Cumberland Bean
Villosa trabalis
5-Year Review:
Summary and Evaluation

Photo Credit: Dr. Monte MacGregor, KY Dept. of Fish and Wildlife Resources

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

Five-Year Review

Species reviewed: Cumberland Bean, *Villosa trabalis*
(= *Venustachoncha troostensis*)

1. GENERAL INFORMATION

1.1. Methodology used to complete the review

Public notice of this review was provided in the *Federal Register* on June 30, 2017 and a 60-day comment period was opened (82 FR 29916). During this comment period, we obtained information on the status of this species from several experts on the taxa, and additional data was obtained from the recovery plan, peer-reviewed scientific literature, and unpublished field observations by Service, State, and other experienced biologists. Once all known literature and information was compiled, Leroy Koch, Recovery Biologist with the Kentucky Ecological Services Field Office completed the review. All literature and documents used for this five-year review are on file at the Kentucky Field Office and are cited below in the References section. The draft document was peer-reviewed by Dan Hua (Tennessee Wildlife Resources Agency), Tim Lane (Virginia Dept. of Game and Inland Fisheries, and Jeff Simmons (Tennessee Valley Authority). Comments received from the peer reviewers were incorporated, as appropriate (see Appendix A).

1.2. Reviewers

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

Lead Field Office – Kentucky Ecological Services Field Office, Frankfort, KY: Leroy Koch (retired)/ Jennifer Garland, 502-695-0468

Cooperating Region –
Martin Miller, North Atlantic – Appalachian Region, Hadley, MA, 617-417-3331

Cooperating Field Offices –
Andy Ford, Tennessee Ecological Services Field Office, 931-528-4982
Jordan Richard, Virginia Ecological Services Field Office, 276-623-1233,
Andrew Henderson, North Carolina Ecological Services Field Office, 828-216-4969.

1.3. Background

Current nomenclature and geographic understanding for the Cumberland Bean and the Purple Bean (= Tennessee Bean)

When listed in 1976 (41 FR 24062) and last reviewed in 2010, the Cumberland Bean (*Villosa trabalis*), was reported to occur in both the Tennessee and Cumberland River

systems as a white-nacred mussel. Its close relative, the Purple Bean (*Villosa purpurpurea*) was limited to the Tennessee River system and recognized as a mussel with a purple nacre. The scientific community has recommended taxonomic changes for the Cumberland Bean and Purple Bean based on recent genetic and phylogenetic taxonomic assessments by Kuenhl (2009) and Lane et al. (2016, 2019). These studies provided evidence supporting recognition of the Cumberland River populations of the Cumberland bean as *Venustaconcha troostensis*, while the Tennessee River populations of *Villosa trabilis* and *Villosa perpurpurea* were combined and recognized as a single species, now *Venustaconcha trabilis* (Tennessee Bean). Williams et al. (2017) provided a revised list of 298 mussel species of the United States and Canada, including the Cumberland Bean, which incorporated changes in nomenclature and systematic taxonomy since the most recent checklist in 1998.

Because the Service has not yet addressed these taxonomic changes relative to each species listing status (see section 4 for future recommended actions based on this new information), it is appropriate to conduct concurrent five-year reviews for the Cumberland Bean and Purple Bean (= Tennessee Bean) in an effort to reduce potential confusion caused by these nomenclatural changes. This five-year review addresses the current understanding of the status of the Cumberland bean (*Villosa trabalis* = *Venustaconcha troostensis*), as it occurs in the Cumberland River basin in Kentucky and Tennessee. This review also includes Purple Bean (= Tennessee Bean) populations in the Hiwassee River and the populations reintroduced using Hiwassee River broodstock in the Nolichucky and Paint Rock Rivers, as they were historically considered to be Cumberland bean. A concurrent review of the Purple Bean (= Tennessee Bean) is being conducted by the Service's Virginia Field Office and will include the same information regarding the Hiwassee River population. When the Service evaluates the taxonomic changes and makes a determination of the listing status of each taxon in the future, the five-year reviews for the Cumberland bean and Purple Bean (= Tennessee Bean) will serve as a baseline assessment and contain the most current status information on the taxa.

The Purple Bean (= Tennessee Bean) has never been thought to exist – historically or currently – within the Cumberland River drainage. The recent taxonomic changes affecting the Purple Bean (= Tennessee Bean) and Cumberland Bean specifically affect the population from the Hiwassee River and the populations reintroduced using Hiwassee River broodstock in the Nolichucky and Paint Rock Rivers. Within the Tennessee River drainage, all other extant localities (Clinch River, Indian Creek, Copper Creek, Beech Creek, Obed River, Emory River, and Clear Creek) have always been – and continue to be – considered Tennessee Bean (formerly Purple Bean). It is important to note that until formal recognition of these changes is completed by the Service, the Hiwassee River population is still considered to be Cumberland Bean.

1.3.1. FR Notice Citation Announcing Initiation of This Review:

June 30, 2017, 82 FR 29916

1.3.2. Species status

Declining. Threats such as siltation, pollution, and impoundment are still contributing to this species' decline. There is no change in threats to the species, and no new threats are known. The species is rarely observed in surveys throughout its range. All populations exhibit low recruitment and low densities. Refer to additional information in this review for further explanation of the current status of this species.

1.3.3. Recovery achieved

1 (1 = 0% to 25% of species recovery objectives achieved).

1.3.4. Listing history

Original Listing
FR notice: 41 FR 24062
Date listed: June 14, 1976
Entity listed: Species
Classification: Endangered

1.3.5. Associated rulemakings

Establishment of Nonessential Experimental Population (NEP) 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, AL, Final Rule; June 14, 2001; 66 FR 32250

Establishment of Nonessential Experimental Population (NEP) Status for 15 Freshwater Mussels, 1 Freshwater Snail, and 5 Fishes in the Lower French Broad River and in the Lower Holston River, Tennessee, Final Rule; September 13, 2007; 72 FR 52434

1.3.6. Review History

Last 5-Year Review – June 21, 2010

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

5c (the 5 indicates a high degree of threat and low recovery potential; the "c" reflects a high degree of conflict).

