Little-wing Pearlymussel
(*Pegias fabula*, Lea, 1838)

Photo by Tom Schirtz, McClung Museum of Natural History and Culture
Female, 27 mm length. UTMM Lot no. 1909

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
North Atlantic-Appalachian Region
Kentucky Ecological Services Field Office
Frankfort, Kentucky

5-YEAR REVIEW
Little-wing Pearlymussel (*Pegias fabula*)

1. GENERAL INFORMATION

1.1 Methodology used to complete this review

Public notice of initiation of this 5-year review was provided in the Federal Register on August 6, 2018 (83 FR 38320) 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, 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, and completed by Jessica Blackwood Miller, lead biologist with the U.S. Fish and Wildlife Service. All literature and documents used for this review are on file at the Kentucky Field Office. We sent the draft 5-year review to cooperating field offices (listed below) and submitted it to four mussel experts for peer review: Steve Ahlstedt (U.S. Geological Survey (retired)), Dr. Monte McGregor (Kentucky Department of Fish and Wildlife Resources), Jeff Simmons (Tennessee Valley Authority), and Brian Witcher (Big South Fork National River and Recreation Area). The Service evaluated and incorporated the comments received into this 5-year review (See Appendix A for further detail).

1.2 Reviewers

Lead Region – Atlanta, Georgia: Kelly Bibb, (404) 679-7132

Lead Field Office – Frankfort, Kentucky: Jessica Miller, (502) 695-0468

Cooperating Regional Office – Hadley, Massachusetts: Martin Miller (617) 876-6173

Cooperating Field Offices
Alabama: Anthony Ford (251) 441-5838
Virginia: Jordan Richard (276) 623-1233; Jess Jones (540) 231-2266

1.3 Background

1.3.1 Federal Register Notice citation announcing initiation of this review:
August 6, 2018; 83 FR 38320

1.3.2 Species status:

Declining. Little-wing Pearlymussel[1] continues to be rare and only a few individuals have been observed over the past few years. It historically occurred in the Tennessee and Cumberland River drainages in northern Alabama, southern Kentucky, western North Carolina, Tennessee, and southwestern Virginia. Currently, a relatively short reach of the Big South Fork Cumberland River (BSFCR) in Tennessee and Kentucky contains the only population that may be viable. The species is extant in Cane Creek, Tennessee, but survey effort has been limited and not sufficient to provide more information about the status of that population.

1.3.3 Recovery achieved: 1 (1 = 0% to 25% of recovery objectives achieved).

1.3.4 Listing history

Original Listing
Notice: 53 FR 45861
Date listed: November 14, 1988
Entity listed: Species
Classification: Endangered

1.3.5 Review History

A recovery plan was completed for the species on September 22, 1989. 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 recommendations like "Unknown" or "Declining" for the Little-wing Pearlymussel. We continue to show this status (see section 1.3.2 above). The most recent evaluation for this species to inform the Recovery Report to Congress was completed in 2019.

A previous 5-year review for the Little-wing Pearlymussel was completed on November 1, 2013 (Service 2013), and no change to the species' endangered status was recommended.

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

4 (indicating a high degree of threat and a low potential for recovery; the taxonomy is monotypic genus)

[1] "Little-wing Pearlymussel" is used as the common name for *Pegias fabula* in the final listing rule and the recovery plan. The 2013 5-Year Review and 2018 notice of initiation for this 5-Year Review use "Littlewing Pearlymussel", the commonly accepted spelling in the literature. In this document, we use "Little-wing Pearlymussel" as the common name.

1.3.7 Recovery Plan

Name of plan: Recovery Plan for Little-wing Pearly Mussel (*Pegias fabula*).
Date issued: September 22, 1989

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 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.

2.2 Recovery Criteria

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

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

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.

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.

The species will be considered for reclassification to threatened status when the likelihood of the species becoming extinct in the foreseeable future has been eliminated by achievement of the following criteria:

(1) Through protection of existing populations and successful establishment of reintroduced populations or discovery of additional

populations, a total of eight distinct viable populations[2] exist in the Cumberland and Tennessee River systems.

