Cumberlandian Combshell
[*Epioblasma brevidens* (*Lea, 1861*)]

5-Year Review:
Summary and Evaluation

Photo by Tim Lane, Virginia Department of Game and Inland Fisheries

U.S. Fish and Wildlife Service
Southeast Region
Tennessee Ecological Services Field Office
Cookeville, Tennessee

5-YEAR REVIEW
Cumberlandian Combshell (*Epioblasma brevidens*)

I. GENERAL INFORMATION

A. Methodology used to complete this review

This review was completed by the Kentucky and Tennessee Ecological Services Field Offices, U. S. Fish and Wildlife Service (Service). All literature and documents used in preparation of this review are on file at the Tennessee Field Office. The primary sources of information used in this analysis were the final recovery plan (Service 2004), the last 5-year review (Service 2007), and the best available information we have gained since our last 5-year review. Public notice of this review was given in the *Federal Register* on May 7, 2018 (83 FR 20092) and a 60-day comment period was opened. During this comment period, we also obtained State partner and expert updates. In addition to sharing this with our state partners, we also sent the draft 5-year review to six mussel experts for peer review. The draft 5-year review was submitted to Steve Ahlstedt (Tennessee Valley Authority (TVA), retired), Don Hubbs (Tennessee Wildlife Resources Agency (TWRA)), Kristin Irwin Womble (Tennessee Technological University), Leroy Koch (Service, retired), Dr. Jess Jones (Virginia Polytechnic Institute and State University (Virginia Tech)), and Dr. Monte McGregor (Kentucky Department of Fish and Wildlife Resources (KDFWR)). The Service evaluated and incorporated any comments received into this 5-year review (See Appendix A).

B. Reviewers

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C. Background

1. Federal Register Notice citation announcing initiation of this review:

May 7, 2018; 83 FR 20092

2. **Species status:** Stable. Extant populations continue to occupy portions of the Big South Fork Cumberland River (Big South Fork) (Kentucky and Tennessee), Clinch River (Tennessee and Virginia), Powell River (Virginia), Buck Creek (Kentucky), and Bear Creek (Alabama and Mississippi). The largest and most viable populations of the Cumberlandian Combshell occur in the Big South Fork and Clinch River, where the species occurs in low to moderate densities (0.01-0.40 mussels/m^2), with multiple age classes represented (evidence of recruitment). The Service and its partners continue to work on augmentation of extant populations and have initiated several reintroduction projects, resulting in new populations in the Duck River (Tennessee), Elk River (Tennessee), Nolichucky River (Tennessee), and Rockcastle River (Kentucky).

3. **Recovery achieved:** 1 = 0-25 percent species recovery objectives achieved

4. **Listing history:**
   Original Listing
   FR notice: 62 FR 1647
   Date listed: January 10, 1997
   Entity listed: species
   Classification: endangered

5. **Associated actions**
   Designation of critical habitat for five endangered mussels (including the Cumberlandian combshell) in the Tennessee and Cumberland River basins. 69 FR 53136; August 31, 2004.

   Establishment of nonessential experimental population status for 16 freshwater mussels (including the Cumberlandian combshell) and 1 freshwater snail in the free-flowing reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties in Alabama. 66 FR 32250; June 14, 2001.

6. **Review History**
   Recovery Plan: 2004

   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 such as “Stable” for this mussel. We continue to show that species status recommendation above as part of our 5-year reviews. The Service completed the most recent evaluation for this mussel in 2018.

Last 5-Year Review: 2007. We reviewed the best available information obtained since completion of the species' recovery plan, and we did not recommend a change in status for this mussel.

7. Species' Recovery Priority Number at start of review (48 FR 43098):
5 (degree of threat is high, potential for recovery is low, and the taxonomy is at the species level)

8. Recovery Plan
Name of plan: Recovery Plan for Cumberland Elktoe, Oyster Mussel, Cumberlandian Combshell, Purple Bean, and Rough Rabbitsfoot.
Date issued: May 4, 2004

II. REVIEW ANALYSIS

A. Application of the 1996 Distinct Population Segment (DPS) Policy:
Not applicable. The Cumberlandian combshell is an invertebrate and, therefore, not covered by the DPS policy.

B. Recovery Criteria

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

2. Does the recovery plan contain recovery (i.e., downlisting or delisting) criteria? Yes.

3. 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 (and there is no new information to consider regarding existing or new threats)? Yes.

4. Recovery criteria

a. Criteria for downlisting to threatened status

Through the protection of extant stream populations (e.g., continuing to use existing regulatory mechanisms, establishing partnerships with various stakeholders, using best management practices (BMPs), minimizing or eliminating threats), discovery of currently unknown stream populations, and/or reestablishment of

historical stream populations, at least six, distinct, viable stream populations of the Cumberlandian Combshell exist in the Cumberland River system, upper Tennessee River system, and/or lower Tennessee River system. This will be accomplished by:

1. **Protecting all extant populations (i.e., Big South Fork and Buck Creek in the Cumberland River system; lower Clinch River and Powell River in the upper Tennessee River system; Bear Creek in the lower Tennessee River system) and ensuring that all these streams have viable population status.**

   While we have not met this criterion, we are working with our State and Federal partners and The Nature Conservancy (TNC) to protect populations of the Cumberlandian Combshell. Our Partners for Fish and Wildlife program has implemented projects in all five watersheds listed in this criterion and continues to look for additional opportunities to work with landowners in Alabama, Kentucky, Tennessee, and Virginia to improve stream habitats for the Cumberlandian combshell.