1.3.8. Recovery Plan

Name of plan: Recovery Plan for the Cumberland Bean Pearly Mussel, *Villosa trabalis* (Conrad, 1834)
Date issued: August 22, 1984

2. REVIEW ANALYSIS

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

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

2.2. Recovery Criteria

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

2.2.2. Adequacy of recovery criteria.

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

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

2.2.3. List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information.

Under Recovery Objectives, "the ultimate objective is to maintain and restore viable populations of this species to a significant portion of its historic range and remove the species from the Federal list of endangered and threatened species. This is to be accomplished by (1) protecting and enhancing habitat containing this species, and (2) by establishing populations in rivers and river corridors which historically contained this species."

The four recovery criteria provided in the Recovery Plan are provided below:

1. A viable population of *Villosa trabalis* exists in Buck Creek, Rockcastle, and the Little South Fork Cumberland Rivers. These three populations are dispersed throughout each river so that it is unlikely that one event would cause the total loss of either population.

   Note: 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 recovery plan was written, the population in the Little South Fork Cumberland River (Little South Fork) was considered to contain the greatest concentration of this species; however, current information suggests that this population is extirpated as the result of coal-related spills and water quality changes in the 1980s. Though present, the Service has no information that viable populations of this species currently exists in the mainstem of Buck Creek, the Big South Fork Cumberland River (Big South Fork), or the mainstem of the Rockcastle River or any of its tributaries (e.g., Sinking Creek, Horselick Creek). Although these populations are not considered to be viable based on the definition in the Recovery Plan, there is evidence the species is reproducing; however, recruitment is considered to be low. The Service is working with state partners and The Nature Conservancy (TNC) to improve the status of this species in these streams. Of these streams, the population in the Rockcastle River and one of its tributaries, Sinking Creek, is the largest currently-known population and may be a viable population (see further population information in Section C. 1. a. below).

2. Through reestablishment and/or discoveries of new populations, viable populations exist in two additional rivers (to include at least one in the Tennessee River system). Each of these rivers will contain a viable population that is distributed such that a single event would be unlikely to eliminate *Villosa trabalis* from the river system.

   In 1992 and after completion of the recovery plan, a population of the Cumberland Bean was discovered in Sinking Creek, a tributary of the Rockcastle River in Kentucky. At the time this population was discovered, the population was considered possibly viable. However, recent survey information on the status of this population has shown very few individuals present, which indicates that it may not be viable. If the Sinking Creek population was determined to be a viable population and if the Recovery Plan was revised to reflect our current understanding of the taxonomy of the Cumberland Bean, the Sinking Creek population could be considered one of the 'additional' rivers necessary to meet Recovery Criteria 2.

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 expect this criterion to be met in the near future. We are working with our state partners and TNC to protect extant populations of this species. In Buck Creek, there are current Partners for Fish and Wildlife projects that are intended to repair and restore stream banks, riparian areas, and in-stream habitats. These efforts have provided protection for approximately seven miles of stream bank in the Buck Creek watershed. Gravel mining in Buck Creek is a significant threat to this species and is contributing to unstable

habitat and substrate conditions. The Rockcastle River, Buck Creek, Sinking Creek, and the lower Big South Fork receive some additional protection because they have been designated by the Commonwealth of Kentucky as Outstanding State Resource Waters; the Rockcastle River also has a Wild Rivers designation. However, large portions of these watersheds are not protected and subject to degradation from a variety of activities, including development, road construction, timber harvest, etc.

4. Noticeable improvements in coal-related problems and substrate quality have occurred in the upper Cumberland and Tennessee drainages and no foreseeable increase in coal-related siltation exists in streams containing *Villosa trabalis*.

   The USACE has completed a large acid mine drainage and sediment remediation project along the Big South Fork near Blue Heron during 2016 as a required measure outlined in the 2014 BO, "Wolf Creek Dam Return to Historical Operations". This involved stabilizing a large, eroding spoil pile just upstream of Devils Jump and remediating some acid mine seeps. Water quality impacts from coal mining in the lower Big South Fork have been most notable in Bear Creek, Roaring Paunch Creek, and Rock Creek, all of which drain to the Big South Fork within a nine river mile section in McCreary County, Kentucky (Hamilton and Turrini-Smith, 1997; Worsham et al., 2013). Additionally, acid mine drainage remediation had been recently conducted in Rock Creek (Carew, 2002) and water quality in Bear Creek and Roaring Paunch Creek seem to be improving (Worsham et al., 2013).

   However, at the present time, there are no noticeable, long-term improvements in coal-related problems and substrate quality across the upper Cumberland River drainages supporting the Cumberland Bean. With the current emphasis and need for coal as an energy source, we do not foresee this situation improving in the near future. In addition, the legacy effects of previous mining continue to degrade watersheds where the mining occurred through increased sedimentation, increased conductivity, etc.

2.3. Updated Information and Current Species Status

2.3.1. Biology and Habitat

2.3.1.1. Abundance, population trends, demographic features, or demographic trends:

Cumberland Bean - Cumberland River drainage:
Buck Creek (Kentucky): The population of this species in Buck Creek appears to be declining; however, a few sub-adult individuals have been observed in the last 10 years, indicating some evidence of recruitment. This species may still be reproducing in Buck Creek; however, recruitment is likely low and the overall

population appears to be small based on limited survey data. Host fish availability may also be a limiting factor. During 2005, the Kentucky Department of Fish and Wildlife Resources (KDFWR) released 151 juvenile the Cumberland Bean into Buck Creek that had been propagated at their Center for Mollusk Conservation (CMC) located in Frankfort, Kentucky. The current status of these released individuals is unknown, but they were very young when released and search efforts soon after they were released resulted in no individuals being found at the release site (McGregor 2018, pers. comm.). In addition, a sampling and survey effort in 2016 by KDFWR resulted in no captures of the Cumberland Bean from a section of lower Buck Creek (McGregor 2018, pers. comm.).

The recently described Buck Darter, *Etheostoma nebra* (formerly *E. virgatum*) is apparently endemic to the Buck Creek system and is a known host for the Cumberland Bean. Near and Thomas (2015) indicate that *E. nebra* has also undergone a significant range reduction in the Buck Creek system where it is now only know from Flat Lick Creek, a tributary to Buck Creek.

