Birdwing Pearlymussel
Lemiox rimosus (Rafinesque, 1831)

Photo by Tom Schirtz, McClung Museum of Natural History and Culture
49 mm length. UTMM Lot no. 3966

5-Year Review:
Summary and Evaluation

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

5-YEAR REVIEW
Birdwing Pearlymussel (*Lemiox rimosus*)

I. GENERAL INFORMATION

A. Methodology used to complete this review

Public notice of initiation of this 5-year review was provided in the *Federal Register* on May 7, 2018 (83 FR 20092) and a 60-day comment period was opened. During this comment period, we obtained information on the status of this species from several experts; additional data was also obtained from the recovery plan, peer-reviewed scientific literature, unpublished reports, and our state partners. Once all known literature and information was collected for this species, the review was drafted by Gerald Dinkins of the McClung Museum of Natural History and Culture, University of Tennessee (UTMM), and finalized by Anthony Ford (species recovery lead) and Santiago Martín with the U.S. Fish and Wildlife Service (Service), Tennessee Field Office. All literature and documents used for this review are on file at the Tennessee Field Office in Cookeville, Tennessee. All recommendations resulting from this review are the result of thoroughly reviewing the best available information on the Birdwing Pearlymussel. The Appendix provides a brief summary of the peer-review approach.

B. Reviewers

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C. Background

1. **Federal Register Notice citation announcing initiation of this review:** May 7, 2018; 83 FR 20092

2. **Species status:** Declining. The Birdwing Pearlymussel was described from shell valves supposedly collected from the Cumberland River (Rafinesque, 1831), but the only record attributed to that drainage is an

undated specimen collected by R. E. Call (who died in 1917) and cataloged in the mollusk collection at the University of Michigan's Museum of Zoology (UMMZ). Despite this specimen in the UMMZ collection, the general consensus among the scientific community is that the Birdwing Pearlymussel is endemic to the Tennessee River and several tributary rivers in Virginia, Tennessee, and Alabama (Parmalee and Bogan 1998, Williams et al. 2008). Based on modern and archeological records, the species occurred in the main channel Tennessee River in Perry and Decatur counties, Tennessee, upstream to Knoxville and in the following tributary rivers: Duck, Sequatchie, and Elk rivers in Tennessee, and the Paint Rock River in Alabama. In the upper Tennessee River drainage, the species was reported from the main channel Holston River upstream to the confluence of North and South Fork Holston rivers, the lower North Fork Holston River (Tennessee and Virginia), and the Clinch and Powell rivers (Tennessee and Virginia). In the French Broad drainage, it was reported from the Little Pigeon and Nolichucky rivers (Tennessee). Currently, the Birdwing Pearlymussel is restricted to 28 miles of the Powell River, 103 miles of the Clinch River, and 40 miles of the Duck River. This represents an 88% reduction in its historical range. A summary of the historical distribution of the Birdwing Pearlymussel is provided in Table 1.

3. **Recovery achieved:** 1 = 0%-25% of recovery objectives achieved. Tennessee Wildlife Resources Agency (TWRA) has performed limited population establishment efforts in the Nolichucky and Elk rivers through translocation of Duck River stock or propagated individuals (Table 2). TWRA observed gravid female Birdwing Pearlymussels in the Nolichucky River reintroduction site in 2014, 2015, and 2016; however, evidence of recruitment has not yet been documented. In addition, the Virginia Department of Game and Inland Fisheries (VDGIF) and Virginia Tech have performed limited population augmentation efforts in the Virginia portions of the Powell and Clinch rivers (Table 2), but no assessment of the viability of those populations has been completed.

4. **Listing history:**
   Original Listing
   FR Notice: 41 FR 24062
   Date Listed: June 14, 1976
   Entity Listed: Species
   Classification: Endangered

5. **Associated rulemakings:**
   Establishment of Nonessential Experimental Population Status for 16 Freshwater Mussels and 1 Freshwater Snail (Anthony's riversnail) in the Free-Flowing Reach of the Tennessee River Below the Wilson Dam, Colbert and Lauderdale Counties, AL. June 14, 2001; 66 FR 32250.