   In response to increasing concern over impacts to freshwater mussels from coal mining in the Clinch River watershed, Regions III and IV of the USEPA, Tennessee Department of Environment and Conservation, Virginia Department of Environmental Quality, and Virginia Department of Mines, Minerals, and Energy signed a Memorandum of Understanding (MOU) to establish a working group for improving communications and coordinating efforts to protect and restore the Clinch and Powell Rivers. These agencies and others are continuing to work together to accomplish common goals of reducing human impacts associated with coal mining and processing, agriculture, urbanization, and the development of transportation corridors. The Clinch-Powell Clean Rivers Initiative (CPCRI) Group (Virginia Department of Conservation and Recreation (VDCR), TNC, and others) continues to carry out the goals stated in the MOU, including Acid and Abandoned Mine Land reclamation, wastewater treatment plant updates, water quality monitoring, the establishment of Total Maximum Daily Loads to limit pollutants in the watershed, and mussel augmentation and reintroduction activities (CPCRI 2019).

   As part of their efforts, the CPCRI has prepared a “Biodiversity Conservation Science Plan for the Clinch-Powell River System, Virginia – Tennessee, USA” to outline science needs

for the watersheds. Since 2009, the CPCRI partners have been using the plan as a guide to coordinate and conduct studies to characterize mussel population status, physical habitat, and water quality in the Clinch and Powell Rivers. In 2014, these studies were published in a special series of articles in the Journal of the American Water Resources Association (Zipper *et al*. 2016). These studies will help landowners, land managers, and regulatory agencies to make decisions regarding the conservation of federally listed and other sensitive species. The plan will be updated on an ongoing basis.

Members of the CPCRI are also working to develop a Clinch River State Park along the Clinch River in Virginia. The park will be comprised of a series of riverside properties situated along the length of the river. Some funds have been secured, and lands are being acquired from willing sellers/donors as opportunities and funding are available (Richard 2019, pers. comm.).

We, along with TNC, local Soil Conservation Districts, the Natural Resources Conservation Service, Farm Service Agency, Clinch-Powell Resource Conservation and Development Council, and many State agencies and local partners, are working together to protect aquatic biodiversity in the Clinch-Powell watershed by providing landowners with monetary assistance to facilitate the protection and recovery of riparian corridors and the reduction and prevention of non-point source pollution on private lands. Through their Landowner Incentive Program, TNC has also provided monetary and technical assistance to facilitate the protection of riparian corridors along the Duck River to prevent non-point pollution from private lands.

A significant mussel site on the lower Clinch River in Hancock County, Tennessee is now protected as part of Kyles Ford Wildlife Management Area, an 850-acre site managed by the Tennessee Wildlife Resources Agency (TWRA). The property (Asher Farm tract) was acquired through partnerships with TNC and other conservation groups in a combined effort to preserve the site's rare mussel community. The Kyles Ford site supports a diverse assemblage of freshwater mussels, including several listed species such as the Cumberlandian Combshell (DOI 2006).

In 2013, TNC and a core team of collaborators developed a strategic plan for Tennessee freshwater mollusk conservation (TNC 2013). The strategy outlines priority areas for mollusk

protection and restoration within the state. It identifies areas for protection based on threats from poor agricultural practices, incompatible resource extraction, current development risk, and future development risk (TNC 2013). In addition, it identifies research needs and next steps for population restoration and augmentation (TNC 2013).

2. **Re-establishing a viable stream population in one of the following streams: (a) Cumberland River system (e.g., Rockcastle River, Little South Fork, Red River); (b) upper Tennessee River system (e.g., upper Holston River/North Fork Holston River, lower Holston River, lower French Broad River); or (c) lower Tennessee River system (e.g., Paint Rock River, Elk River, Tennessee River at Muscle Shoals, Duck River, Buffalo River).**

   This criterion has not been met; however, the Service and its many partners in Alabama, Kentucky, Tennessee, and Virginia have been working to re-establish or to augment populations in the Tennessee and Cumberland River systems.

   Tennessee River system

   Between 2009 and 2018, the Virginia Aquatic Wildlife Conservation Center (AWCC) released 17,090 and 2,476 Cumberlandian Combshells (a mixture of propagated and translocated mussels) into the Clinch River (four sites) and Powell River (five sites), respectively (Phipps *et al.* 2017, 2018; Hyde and Jones 2019). During the same time period, Virginia Tech's Freshwater Mollusk Conservation Center (FMCC) released 12,778 Cumberlandian Combshells (a mix of adults, sub-adults, and juveniles) into the Clinch River (four sites) and 2,350 individuals into the Powell River (five sites). Based on quantitative surveys completed from 2015 to 2017, the species is persisting at 6 sites, where it occurs at estimated densities/site ranging from 0.03 to 0.43 mussels/m^2 (Clinch River) and 0.01 to 0.11 mussels/m^2 (Powell River) (Phipps *et al.* 2018; Hyde and Jones 2019).

   Between 2009 and 2019, TWRA released 3,852 Cumberlandian Combshells into the Nolichucky River near Pates Hill, Tennessee (upstream of heavy agricultural inputs). TWRA propagated adult and juvenile mussels from Clinch River broodstock collected at Kyles Ford. The Nolichucky River reintroductions appear to be successful based on post-stocking monitoring results (Phipps *et al*. 2017, 2018). From 1980 to 2016, mussel richness in the Nolichucky River (at

Pates Hill, Tennessee) increased from 5 to 16, with densities of 0.23 mussels/m^2 for Cumberlandian Combshell and 0.25 mussels/m^2 for Fluted Kidneyshell – two species not observed in 1980. From 2006 to 2017, TWRA also released a total of 3,224 sub-adult mussels at two sites on the Duck River – Lillards Mill (2006-2016) and Venable Spring (2017) (Hubbs 2016a, pers. comm.). Growth and reproductive behavior (gravid females displaying lures) were observed at both reintroduction sites, while additional stocking efforts were undertaken in subsequent years (Hubbs 2016a, pers. comm.). In 2017, 955 propagated sub-adults were reintroduced into the Elk River (Hubbs 2017, pers. comm.).

