Slabside Pearlymussel
(*Pleuronaia dolabelloides*)

Photo courtesy of David Pelren, USFWS.

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
Atlanta Regional Office
Tennessee Ecological Services Field Office
Cookeville, Tennessee

5-YEAR REVIEW
Slabside Pearlymussel (*Pleuronaia dolabelloides*)

I. GENERAL INFORMATION

A. Methodology used to complete the review:

We provided public notice of this five-year review in the Federal Register on March 25, 2020 (85 FR 16951) and opened a 60-day comment period. We did not receive any public comments. We obtained information from several experts, peer-reviewed scientific literature, and our state partners. Once all known literature and information was collected for this taxon, the review was completed by Anthony Ford with the Tennessee Ecological Services Field Office (TNFO). The primary sources of information for this analysis included: the final listing rule for this species under the Endangered Species Act (Act) (78 FR 59269), the final rule designating critical habitat (78 FR 59555), the recovery outline dated August 27, 2013, peer-reviewed reports, agency reports, unpublished survey data and reports, and personal communication with recognized experts. All literature and documents used for this review are on file at the TNFO. Comments and suggestions regarding this review were also received from four peer reviewers from outside the U.S. Fish and Wildlife Service (Service). See Appendix for a summary of peer reviewer comments. No part of the review was contracted to an outside party.

B. Reviewers:

Lead Regional Office:
Atlanta, Georgia: Carrie Straight (404) 679-7226

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C. Background

1. Federal Register Notice citation announcing initiation of this review:
March 25, 2020 (85 FR 16951)

2. Listing history
Original Listing
Notice: 78 FR 59269
Date listed: September 26, 2013
Entity listed: Species
Classification: Endangered

3. **Associated rulemakings**:
Final Critical Habitat Rule
Notice: 78 FR 59555
Date: September 26, 2013

4. Review History:
Every two years, we review and update listed species information for inclusion in the required Recovery Report to Congress. Through 2013, we did a recovery data call that included status recommendations. The most recent evaluation for this taxon was completed in 2016.

5. Species' Recovery Priority Number at start of review:
The slabside pearlymussel's recovery priority number is 5. The "5" indicates a species with a high degree of threat and a low recovery potential.

6. Recovery Plan or outline:
Name of plan: Recovery Outline for Slabside Pearlymussel (*Pleuronaia dolabelloides*)
Date issued: August 27, 2013

II. REVIEW ANALYSIS

A. Updated Information and Current Species Status

1. Biology and Habitat

(a) Distribution:
The slabside pearlymussel is currently known from approximately 1,300 river kilometers (rkm). The slabside pearlymussel is endemic to the Cumberland and Tennessee River drainage of the Ohio River Basin, and has been reported from Alabama, Kentucky, Mississippi, Tennessee, and Virginia. It is currently considered extirpated from the entire Cumberland River drainage, historically it was found in the main channel Cumberland River (TN) and its tributaries, Caney Fork River (TN) and the Red River (TN/KY) (Haag and Cicerello 2016). More widespread in the Tennessee River drainage, it was known to occur from headwaters in southwestern Virginia, downstream through Tennessee, Alabama, Mississippi, to, and including the Duck River (TN) (Parmalee and Bogan 1998; Williams *et al.* 2008). The species is believed extirpated from the Tennessee River mainstem and from numerous of its larger tributaries and has suffered substantial population losses and range reductions across the drainage. However, the slabside pearlymussel does continue to survive within the Tennessee River drainage, and is currently extant within the following tributaries (presented from upstream to downstream): Powell River (VA/TN); Clinch River (VA/TN) and its tributaries Plum Creek (VA), Little River (VA), and Copper Creek (VA); North Fork Holston River (VA) and its tributary Big Moccasin Creek (VA); Middle Fork Holston River (VA); Little River (TN); Nolichucky River (TN); Little Pigeon River (TN); Hiwassee River (TN); Sequatchie River (TN); Paint Rock River (AL) and its tributaries Estill Fork (AL), Larkin Fork (AL), and Hurricane

Creek (AL); Flint River (AL); Elk River (TN/AL); Bear Creek (AL/MS) and its tributary Cedar Creek (MS); and the Duck River (TN) and its tributaries Big Rock Creek (TN) and the Buffalo River (TN).