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

6. **Review History:**
   Each year, the Service reviews and updates listed species information for inclusion in the required Recovery Report to Congress. Through 2013, we submitted information for the annual recovery data call that included status determinations like "Declining" or "Stable" for the Birdwing Pearlymussel. We continue to show similar determinations as part of our 5-year reviews. The most recent evaluation for this mussel to inform the Recovery Report to Congress was completed in 2019.

   A 5-year review for the Birdwing Pearlymussel was completed on August 15, 2011 (Service 2011). The Service did not recommend a change to the species' endangered status.

7. **Species' Recovery Priority Number at start of review (48 FR 43098):**
   4C, indicating that the Birdwing Pearlymussel is categorized as a species, has a high degree of threat, and a low potential for recovery; C indicates conflict with construction or other development.

8. **Recovery Plan:**
   Name of plan: Recovery Plan for the Birdwing Pearly Mussel (*Conradilla caelata*)
   Date issued: November 1983

II. REVIEW ANALYSIS

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

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

B. Recovery Criteria

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

2. **Adequacy of recovery criteria.**

a. **Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat?** Yes.

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

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

The Birdwing Pearlymussel will be considered for delisting when the following criteria are met:

(1) A viable population[1] of Birdwing Pearlymussel exists in the Clinch River from the backwaters of Norris Reservoir upstream to approximately Clinch River mile 280 (CRM) and in the Powell River from the backwaters of Norris Reservoir upstream to approximately Powell River mile (PRM) 130. These two populations are dispersed throughout each river, so that it is unlikely that any one event would cause the total loss of either population.

Status: This criterion has not been met. While the species does remain extant in both river systems, the current distribution of the Birdwing Pearlymussel in the Clinch and Powell rivers does not extend downstream to the backwater of Norris Reservoir (CRM 154, PRM 57) or upstream to CRM 280. The current distribution of the species in the Clinch River is between CRM 172 and CRM 275; the current distribution of the species in the Powell River is between PRM 95 to PRM 123.

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

Status: This criterion has not been met. The Duck River Columbia Dam project was not completed, and a viable population of the Birdwing Pearlymussel continues to exist in the Duck River between Duck River mile (DRM) 139 and 179. However, efforts to locate other existing populations or introduce the species have not yielded results that would

[1] Viable population: 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.

meet this criterion. No new populations have been found, and introduction efforts have had mixed results. Efforts to reestablish the species in the main channel of the lower Tennessee River have failed (Hubbs per. comm. 2019) and efforts to establish a new population in suitable habitats in the Hiwassee and Emory rivers in Tennessee have also been unsuccessful, presumably due to the low number of Birdwing Pearlymussels released and the lack of suitable habitat for the species in the Hiwassee and Emory rivers (Phipps et al. 2018a). Introduction efforts in the Nolichucky River have been moderately successful. Between 2004 and 2019, 3,764 live Birdwing Pearlymussels were stocked in the Nolichucky River at Pates Hill, Tennessee (Table 2), and subsequent monitoring efforts indicate the relocated individuals are surviving (Phipps et al. 2018b), but evidence of reproduction has not been documented (TWRA 2020). Ongoing augmentation efforts by VDGIF and Virginia Tech University in the Clinch River, Russell County, Virginia, are also encouraging, as evidenced by the survival and growth of propagated Birdwing Pearlymussels (Jones per. comm. 2020).

(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 populations.

Status: This criterion has not been met. Between the fall of 2016 and 2019, large-scale die-offs of freshwater mussels occurred in the Clinch River beginning at the Tennessee-Virginia state line and extending at least 27 miles downriver (Richard per. comm. 2020). The die-offs coincided with a human related activity (widespread spraying of herbicides around road and power-line rights of way) and a natural threat (unusually low flows and warm water temperatures) (Ahlstedt per. comm. 2019; Richard per. comm. 2019); however, these threats were not consistently present between 2016 and 2019. For example, pesticide use, as far as we can tell, only occurred in 2016, while low flow/warm term water occur only in 2016 and 2019 (Richard per comm. 2020). In 2016, 87 fresh dead Birdwing Pearlymussels were recovered from nine locations between CRM 172 and CRM 199; in 2017, 18 fresh dead Birdwing Pearlymussels were recovered from this same reach (G. Dinkins, unpublished data, 2019).