In 2007, the Service finalized a Non-Essential Experimental Population (NEP) for the Oyster Mussel, a close relative of the Cumberlandian Combshell, in the lower French Broad and lower Holston Rivers. As part of the NEP, Moles (2014) translocated 800 adult oyster mussels from the Clinch River, Tennessee to the French Broad River in Tennessee. One year later, less than 40 percent of translocated mussels were observed, with further declines observed over the next two years. After a period of 3 years, less than 10 percent of translocated oyster mussels were observed (Moles 2014). Males had higher retention rates than females, but both sexes experienced declines in growth, and less than half of females were able to undergo gametogenesis post-stocking. Gravid females did retain high fertilization success throughout the study (> 95 percent) (Moles 2014). Based on these results and due to high flows from Douglas and Cherokee Dams, Cumberlandian Combshell restoration efforts are currently not a recommended option in the French Broad and Holston Rivers.

Cumberland River system

The Cumberlandian Combshell continues to be common in portions of the Big South Fork Cumberland River, with ample evidence of reproduction and recruitment. The Big South Fork population has been used frequently for the collection of broodstock, which have been used as the basis for reintroduction activities elsewhere in the upper Cumberland River system (McGregor 2019, pers. comm.). Since 2015, KDFWR has released approximately 2,411 propagated Cumberlandian Combshells back into the Big South Fork (6 sites) (KDFWR 2015, 2017-2018). Subsequent monitoring at these sites has produced Cumberlandian Combshell densities

ranging from 0.12 – 0.35 mussels/m^2. KDFWR is planning more releases over the next few years (McGregor 2019, pers. comm.).

The Little South Fork mussel fauna has declined significantly, with only five species observed during recent surveys and no evidence of reproduction (Ahlstedt *et al*. 2014). Ahlstedt *et al*. (2014) noticed numerous gas wells in the watershed, with an oily sheen and odors observed at one of their study sites. As a result, Ahlstedt *et al*. (2014) did not recommend re-establishment of the Cumberlandian Combshell in the Little South Fork. Recent observations by KDFWR suggest that habitat conditions in the Little South Fork have improved and now may be suitable for the species. Over the next couple of years, KDFWR plans to release a limited number of Cumberlandian Combshells in the Little South Fork to determine if habitats are suitable. Depending on project success, KDFWR will expand reintroduction efforts in the Little South Fork system (McGregor 2019, pers. comm.).

The species is persisting and recruiting in lower reaches of Buck Creek, but densities are low. From 2017-2018, KDFWR released approximately 200 Cumberlandian Combshells (propagated from Big South Fork broodstock) at one site on the Rockcastle River (KDFWR 2018). Success of those reintroduction efforts are unknown, but KDFWR plans to monitor the site in 2019 and will consider additional reintroduction activities based on those results (KDFWR 2018; McGregor 2019, pers. comm.).

3. **One distinct naturally reproduced year class exists within each of the viable populations. The year class must have been produced within 5 years prior to the time the species is reclassified from endangered to threatened. Within 1 year before the delisting date, gravid females of the mussels and their host fish must be present in each viable population.**

   This criterion has not been met. There are two extant populations (Clinch River and Big South Fork) that meet this criterion. The remaining three extant populations (Powell River, Buck Creek, and Bear Creek) are much smaller, exhibit sporadic recruitment, and their viability has not been determined (Jones 2019, pers. comm.; McGregor 2019, pers. comm.).

4. **Research studies of the mussels' biological and ecological requirements have been completed and any required recovery measures developed and implemented from these studies are beginning to be successful (see Recovery Tasks 1.4.1, 1.4.2, 1.4.5, and 1.4.6), as evidenced by an increase in population density of approximately 20 percent and/or increase in the length of the river reach of approximately 10 percent inhabited by the species as determined through biennial monitoring (see Recovery Task 5).**

   Recovery task 1.4.1 involves conducting life history research on the Cumberlandian combshell. Hua *et al.* (2015) evaluated Cumberlandian combshell reintroductions at the Brooks Bridge site on the Powell River using PIT tagged subadult mussels propagated in the laboratory. During the two-year study, the survival rate of released individuals and mark-recapture detection probability reached 98 percent (Hua *et al*. 2015).

   Jones and Neves (2011) observed maximum ages of 28 and 15 and lengths of 71.5 and 56.6 mm for male and female Cumberlandian Combshells, respectively, from the Clinch River, Tennessee. They estimated a population size of 46,436 individuals, and population growth appeared to be stable over time, suggesting that population dynamics are governed over larger spatial scales compared to the Oyster Mussel, a closely related species. Juvenile (1-year old) recruitment ranged from 12.0-24.0 percent (Jones and Neves 2011). Between 1979 and 2004, mean annual population growth rate was 6.3 percent, and it increased to 21.0 percent from 2004-2008 (Jones and Neves 2011).

   Jones *et al*. (2012) conducted reintroduction modeling, which indicated that the initial population size for a 5-year reintroduction effort greatly affected the final population size after a 25-year period. Thus, the target population size should be reached at the end of the 5-year build-up period for the reintroduction effort to reach its projected goals. Genetic and demographic data suggested that the ratio of effective to census population size was about 5 percent, which would equate to a target size of 10,000 individuals (assuming an effective size of 500 individuals) for reintroduced populations (Jones *et al*. 2012). The age class distribution for a stable to increasing population should have multiple size classes and be comprised of small clusters or subpopulations throughout each river targeted for restoration efforts (Jones *et al*. 2012).

Recovery task 1.4.2 involves characterizing the species' habitat for all life history stages. No additional work has occurred on this task since the Recovery Plan was approved and the last 5-year review was completed.

Recovery task 1.4.5 deals with investigating the need for management, including habitat improvement.
No additional work has occurred on this task since the Recovery Plan was approved and the last 5-year review was completed.

Recovery task 1.4.6 involves determining the number of individuals and the sex ratio required to maintain long-term viable natural populations. Lane and Jones (2014) implemented mark and recapture methods for juveniles released into the Nolichucky, Clinch, and Powell Rivers to estimate survival, growth, fecundity, and sex ratio for Cumberlandian combshell. Recapture and growth rates were highest in the Clinch River, and lowest in the Powell River. The ratio of males to females was nearly 1:1 in the Clinch River, but due to low growth and recapture rates, the number of individuals sexed in the other two rivers was low (Lane and Jones 2014). The average fecundity of 15 females examined was 33,884.8 (SE = 2,645.6) (Lane and Jones 2014).