Status: *This criterion has not been met. Only one potentially viable population likely exists, the population in BSFCR. Additional studies and data are needed to determine if this population meets the definition of viable.*

(2) Biological and ecological studies have been completed, and the recovery measures developed and implemented from these studies are beginning to be successful as evidenced by recruitment and an increase in population density and/or an increase in the population size and length of stream or river reach inhabited within each of the eight populations.

Status: *This criterion has not been met. Since 2011, the National Park Service (NPS) and its contractors have conducted quantitative surveys of the mussel community in the BSFCR at selected locations. In several of these surveys, live Little-wing Pearlymussel individuals have been found; however, these studies have been infrequent and of limited geographic coverage. Additional surveys will be necessary to determine the degree to which the species is viable across its current distribution within the BSFCR. The completed surveys, in general, did not focus on the Little-wing Pearlymussel and its biological and ecological requirements.*

The species will be considered for removal from Endangered Species Act protection when the likelihood of the species becoming threatened in the foreseeable future has been eliminated by the achievement of the following criteria:

(1) Through protection of existing populations and successful establishment of reintroduced populations or discovery of additional populations, a total of 13 distinct viable populations exist in the Cumberland and Tennessee River systems.

Status: *This criterion has not been met. See previous explanation above relating to downlisting criterion #1.*

(2) Studies of the mussel's biological and ecological requirements have been completed and recovery measures developed and implemented from these studies have been successful, as evidenced by recruitment and an

[2] A viable population is defined 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 obtain a viable population will be determined as one of the recovery tasks.

increase in population density and/or an increase in the population size and length of river reach inhabited within each of the 13 populations.

Status: *This criterion has not been met. See previous explanation above relating to downlisting criterion #2.*

(3) No foreseeable threats exist that would likely threaten survival of any of these 13 populations.

Status: *This criterion has not been met. Across its historical range, the Recovery Plan gave the primary reasons for the species' imperilment as habitat loss and water quality deterioration, impoundments, industrial and municipal pollution, acid mine drainage, and siltation resulting from mining, agriculture, and construction activities. These threats to the species remain in the watersheds where the species historically occurred. The Little-wing Pearlymussel may be especially vulnerable to threats compared to other freshwater mussel species, given that robust and diverse mussel communities still exist in some stream reaches where the species has apparently been extirpated.*

4) Where habitat had been degraded, noticeable improvements in water and substratum quality have occurred.

Status: *This criterion has not been met. Habitat improvements, if any, are either negligible and/or have not been studied well enough to document that the conservation status of the species has improved or habitat degradation has been reversed.*

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

When the Recovery Plan was published in 1989 (Service 1989), only very limited data on the species' life history existed. The species inhabits small to medium, low turbidity, cool-water, high to moderate gradient streams in the Cumberland and Tennessee River basins (Bogan and Parmalee 1983, Ahlstedt 1986). No new information has become available regarding the habitat preferences for the Little-wing Pearlymussel since the 2013 5-year review.

Like other freshwater mussels, Little-wing Pearlymussel feeds by filtering food particles from the water. Its specific food habits are unknown, but it likely feeds on items similar to those consumed by other

freshwater mussels: detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924).

Freshwater mussels have a complex reproductive cycle. Males release sperm into the water column. The sperm are taken in by the females through their siphons during feeding and respiration. The fertilized eggs are retained in the gills until the glochidia (larvae) fully develop. Female Little-wing Pearlymussels can become mature at age 3-4; their fecundity is relatively low, ranging a few hundred to possibly 1,000 glochidia per female (McGregor, pers. comm., 2019). The Little-wing Pearlymussel is a long-term brooder, becoming gravid in September and remaining gravid until the following spring or summer (Ortmann 1914; Ortmann 1921; McGregor, pers. comm., 2019). When the glochidia are released, they attach and encyst on the gills or fins of a fish host. Little-wing Pearlymussel glochidia are relatively large (426 microns) and have larval threads that are used attach to substrate or intertwine with other glochidia to increase their chances of connecting with a host fish (McGregor, pers. comm., 2019) (Figure 1). When they complete metamorphosis on the host fish, the juveniles drop off to the substrate (Figure 2).