The degree to which these annual seasonal die-offs may be affecting the survival of the Clinch River population is unknown but represents a threat to the stability of that population. Upstream of the Tennessee/Virginia state line, the mussel density at Pendleton Island (CRM 226.5) diminished from as high as 25.5 m^2 in 1979 to its current density of <1 m^2, a reduction of approximately 96% (Jones et al. 2014). Across a larger portion of the upper Clinch River and concomitant with the collapse of the fauna at Pendleton Island, there has been a severe reduction in overall mussel

abundance from St. Paul (CRM 255) to approximately Clinchport (CRM 213) (Jones et al. 2014, Jones et al. 2018).

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

Status: This criterion has not been met. Jones et al. (2018) noted that water quality in the Clinch River has not improved over the last decade, and attributed the mussel decline in the Clinch River to a variety of factors, including degraded water and sediment quality associated with coal-mining activities. Jones et al. (2018) summarized data, analyses, and discussion available in Krstolic et al. (2013), Johnson et al. (2014), Price et al. (2014) Zipper et al. (2014), and Cope and Jones (2016) and concluded that water quality in upper Clinch River is adversely affected by increased levels of contaminants, including dissolved solids, trace metals, and polycyclic aromatic hydrocarbons, which, in turn, may limit mussel survival and reproduction. Similarly, Zipper et al. (2016) found a correlation between declines in mussel densities and increasing concentrations of dissolved solids in the Powell River watershed.

C. Updated Information and Current Species Status

1. Biology and Habitat

a. New information on the species' biology and life history:
When the Recovery Plan was published in 1983, life history data on the Birdwing Pearlymussel was limited to generalized information applicable to nearly all freshwater mussel species, combined with a few species-specific observations made by Ortmann (1916), Coker and Surber (1911), Lefevre and Curtis (1908). More recently, Jones et al. (2010) summarized the life history and population demographics of the Birdwing Pearlymussel in the Clinch and Duck rivers, Tennessee.

Period of Gravidity
Female Birdwing Pearlymussels are long-term winter brooders, typically gravid and over-wintering their larvae (glochidia) from October to May (Jones et al. 2010).

Fish Hosts
Jones et al. (2010) conducted laboratory tests to determine potential fish host species; five species of darters (Percidae) were identified as hosts from induced infestations of glochidia: greenside darter (*Etheostoma blennioides*), Bluebreast Darter (*E. camurum*), Redline Darter (*E. rufulineatum*), Snubnose Darter (*E. simoterum*), and Banded Darter (*E. zonale*). All of the fish hosts identified by Jones et al.

(2010) are native to the Tennessee River system and are sympatric (i.e., occurring in the same geographic area) with Birdwing Pearlymussel.

Age and Growth

Jones et al. (2010) used a length-at-age model, as computed by a von Bertalanffy growth curve, to predict age-class frequency of live mussels collected between 2004 and 2007. Based on shells collected in the Clinch and Duck rivers, Jones et al. (2010) determined that the maximum age of males was 15 years and 11 years for females. In addition, predicted shell growth for males averaged 3.8 mm per year through age 0 to 10 years old and decreased to 1.9 mm per year thereafter; females averaged 4.4 mm per year through age 0 to 6 years old and decreased to 0.6 mm per year thereafter. In the Duck River, shell growth for males averaged 4.7 mm per year through age 0 to 10 years old and decreased to 0.6 mm per year thereafter; females averaged 5.1 mm per year through age 0 to 6 years old and decreased to 0.5 mm per year thereafter (Jones et al. 2010). The smallest gravid females observed by Jones et al. (2010) in the Clinch and Duck rivers ranged in length from 28 to 32 mm, indicating that females could become sexually mature at 4 to 5 years old.