Updates to the distribution of slabside pearlymussel since the final listing rule (2013) include a new drainage record discovered in 2014 from the Little River, Blount County, TN (Schilling *et al.* 2015). Surveys of the Clinch River tributaries, Plum Creek and Little River (Tazewell County, VA) (Lane and Neves 2014 and Brian Watson, Malacologist, Virginia Department of Wildlife Resources, pers. comm. 2020), have also resulted in new tributary records, increasing species' ability to withstand certain stochastic events like spills in the Clinch River watershed. The final listing rule had listed the West Prong Little Pigeon River, Sevier County, TN as a historical species occurrence. In 2014, one fresh dead individual was collected from the Little Pigeon River above the confluence with the West Prong Little Pigeon River (Gerry Dinkins, Curator Malacology, McClung Museum, University of Tennessee, pers. comm. 2020). These records indicate new or rediscovered occurrences of the slabside pearlymussel in these systems and an increase in overall redundancy for the species.

(b) Abundance, population trends, demographic features or demographic trends: We define a population segment as where two or more stream populations occur continuously with no absolute barriers (e.g., large impoundments) or long reaches of unoccupied habitat. The Paint Rock River system (including Larkin Fork, Estill Fork, and Hurricane Creek) and the Duck River system (including Big Rock Creek and the Buffalo River) are considered single population segments due to their connected nature. The North Fork and Middle Fork Holston River are separated by impoundments (e.g., Boone Lake, Fort Patrick Henry Lake) and distance (long reaches of unoccupied habitat) and are treated as different population segments.

The final listing rule identified 30 historical populations delineated by streams or contiguous segments of multiple streams (Service 2013). Of those 30 historical populations, 13 were believed to be extant at the time of listing. The criterion for being considered extant in the listing rule was for collections to have been made since 1980 (Service 2013). Given the time that has passed since the final rule, 1980 may not be the best "current" metric at this time. For the purposes of this review, we consider any collections of live or fresh dead individuals of slabside pearlymussel in the past 30 years (since 1990) to be extant. If no collections have been made during this timeframe, we consider that population is likely extirpated.

We currently recognize 14 extant population segments; they are the:

1. Powell River (VA/TN; last record 2012),
2. Clinch River (VA/TN; last record 2020),
3. North Fork Holston River (VA; last record 2013),
4. Middle Fork Holston River (VA; last record 2018),
5. Little River (TN; discovered in 2014),
6. Nolichucky River (TN; last record 2010),
7. Little Pigeon River (TN; last record 2014),

8. Hiwassee River (TN; last record 2002),
9. Sequatchie River (TN; last record 2021),
10. Paint Rock River (AL; last record 2018),
11. Flint River (AL; last record 2015),
12. Elk River (TN/AL); last record 2021),
13. Bear Creek (AL/MS); last record 2020), and
14. Duck River (TN; last record 2020).

Since listing (2013), the slabside pearlymussel has been discovered in the Little River, Blount County, TN, which represents a new drainage record (listed as population 5, above; Schilling *et al.* 2017). Additionally, two populations and a tributary in a population believed extirpated at the time of listing have been discovered extant (the Flint River (AL) population (AST Environmental 2007 and 2015); the Little Pigeon River population (G. Dinkins pers. comm. 2020) and a tributary to the Duck River population, Big Rock Creek (TN) (Irwin and Alford 2018), (populations listed above as 11, 7, and 14, respectively)).

Powell River (VA/TN)

The last collection of slabside pearlymussel from the Powell River was in 2012 (Schilling 2015). No new information has been generated relative to species abundance, population trends, demographic features, or demographic trends in the Powell River since publication of the final listing rule. Based on the best available information, the species resiliency remains very low within the Powell River.