Rockcastle River drainage (Kentucky): The Cumberland Bean remained common in the Rockcastle River until the 1960s, and although it survives in some sections of the river, it is now very rare. Robust populations remained in Buck Creek, Horse Lick Creek, and Sinking Creek (Haag and Cicerello 2016) until the 1990s; however, the species has likely been eliminated from Horse Lick Creek, apparently by the downstream effects of coal mining on water quality and habitat suitability. The Buck Creek and Sinking Creek populations have declined dramatically for unknown reasons (Haag and Cicerello 2016).

Recently, KDFWR surveys in the Rockcastle River indicate that a population of this species occurs sporadically in an approximate 40-mile reach of the lower and middle sections of the river. Only a small number of individuals have been observed; however, one gravid female was collected in 2016. This individual was used to propagate about 20 juveniles that were later released in 2017 near the mouth of Lick Creek. Additional survey efforts are needed in the mainstem Rockcastle River to determine the extent of the population. A survey effort in Horse Lick Creek (Haag and Warren 2004) indicated a declining mussel fauna and probable extirpation of the Cumberland Bean. Currently, the Rockcastle River population (together with the Sinking Creek population) is the best remaining population of Cumberland Bean in the upper Cumberland River system (McGregor 2018, pers. comm.).

Survey efforts have not been extensive in Sinking Creek, but an initial survey in 2000 (Groves 2000) and repeated observations at selected sites in recent years indicate that the population may be recruiting. At the time of discovery, the Sinking Creek population was considered to be the most viable population of this species in Kentucky; however, this appears to have changed in recent years. From 2012 – 2013, the species was observed at 14 of 19 survey sites in Sinking Creek; however, the species was considered to be rare or very rare at 13 sites and

uncommon at the remaining site (McGregor 2018, pers. Comm.). In 2009, KDFWR released 42 juveniles (average length of 25 mm) into Sinking Creek, along with 43 adult Striped Darters, *Etheostoma virgatum,* a known host fish for the Cumberland Bean mussel. A number of these released juveniles have persisted and have shown signs of reproduction (e.g., gravid females). They may also be recruiting, but because this site also supports Cumberland Beans that were not propagated, young mussels observed at this site could have originated from either the transplanted individuals or the wild stock already present. A population of 26 individuals was estimated to occur at this site in 2013, while 13-14 individuals were estimated to occur at another site further downstream (McGregor 2018, pers. comm.). These sites are currently considered the two best sites for the species in Sinking Creek.

Big South Fork drainage (Kentucky and Tennessee): Robust populations of this species remained in the Big South Fork and Little South Fork Rivers until the 1990s; however, the species was eliminated from the Little South Fork River by impacts from oil drilling and coal mining, and the Big South Fork population appears to have declined for similar reasons (Haag and Cicerello 2016). Ahlstedt et al. (2005) reported a total of 49 live individuals from 7 collection sites on the Big South Fork in Tennessee and Kentucky (1999-2002). One live female was also found at Station Camp Creek of Big South Fork on April 19, 2006.

Researchers at Virginia Tech have done some limited work with *the* Cumberland Bean from the Big South Fork drainage. Four gravid female were collected and used for fish host identifications and propagation of juveniles in 2004-2007 (Guyot 2005). As a result of these efforts, it was determined that the Banded Sculpin (*Cottus carolinae*), Striped Darter (*Etheostoma virgatum*), Fantail Darter (*E. flabellare*), Greenside Darter (*E. blennioides*) and Redline Darter (*Nothonotus rufilineatus*) could all serve as hosts for this species (Guyot 2005). Approximately 1,200 glochidia were transformed into juveniles in 2005 and 2006; however, only 10 of these were raised to the age of 6 -7 weeks old, at which time they were released into the Big South Fork (Petty and Neves 2007). No information is available on the success of these releases. This species is considered rare in Big South Fork, but size-class distribution of measured individuals (30-90 mm) suggests that there is some low level of recruitment. Host fish availability may also be a limiting factor based on observations by KDFWR (McGregor, 2018, pers. comm.).

In 2013, 2015, and 2016, five individuals were observed at two sites in the Big South Fork (McGregor 2018, pers. comm.). All were males except for one gravid female collected in 2016. Using this one female, KDFWR cultured 50 to 60 juveniles which are expected to be released back into the Big South Fork in 2018 and/or 2019 (McGregor 2018, pers. comm.). Two individuals of this species have been recorded recently from one location in the Tennessee portion of the Big South Fork near the Kentucky and Tennessee state boundary (Dinkins 2017).

Fish community surveys conducted 2014-2018 from river mile 39 to 44.5 in the Big South Fork have documented 63 fish species, including 15 species of darters (Simmons, 2018, per. comm.), which demonstrates significant recovery of the fish community as compared to historical conditions when acid mine drainage had eliminated most of these species from this reach. Of the documented hosts listed by Guyot (2005), only the Greenside Darter occurs in the mainstem Big South Fork. However, the Tuxedo Darter, *E. lemniscatum*, may be a surrogate host from the subgenus Catonotus for *E. flabellare* or *E. virgatum*; the Bloodfin Darter (*Notonotus sangifluus*), Bluebreast Darter (*N.camurus*), and/or Tippecanoe Darter (*N. tippecanoe*) may be a surrogate for *N. ruflineatus*. Banded Sculpin has not been documented from this sample reach.

Purple Bean (= Tennessee Bean) - Tennessee River drainage:
Hiwassee River: The Hiwassee River population was originally thought to be Cumberland Bean, but the genetics data from Lane et al. (2016, 2019) and changes to taxonomic status from Williams et al. (2017) provided strong evidence that the population is entirely comprised of Tennessee bean. This is believed to be a viable, actively-recruiting population and serves as a source of broodstock for captive propagation (Service 2010). In 2010, the Alabama Aquatic Biodiversity Center (AABC) began captive propagation efforts using Hiwassee River broodstock Tennessee bean for reintroduction efforts to the Paint Rock River. The population range within the Hiwassee River is limited to the Apalachia Cutoff. The population has been stable to increasing since 2005 when TVA began flow restoration in the reach between Appalachia Cutoff, a stretch of reduced flow between Apalachia Reservoir and the Apalachia Dam powerhouse 12 miles downstream (Don Hubbs, pers. comm. 2019). There is evidence of recent recruitment, and 10-20 broodstock females of 38-56 mm total length now require approximately three to four person hours of effort to acquire (Don Hubbs pers. comm. 2019).