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

The Birdwing Pearlymussel historically occupied approximately 1,414 miles of river in the Tennessee River drainage of Virginia, Tennessee, and Alabama. It has been extirpated from the main channel Tennessee River, Sequatchie River, Paint Rock River, Holston River, North Fork Holston River, Little Pigeon River, and North Fork Clinch River. It has not been observed live in the Elk River since 1980, and individuals transplanted there in 2017 have not been found in subsequent surveys. The Birdwing Pearlymussel has been stocked in a limited reach of the Nolichucky River, Greene County, Tennessee, and appears to be surviving (Hubbs, per. comm. 2019). The reach of the Tennessee River below Wilson Dam was designated as a non-essential experimental population in 2007, but efforts to reestablish a population there have been unsuccessful. In the Duck River, Tennessee, the distribution and abundance of the Birdwing Pearlymussel had diminished significantly between publication of the Recovery Plan in 1983 and a survey conducted by TVA in 1988 (Service 1984, Jenkinson 1988). By 2003, the Duck River population had made a remarkable recovery in distribution and abundance because numerous point source discharges to the river had been eliminated. Improvements have been made in the wastewater de-chlorination process at the Shelbyville sewage treatment plant, and increased minimum flow improvements had been made to water being released

from Normandy Dam (Ahlstedt et al. 2017). Currently, the Birdwing Pearlymussel occupies approximately 45 river miles between the Old Columbia Dam and Lillard's Mill. In contrast, the species' range in the Clinch and Powell rivers has decreased over this same general time span. In the early 1980s, the Birdwing Pearlymussel was known to occur in the Clinch River between CRM 173 and CRM 279, a distance of 106 river miles (Service 1984). Currently, the Birdwing Pearlymussel's distribution in the Clinch River is from CRM 172 to 275, a distance of 103 river miles (a 2.8% reduction in distribution) (Jones per. comm. 2020). In the Powell River, the Birdwing Pearlymussel distribution diminished from PRM 79 to PRM 131 (52 river miles) in the early 1980s to its present distribution of PRM 95 to PRM 123 (28 river miles), a 54% reduction in distribution.

c. Genetics, genetic variation, or trends in genetic variation:
There is no new information available on genetics, genetic variation, or trends in genetic variation.

d. Taxonomic classification or changes in nomenclature:
The nomenclature for the Birdwing Pearlymussel has been unclear since Rafinesque (*Lemiox rimosus,* 1831) and Conrad (*Conradilla caelata*, 1834) described the species in the 1830s. Since then, the binomial *Lemiox rimosus* has gained favor in the scientific community as demonstrated by its current use in authoritative lists of freshwater mussels for the United Stated and Canada (Turgeon et al. 1998; Williams et al. 2017)

The Service used the binomial *Conradilla caelata* (Conrad 1834) for the Birdwing Pearlymussel at the time of listing; however, we recognized the binomial *L. rimosus* in rule 64 FR 28779, although we erroneously credited Conrad (1834). Our current nomenclature is consistent and follows Williams et al. (2017).

e. Spatial distribution, trends in spatial distribution, or historical range:
The species was historically widespread in the Tennessee River drainage but was confined to the main channel of the Tennessee River and the several tributaries. Including archaeological records in the Tennessee River system, it occurred throughout the Clinch River drainage from the confluence with the Tennessee River, upstream to the Clinch River and Powell River in southwestern Virginia. In all, approximately 1,414 miles of water in the Tennessee River drainage were historically occupied by this species. Currently, the Birdwing Pearlymussel is extant only in 40 miles of the Duck River, 103 miles of the Clinch River, and 28 miles of the Powell River, an 88% reduction in number of river miles occupied (Table 1).

f. Habitat:

The Birdwing Pearlymussel inhabits clean, fast-flowing areas in small to large-sized streams, such as riffles and gravel/sand shoals (Parmalee and Bogan 1998; Williams et al. 2008). In 2018, personnel from the TWRA found a diverse mussel assemblage in pool/run habitat within a 30-mile reach of the Clinch River between Horton Ford and Lawson Road (TWRA 2019), including six Birdwing Pearlymussels.