Clinch River (VA/TN)

The Clinch River population is small but continues to successfully reproduce. Most observations of this species in the Clinch River are of one or two animals per survey event. One hundred slabside pearlymussel were released into the upper Clinch River, VA in 2014 at two different focal restoration reaches (Artrip and Bennett Property, 50 individuals each). One individual was recaptured during a survey of the Bennett Property in 2020, indicating some persistence of these individuals (Tim Lane, Mussel Recovery Coordinator, Virginia Department of Wildlife Resources, pers. comm. 2021). No additional individuals have been propagated or stocked within the Clinch River because Clinch River broodstock has been increasingly hard to locate (T. Lane pers. comm. 2020). The slabside pearlymussel seem to be persisting at low numbers within the Clinch River tributaries of Plum Creek, last collected in 2014 (Lane and Neves 2014), and Little River, last collected in 2020 (B. Watson pers. comm. 2020). The current status in Copper Creek is unknown with the most recent collection occurring in 1998. Little new information has been generated relative to species abundance, population trends, demographic features, or demographic trends in these systems since the final listing rule.

North Fork Holston River (VA)

A large portion (approximately 90 rkm) of the North Fork Holston River downstream of Saltville, Virginia continues to remain unoccupied due to contamination from a former chlor-alkali processing plant (Seivard *et al.* 1993, Henley *et al.* 2016, Rose Agbalog, Biologist, U.S. Fish and Wildlife Service, pers. comm. 2021). Significant declines in

abundance have also been documented with slabside pearlymussel in this population (upstream of Saltville) since 2000 (Jones and Neves 2007, Ostby *et al.* 2010). Little new information has been generated relative to species abundance, population trends, demographic features, or demographic trends in the North Fork Holston River, or its tributary, Big Moccasin Creek, since publication of the final listing rule.

Middle Fork Holston River (VA)

The Middle Fork Holston River has been in decline over the last 20 years, resulting from an enigmatic mussel decline marked by curtailed recruitment, densities, and species richness over a period of years (Henley *et al.* 2013, Haag 2019). Henley *et al.* (2013), observed no evidence of recent recruitment at any of their survey sites in 2010 (n=44 individuals) with a mean and minimum length of 78.3 and 57.0 mm, respectively. The slabside pearlymussel was more recently surveyed in 2016 and 2018 (n=42 individuals) from the Middle Fork Holston River south of Abingdon, VA. The size distribution was similar to those found in 2010 with a mean and minimum length of 77.2 and 50 mm, respectively (T. Lane unpublished data 2021). While these data seem to indicate a comparable abundance and size class distribution between these survey efforts, the age structure still seems to be skewed toward older individuals with recent recruitment lacking.

Little River (TN)

Four adult individuals were discovered from a single location during a 2014 survey effort, two of the four individuals collected were gravid, suggesting that recruitment could be occurring (Schilling *et al.* 2017). Additional surveys are needed to better assess the level of resiliency this population may be expected to have in order to withstand foreseeable stochastic events.

Nolichucky River (TN)

The Nolichucky River population of slabside pearlymussel is very small and has very low resiliency. Monitoring of the mussel community at Nolichucky rkm 28.9 has been conducted annually since 2016 producing over 1500 live mussels representing 13 species, but no live slabside pearlymussels have been found (G. Dinkins unpublished data 2020). The species has only been collected recently at a single site, with a single fresh dead valve located in 2010 at Nolichucky rkm 9.6 (Dinkins 2010).

Little Pigeon River (TN)

The Little Pigeon River population is also very small and has very low resiliency. It has only been collected recently from a single location from the Little Pigeon River above the confluence with the West Prong Little Pigeon River as a fresh dead specimen in 2014 (G. Dinkins pers. comm. 2020).

Hiwassee River (TN)

No new information has been generated relative to species abundance, population trends, demographic features, or demographic trends since publication of the final listing rule. Based on the best available information, the species resiliency remains very low within the

Hiwassee River. The most recent record of a live slabside pearlymussel from the Hiwassee River was during a 2002 survey (Ahlstedt 2002).

Sequatchie River (TN)
Limited mussel survey efforts have been conducted within the Sequatchie River system since listing. However multiple live individuals representing multiple size classes were discovered during a 2021 survey effort within the lower Sequatchie River (G. Dinkins pers. comm. 2021), the previous most recent record was from 1980 (Hatcher and Ahlstedt 1982). Additional surveys are needed to better assess the level of resiliency this population may be expected to have in order to withstand foreseeable stochastic events.