5. **No foreseeable threats exist that would likely impact the survival of any of the species over a significant portion of their ranges (see Recovery Tasks 1.4.3 and 1.4.4).**

Recovery task 1.4.3 involves addressing present and foreseeable threats. Our Partners for Fish and Wildlife staff in Tennessee, Kentucky, Alabama, and Virginia are looking for additional opportunities to work with private landowners to protect watersheds that contain threatened and endangered species, including the Cumberlandian combshell. Our State partners are working with us to identify and address threats to mussel resources throughout the Cumberlandian region. No other threats have been addressed since the Recovery Plan and 5-year review.

Recovery task 1.4.4 deals with determining contaminant sensitivity for each life history stage. In the early 2000s, researchers began a review of contaminant sensitivity (e.g., trace metals, copper, mercury, and ammonia) for multiple life history stages of mussels. A summary of the relevant literature can be found in 78 FR 59281.

6. **Within larger streams (e.g., Rockcastle River, Big South Fork, Clinch River, Powell River, upper Holston River/North Fork Holston River, Elk River, Duck River, Buffalo River), the species are distributed over a long enough reach that a single catastrophic event is not likely to eliminate or significantly reduce the entire population in that stream to a status of nonviable (see Recovery Task 4.1).**

   Recovery task 4.1 involves refining techniques and methodologies for propagating and translocating mussels as a prelude to potential augmentation and reintroduction efforts. The States of Alabama, Kentucky, Tennessee, and Virginia and Virginia Tech are working on refining mussel propagation techniques and methodologies for the Cumberlandian combshell. The Cumberlandian Region Mollusk Restoration Committee (CRMRC, 2010) has developed a comprehensive plan for controlled propagation, augmentation and reintroduction of freshwater mollusks in the Tennessee and Cumberland watersheds.

   Carey *et al*. (2015) evaluated oyster mussel reintroductions at three sites in the Clinch River, Virginia, using four reintroduction techniques: translocation of adults, release of laboratory-produced sub-adult stock, release of eight-week old laboratory-produced juveniles, and release of artificially infested fish hosts. Their results indicated that translocations of adults and release of laboratory-propagated sub-adults (> 20 mm) were the most effective reintroduction techniques for the oyster mussel. These results for a similar species may also apply to the Cumberlandian Combshell.

7. **Biennial monitoring of the five species yields the results outlined in "criterion 1 and 2" over a 10-year period (see Recovery Task 5).**

   Biennial monitoring has not occurred to date, primarily due to insufficient funds. Some yearly monitoring does occur by partners on a site-by-site basis. Monitoring has occurred on the Clinch and Powell Rivers at 5-year intervals since the late 1970s (Ahlstedt *et al.* 2014). Additionally, three sites in the Clinch River, TN have been monitored annually from 2004-2018 (Jones *et al*. 2014, 2018; Hyde and Jones 2019). Since 2010, the TWRA has monitored mussel populations at 5-year intervals at three sites (Lillard's Mill, Venable Spring, and Hooper Island) on the Duck River. Since 2004, KDFWR and

the National Park Service (NPS) have been monitoring mussels on the Big South Fork National River and Recreation Area and the Obed River in Tennessee. The KDFWR and NPS have been conducting annual quantitative surveys at five Big South Fork sites since 2011 (KDFWR 2018; McGregor 2019, pers. comm.).

b. Criteria for delisting

Through the protection of extant stream populations (e.g., continuing to use existing regulatory mechanisms, establishing partnerships with various stakeholders, using BMPs, minimizing or eliminating threats), discovery of currently unknown stream populations, and/or re-establishment of historical stream populations, there exists the following:

1. **At least nine (six for downlisting) distinct viable stream populations of the Cumberlandian Combshell, including three (3) in the Cumberland River system, four (4) in the upper Tennessee River system, and two (2) in the lower Tennessee River system.**

2. **Two (one for downlisting) distinct naturally reproduced year classes exist within each viable population. All previously summarized downlisting criteria remain the same for the delisting criteria.**

All the work to-date for this species has been described above under the "Criteria for downlisting." There are presently only five extant populations of the Cumberlandian Combshell.

C. Updated Information and Current Species Status

1. Biology and Habitat

a. **Abundance/population trends:** The largest and most viable populations of the Cumberlandian Combshell occur in the Clinch River in Tennessee and Virginia and in the Big South Fork in Kentucky and Tennessee. Cumberlandian Combshell densities at Kyles Ford, Tennessee (a source site on the Clinch River for translocations) were 0.31 and 0.25 individuals/m^2 in 2016 and 2017, respectively (Phipps *et al*. 2017, 2018). At occupied sites on the Clinch River, Virginia, Cumberlandian Combshell density ranged from 0.05 to 0.10 individuals/m^2 in 2016 and 2017, including a total abundance of 12 individuals (Phipps *et al.* 2017, 2018). Jones *et al.* (2014), Ahlstedt et al.

(2016), and Phipps *et al.* (2017, 2018) agree that overall mussel densities (and densities of Cumberlandian Combshell) are lower in the Virginia portion of the Clinch River, and prominent mussel beds (e.g., Pendleton Island) in the Virginia portion have experienced drastic declines since surveys began in the late 1970s (Ahlstedt *et al*. 2016, Jones *et al.* 2018). This "Zone of Decline" is a concern to malacologists and is now beginning to manifest itself in mussel beds farther downstream near the Tennessee-Virginia border (Jones *et al*. 2014, 2018; Cope and Jones 2016). Within the Tennessee portion of the Clinch River, mussel densities are higher and have increased at an annual rate of 2.3 percent, stabilizing at a mean density of 29 mussels/m^2 over the last 10-year period (Jones *et al*. 2018). However, total mussel abundance has declined by about 50 percent over the last few years in surveyed mussel beds near Kyles Ford and massive mortality events (including mortality of Cumberlandian Combshells) have been observed since 2016 in other shoals just downstream of the Tennessee-Virginia border (Jones *et al*. 2014, Cope and Jones 2016; Richard 2019, pers. comm.).

