel die-off are strongly associated with infection and high viral load of densovirus, which is known to be the cause of lethal epidemics in other invertebrate groups, indicating that some freshwater mussel declines could be the result of viral epidemics (Richard et al. 2020).
- d. **Inadequacy of existing regulatory mechanisms:** The inadequacy of existing regulatory mechanisms was not specifically considered to be a limiting factor in the Recovery Plan. The Cumberland monkeyface is listed as endangered by the states of Tennessee and Virginia. The species is afforded protections by the state of Tennessee by

the Tennessee Nongame and Endangered or Threatened Wildlife Species Conservation Act (1974) (Tennessee Code Annotated 70-8-101 through 70-8-112), and Virginia under Title 29.1 of their Game, Inland Fisheries, and Boating laws (Chapter 5, Article 6) (Virginia Code Annotated § 29.1-564, (1972) c. 329, § 29-232; (1977) c. 377; (1987) c. 488). The Cumberland monkeyface is considered extirpated from Alabama, with conservation actions underway, due to the established NEP below Wilson Dam (66 FR 43808). Though these state designations prohibit the collection of the species without a valid collecting permit, they do not provide any protection to the species from other forms of take or offer any regulatory protection to its habitat.

- e. **Other natural or manmade factors affecting its continued existence:** Rare species with small, highly disjunct populations like the Cumberland monkeyface may face various threats inherent with small population size. These threats are associated primarily with isolation and the deleterious effects of population bottlenecks. The Cumberland monkeyface is limited to two populations, which due to their relatively small population size may already have reduced genetic diversity and decreased fitness. Species that are restricted in range and population size are more likely to suffer loss of genetic diversity due to genetic drift, potentially increasing their susceptibility to inbreeding depression, decreasing their ability to adapt to environmental changes, and reducing the fitness of individuals (Allendorf and Luikart 2007). The effects of climate change on this species and its host fishes are currently unknown.

D. Synthesis

Threats to the species remain similar to what they were in 1976, when this species was listed as endangered, and 1984 when the Recovery Plan was written. Additionally, the Elk River population, one of the three identified in the Recovery Plan, is now considered extirpated (Service 2011). Additional research on life history and dedicated long-term monitoring efforts in the Powell and Duck rivers will increase our level of knowledge for the Cumberland monkeyface and aid significantly in its recovery.

The current viability of the population in the Powell River is difficult to ascertain due to limited recent detections of the species. The population in the Duck River has been recently surveyed and was found to be present at only three of the six sites sampled. The survey data from the Duck River is not robust enough to make strong inferences about species trends at the three sites, but the Duck River population appears to be small but stable, based on recent survey information.

Coal mining activities and their residual impacts to the waterways are still prevalent in southwestern Virginia and northeastern Tennessee. There have been no substantial improvements to habitat, and coal mining is a continuous threat to the Powell River population. Although improvements in discharge and DO at Normandy Dam on the Duck River have improved water quality downstream, aquatic habitats occupied by the Cumberland monkeyface are fragmented by low-head mill dams and discharge is altered through agricultural activities such as irrigation. The Duck River population of Cumberland monkeyface is also threatened by human development encroaching from the city of Nashville and nearby smaller developing areas.

The two remaining populations continue to be threatened by many of the same factors identified at the time of listing and the Recovery Plan. These factors contributed to the loss and decline of the species throughout significant portions of its historical range, and continue to threaten surviving populations (e.g., habitat fragmentation, loss, and alteration resulting from impoundments;

stochasticity; operation of hydroelectric dams; instream mining; wastewater discharges; water withdrawal; and the runoff of silt and other pollutants from ground disturbance activities). If either the Powell or Duck River populations are lost, this species will become restricted to a linear population in a single river that would be highly susceptible to a stochastic event, such as a contaminant spill or extreme drought. In view of this status summary, the Service believes the Cumberland monkeyface continues to meet the definition of endangered.