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

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

When the recovery plan was completed in 1983, the only extant populations were in the Duck River, Tennessee, and the Clinch and Powell rivers, Tennessee and Virginia. The recovery plan included impoundments, siltation, and pollution as the primary reasons for the decline of this species. The current status of this species is likely still attributable to the continued impacts of these threats.

b. Overutilization for commercial, recreational, scientific or educational purpose:

The Birdwing Pearlymussel was historically widespread in the Tennessee River drainage and some of its tributary rivers, but it was rarely encountered and always in low numbers (Ortmann 1918). The species has become increasingly rare throughout its range, but overutilization for commercial, recreational, scientific or educational purposes is not believed to be a threat to its continued existence.

c. Disease and predation:

In 2016, 2017, and 2019, tens of thousands of mussels died of unknown cause(s) in several miles of the Clinch River between Kyles Ford, Tennessee and the Tennessee/Virginia border (Jones per. comm. 2020). Sampling of obviously sick and moribund mussels by the Service revealed five undescribed viruses that may contributed to development of an unknown disease, but the identity of the causative agent(s) remains unknown (Richard per. comm. 2019). In 2016, 3,533 fresh dead mussels were recovered and brought to the McClung Museum for archiving, including 87 Birdwing Pearlymussels. In 2017, 654 fresh dead mussels were recovered and brought to the McClung Museum for archiving, including 18 Birdwing Pearlymussels. The Service and its partner agencies have no other information on disease or predation of the Birdwing Pearlymussel, but it appears that whatever is causing sudden and dramatic mortality in the mussel community of the Clinch River near the Tennessee/Virginia

border has the potential to be a limiting factor for the long-term viability of the Birdwing Pearlymussel in the Clinch River.

d. **Inadequacy of existing regulatory mechanisms:**
The Birdwing Pearlymussel and its habitats are afforded limited protection from water quality degradation under the Clean Water Act of 1977 (33 U.S.C. 1251 et seq.), Surface Mining Control and Reclamation Act of 1977 (30 U.S.C. 1234 – 1328), and state laws, such as Tennessee's Water Quality Control Act of 1977 (T.C.A. 69-3-101) and Virginia's State Water Control Act (§ 62.1). These laws focus on point-source discharges; however, while they have resulted in some improvements in water quality and stream habitat for aquatic life, many water quality problems are generated by non-point source discharges. Therefore, these laws and corresponding regulations have been inadequate to halt population declines and degradation of habitat for the Birdwing Pearlymussel.

In addition to the federal listing, the Birdwing Pearlymussel is listed as Endangered by the State of Tennessee. Under the Tennessee Nongame and Endangered or Threatened Wildlife Species Conservation Act of 1974 (Tennessee Code Annotated §§ 70-8-101-112), "…it is unlawful for any person to take, attempt to take, possess, transport, export, process, sell or offer for sale or ship nongame wildlife, or for any common or contract carrier knowingly to transport or receive for shipment nongame wildlife." Further, regulations included in the Tennessee Wildlife Resources Commission Proclamation 00-15 Endangered Or Threatened Species state the following: except as provided for in Tennessee Code Annotated, Section 70-8-106 (d) and (e), it shall be unlawful for any person to take, harass, or destroy wildlife listed as threatened or endangered or otherwise to violate terms of Section 70-8-105 (c) or to destroy knowingly the habitat of such species without due consideration of alternatives for the welfare of the species listed in (1) of this proclamation, or (2) the United States list of Endangered fauna. Potential collectors of this species would be required to have a state collection permit.

In Virginia, the Birdwing Pearlymussel is listed as Endangered and is protected under State law (4VAC15-20-130). It is unlawful to "…take, transport, process, sell, or offer for sell within the Commonwealth any threatened or endangered species of fish or wildlife except as authorized by law" (§ 29.1-566). A State permit is required for the taking, exportation, or possession of any threatened or endangered species of fish or wildlife for zoological, educational, or scientific purposes, and for propagation of such fish and wildlife in

captivity for preservation purposes (§ 29.1-568); however, this law does not protect the Birdwing Pearlymussel's habitat.

e. Other natural and manmade factors affecting its continued existence:

Because the Birdwing Pearlymussel was primarily a species of the main channel Tennessee River and tributary rivers, the recovery plan listed the network of dams constructed by the Tennessee Valley Authority (TVA), Aluminum Company of America (Alcoa), and the U.S. Army Corps of Engineers (COE) in the Tennessee River system as the single greatest factor that contributed to this species' decline. The plan also pointed out that some populations have been affected by alteration of stream flow and temperature regime from an upstream reservoir (e.g., TVA's Norris Dam discharges cold water into TVA's Melton Hill Dam, which in turn affects the lower Clinch River, and COE's Center Hill Dam affects the lower Caney Fork River). The Birdwing Pearlymussel now exists only in limited, free-flowing reaches of the Duck, Clinch, and Powell rivers. As a result of the Norris Reservoir, free-flowing sections of the Clinch and Powell rivers are now separated. The population of the Birdwing Pearlymussel in the Duck River is limited from upstream dispersal by Lillard's Mill Dam, and its range does not extend downstream past the town of Columbia, Tennessee. This means the range of the Birdwing Pearlymussel does not extend downstream to the Duck River's confluence with the Buffalo River, a free-flowing river of comparable size that has been identified as a suitable site for the reintroduction of this species.

As a consequence of the isolations, the Birdwing Pearlymussel is limited to three disjunct populations and there is the likelihood of decreased fitness from reduced genetic diversity. Species that are restricted in range and population size are more likely to suffer loss of genetic diversity due to genetic drift (i.e., a random change in gene frequency over time), potentially increasing their susceptibility to inbreeding depression, decreasing their ability to adapt to environmental changes, and reducing the fitness of individuals (Soule 1980, Hunter 2002, Allendorf and Luikart 2007). The long-term viability of a species is founded on the conservation of numerous local populations throughout its geographic range (Harris 1984). These separate populations are essential for the species to recover and adapt to environmental change (Noss and Cooperrider 1994, Harris 1984). The level of isolation seen in the Birdwing Pearlymussel makes natural recovery of extirpated populations virtually impossible without human intervention.

No information was provided in the Recovery Plan relative to the threat posed by nonnative species such as Asian Clams (*Corbicula*), Zebra Mussels (*Dreissena*), or Asian Carp (i.e., *Hypophthalmichthys and Mylopharyngodon*), and all these invasive species are now present in the Tennessee River drainage.

The number of individuals remaining in the Clinch and Powell rivers is unknown but appears to be relatively low. Both populations are extremely vulnerable to extirpation from intentional or accidental toxic chemical spills, habitat modification, progressive degradation from land surface runoff (nonpoint-source pollutants) and natural stochastic events (e.g., floods, drought). Potential sources of accidental spills include accidents involving vehicles transporting chemicals over road crossings of the main channel of or tributaries to where the species occurs, and accidental or intentional release of chemicals used in agricultural or residential applications.

D. Synthesis

The Birdwing Pearlymussel is endemic to the Tennessee River drainage in Virginia, Tennessee, and Alabama. Based on modern and archeological records, the species occurred from the main channel Tennessee River in Perry and Decatur counties, Tennessee, upstream to Knoxville and in the following tributary rivers: Duck, Sequatchie and Elk rivers (Tennessee) and the Paint Rock River (Alabama). In the upper Tennessee River drainage, the species was reported from the main channel Holston River upstream to the confluence of North and South Fork Holston rivers, the lower North Fork Holston River (Tennessee and Virginia), and the Clinch and Powell rivers (Tennessee and Virginia). In the French Broad drainage, it was reported from the Little Pigeon and Nolichucky rivers (Tennessee). Across its range, it historically occurred in approximately 1,414 river miles, but the species is now restricted to approximately 171 river miles, a reduction of approximately 88%. It currently occurs in 40 miles of the Duck River, 103 miles of the Clinch River, and 28 miles of the Powell River. The population in the Duck and Clinch rivers appear to be stable, but the populations in the in the Powell River is declining. Since 1983, the range of the Birdwing Pearlymussel in the Powell River has declined 54%.

Over the last several years, the Birdwing Pearlymussel stock from the Duck River has been translocated or propagated for reintroduction into the Nolichucky River. In addition, propagated Birdwing Pearlymussels have been released in several sites in the Virginia portion of the Clinch River. These population reintroduction and augmentation efforts have been moderately successful, as evidenced by persisting individuals at these sites; however, it is not known if these individuals are reproducing.