In the Powell River in Tennessee, Cumberland Combshell densities ranged from 0 to 0.3 individuals/m^2 in 2016-2017 (Phipps *et al*. 2017, 2018), which was similar to the density of 0.03 individuals/m^2 reported at one Powell river site by Johnson *et al*. (2012). In 2010 and 2015, TWRA completed quantitative surveys of mussel populations at five sites (Lillard's Mill, Venable Spring, and Hooper Island) on the Duck River, but no Cumberlandian Combshells were observed (Hubbs 2016b, Hubbs *et al.* 2011). Overall, mussel densities and abundance in the Powell River have exhibited drastic declines since the 1970s (Ahlstedt *et al.* 2016). The Cumberlandian Combshell is now extant in the Nolichucky River due to a successful mussel reintroduction effort near Pates Hill, Tennessee (Phipps *et al.* 2018). The reported density for the Cumberlandian Combshell was 0.01 individuals/m^2 (Phipps *et al*. 2017, 2018).

In the Big South Fork system, Kentucky and Tennessee, Cumberland Combshell densities have ranged from 0.12 – 0.40 mussels/m^2 during quantitative surveys (2011-2018) completed by KDFWR at four sites (KDFWR 2011, 2014-2015, 2017-2018). The species continues to be extant in Buck Creek, with recent evidence of reproduction and recruitment. In 2017, KDFWR initiated a reintroduction effort on the Rockcastle River, Kentucky, by releasing 200 propagated individuals at

the confluence with Lick Creek. Recent surveys in Bear Creek (Alabama and Mississippi) have demonstrated that the species continues to be extant in the system, including evidence of recruitment and observations of multiple age classes (Johnson 2019, pers. comm.).

b. **Genetics:** The Service and several state partners (KDFWR, VDGIF) have initiated a study of the species' population genetics (Whelan 2019, pers. comm.). Tissue samples have been collected from Bear Creek, Big South Fork, and Clinch River. The study will examine genetic diversity (e.g., allelic richness, heterozygosity), as well evolutionary relationships among extant populations.

c. **Taxonomic classification or changes in nomenclature**: None.

d. **Spatial distribution:** No new information has been obtained since the Recovery Plan and 2007 5-year review.

e. **Habitat or ecosystem conditions:**

No new information is available on the species' habitat or ecosystem conditions. The recovery plan describes the species' habitat as medium-sized streams to large rivers on shoals and riffles in coarse sand, gravel, cobble, and boulders (Service 2007). The species is not associated with small stream habitats and generally occurs in larger tributaries than the Oyster Mussel, a related species, (Dennis 1985, Service 2007).

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

Factor A. The present or threatened destruction, modification, or curtailment of its habitat or range: The species' recovery plan identified impoundments, channelization, mineral extraction (surface coal mining), gravel mining, contaminants, toxic chemical spills, and sedimentation as threats to the Cumberlandian Combshell; all of these threats remain. Additional, ongoing threats to the mussel include increased urbanization, streambank erosion, water withdrawals, and impacts associated with agricultural practices (e.g., sedimentation).

Coal mining activity has decreased in the Clinch and Powell River watersheds in recent years; however, current and previous mining in the Powell River watershed still impacts water quality in that watershed (Zipper *et al.* 2014, 2016). In particular, specific conductance, pH, dissolved solids, alkalinity, hardness, and sulfate are temporally correlated with the progression of mining in the Powell River watershed (Zipper *et al.* 2014, 2016). New research is beginning to shed light on the specific chemical constituents primarily responsible for declines in freshwater mussels, such as the Cumberlandian combshell. In sites impacted by coal mining or natural gas extraction, total recoverable metals, polycyclic aromatic hydrocarbons (PAHs), major ions, or a combination of the three likely have contributed to sediment toxicity and mussel declines in the Upper Tennessee and Cumberland River systems (Wang *et al.* 2013, Cope and Jones 2016). Oil and gas wastewater from both conventional and unconventional wells have been shown to be a risk to aquatic organisms due to halide and ammonium levels in waters, even after brine treatment (Harkness *et al.* 2015).

Price *et al*. (2011) indicated that concentrations of total dissolved solids have continued to rise in the Powell and Clinch Rivers, with rapid increases in the upper Powell River, where coal mining is most prominent. Price *et al.* (2014) and Zipper *et al*. (2016) found a temporal increase of dissolved solids in the Clinch and Powell Rivers between 1964 and 2010 that corresponds to declining mussel densities in the Virginia portions of each river. In addition, water-column ammonia and sediment metals have occurred at levels likely to contributing to the decline of freshwater mussels in the Virginia portions of each river (Price *et al.* 2014). The increased levels of ammonia, metals, and dissolved solids were seen in watersheds with both agricultural activity and coal mining; however, mussel declines are greater in close proximity to and downstream of watersheds impacted by coal mining (upper Powell River and Guest River, a tributary to the Clinch River) (Price *et al*. 2014).

Johnson *et al*. (2014) found higher turbidity and specific conductance in Clinch River reaches with low quality mussel assemblages when compared to reaches with high quality mussel assemblages. Additionally, higher concentrations of major ions and metal were also observed in reaches with low quality mussel assemblage (Johnson *et al.* 2014, Zipper *et al*. 2016). The low quality mussel assemblages were spatially associated with tributary inflows from systems draining Pennsylvanian shale and coal geologic formations and were diluted by tributaries with no mining (Johnson *et al*. 2014).

Land cover analyses of the Clinch River watershed between Clinchport and Artrip, Virginia, (Cope and Jones 2016) indicate that developed land cover and impervious surfaces increased by approximately 40 percent between 2001 and 2011. This area has been described as a "Zone of Decline" for freshwater mussels, with expected stressors including wastewater and stormwater discharges, industrial and commercial discharges, oil and gas operations, and surface coal mining operations (Jones *et al*. 2014, Cope and Jones 2016).