Paint Rock River (AL)
The population of slabside pearlymussel in the Paint Rock River is characterized by good recruitment and numerous individuals in multiple age classes. Fobian *et al.* (2014) conducted the most recent comprehensive survey of the Paint Rock system in 2008. They found the species comprised 3.6% of the cumulative mussel relative abundance. Subsequent surveys continue to document a large population of slabside pearlymussel in the Paint Rock River, including a 2018 survey near mile 33.3 where 52 individuals were recorded (Todd Fobian, Environmental Affairs Supervisor, Alabama Department of Conservation and Natural Resources, pers. comm. 2020). Overall, the Paint Rock River is thought to have a high level of resiliency, capable of withstanding foreseeable stochastic events, and represents one of the most important strongholds for the species.

Flint River (AL)
Four individuals were discovered during a 2007 survey (omitted from the assessment prior to listing) and an additional animal was found during a 2015 survey (AST Environmental 2007 and 2015). Based on the best available information, the species resiliency is likely very low within the Flint River.

Elk River (TN/AL)
An individual measuring 37 mm in length found by a Tennessee Valley Authority (TVA) biologist in 2012 indicates some recruitment was likely still occurring at that time. The most abundant site in the Elk River appears to be below Harms Mill Dam near Elk River km 121.8 (mile 75.7) where 12 individuals were collected by TVA during qualitative sampling in 2015 (TVA unpublished data). Water quality improvements were made to the releases below Tims Ford Dam in 2008 by modifying spring through fall tailwater flows to more closely resemble natural temperature and flow regimes (TVA 2008), and the proposed removal of Harms Mill Dam may provide additional opportunity for this population to improve in the future.

Bear Creek (AL/MS)
Multiple size classes (45-70 mm) have been collected alive during the recent surveys by TVA in 2019 and the Mississippi Department of Wildlife, Fisheries, and Parks in 2020 (TVA unpublished data, Wagner and Ellwanger 2020) showing evidence of successful recruitment over time. Collections of this species are usually five individuals or fewer. However, the resiliency of slabside pearlymussel in Cedar Creek (a Bear Creek tributary)

is likely very low as the last collection (fresh dead individual) was from 2006 and no specimens (live or fresh dead) were collected during the most recent (2020) comprehensive survey effort of this system (Wagner and Ellwanger 2020).

Duck River (TN)

The Duck River represents a stronghold population for slabside pearlymussel and may be the most robust and resilient population for the species. During the most recent surveys by the Tennessee Wildlife Resources Agency in 2020, the species represented 3.11% of the total mussel composition in quantitative mussel surveys at four long-term monitoring sites and estimated densities of the species were 0.16-0.82 individuals per square meter between the sites (Wisniewski 2020). Multiple age classes were represented in the collection, including recent reproduction (<25 mm in length) (Wisniewski 2020). Additionally, this population has been identified by the Cumberlandian Regional Mollusk Recovery Plan as being resilient enough to be a source population for translocation recovery efforts (CRMRC 2010).

The Duck River population segment is further strengthened by two of its tributaries, Big Rock Creek and Buffalo River. Irwin and Alford (2018) collected three live individuals with sizes of 30-42 mm from Big Rock Creek in 2017, indicating recruitment has recently occurred in this stream. The Buffalo River tributary population has high resiliency as the slabside pearlymussel was the most abundant species of mussel collected in the Buffalo River during recent quantitative sampling, which documented individuals of multiple size classes and evident recruitment (Reed *et al.* 2019). Healthy populations continue to persist in the upper and lower reaches of the Buffalo River, while the best-known population occurs at Buffalo River km 5.1 (mile 3.2) (Reed *et al.* 2019). These two tributaries increase the resiliency of the Duck River mainstem population.