Habitat degradation in the Powell River continues to threaten the Birdwing Pearlymussel, and while the species still occurs in this river, its abundance is very low. Coal mining continues to degrade habitat and water quality in the system, and these effects are pervasive and will be long lasting, decades into the future (Zipper et al. 2016; Jones pers. comm. 2020).

Disease may be an emerging threat for the Birdwing Pearlymussel. A large number of freshwater mussels in the Clinch River near the Tennessee/Virginia border died over a relatively short period of time in fall 2016, 2017, and 2019. Among the several thousand dead mussels found in 2016 and 2017 were 87 and 18 dead Birdwing Pearlymussels, respectively. It is not known if dead Birdwing Pearlymussels were found in the 2019 die-off (Dinkins, unpublished data, 2019). The cause(s) of the die-offs is still not clear, but viral pathogens may have played a roll. Whatever caused these sudden and dramatic die-offs has the potential to be a limiting factor for the long-term viability of the Birdwing Pearlymussel in the Clinch River.

Because of its restricted distribution, continued vulnerability habitat degradation, and unexplained die-offs, 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 endangered.

III. RESULTS

Recommended Classification:
Endangered – No change in the existing classification for the Birdwing Pearlymussel is needed.

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

- Develop and implement a plan to quantify and monitor surviving populations.
- Reintroduce and reestablish viable populations in other streams within the historical range that have suitable habitat and water quality. For example, the following streams were recommended by the Cumberlandian Region Mollusk Restoration Committee (2010):

  Alabama
  -Tennessee River main steam below tailwaters of Wilson Dam
  -Elk River
  -Paint Rock River
  Tennessee
  -Upper and Lower French Broad River
  -Upper and Lower Holston River
  -Lower Pigeon River
  -Buffalo River
  -Elk River

- Conduct studies to determine the cause of the mussel die-offs in the Clinch River.
- Continue to educate the public about water quality and freshwater mussels.

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Provided new/updated information

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Table 1. Historical and present occurrence of Birdwing Pearlymussel. Data taken from museum records in Invertebase, UTMM, Parmalee and Bogan (1998), Williams et al. (2008), and from sources indicated in the footnotes.

Waterbody	County(s)	State	Last Year Observed	Present Status	App. No. of River Miles Occupied (Historical/Current)
Tennessee River	Colbert, Lauderdale, Moran, Russel, Jackson	AL	<1918	Extirpated[1]	507/0
	Knox, Decatur, Perry, Hardin	TN	<1918	Extirpated	
Sequatchie River	Marion	TN	1983[2]	Extirpated	11/0
Paint Rock River	Jackson	AL	<1919[3]	Extirpated	30[4]/0
Elk River	Giles, Lincoln	TN	1980[5]	Unknown	133/0.1
Duck River	Maury, Marshall, Bedford, Hickman	TN	2019	Extant	81[6]/40
Holston River	Hawkins, Grainger, Knox	TN	1914	Extirpated	142/0
North Fork Holston River	Washington	VA	1973	Extirpated	59/0
	Hawkins	TN	1977[7]	Extirpated	
Nolichucky River	Greene	TN	2019	Extant[8]	0/0.2
Little Pigeon River	Sevier	TN	Archeological[9]	Extirpated	5/0
Clinch River	Scott, Russell	VA	2009	Extant	280/103[10]
	Anderson, Campbell, Claiborne, Union, Grainger, Hancock, Knox	TN	2018	Extant	
North Fork Clinch River	Scott	VA	<1915[11]	Extirpated	23/0
Powell River	Lee	VA	2009	Extant	143/28[12]
	Hancock, Claiborne, Union, Campbell,	TN	2009		
Total no. of miles historically occupied/current number of miles occupied: 1414/171					