Paint Rock River: In July 2012, a small population of Tennessee bean was established in the Paint Rock River with 269 captive-propagated individuals from the Alabama Aquatic Biodiversity Center (AABC) using Hiwassee River broodstock. The population was established at river mile 33.1 (Johnson 2012). In 2013, re-sampling of the site found persistence of live individuals from the reintroduction during quantitative monitoring surveys (Johnson 2015). A second cohort of 100 captive-propagated individuals from Hiwassee River broodstock was released in 2015 at the same site (Johnson 2015). In 2019 there were two additional releases augmented the population. The first was a batch of 16 individuals propagated by AABC using Hiwassee River broodstock (Johnson 2019). The second release was a batch of 300 individuals propagated from mixed broodstock of Hiwassee River (n = 2) and Beech Creek (Holston River basin) (n = 5) adults by the Aquatic Wildlife Conservation Center (AWCC) in Marion, VA.

Nolichucky River and Little Chucky Creek: The 2010 5-year review for Cumberland bean notes “Occasionally a fresh dead individual has been observed

in Little Chucky Creek, a tributary of the Nolichucky River in the French Broad River system. Although *V. trabalis* may still occur in this stream, the population is not considered viable." TWRA began efforts to establish a viable Tennessee bean population in the Nolichucky River in 2018 by releasing 250 hatchery-propagated individuals from Hiwassee River broodstock. In 2019, TWRA released 903 hatchery-propagated individuals at the same site. Of these, 153 were produced at the Cumberland River Aquatic Center (CRAC) from Hiwassee River broodstock, and 750 were produced by AWCC using a mix of Hiwassee River and Beech Creek broodstock.

2.3.1.2.Genetics, genetic variation, or trends in genetic variation

Recent genetic and phylogenetic taxonomic assessments by Kuenhl (2009) and Lane et al. (2016 & 2019) provide evidence supporting recognition of the Cumberland River populations of the Cumberland Bean as *Venustaconcha troostensis*, while the Tennessee River populations of the Cumberland Bean and Purple Bean should be combined and recognized as *Venustaconcha trabalis* (Tennessee Bean). Williams et al. (2017) provided a revised list of 298 mussel species of the United States and Canada, including the Cumberland Bean, which incorporated changes in nomenclature and systematic taxonomy since the most recent checklist in 1998.

In the study by Lane et al. (2019), all 3 populations listed of the Cumberland Bean were determined to have significantly low effective population sizes. Given the demographic limitations and few locations outside of these 3 streams to re-establish populations, it would be advisable to mix/cross these genetic stocks using cautious approaches in order to genetically rescue each segment from the effects of inbreeding depression. To date, KDFWR has been separating Cumberland Beans propagated and cultured from Buck Creek, Rockcastle River, and Big South Fork systems (McGregor 2018, pers. comm.) to avoid mixing the species.

2.3.1.3. Taxonomic classification or changes in nomenclature

Lane et al. (2016) completed a genetic and phylogenetic study that recommends taxonomic changes for the Cumberland Bean, *Villosa trabalis,* and its close relative, the Purple Bean, *Villosa perpurpurea*. Populations of the Cumberland Bean in the Cumberland River system were identified as *Venustaconcha troostensis*, while populations of *V. trabalis* and *V. perpurpurea* in the Tennessee River system are now recognized as *Venustaconcha trabalis* (Tennessee Bean).

2.3.1.4. Spatial distribution, trends in spatial distribution, or historic range

When listed in 1976 (41 FR 24062) and last reviewed in 2010, the Cumberland Bean, *Villosa trabalis*, was reported to occur in both the Tennessee and Cumberland River systems as a white nacred mussel. Its close relative, the Purple

Bean (*Villosa purpurpurea*) was limited to the Tennessee River system and recognized as a mussel with a purple nacre. However, recent genetic assessments of these two species support recognizing of the Cumberland River populations of *Villosa trabalis* as the Cumberland Bean, while combining the Tennessee River populations of *V. trabalis* and *V. perpurpurea* and recognizing them as a separate species, the Tennessee Bean, *Venustaconcha trabalis* (Kuenhl 2009; Lane et al. 2016 & 2019).

Considering the recommended genetic and taxonomic changes for this species, the Cumberland Bean was historically common throughout the middle Cumberland River and most major tributaries. However, it was not reported from Laurel River, nor the Cumberland River above the base of Cumberland Falls (Haag and Cicerello 2016). This species was eliminated from the Cumberland River by Wolf Creek Dam with the exception of the population at the base of Cumberland Falls, which persisted until at least the early 1960s, but it now appears to be extirpated (Haag and Cicerello 2016). Currently, the species is known to occur only in the upper reaches of the Cumberland River, with populations restricted to Buck Creek, Rockcastle River, and Big South Fork (see map in Appendix B). The three remaining populations are separated by large distances due to the creation of Lake Cumberland and are believed to be genetically isolated from one another.

Table 1: Summary of Remaining Populations

Stream (State)	**Last Observed**	**Recruitment**	**Viability**	**Trend**
Cumberland Bean				
Buck Creek (KY)	2004	Unknown	Unknown	Declining
Rockcastle R. (KY)	2017	Yes	Unknown	Declining
Sinking Creek of (KY)	2017	Yes	Unknown	Declining
Big South Fork Cumberland River (KY & TN)	2017	Yes	Unknown	Declining
Purple Bean (= Tennessee Bean) (previously thought to be Cumberland Bean)				
Hiawassee River	2019	Yes	Good	Stable
Paint Rock River (Introduced)	2019	Unknown	Unknown	Unknown
Nolichucky River (Introduced)	2019	Unknown	Unknown	Declining

As a member of the Cumberlandian Region fauna, the Cumberland Bean is restricted to tributary streams of the upper reaches of the Cumberland River. This species is most often found associated with clean, fast-flowing water in stable substrate, which contains relatively firm rubble, gravel, and sand swept-free from siltation. Typically, this species is found buried in shallow riffle and shoal areas and is often located under large rocks that must be removed by hand to inspect the

habitat underneath. Much of the historical habitat for the species has likely been degraded and may no longer be suitable for the species.