III. RESULTS

A. Recommended Classification: No change is needed.

IV. RECOMMENDATIONS FOR FUTURE ACTION

The 2011 5-year review included a list of recommendations to improve recovery of the Cumberland monkeyface, these actions remain applicable to species recovery. Additional recommendations are below.

- Conduct additional life history research, confirm fish hosts, and develop propagation technology. Age studies have been completed but growth and survival of age classes are lacking. Additional host fish testing and development of culture techniques are underway by VDWR. These steps are crucial in order to re-establish the species in the Elk River, Tennessee.
- Reassess status and viability of currently known populations in the Powell and Duck rivers at minimum every five years. Additionally, conduct targeted surveys within both rivers to develop population estimates and effective population size targets. Continue working with TVA, TWRA, and other partners to gather quantitative and qualitative mussel community data in the Elk River, Tennessee.
- Evaluate flow release benefits from operational changes at Tims Ford Dam on the upper Elk River, to assess the benefits of naturally variable seasonal flows, temperatures, and associated DO level increases on freshwater mussels. Continue mussel monitoring and riparian restoration efforts in the Elk River and explore ways to improve instream habitat conditions.
- Reintroduce populations through propagation of juveniles in other rivers within the historical range that have potential for viability (e.g., Clinch, Nolichucky, upper Holston, upper French Broad, and Paint Rock rivers, as well as the Tennessee River below Wilson Dam).

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Cumberland Monkeyface 5-Year Review Addendum

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Zipper, C.E., P.F. Donovan, J.W. Jones, J. Li, J.E. Price, and R.E. Stewart. 2016. Spatial and Temporal Relationships Among Watershed Mining, Water Quality, and Freshwater Mussel Status in an Eastern USA River. *Science of the Total Environment* 541:603-615.

US FISH AND WILDLIFE SERVICE

5-YEAR REVIEW OF CUMBERLAND MONKEYFACE

Current Classification: Endangered.

Recommendation resulting from the 5-Year Review:

- Downlist to Threatened
- Delist
- No change needed

Review Conducted By: Andrew Henderson, Asheville Ecological Services Field Office.

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve _____ Date _____

*Since 2014, Southeast Region Field Supervisors have been delegated authority to approve 5-year reviews that do not recommend a status change.

COOPERATING REGIONAL OFFICE APPROVAL:

We emailed this 5-year review to the following regional and/or field offices for their concurrence prior to finalizing the document: North Atlantic-Appalachian Region. We will retain any comments that we received, as well as verification of concurrence from other regions, in the administrative record for this 5-year review.

APPENDIX A
Peer Review

Summary of peer review for the 5-year review of Cumberland monkeyface (*Quadrula intermedia*).

A. Peer Review Method: Peer review was coordinated by the Interior Region 2 and 4 office. Four peer reviewers were selected by the Service for their knowledge of and expertise with Cumberland monkeyface. Individual responses were received from four reviewers. Additionally, internal review was conducted by two members of the Service's Southeast Region and one member of the Service's Northeast Region.

B. Peer Reviewers: Tim Lane, VDWR; Robert Butler, USFWS (retired); Jason Wisniewski, TWRA

C. Peer Review Charge: Reviewers were asked to conduct a scientific review of the document by assessing if there was any missing information related to the status of the species, if our analysis of the information was appropriate, and if they had any new information related to the species or their status to supplement the review. Reviewers were not asked to review the legal status determination.

D. Summary of Peer Review Comments: The reviewers confirmed information and comments related to abundance, distribution, and threats of the species, and provided data which supports conclusions in agreement with the draft review. Additionally, comments regarding fixing minor grammatical errors and suggesting more clear wording were incorporated.

E. Response to Peer Review: All substantive comments received were reviewed by the Service and incorporated into a revised version of this document, where appropriate. Documentation of the peer review and responses to those reviews are part of the administrative record and kept in the Asheville Field Office.