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

Schilling (2015) assessed morphology and molecular genetics of 52 slabside pearlymussels from 5 different drainage populations. Those included individuals from the Powell River (n=2), Clinch River (n=17), Middle Fork Holston River (n=18), Little River (n=4), and Duck River (n=11) representing 12 different haplotypes (i.e., set of DNA variations that tend to be passed down through generations or inherited together). A common haplotype was shared among the five populations, while two haplotypes were shared between the Clinch and Middle Fork Holston, and unique haplotypes were observed in the Clinch (n=2), Middle Fork Holston (n=3) and Duck (n=4). Intraspecific distances among these haplotypes ranged from 0.11% to 1.92% and averaged 0.80%. Interspecific pairwise genetic mean distances between the other species in the study (i.e., mussels from the genera *Fusconaia*, *Pleurobema*, and *Pleuronaia* in the Upper Tennessee River basin) ranged from 2.85% to 17.23%. These 12 different haplotypes among 52 total individuals suggest good representation within the species, both among and between populations.

There are individuals in the South Chickamauga Creek drainage, Whitfield County, GA that morphologically resembles slabside pearlymussel, but these individuals show considerable genetic disparity from what is currently recognized as the putative species.

Schilling (2015) conducted molecular genetic analyses on seven individuals of this cryptic species (*P.* sp. *cf. dolabelloides*) and observed two haplotypes with an intraspecific distance of 0.45%. The interspecific distance between *P. dolabelloides* and *P.* sp. *cf. dolabelloides* was 3.17%. Schilling (2015) determined that the cryptic *Pleuronaia* from Georgia formed a monophyletic clade distinct from slabside pearlymussel based upon this large genetic distance. Additional research is needed to determine if there is another taxa occurring in South Chickamauga Creek drainage distinct from but closely related to slabside pearlymussel. Until the status of the population in the South Chickamauga Creek drainage is resolved through peer-reviewed research, we do not consider the cryptic species in Georgia to be a population of slabside pearlymussel.

(d) Taxonomic classification or changes in nomenclature:
No changes to the nomenclature (Williams *et al.* 2017, FMCS 2019) have been made to the species since the final listing rule (Service 2013). The best available information continues to indicate that the species is a valid entity.

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

(a) Present or threatened destruction, modification or curtailment of its habitat or range:
The slabside pearlymussel is currently known from approximately 1,300 of 4,450 historically occupied rkm, representing over a 70 percent reduction in range. The final listing rule (Service 2013) identified this factor as the primary cause of the species' decline and cited impoundments, gravel and coal mining, sedimentation, water pollution, and stream channel alterations as major causes of habitat loss and degradation. The construction of dams within the range of the slabside pearlymussel has resulted in major and enduring effects to the species by isolating populations, altering the physical habitat, blocking upstream and downstream movement, and changing flow and temperature regimes. In recent years, some improvements have been made to improve riverine conditions. For example, operational changes were initiated at the Tims Ford Dam on the Elk River by TVA in 2006 to improve habitat below the dam by altering the discharge to better mimic a natural flow and temperature regime (TVA 2008). Although these improvements have occurred, this threat is still a primary driver to species declines and still impacts all populations and historical reaches throughout its range.

Mining continues to be an ongoing threat to the species. Additional research has been completed relative to the impacts of coal mining in the Powell River and Clinch River on mussel populations since the final listing rule was published (Zipper *et al.* 2016, Phipps 2019, Cope *et al.* 2021). Zipper *et al.* (2016) conducted an analysis of spatial and temporal patterns of mining disturbance in the Powell River and found that mussel declines are correlated with increasing mining-related water constituents (e.g., dissolved solids, specific conductance, pH, and sulfates), even though the direct causal mechanisms for the declines are still unknown (Zipper *et al.* 2016). Phipps (2019) identified several major ions and trace elements from mining negatively affecting the growth of freshwater mussels in the Powell River from mining in the headwaters. Cope *et al*. (2021) found PAH (Polycyclic Aromatic Hydrocarbon) concentrations in mussels were negatively

related to the spatial pattern in mussel densities and were highest in a "zone of mussel decline." They also concluded that PAHs and Manganese are some of the legacy mining pollutants, largely delivered through the Guest River tributary watershed, continuing to act as stressors to mussels in the Clinch River.