2.4. Five-Factor Analysis

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

The recovery plan for this species lists impoundments, siltation, and pollution as major causes for the decline of this species; however, it also indicates that the reasons for declines are not totally understood. The population is considered to be vulnerable to decline in the Big South Fork due primarily to legacy coal mining activities in the headwaters (New River system). Acid mine wastes and resulting impacts to water quality are either known and/or suspected causes in streams like the Little South Fork, Big South Fork, and Rockcastle River systems. The Little South Fork population is now considered extirpated due to coal-related activities in the 1980s. An assessment of potential restoration sites was conducted in the Big South Fork (Guyot, J.A., 2005), but threats from transportation corridors, coal mines, and oil and gas wells were still considered to be significant at these sites. In-stream gravel mining and non-point source pollution are considered to be significant threats in Buck Creek. The Service and its partners, (e.g., KDFWR, TNC) are working on improving stream habitat conditions in Buck Creek and in Sinking Creek through Partners for Fish and Wildlife projects and other stream bank and riparian restoration activities. Many of these projects are relatively new, so it is unclear if any of these improvements have benefitted the Cumberland Bean.

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

Over utilization 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 that this has changed. Currently, the only known individuals in captivity are located in the Center for Mollusk Conservation propagation facility operated by KDFWR in Frankfort, Kentucky. The number of individuals that have been used in propagation facilities in the past, and that are currently being held, is not considered to be sufficient to constitute overutilization of the species.

2.4.3. Disease or predation:

The Recovery Plan does not discuss disease or predation as limiting factors for this species. We have no new information on disease or predation that would indicate either is a limiting factor.

2.4.4. Inadequacy of existing regulatory mechanisms

In Kentucky, the Cumberland Bean may occur in streams that are designated as Wild River and/or designated as an Outstanding State Resource Water. These designations have limited benefits to the species. Wild River designation provides some restrictions on new land uses and provides a means to acquire stream areas and keep them in a natural state (Compton 2018, pers. comm.). Regarding Outstanding State Resource Waters that support Federal T&E species, the intent is to require that the existing water quality and habitat be maintained and protected unless it is demonstrated that lowering water quality or habitat modification will not have a harmful effect. For all OSRWs, the Kentucky Division of Water can establish more-stringent criteria than current criteria but they have not yet pursued that option (Fredenburg 2018, pers. comm.).

The Cumberland Bean and its habitats are afforded some protection from water quality and habitat degradation under the Clean Water Act of 1977 (33 U.S.C. 1251 et seq.), Kentucky's Forest Conservation Act of 1998 (KRS 149.330-355), Kentucky's Agriculture Water Quality Act of 1994 (KRS 224.71-140), Kentucky laws and regulations regarding natural resources and environmental protection (KRS 146.200-360; KRS 224; 401 KAR 5:026, 5:031), Tennessee Nongame and Endangered or Threatened Wildlife Species Conservation Act of 1974, and Tennessee's Water Quality Control Act of 1977 (T.C.A. 69-3-101). However, population declines and degradation of habitat for this species are on-going despite the protection afforded by these laws and corresponding regulations. While these laws have resulted in some improvements in water quality and stream habitat for aquatic life, they alone have not been adequate to fully protect this species, and sedimentation and nonpoint-source pollutants continue to be a significant problem (KDOW 2016).

The Cumberland Bean has been designated as an endangered species in Tennessee (TWRA 2015, 2018; TDEC 2016) and Kentucky (KSNPC 2005, KDFWR 2013), but the state designation in Kentucky conveys no legal protection. 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. While this regulation provides for the consideration of alternatives, it does not require the level of project review afforded by the Endangered Species Act.

2.4.5. Other natural or manmade factors affecting its continued existence

Other natural or manmade factors may affect this mussel, including changes in land use that accelerate pollutant (e.g., sediment) delivery. Other potential threats include contaminant spills, resource extraction (e.g. coal, oil, gas, and gravel), siltation from land use practices, and stream impoundments. A portion of the headwaters of Sinking Creek is impacted by development and other urban activities in London, Kentucky, and from historical surface coal mining. To help address these issues, a port ion of the upper section of Sinking Creek was purchased by The Nature Conservancy in order to restore this upstream segment of Sinking Creek and improve water quality conditions downstream where known populations of the Cumberland Bean occur. Once restored, this segment of Sinking Creek may be suitable for introduction of the species and/or its fish hosts.

The majority of the remaining Cumberland Bean populations are generally small and geographically isolated, making natural repopulation of extirpated populations unlikely. Furthermore, many of the remaining populations are likely below the effective population size, making future extirpations more likely.

There is positive and encouraging activity regarding the propagation and culture of this species that may help restore populations in the upper Cumberland River system. Since 2005, Dr. McGregor has been collecting, holding, propagating, and culturing this species at the KDFWR Center for Mollusk Conservation in Frankfort, Kentucky. Success in working with this species has been slow primarily due to the lack of available gravid females. Over time, however, the numbers of Cumberland bean individuals available for propagation efforts has increased to over 200 individuals in captivity (about 100 males and 100 females), most of which have been propagated and cultured at KDFWR's facility. In addition to working with the fish host, KDFWR has utilized in-vitro methods to propagate this species. As indicated in the aforementioned paragraphs, success has been limited to a relatively small number of cultured Cumberland Beans. That changed in 2018 when KDFWR was able to propagate and culture approximately 6,000 juveniles from gravid females collected from Sinking Creek. These 6,000 individuals will likely be released to multiple sites in the Rockcastle River and Sinking Creek in 2018 and 2019, but the release sites will need to be determined.

Finding potential augmentation or reintroduction sites within the upper Cumberland system is problematic. Many of the streams that once supported the Cumberland bean are no longer considered suitable for the species. Haag (2012) discussed what he called enigmatic mussel declines caused by no single clear cause. He also indicated that juvenile mussels were particularly sensitive to the factors causing these declines, as evidenced by the fact that many populations are often composed of only old adults. Nonetheless, some insight on future suitable release sites may result from a current study Haag is conducting in the Rockcastle River watershed (Haag 2018, pers. comm.). This study involves the use of approximately 200 cages to evaluate how juvenile mussels survive at these sites. This project should provide information regarding potential reintroduction sites for the Cumberland bean in the Rockcastle River system or other

locations, within the Cumberland bean's historical range, where populations could be established to help accomplish recovery.