Layzer and Anderson (1992) and Jones *et al.* (2003) reported the Greenside Darter (*Etheostoma blennioides*) and Emerald Darter (*E. baileyi*) as host fishes. Mair *et al.* (2002) reported that Black Sculpin (*Cottus baileyi*) was a successful fish host. Black Sculpins are endemic to the upper Clinch and Holston Rivers in Tennessee and Virginia, so other sculpin species may serve as hosts for the Little-wing Pearlymussel elsewhere in its range. The Kentucky Department of Fish and Wildlife Resources Center for Mollusk Conservation produced juveniles on Striped Darter (*Etheostoma virgatum*) (McGregor, pers. comm., 2019).

2.3.2 Abundance, population trends, demographic features, or demographic trends:

For several years, the NPS has conducted annual quantitative sampling in BSFCR at selected locations as part of their natural resource management activities and plans to continue monitoring selected areas on a rotational basis (Witcher, pers. comm., 2019). Densities calculated from quantitative surveys were 0.13 individuals/m^2 in 2012 and 0.12 individuals/m^2 in 2017 (McGregor, pers. comm., 2019). In 2017, numerous individuals representing several size classes were found a little south of the Kentucky/Tennessee state line during a monitoring effort led by the NPS (Witcher, pers. comm., 2019). These findings support that BSFCR may potentially contain a viable population of Little-wing Pearlymussels in a portion of the BSFCR.

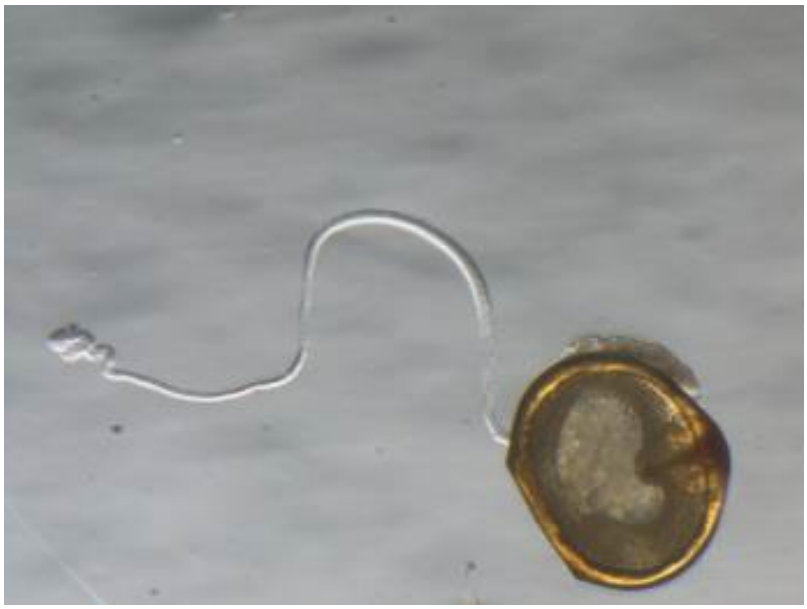

Figure 1. Little-wing Pearlymussel glochidium with larval thread (photo by Dr. Monte McGregor, Kentucky Department of Fish and Wildlife Resources).

Figure 2. Little-wing Pearlymussel juveniles (1 day old) (photo by Dr. Monte McGregor, Kentucky Department of Fish and Wildlife Resources).

2.3.3 Genetics, genetic variation, or trends in genetic variation:

Some genetic work is currently being conducted by the U.S. Environmental Protection Agency in Cincinnati for an eDNA barcoding assay to detect and identify freshwater mussels (McGregor, pers. comm., 2019). Analysis conducted to date has confirmed the placement of Little-wing Pearlymussel in the Anodontinae subfamily.

2.3.4 Taxonomic classification or changes in nomenclature:

A revised list of the freshwater mussels of the United States and Canada was recently published by Williams *et al.* (2017), incorporating changes in nomenclature and systematic taxonomy since publication of the most recent checklist by Turgeon *et al.* (1998). No change was recommended for the Little-wing Pearlymussel in Williams *et al.* (2017). Additionally, no nomenclature change is reflected in the Integrated Taxonomic Information System (ITIS 2019).