[1]Experimental population established in Tennessee River below Wilson Dam in 2003 (Williams et al. 2008); current state of population is unknown.
[2]Occurrence based on relict shell.
[3]No date of collection assigned to specimens collected by H.H. Smith and cataloged in CM (Lot 26857). Date given here is death year for H.H. Smith.
[4]Coordinates for specimen in CM (Lot 26857) are for town of Paint Rock; location may have been assigned to the lot based on similarity between town and name of river.
[5]Two fresh dead specimens found in Elk River by TVA. Transplanted specimens (120 individuals) stocked in Elk River at River Mile 35.0 by TWRA in 2017 (TWRA 2020). None seen in Elk River in surveys conducted 2005, 2008, 2011, 2015 or 2018 (Hubbs per. comm. 2019).
[6]Historical records for Duck River extend downstream to unspecified location in Hickman County and upstream to Lillard's Mill (DRM 179). Duck River borders Hickman County from DRM 98 to 103. Currently, species extends downstream to DRM 139.
[7]Subfossil specimen (TVA 1977). Most recent live individual found in 1915 (Ortmann 1918).
[8]Stocked in Nolichucky River 2010-2016, 2019 (TWRA 2020); live individuals at stocking site observed in 2018 (Phipps et al. 2018b).
[9]Parmalee (1988).
[10]Jones per. comm. 2020 and Jones et al. (2014). Extant from Clinch River mile 172 to 275
[11]Undated specimen cataloged at UMMZ (Lot 92841). Based on the lot number assigned to the specimen, the collection date is likely from the period 1900-1915.
[12]Johnson (2011). Extant from Powell River mile 95 to 123.

Table 2: Number of mussels translocated or propagated for Birdwing Pearlymussel population augmentation and establishment efforts. Years 2005, 2006, 2009, and 2018 have been omitted due to lack of data (TWRA 2020; Lane pers. comm. 2020).

River	Reintroduction Site	Type	2004	2007	2008	2010	2011	2012	2013	2014	2015	2016	2017	2019	Total
Powell, VA	Fletcher Ford	Propagation							63						63
	Fugate Property	Propagation	67												67
Clinch, VA	Bennett Property	Propagation					19					39	25	50	133
	Bennett Island	Propagation												22	22
	Artrip	Propagation												50	50
	Speers Ferry	Propagation						73	63	22				50	208
	Cleveland Islands, LDC	Propagation							63						63
	Cleveland School	Propagation												26	26
	Sneedville	Propagation	100												100
	Clinchport Boat Ramp	Propagation												50	50
Elk, TN	Veto Fish Trap	Translocation											120		120
Nolichucky, TN	TWRA Canoe Access at Evan Island	Translocation				380	562	390	330	278	278	325			2543
		Propagation									83			750	833
	TWRA at Upper Hale Bridge	Translocation		212	176										388

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Birdwing Pearlymussel (*Lemiox rimosus*)

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

__X__ No change is needed

Review Conducted By: Anthony Ford and Santiago Martín, Tennessee Ecological Service Field Office, with assistance from Gerald Dinkins, University of Tennessee.

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve VIRGIL ANDREWS Digitally signed by VIRGIL ANDREWS Date: 2020.04.29 10:44:32 -04'00' Date April 29, 2020

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

Field Supervisor signature on this document reflects:

1. __X__ We have no new information, received no new public comments, and the original five factor analysis remains an accurate reflection of the species current status.
2. _____ We have obtained a small amount of new information that we have summarized in Appendix B, received no new public comments, and the original five factor analysis remains an accurate reflection of the species current status.

OTHER REGIONAL OFFICE APPROVAL:

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

APPENDIX A: Summary of peer review for the 5-year review of the Birdwing Pearlymussel (*Lemiox rimosus*)

Peer Review Method:

This document was peer-reviewed internally by multiple cooperating Ecological Services field offices within the range of the Birdwing Pearlymussel. Reviewers of this document include: Jordan Richard (Abingdon, VA), Jess Jones (Blacksburg, VA), Martin Miller (Hadley, MA), and Evan Collins (Daphne, AL).

No formal public comments were received following the Federal Register Notice citation announcing initiation of this review. Since minimal new information was obtained since the last 5-year review in 2011, we did not seek external independent peer review of this document. As we continue to support recovery actions with partners, we look forward to having additional data and surveys for our next 5-year review, and the Service will determine if external peer review is appropriate at that time.