2.5. Synthesis

Haag and Cicerello (2016) summarized the current status of the Cumberland Bean to be the following: "Formerly generally distributed and common throughout the middle Cumberland River to the base of Cumberland Falls and in most tributaries, but not reported from the Laurel River; absent in the upper Cumberland River drainage above Cumberland Falls."

Populations of this species remain in small segments of Buck Creek, Big South Fork Cumberland River, and the Rockcastle River system, including Sinking Creek. The best population of this species is in the mainstem of the Rockcastle River (i.e., about a 40 mile reach), including lower Sinking Creek, but the species only occurs at sporadic locations. All streams show limited evidence of reproduction and recruitment. In populations in Buck Creek and Big South Fork Cumberland River, recruitment is likely very low and may be undetectable by standard survey techniques, if recruitment is occurring at all. In Buck Creek, the species is observed in about a four-mile reach and in the Big South Fork Cumberland River in only a few shoals.

This species is most often found associated with clean, fast-flowing water in stable substrate, which contains relatively firm rubble, gravel, and sand swept-free from siltation. Typically, the Cumberland Bean is found buried in shallow riffle and shoal areas and is often located under large rocks that must be removed by hand to inspect the habitat underneath. The Banded Sculpin (*Cottus carolinae*), Striped Darter (*Etheostoma virgatum*), Fantail Darter (*E. flabellare*), Greenside Darter (*E. blennioides*) and Redline Darter (*E. rufilineatum*) can all serve as hosts for this species (Guyot 2005). There is concern that the number of host fishes may not be adequate in the Big South Fork and Buck Creek to promote successful recruitment. Recent fish community surveys demonstrate significant recovery of the fish community as compared to historical conditions. Of the documented hosts listed by Guyot (2005), only Greenside Darter occurs in the mainstem of the Big South Fork Cumberland River. However, the Tuxedo Darter, *E. lemniscatum*, may be a surrogate host from the subgenus Catonotus for *E. flabellare* or *E. virgatum*; the Bloodfin Darter (*Notonotus sangifluus*), Bluebreast Darter (*Nothonotus camurus*), and/or Tippecanoe Darter (*Nothonotus tippecanoe*) may be a surrogate for *N. ruflineatus*.

Threats such as siltation, pollution, and habitat loss and siltation due to impoundments are likely still contributing to its decline. Since the recovery plan was completed in 1984, the Little South Fork Cumberland River population has likely been extirpated, but a new population has been discovered in Sinking Creek, a tributary of the Rockcastle River, Laurel County, Kentucky. The availability and/or presence of suitable fish hosts may be a reason for its decline. The population is considered to be vulnerable to decline in the Big South Fork due primarily to legacy coal mining activities in the headwaters (New River system). Acid mine wastes and resulting impacts to water quality are either known

and/or suspected causes in streams like the Little South Fork, Big South Fork, and Rockcastle River systems. In-stream gravel mining and non-point source pollution may be impacting the species in Buck Creek. As a result, all populations remaining are considered vulnerable to further decline.

The population in the mainstem of the Rockcastle River needs to be surveyed more completely to better determine its status; however, thorough surveys need be done in all streams in which this species occurs. Propagation has been most successful in the laboratory using sculpins and darters, and in-vitro has proven to be a successful method to propagate this species. It is still too early to determine if releasing propagated individuals into the wild will be successful enough to help reverse the decline and/or improve the status of this species.

Propagation efforts on this species have been conducted at the CMC, including a release of 151 juveniles into Buck Creek. Virginia Tech (Blacksburg, VA) has been involved in multiple releases into the Big South Fork totaling approximately 2,000 juveniles from six to eight weeks old, but no releases have occurred there since 2007. No information is available to determine if these releases have been successful beyond the actual release itself. In 2009, KDFWR released 42 juveniles (average length of 25 mm) into Sinking Creek, as well as 43 adult Striped Darters, a known host fish for the Cumberland bean mussel. A number of these released juveniles have persisted and have shown signs of reproduction (e.g., gravid females). They may also be recruiting, but, because this site also supports wild (i.e., non-propagated) Cumberland Beans, young Cumberland bean mussels observed at this site could have originated from either the transplanted individuals or the wild stock already present. Until recently, propagation success has been limited to a relatively small number of cultured Cumberland bean. That changed in 2018 when KDFWR was able to propagate and culture approximately 6,000 juveniles from gravid females collected from Sinking Creek. These 6,000 individuals will likely be released at multiple sites in the Rockcastle River and Sinking Creek in 2018 and 2019, and the release sites will need to be determined. Overall, it is still too early to tell how successful the limited augmentations of juveniles and/or sub-adults have been; however, at least some have survived in Sinking Creek.

Because of the species' restricted distribution, continued vulnerability to a variety of threats, and continuing population declines, we believe that the species continues to meet the definition of endangered (in danger of extinction throughout all or a significant portion of its range) and should remain classified as such. Improvements to the species habitat or populations have not been enough the change this status.

3. RESULTS

3.1. Recommended Classification:

__x__ No change is needed

4. RECOMMENDATIONS FOR FUTURE ACTIONS

Based on our review of the Cumberland bean, we believe the following measures are appropriate:

- Revising the listing information, through the public rulemaking process, for the Cumberland Bean and Purple Bean to reflect the current understanding of the taxonomy of these species.
- Augment and expand extant populations through propagation of juveniles.
- Determine status and viability of known populations in Buck Creek, Rockcastle River, Sinking Creek, and Big South Fork of the Cumberland River.
- Reestablish viable populations in other streams within the historical range that have suitable habitat and water quality conditions.
- Determine the degree of threat (e.g., coal mining, oil and gas drilling and water withdrawals, etc.) to each stream in which this species occurs. This could include assessments and/or a threats analysis using GIS.
- Conduct more surveys in selected streams in the Cumberland River system to determine if additional populations exist.
- Conduct a Species Status Assessment and revise the Recovery Plan so that it incorporates the best available information on the Cumberland Bean.
- Conduct a population viability assessment to estimate the likelihood of the species population dynamics, and also conduct a risk assessment to understand the uncertainty and provide guidance for conservation management.
- Develop a protocol to evaluate release sites and determine the population size of cultured Cumberland Bean mussels for the reintroduction and restoration efforts (e.g., utilize pit tags to locate previously introduced individuals)

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Peer Reviewers:

Dr. Dan Hua, Cumberland River Aquatic Center, Tennessee Wildlife Resources Agency, Gallatin, Tennessee

Mr. Tim Lane, SW Virginia Mussel Recovery Coordinator, Virginia Dept. of Game and Inland Fisheries, Marion, Virginia

Mr. Jeff Simmons, Resources and River Management, Tennessee Valley Authority, Chattanooga, Tennessee

5-YEAR REVIEW OF
VILLOSA TRABALIS

Current classification: Endangered

Recommendation resulting from the 5-Year review: Retain endangered classification.