A combination of factors appears to be impacting this reach of the Clinch River; however, polycyclic aromatic hydrocarbons (PAHs) were consistently prevalent at sites within the Zone of Decline, and there were consistent concentrations when comparing mussel tissues and samples of sediment and surface water (Cope and Jones 2016). The PAH sources within the study reach are thought to be tributaries associated with mining, such as the Guest River and Dumps Creek (Cope and Jones 2016). Furthermore, their observations show that the PAH levels (and most metals tested) in tissues are the result of recent rather than long-term exposure (Cope and Jones 2016). The PAHs might have a chronic lethal effect on mussels, while metals have a sub-lethal effect on the growth of mussels; however, conductivity, turbidity, and other environmental stressors likely interact in unpredictable ways to impact mussel health and survival (Cope and Jones 2016). Cope and Jones (2016) also observed that ammonia and manganese were detrimental to mussel survival and biomass, particularly in sediments from the Guest River and Copper Creek. The source of these pollutants appears to be surface coal mining activities in the Guest River watershed, while agriculture is the predominant land use in the Copper Creek watershed. The source of the high levels of manganese in Copper Creek are unknown at this time (Cope and Jones 2016).

Echols *et. al*. (2012) assessed the toxicity of brine discharge using routine test organisms and freshwater mussels, but not the Cumberlandian Combshell, specifically. However, Cumberlandian Combshell glochidia were used for 48-hour reference toxicant sodium chloride tests. Lethal concentrations for the Cumberlandian Combshell were consistent with those for other mussel species (Echols *et al*. 2012).

In June 2016, a mussel die-off was observed at Kyles Ford and Frost Ford in the Clinch River, Tennessee (Chance and Hubbs 2016, pers. obs.). These declines continued through 2019,

affecting even the most common species. Population estimates for the Pheasant Shell (*Actinonaias pectorosa*) at Kyles Ford decreased from a baseline of 94,530 individuals in 2016 to 48,284 individuals in 2017, 28,207 individuals in 2018, and 13,762 individuals in 2019 (Richard 2019, pers. comm.). Causes of the die-off and mussel population impacts are still being investigated at the time of this review (Phipps *et al.* 2018).

Non-point source pollution from land surface runoff can originate from virtually any land use activity (such as coal mining and agricultural activities) and may be correlated with impervious surfaces and storm water runoff from urban areas. Pollutants entering the Nolichucky, Clinch, and Duck rivers may include sediments, fertilizers, herbicides, pesticides, animal wastes, pharmaceuticals, septic tank and gray water leakage, and petroleum products. These pollutants tend to increase concentrations of nutrients and toxins in the water and alter the chemistry of affected streams such that the habitat and food sources for species like the Cumberlandian Combshell are negatively impacted.

Factor B. Overutilization for commercial, recreational, scientific or educational purpose: The overutilization for commercial, 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.

Factor C. Disease and predation: The Recovery Plan stated that there is little data indicating that disease or predation are limiting factors for this species. We currently have no information showing that disease is a limiting factor for the Cumberlandian Combshell; however, disease is being examined as a potential cause or contributing factor of recently observed population declines in the Clinch River.

Factor D. Inadequacy of existing regulatory mechanisms: The Cumberlandian combshell and its habitats are afforded limited protection from water quality degradation under the Clean Water Act of 1977 (33 U.S.C. 1251 et seq.), Surface Mining Control and Reclamation Act of 1977 (30 U.S.C. 1234-1328) and the Tennessee Water Quality Control Act of 1977 (T.C.A. 69-3-101). It is difficult to determine whether these statutes and regulations are adequately addressing the habitat and water quality threats to the Cumberlandian Combshell; however, as demonstrated under Factor A, some population declines and degradation of habitat for this species are ongoing despite the protection afforded by these

statutes and associated regulations. While these laws have undoubtedly resulted in some improvements in water quality and stream habitat for aquatic life, including the Cumberlandian Combshell, we must conclude that they alone have been inadequate in fully protecting this species in all portions of its range.

The species is also afforded protection by the Endangered Species Act (Act) of 1973, as amended (87 Stat. 884, as amended: 16 U.S.C. 1531 *et* 39 *seq*), which requires federal agencies to consult with the Service when activities they fund, authorize, or carry out may affect a listed species. The Act requires that federal permits must be obtained for any activity that may result in "take" of a listed species. Since listing, section 7 of the Act has required Federal agencies to consult with the Service when projects they fund, authorize, or carry out may affect listed species such as the Cumberlandian Combshell. However, the lack of Federal authority over the many actions likely affecting Cumberlandian Combshell habitat has become apparent. Many of the threats (including those identified at the time of listing, during recovery planning, and since development of the Recovery Plan and 2007 5-year review) involve activities that likely do not have a Federal nexus (such as water quality changes resulting from development, water withdrawals, or indiscriminate logging) and, thus, may not result in section 7 consultation. Although the take prohibitions of section 9 of the Act do apply to these types of activities and their effects on the Cumberlandian combshell, enforcement of the section 9 prohibitions is difficult, at best. The Service is not informed when many activities are being considered, planned, or implemented; therefore, we have no opportunity to provide input into the design of the project or to inform project proponents of the need for a section 10 permit. Unlike other more publicized species, conservation of the Cumberlandian Combshell may not be as familiar to the public, reducing the likelihood that citizens would report habitat destruction or illegal taking to the Service. A non-regulatory approach to providing for conservation of the Cumberlandian combshell may be most effective in alleviating threats and providing for conservation of the species.

Regulatory mechanisms associated with other Federal and State lands in Kentucky and Tennessee provide additional protections for the species. These lands and corresponding statutes/regulations include Big South Fork National River and Recreation Area in McCreary County, Kentucky and Scott County, Tennessee (National Park Service Organic Act of 1916 (16 U.S.C. 1 *et seq*.)); Daniel Boone National Forest in McCreary County, Kentucky

(National Forest Management Act of 1976); and Kyles Ford Wildlife Management Area, Tennessee (Tennessee Code Annotated §§ 70-5-101-113). In general, streams occupied by Cumberlandian Combshell in these areas are protected from general disturbance and receive some level of management and protection under a formal land management or natural resource plan.