2.3.5 Spatial distribution, trends in spatial distribution, or historical range:

The species was historically widespread but uncommon in smaller tributaries of the upper Cumberland and Tennessee River basins in Alabama, North Carolina, Kentucky, Tennessee, and Virginia (Stansbery 1976, Clarke 1981, Ahlstedt 1986, Parmalee and Bogan 1998, Williams *et al.* 2008, Haag and Cicerello 2016). It was never documented in Georgia, but likely occurred in the South Chickamauga Creek system (Dinkins 2019). It appears the species has been extirpated from Alabama (Williams *et al.* 2008). A fresh dead individual was last found in North Carolina in the mid-2000s (Luke Etchison, pers. comm., 2019).

When the recovery plan was completed in 1989, the only potentially viable populations thought to exist occurred in BSFCR in Kentucky and Tennessee and in Horse Lick Creek in Kentucky. The population in Horselick Creek has declined from the 1980s to 2000s and is now likely extirpated as a result of impacts from coal mining and oil and gas activities (Haag and Cicerello 2016).

The population in approximately nine miles of the BSFCR is likely the only remaining potentially viable population. The population in Cane Creek, Van Buren County, Tennessee is the only other population in which live individuals have been found since the last 5-year review (Simmons, pers. comm., 2019). All other populations appear to be extirpated or existing in such low numbers that their status is uncertain. Dead shells are occasionally found in Copper Creek, North Fork Holston River, and Clinch River in Virginia, but these shells do not appear to be

fresh (Jones, personal communication, 2019; Ostby, personal communication, 2019). However, it is very difficult to distinguish between fresh dead and relict shells in this species, because the shell tends to lose its outer covering while the individual is living. The Little-wing Pearlymussel is a small, cryptic species that often occurs under large flat rocks, making it is difficult to detect in surveys. This contributes to the incomplete historical distribution of the species and uncertainties of the status within its current distribution.

A summary of each historical population is provided in Table 1, and each of the extant populations and populations of unknown status are discussed in detail below.

Cumberland River drainage:

Big South Fork Cumberland River – Little-wing Pearlymussel was first found in the Little South Fork, a direct tributary to the BSFCR, in the 1970s (Starnes and Starnes 1980) and was found in the main channel BSFCR in 1985 (Ahlstedt *et al.* 2003-2004). It has since been documented in the main channel at regular intervals (Bakaletz 1991; Shute *et al.* 1999; Dunn 2000; Ahlstedt *et al.* 2003-2004; McGregor 2012; Emmott, pers. comm., 2019). Biologists with the Tennessee Valley Authority have surveyed the reach between Blue Heron and Highway 92 annually between 2013 to 2019 and have not detected the species there (Simmons, pers. comm., 2019), though the apparent recovery of the mussel fauna from historical acid mine pollution in this reach indicates some potential for downstream expansion of Little-wing Pearlymussel (Simmons, pers. comm. 2019). At the time of this review, we believe the Little-wing Pearlymussel is restricted to approximately nine miles in Scott County, Tennessee, downstream to McCreary County, Kentucky. Across the entirety of its historical range, BSFCR is likely the only population that may potentially be considered viable.

Cane Creek – Cane Creek is in the Upper Caney Fork River system in Van Buren County, Tennessee. The earliest record for the Little-wing Pearlymussel in Cane Creek appears to be 36 specimens taken by Herb Athearn in 1967 (North Carolina State Museum lot number 55006). A few live individuals have been found in Cane Creek periodically since then, with the most recent collection being two live individuals collected in 2019, during the first targeted mussel survey of the creek in several decades (Simmons, pers. comm. 2019a, 2019b). Difficult access has limited survey effort in Cane Creek. Surveying effort has not be sufficient to determine the current status of the Cane Creek population. The downstream portion of Cane Creek is impounded by Great Falls Lake and the upper reaches are often subterranean. Cane Creek has limited mussel habitat, and the species is apparently restricted to a few

shoals immediately upstream of the swinging bridge at Sweetgum, Tennessee (USFWS 1989).