Suitable habitat for slabside pearlymussel continues to be fragmented by impoundments and sections of river with unsuitable habitat. Each of these isolated populations is vulnerable to extirpation by pollutants, habitat modification, progressive degradation from land surface runoff (nonpoint-source pollutants), and natural stochastic events (e.g., floods, drought). Foreseeable threats to existing populations include accidents involving vehicles transporting chemicals over road crossings over streams, and accidental or intentional release of chemicals used in agricultural or residential applications. The lack of connection between slabside pearlymussel populations throughout much of the species current range eliminates the possibility for recolonization if some populations become extirpated.

(**b) Overutilization for commercial, recreational, scientific, or educational purposes:** The overutilization for commercial, recreational, scientific or educational purposes was not considered to be a limiting factor in the final listing rule (Service 2013). We have no new information to indicate that this has changed.

(**c) Disease or predation:**
Disease was not considered a significant threat in the final listing rule (Service 2013). Since then, numerous mussel species in the Clinch River have experienced annual die-offs affecting individuals across multiple size classes. The first observed die-off was in June 2016 at Kyles Ford and Frost Ford in the Clinch River, Tennessee (Phipps *et al.* 2018). Similar mortality events were observed again during the late summer to early fall in 2017-2020. Research suggests that pathogens (i.e., bacteria, parasites) contributed to these die-offs (Henley *et al.* 2019). Richard *et al.* (2020) identified a novel densovirus (Clinch densovirus 1) that was epidemiologically linked to morbidity in the Clinch River mussels. While relatively few fresh dead slabside pearlymussel have been recovered during this die off, (i.e., only 1 of the 3,533 specimens deposited at the McClung Museum in 2016 from this event was a slabside pearlymussel; G. Dinkins Unpublished Data 2020), it may be due to the low relative abundance of this species in the Clinch River. A similar die-off occurred in the North Fork Holston River from 1999 to 2002, and primarily affected the slabside pearlymussel (n=348 fresh dead individuals) and shiny pigtoe (*Fusconaia cor*) (n=114 fresh dead individuals) (Jones and Neves 2007). While the cause of this die-off was unknown at the time, similarities between this event and the more recent one in the Clinch River may suggest it was also disease related (R. Agbalog pers. comm. 2021). Regardless, disease is now be considered a significant threat to the species if this or other viruses are shown to result in acute mortality.

(d) Inadequacy of existing regulatory mechanisms: The final listing rule specifically mentioned that the Clean Water Act (33 U.S.C. 1251 *et seq*.) was insufficient at reducing the threats to habitat and water quality (Service 2013). These threats are projected to continue and potentially worsen in the future. The Surface Mining Control and

Reclamation Act of 1977 also regulates the environmental effects of coal mining in the United States and the prominence of mining in the Powell River and Clinch River has been studied for its impacts to the mussels of those rivers (Zipper *et al.* 2016; Rogers *et al.* 2018, Cope *et al.* 2021). Major stressors identified in the rule, siltation and pollution, are influenced by the efficacy of State and Federal regulations. These threats have not been abated and continue to show impacts on mussel populations (Zipper *et al.* 2016; Rogers *et al.* 2018, Cope *et al.* 2021) and are likely causing continued decline of the slabside pearlymussel. Existing regulatory mechanisms have been inadequate to protect the species and its habitat from these threats.

(e) Other natural or manmade factors affecting its continued existence:

Climate Change

Small and isolated slabside pearlymussel populations are less resilient to natural stochastic events (e.g., floods, drought, etc.) (Hastie *et al*. 2001, Haag and Warren 2008). In its Fifth Assessment Report, the Intergovernmental Panel on Climate Change (IPCC) concluded that warming of the climate system is unequivocal (IPCC 2014). Droughts in the Southeast are likely to increase in frequency, duration, and intensity (NCILT 2012). Stream temperatures in the Southeast have increased roughly 0.2–0.4 ºC (0.4–0.7 ºF) per decade and are expected to continue increasing based on projected increases in air temperature (Kaushal *et al.* 2010). Thermal thresholds for mussels could be exceeded within the next 50 years, based on models designed to simulate daily mean stream temperatures associated with climate change and land use change projections (Daraio *et al.* 2014), and will likely have adverse impacts on recruitment in freshwater mussels like the slabside pearlymussel.