The Cumberlandian Combshell has been designated as an Endangered species in Kentucky (Kentucky State Nature Preserves Commission (KSNPC 2005)), but this state designation conveys no legal protection. Kentucky law prohibits the collection of the species for scientific purposes without a valid state-issued collecting permit (KRS 150.183). Enforcement of this permit is difficult, but we do not believe that these activities represent a significant threat to the species. In addition to its federal listing, the Cumberlandian Combshell is listed as Endangered by the State of Tennessee. Under the Tennessee Nongame and Endangered or Threatened Wildlife Species Conservation Act of 1974 (Tennessee Code Annotated §§ 70-8-101-112), "…it is unlawful for any person to take, attempt to take, possess, transport, export, process, sell or offer for sale or ship nongame wildlife, or for any common or contract carrier knowingly to transport or receive for shipment nongame wildlife." Further, regulations included in the Tennessee Wildlife Resources Commission Proclamation 00-15 Endangered Or Threatened Species state the following: except as provided for in Tennessee Code Annotated, Section 70-8-106 (d) and (e), it shall be unlawful for any person to take, harass, or destroy wildlife listed as threatened or endangered or otherwise to violate terms of Section 70-8-105 (c) or to destroy knowingly the habitat of such species without due consideration of alternatives for the welfare of the species listed in (1) of this proclamation, or (2) the United States list of Endangered fauna. Potential collectors of this species would be required to have a state collection permit.

Factor E. Other natural and manmade factors affecting its continued existence: The Recovery Plan listed the presence or potential introduction of non-native species (especially zebra mussels and black carp), insufficient densities of host fish species, inbreeding depression and other genetic considerations, and possible weak links in the species' life cycles.

New species of Asian carp (*Hypophthalmichthys* spp.) have spread into the Duck River. It is unknown how these exotic carp will influence the Cumberlandian Combshell; however, there is some concern that because both Asian Carp and mussels are filter-

feeders, mussels like the Cumberlandian Combshell may be impacted by food web disruption.

The species' restricted range and low abundance in some reaches makes it more vulnerable to extirpation from toxic chemical spills, habitat modifications, progressive degradation from land surface runoff (nonpoint-source pollutions), and natural catastrophic changes to their habitat (*e.g.*, flood scour, drought). Over the last 25 years, habitats within the upper Tennessee River system have been subjected to two large pollution events that had devastating effects on mussel species like the Cumberlandian Combshell.

a. **Certus, Inc. Spill:** On August 27, 1998, a tanker truck (Certus, Inc.) overturned on U.S. Route 460 in Tazewell County, Virginia, spilling 5110 liters (1,350 gallons) of Octocure-554 revised, a rubber accelerant, into a tributary of the Clinch River (Hyde and Jones 2019). The Clinch River turned a snowy white color downstream of the spill for 9.6 km (6 mi) and took at least 12 hours to clear. The spill affected all organisms within an approximately 11.3-km (7-mi) impact zone from Cedar Bluff, Virginia downstream to Richlands, Virginia in the Clinch River. An extensive proportion of the fish population, as well as most aquatic macroinvertebrates, were killed, including populations of three mussel species listed as federally endangered (Golden Riffleshell (*Epioblasma aureola*), Purple Bean (*Villosa purpurea*), and Rough Rabbitsfoot (*Quadrula cylindrica strigillata*)). This spill also eliminated one of the last two known reproducing populations of the Golden Riffleshell, making the spill one of the worst kills of species listed as federally endangered since the inception of the Act. A total of 6,207 dead mussels of thirteen species were collected from the surface of the substrate immediately following the spill, including 250 individuals of the three federally listed endangered species. The final injury estimate was 18,621 mussels representing 13 species.

b. **Lone Mountain Processing, Inc. Spill:** On October 24, 1996, failure of a coal slurry impoundment at a coal processing plant (Lone Mountain Processing, Inc.) in Lee County, Virginia, released over 22,700,000 liters (6,000,000 gallons) into a system of abandoned underground mine-works and ultimately a series of tributaries of the Powell River (Hyde and Jones 2019). The resulting "blackwater", a mixture of water, coal fines, and

clay, impacted a large section of the Powell River, and coal particle sediment ultimately was deposited in Norris Reservoir, Tennessee, 104.5 km (65 mi) downstream from the release site. Fifteen species of federally endangered mussels (3 were listed after the spill), as well as critical habitat of two federally endangered fishes, were impacted. The Virginia Department of Environmental Quality (VDEQ) also estimated that at least 11,240 fishes of various species were directly killed. These fishes included species that serve as hosts to endangered mussels.

The species' limited range and disjunct populations may also limit the natural interchange of genetic material between populations, and the small size of some populations (e.g., Buck Creek) may reduce the reservoir of genetic diversity among populations. This can lead to inbreeding depression, a reduced ability to adapt to environmental change, and reduced fitness of individuals (Soule 1980; Hunter 2002; Allendorf and Luikart 2007). Low genetic diversity may further reduce the species' ability to adapt to changing environmental conditions over time, making it more susceptible to local extirpations.

D. Synthesis

Historically, the Cumberlandian combshell ranged throughout the Cumberlandian Region, occurring in three physiographic provinces (Interior Low Plateau, Cumberland Plateau, and Ridge and Valley) and five states (Alabama, Kentucky, Mississippi, Tennessee, and Virginia). It has now been extirpated from a large percentage of its former range, including the Cumberland River mainstem and Tennessee River mainstem (Service 2004). The species' current distribution is limited to Bear Creek (Alabama and Mississippi), Big South Fork (Kentucky and Tennessee), Buck Creek (Kentucky), Clinch River (Tennessee and Virginia), Duck River (Tennessee), Elk River (Tennessee), Nolichucky River (Tennessee), and Powell River (Virginia). The most viable populations occur in the Big South Fork and Clinch River. The species is reproducing and recruiting in the Powell River, Bear Creek, and Buck Creek, but the species occurs in lower densities in these watersheds. Populations in the Duck River, Elk River, Nolichucky River, and Rockcastle River are the result of recent reintroduction efforts. The Service and its partners are monitoring these populations.