Review conducted by: Kentucky Field Office, Frankfort, Kentucky

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve VIRGIL ANDREWS Digitally signed by VIRGIL ANDREWS Date: 2020.03.09 11:17:44 -04'00' Date_____

REGIONAL CONCURRENCE

Assistant Regional Director, North Atlantic – Appalachian Region, Fish and Wildlife Service

For Signature_____ Date 3/5/20

APPENDIX A: Summary of peer review for the 5-year review of Cumberland Bean

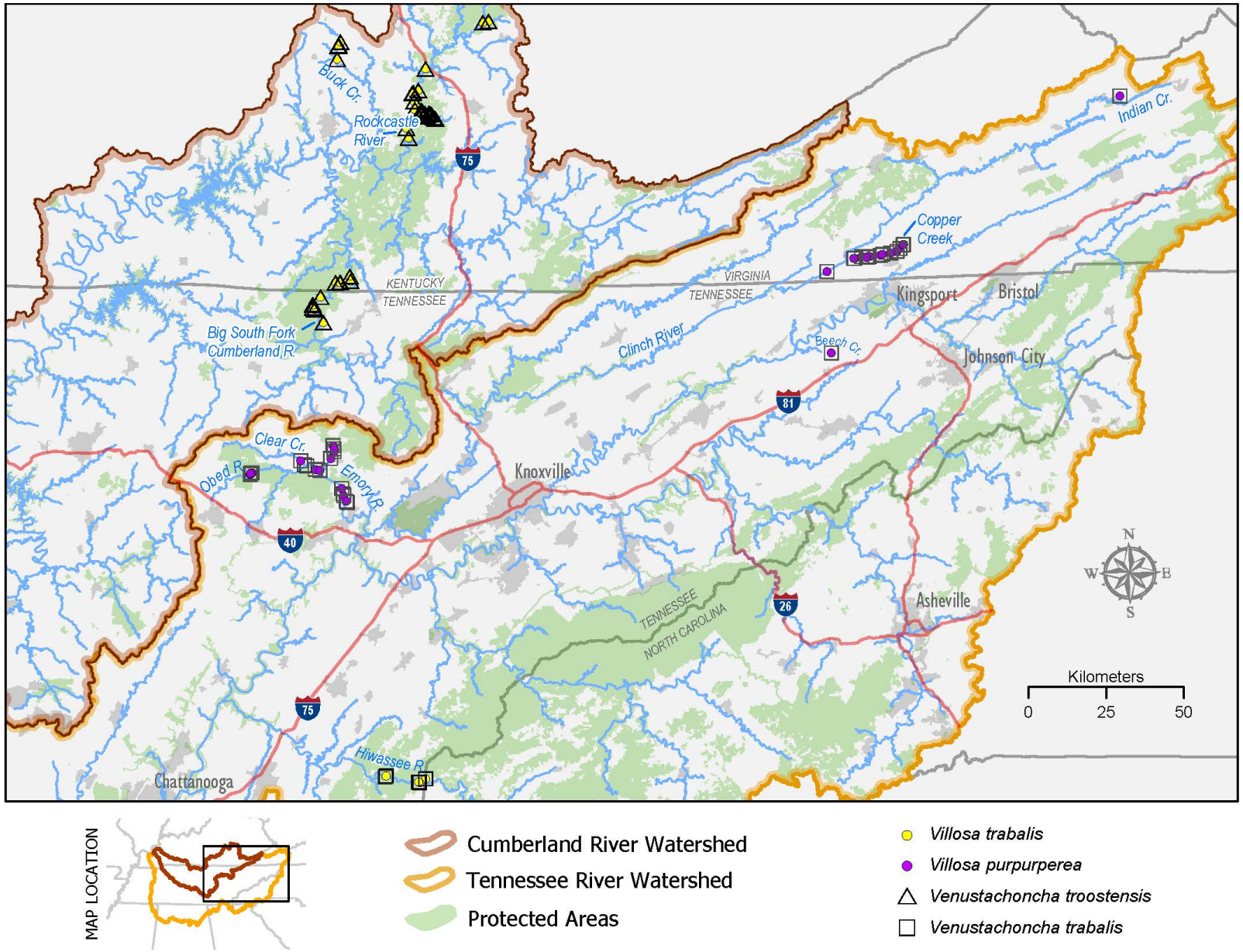
Peer Review Method: A draft document was sent to five reviewers as an attachment to an email requesting their review and any other comments or additions that should be included in the document. The Cookeville FO sent out the requests for the Kentucky FO. Three reviewers responded with comments, one reviewer did not have time to review and another did not think they would have anything substantive to provide and indicated they were not intimately knowledgeable with this species. Peer review comments were incorporated into the document as appropriate.

Peer Review Charge: Peer reviewers were asked to read the 5-year review and provide any comments, both editorial and content. Peer reviewers were not asked to provide recommendations on the classification of the species.

C. Summary of Peer Review Comments/Report: The peer reviewers considered the revised five-year review to be biologically sound, and they generally agreed with the species' status information and conservation actions provided in the review. They considered the information used to determine the species' status to be current and consistent with the recovery plan and a good measure of recovery success. Most specific comments were editorial in nature, with very minor substantive comments on the content. Substantive comments are detailed in the table in Appendix C.

Response to Peer Review: General edits and minor substantive changes were added to the review as appropriate. More substantive comments summarized above were addressed as specified in Appendix C.