There is uncertainty about the specific effects of climate change (and their magnitude) on the slabside pearlymussel and its host fishes; however, species with limited ranges, fragmented distributions, and small population sizes are thought to be especially vulnerable to the effects of climate change (Byers and Norris 2011). Thus, we consider climate change to be a potential threat to the persistence and long-term viability of remaining slabside pearlymussel populations.

Undefined Threats

We are still learning much about threats to the slabside pearlymussel and other freshwater mussels. A number of streams have experienced "enigmatic declines" in their mussel fauna since the 1960s, including several within the historical range of the slabside pearlymussel (e.g., Red River, Cumberland River, and Tellico River) (Haag 2019), and with the extant populations of the Middle Fork Holston River (Henley *et al.* 1999; Henley *et al.* 2013) and North Fork Holston River (Jones and Neves 2005; Ostby *et al.* 2010). These declines have been similar in that they were relatively rapid (often with faunal collapse within 10 years), affected all species of mussels but no other aquatic taxa, and appear to have specifically affected recruitment (Haag 2019). The cause of these enigmatic declines has not been identified, though many factors have been hypothesized (e.g., agricultural effects, disease, introduction of Asian clam), but is concerning and remains a priority of ongoing research.

B. Synthesis

The status of the slabside pearlymussel remains largely unchanged since the time of listing. The slabside pearlymussel has been eliminated from more than 70 percent of its historical range. Of remaining populations, the majority seem to be declining or suffering low resiliency and are at risk of extirpation. The North and Middle Fork Holston have been suffering from an enigmatic mussel decline that has resulted in drastic losses of formerly and recently robust and healthy populations. The Powell River, Nolichucky River, Little Pigeon River, Hiwassee River, and Flint Rivers show very low resiliency and lack any evidence of recent recruitment. The Elk River and Bear Creek appear to be stable and show at least some recruitment potential. The Little River, which was not a recognized population at the time of listing, and the Sequatchie River population, which was recently rediscovered (G. Dinkins pers. comm. 2021) after almost 40 years without positive survey records, may need additional surveys to fully document its population's status. The Paint Rock River and Duck/Buffalo River populations remain the strongest populations and are characterized by recent recruitment and a multiple age class structure. These populations will likely be considered as source populations for any propagation and/or translocation recovery efforts (reintroductions or augmentations).

Reservoir construction has impounded and fragmented much of the habitat within the species' range; these habitat changes continue to have lasting effects through isolation of extant populations. Habitat degradation and water quality threats from land use activities (e.g., agriculture, development) continue at varying levels across the species' range. Additionally, climate change, pathogens, and/or other undefined threats may be affecting the species or could affect the species in the future; however, we do not know which specific factor or combination of factors are most significant in the continued decline of the species. The recent die-offs in the Clinch River and the enigmatic declines that have occurred in other populations demonstrate the precarious status of these populations and reveal our poor understanding of the threats to the species. Because of its distribution in small, isolated populations, its continued vulnerability to threats, our poor understanding of the threats, and the low to moderate resiliency of extant populations, we believe that the slabside pearlymussel continues to meet the definition of endangered (in danger of extinction throughout all or a significant portion of its range).

III. RESULTS

A. Recommended Classification: Endangered, no charge is needed.

B. Recommended Recovery Priority Number: 5, no change.

IV. REFERENCES

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Slabside Pearlymussel (*Pleuronaia dolabelloides*)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

___ Downlist to Threatened
___ Uplist to Endangered
___ Delist
_X_ No change needed

Review Conducted By: Anthony Ford, Tennessee Ecological Services Field Office.

FIELD OFFICE APPROVAL:

Field Supervisor, Tennessee Ecological Services Field Office, Fish and Wildlife Service

DANIEL ELBERT Digitally signed by DANIEL ELBERT
Date: 2021.08.06 16:25:07 -05'00'

Approve _____ Date _____

REGIONAL OFFICE APPROVAL:

Assistant Regional Director-Ecological Services, Fish and Wildlife Service

Approve CATHERINE PHILLIPS Digitally signed by CATHERINE PHILLIPS
Date: 2021.08.09 12:54:26 -04'00' Date _____

COOPERATING REGIONAL OFFICE APPROVAL:

We emailed this 5-year review to the North Atlantic-Appalachian Regional Office for their concurrence prior to finalizing the document. We will retain any comments that we received, as well as verification of concurrence from other regions, in the administrative record for this 5-year review.