The Recovery Plan listed excessive sedimentation (primarily resulting from nonpoint-source loading), coal mining, gravel mining, reduced water quality below existing dams, developmental activities, water withdrawal, impoundments, and alien species as threats to the Cumberlandian

Combshell and its habitat. Because of the past occurrence of multiple pollution events in the Powell and Clinch rivers and the declines in mussel populations that resulted from those spills, the Service considers toxic spills to be a threat that could either reduce Cumberlandian Combshell populations to inviable status or lead to their extirpation from portions of the species' restricted range. All of these threats continue to impact the species across its range.

The recovery criteria listed in Section B above have not been met for delisting or downlisting the species. Because of the Cumberlandian Combshell's limited distribution, the upper Tennessee River system's history of significant chemical spills, the recent unexplained declines of mussel communities in the Clinch River (e.g., Zone of Decline), and continued threats to the species' five extant populations, it remains in danger of extinction throughout all or a significant portion of its range. Therefore, the status of the Cumberlandian combshell should remain as endangered.

At the time of listing (Service 1997), this species had a high degree of threat and a low recovery potential, which results in a Recovery Priority Number of 5 for the taxonomic level of species. The Recovery Plan also describes this species as having a high degree of threat and a low recovery potential (Service 2004). While the Service and its state partners have worked to protect some significant habitat areas, the degree of threat for this species remains high. We continue to believe that threats to this species remain high and that the recovery potential remains low. Augmentation of juveniles are taking place, but the success of those efforts are unknown at this time. Therefore, a change in the existing Recovery Priority Number is not currently warranted.

III. RESULTS

A. Recommended Classification: No change is needed for the existing classification of endangered.

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

- Continue efforts to augment and expand the range of extant populations to ensure their viability. For example, CRMRC (2010) recommended the following Cumberlandian Region streams as potential reintroduction sites: Tennessee River system – Bear Creek, Alabama/Mississippi; Duck River, Tennessee.
- Reestablish viable populations in other streams within the historical range that have suitable habitat and water quality. For example, CRMRC (2010) recommended the following Cumberlandian Region streams as potential augmentation or reintroduction sites:

    - Tennessee River system – Tennessee River tributary tailwaters, Alabama and Tennessee: Elk River, Alabama; Nolichucky River, Tennessee; Paint Rock River, Alabama; Limestone Creek, Alabama; Copper Creek, Virginia; upper French Broad River, Tennessee; lower Pigeon River, Tennessee; Hiwassee River, Tennessee; Tennessee River mainstem tailwaters (Lake Guntersville), Alabama; Wilson Creek, Alabama; upper Holston River, Tennessee.
    - Cumberland River system – Rockcastle River, Kentucky; Middle Fork Rockcastle River, Kentucky; and Red River, Kentucky/Tennessee.
- Continue investigations into the cause of long-term mussel declines in the Virginia portion of the Clinch River (Zone of Decline), as well as more recent acute declines (die-offs) in downstream portions of the Clinch River in Tennessee.
- Protect habitat through acquisitions and easements with federal, state, and private partners.
- Continue to educate the public about water quality and freshwater mussels.
- Continue quantitative and qualitative efforts to monitor existing populations, including long-term monitoring efforts. The Service and its partners should use demographic and genetic monitoring to monitor populations over time.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Cumberlandian combshell (*Epioblasma brevidens*)

Current Classification: Endangered
Recommendation resulting from the 5-Year Review:

__X__ No change is needed

Review Conducted By: Stephanie Chance, Tennessee Ecological Services Field Office, Cookeville, Tennessee, and Michael A. Floyd, Kentucky Ecological Services Field Office, Frankfort, Kentucky

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve VIRGIL ANDREWS Digitally signed by VIRGIL ANDREWS Date: 2019.11.05 15:03:10 -05'00' Date _____

Cooperating Regional Director, Fish and Wildlife Service

✓ Concur ____ Do Not Concur

Signature _____ Date 11/4/2019

APPENDIX A: Summary of peer review for the 5-year review of the Cumberlandian combshell (*Epioblasma brevidens*)

A. Peer Review Method: The draft document was peer-reviewed by Kristin Irwin Womble (Tennessee Technological University, Cookeville, Tennessee) and Don Hubbs (Tennessee Wildlife Resources Agency, Camden, Tennessee). The Service submitted the draft 5-year review to three other reviewers, but we received no additional comments.

B. Peer Review Charge: The Service asked peer reviewers to read the 5-year review and provide any comments, both editorial and content related. The Service did not ask peer reviewers to comment on the recommendation regarding listing status.

C. Summary of Peer Review Comments/Report: The peer reviewers considered the revised 5-year review to be biologically sound and generally agreed with the species' status information and proposed conservation actions. They agreed that the 5-year review was based on the best available scientific information. One peer reviewer (K. Irwin Womble) commented that the Service needed to conduct a more thorough assessment of the habitat and water quality of the Harpeth River prior to any mussel reintroduction activities. The peer reviewer also stated that the Service (or its partners) should assess the current state of the entire mussel fauna of the Harpeth River prior to any reintroduction efforts. The second reviewer (D. Hubbs) provided updated information regarding the total number of Cumberlandian Combshells released by TWRA into the Duck River and Nolichucky River (2006 to 2019).

D. Response to Peer Review: The Service has excluded the Harpeth River from the list of potential augmentation / reintroduction sites in the *Recommendations for Future Actions* section. The Service agrees that we need additional information on habitat and water quality and on the status of the mussel fauna in the Harpeth River prior to any augmentation or reintroduction activities. With respect to the second reviewer's comment, we updated the 5-review by adding new information on the number of Cumberlandian Combshells released by TWRA into the Duck River and Nolichucky River.