APPENDIX B: Map of current distribution of the Cumberland Bean relative to the Purple Bean (=Tennessee Bean)



APPENDIX C: Substantive Peer Review Comments and Responses

Reviewer	Page	Section	Comment	Response
Tim Lane	6	Section B.3.2 note	Possibilities are the Obey River system in Tennessee and the Stones River basin (both Cumberland tribs). In fact the type locality of the species is Stones River near Nashville, TN. Although these systems are cutoff and the mainstems of the rivers have little suitable habitat left, tributaries may offer alternatives. The species and its close relative in the Tennessee River Basin have shown the ability to persist in moderately small watersheds.	This is good information, but more appropriate to be incorporated into a revised recovery plan.
Jeff Simmons	7	Recovery Criterion 4	The USACE has completed a large acid mine drainage and sediment remediation project along the Big South Fork near Blue Heron during 2016 as a required measure outlined in the 2014 BO- "Wolf Creek Dam Return to Historical Operations." This involved stabilizing a large, eroding spoil pile just upstream of Devils Jump and remediating some acid mine seeps. Water quality impacts from coal mining in the lower Big South Fork have been most notable in Bear Creek, Roaring Paunch Creek, and Rock Creek, all of which drain to the BSF within a nine river mile section in McCreary County, Kentucky (Hamilton and Turrini-Smith, 1997; Worsham et al., 2013). Additionally, acid mine drainage remediation had been recently conducted in Rock Creek (Carew, 2002) and water quality in Bear Creek and Roaring Paunch Creek seem to be improving (Worsham et al., 2013).	This information has been incorporated into the 5 year review.

Reviewer	Page	Section	Comment	Response
Jeff Simmons	7	Section C.1.a (Buck Creek)	Recently described *Etheostoma nebra* (formerly *E. virgatum*) is apparently endemic to the Buck Creek system and is a known host for the Cumberland Bean. Near and Thomas (2015) indicate that *E. nebra* has also undergone a significant range reduction in the Buck Creek system where it is now only know from Flat Lick Creek, a tributary to Buck Creek.	This information has been incorporated into the 5 year review.
Hua Dan	8	Table 1 (Rockcastle River) and (Sinking Creek)	Viability (Yes): I would be very careful to conclude this and suggest to conduct risk assessment for the Population Viability Analyses (PVA) of this species. We can then classify this population as a viable population if it meets the criteria for the minimum viable population (MVP).	Acknowledged and recommendation for a PVA has been incorporated in the Section, "Recommendations for Future Actions."
Tim Lane	9	Section C.1.b	Lane et al. also have a manuscript for the population genetics portion of the study in review (possibly in publication before the end of 2018). In this study, all 3 populations listed of *V. troostensis* have significantly low effective population sizes. Given the demographic limitations and few locations outside of these 3 streams to re-establish populations, it would be advisable to mix/cross these genetic stocks using cautious approaches in order to genetically rescue each segment from the effects of inbreeding depression.	This information has been incorporated into the 5 year review using Lane et al. 2019.
Hua Dan	13	Section 2. e.	I would suggest to monitor population dynamics of released mussels using PIT tag method in order to assess the success of restoration efforts. link for PIT tag methods: https://onlinelibrary.wiley.com/doi/full/10.1002/ece3.1348 , https://www.int-res.com/articles/esr2016/31/n031p325.pdf	This information has been incorporated into the section on Recommendations for Future actions

Reviewer	Page	Section	Comment	Response
Jeff Simmons	14	Synthesis (recruitment)	Fish community surveys conducted 2014-2018 from river mile 39 to 44.5 in the Big South Fork have documented 63 fish species, including 15 species of darters (TVA unpub. data), which demonstrates significant recovery of the fish community as compared to historical conditions when acid mine drainage had eliminated most of these species from this reach. Of the documented hosts listed by Guyot (2005), only greenside darter occurs in the mainstem Big South Fork. However, the tuxedo darter, *E. lemniscatum*, may be a surrogate host from the subgenus Catonotus for *E. flabellare* or *E. virgatum*; the bloodfin darter (*Notonotus sangifluus*), bluebreast darter (*Nothonotus camurus*), and/or tippecanoe darter (*Nothonotus tippecanoe*) may be a surrogate for *N. ruflineatus*. Banded sculpin has not been documented from this sample reach.	This information was added to section C.1.a Big South Fork drainage and synthesis
Hua Dan	16	Recommendations for Future Actions	I would also suggest 1/ to conduct PVA to estimate the likelihood of the species population dynamics, and also conduct risk assessment to understand the uncertainty and provide guidance for conservation management. 2/ to develop a protocol on evaluation of release sites and determination of population size of propagated *V. troostensis* for the restoration or reintroduction efforts.	This information has been incorporated into the section on Recommendations for Future actions
Jeff Simmons	16	Recommendations for Future Actions	Item 1 - TVA has documented 13 live mussel species near Blue Heron from 2013-2018, including live and fresh dead *Epioblasma brevidens*. Shoals upstream of Lake Cumberland reservoir backwaters (~RM 43) may be potential introduction sites due to a diverse fish community, appearance of a recovering mussel fauna, and recent sediment/acid mine drainage remediation.	This is good information, but more appropriate to be incorporated into a revised recovery plan.

Reviewer	Page	Section	Comment	Response
Tim Lane	16	Recommendations for Future Actions	Another possibility would be attempts for genetic rescue through limited translocations (e.g., 2-3 adult individuals from one system going to another and repeating this process for several years; not just demographic enhancement from juvenile propagation….which in all likelihood decreases effective population size and limits genetic variability). This type of action offers the potential for increased viability in recruitment. It is also a method that has shown the most promise for successful recruitment in mussel restoration efforts in Virginia and Tennessee.	This is good information, but more appropriate to be incorporated into a revised recovery plan.
Tim Lane	16	Recommendations for Future Actions, Item #5	And other parts of the Cumberland systems (Caney Fork, Collins, Stones). Even if additional populations do not exist, could identify high number of potential restocking locations….all of these systems have shell records of the animal there in the last century.	Changed "upper Cumberland River system" to "Cumberland River system"
Jeff Simmons	Appendix B	Distribution Map	This map indicates that the Cumberland Bean occupies a much larger reach of the Big South Fork than it does. The lower 42 miles are inundated part or all of the year by Lake Cumberland and do not provide suitable habitats for the Cumberland Bean or for many host fishes used by this species.	Map was revised