APPENDIX: Summary of peer review for the 5-Year Review of Slabside Pearlymussel

Reviewers:

A. Peer Review Method: Peer review was coordinated by our Atlanta Regional Office. We selected four peer reviewers based on their knowledge of and expertise with the slabside pearlymussel and its habitat. Responses were received from all of the four invited peer reviewers. Additionally, internal review was conducted by individuals in the Tennessee, Alabama, Virginia, and Mississippi Ecological Services field offices, and the Atlanta Regional Office.

Peer reviewers that responded include:

- Gerry Dinkins, University of Tennessee - McClung Museum of Natural History and Culture, Curator of Natural History and Malacology
- Robert Ellwanger, Mississippi Museum of Natural Science, Curator of Fishes and Mussels
- Tim Lane, Virginia Department of Wildlife Resources, Southwest Virginia Mussel Recovery Coordinator
- Todd Fobian, Alabama Department of Conservation and Natural Resources, Environmental Affairs Supervisor

B. Peer Review Charge: When sending out the document for peer review, we asked for comments on whether we assembled the best available scientific and commercial information, if our analysis of this information was correct and properly applied, and if the reviewer could identify any additional new information related to the species that has not been considered in the review. Additionally, as part of the peer review process, we evaluated the potential for conflicts of interest with the subject species.

C. Summary of Peer Review Comments/Report

Gerry Dinkins, University of Tennessee:
Mr. Dinkins noted that Big Rock Creek may not have connectivity with the Duck River because of the impoundment created by Lillard Mill Dam creates approximately 3 river miles of impounded stream that may be a migration barrier by the host fishes. Mr. Dinkins also remarked that a recent survey that he conducted in the Lillard Mill pool indicated it was unsuitable for slabside pearlymussel and provided a citation to his survey report (Dinkins and Dinkins 2019). Mr. Dinkins remarked that the slabside pearlymussel records from Big Rock Creek could be suspect and should also be verified genetically due to all of these recent collections being juvenile specimens that could be confused with the more common *Pleuronaia barnesiana* (Tennessee pigtoe) in that system. Mr. Dinkins also provided recent mussel survey information for the Nolichucky River and provided survey report reference to the last slabside pearlymussel collected in this system in 2010. Other comments by Mr. Dinkins were primarily editorial in nature.

Robert Ellwanger, Mississippi Museum of Natural Science:

Provided no substantial comments or edits, but did verify that all information related to the species' presence in Mississippi was accurately represented with current information in this review.

Tim Lane, Virginia Department of Wildlife Resources:
Provided an updated reference to more recent survey information on slabside pearlymussel within the Powell River. Mr. Lane also provided some management recommendations for the slabside pearlymussel in the Middle Fork Holston that could assist in recovery of the species in that system.

Todd Fobian, Alabama Department of Conservation and Natural Resources:
Provided updated slabside pearlymussel survey records within the Paint Rock River and provided a relic shell record for an Elk River tributary (Sugar Creek) in Alabama. Mr. Fobian also noted water quality and discharge improvements by TVA in the Bear Creek and Duck River systems in addition to the Elk River example already included in the review.

D. Response to Peer Review:

Gerry Dinkins:
We have not regarded the 3 river miles of unoccupied habitat created by the Lillard Mill pool as a barrier to genetic exchange between the Duck River and Big Rock Creek in this review, but recognize this may be a real barrier to some of the fishes (shiner and dace) identified as primary hosts of the slabside pearlymussel. We agree that additional collections of larger slabside pearlymussel in Big Rock Creek or the collection of genetic samples may be needed to further verify slabside pearlymussel in this system. If additional sampling fails to produce additional slabside pearlymussel individuals, we may reassess the new record reported by Irwin and Alford (2018) in a successive status review.

Gerry Dinkins, Robert Ellwanger, Tim Lane, and Todd Fobian:
New survey records reported by Mr. Dinkins, Mr. Lane, and Mr. Fobian were incorporated and cited in the text. All other comments or edits were reviewed and incorporated as appropriate into the document.