Tennessee River Drainage:

Clinch River and tributaries – In 1999, one live Little-wing Pearlymussel was found in the Clinch River at Cliffield, Tazewell County, Virginia, and, in 2002, one relict shell was found in the Clinch River, Tazewell County, Virginia, near the mouth of Cavitts Creek (Jones, pers. comm., 2019). Relict shells have been found in the Little River, a direct tributary to the Clinch River, Tazewell County, Virginia, in 2010 (Ostby, pers. comm., 2019). In Copper Creek (large, direct tributary to the Clinch River, Scott County, Virginia), dead shells of the Little-wing Pearlymussel have been found periodically over the last several years around the mouth of Lark Creek, but no live individuals have been found (Ostby, pers. comm., 2019). Based on this information, it appears doubtful that a population remains in the Clinch River system.

North Fork Holston River – Dead shells have been found in the North Fork Holston River in the last ten years near Nebo, Smyth County, Virginia (Jones, pers. comm., 2019). However, no live individuals have been found in the North Fork Holston River despite numerous mussel surveys conducted by various researchers. As a result, we believe the species is likely extirpated from the North Fork Holston River.

Little Tennessee River – The last time a live Little-wing Pearlymussel was found it the Little Tennessee River was in the mid-2000s. In October 2018, a single dead shell was collected from Swain County, North Carolina (Etchison, pers. comm., 2019). The status of this population is uncertain, though likely declining.

Summary – Although this species has always been uncommon across its wide historical range, its distribution continues to be truncated. Additionally, the status of the species is uncertain to declining or extirpated in all but one stream. Only the Big South Fork Cumberland River is believed to support a viable population of the Little-wing Pearlymussel.

2.3.6 Other

Summary of Propagation Efforts – Instances where this species has been placed into mussel propagation facilities for extended periods have usually resulted in the eventual mortality of captive adult individuals. A few propagation efforts have successfully produced juveniles. Eight females from the BSFCR population were collected in 2001 and used for fish host determination and propagation studies at Virginia Tech in

Blacksburg, Virginia; 569 juveniles were released back into the BSFCR in 2002 (Mair *et al.* 2002). The Kentucky Department of Fish and Wildlife Resources Center for Mollusk Conservation has propagated the species on host fish and in vitro; however, less than 1% of juveniles produced have survived more than a few months (McGregor, pers. comm., 2019). Additional research is needed to refine propagation techniques to support recovery actions.

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

2.4.1 Factor A: Present or threatened destruction, modification, or curtailment of its habitat or range:

The recovery plan (Service 1989) included habitat loss and water quality deterioration, attributed to impoundments, industrial and municipal pollution, acid mine drainage, and siltation (i.e., sedimentation) resulting from mining, agriculture, and construction activities, as the primary reasons for the decline of this species. The species' current status is likely still attributable to the continued impacts of these threats.

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

The reach of BSFCR where the only potentially viable population of Little-wing Pearlymussel exists is part of the Big South Fork National River and Recreation Area (NRRA), administered by the NPS. Approximately 20 miles of Clear Fork and two miles of the New River (BSFCR's two main upper tributaries) are also protected in the NRRA. Physical habitat destruction or modification resulting from a variety of human-induced impacts (particularly coal mining) are unlikely to happen within the reaches of the New and Clear Fork Rivers and BSFCR that lie within the NRRA boundaries. However, the NPS only has jurisdiction

over approximately 17% of the estimated 18,000 square-mile BSFCR watershed and cannot control activities that occur upstream.

Currently, there is no active coal mining in the New or Clear Fork River drainages, but coal was strip-mined in both for many decades with little reclamation prior to 1977 (Walker, pers. comm., 2019). The Office of Surface Mining (OSM) lists seven High Priority sites in the New River drainage upstream of the BSF National River and Recreation Area (https://amlis.osmre.gov/About.aspx). High Priority sites are abandoned sites where there is a need to protect public health, safety, and general welfare from hazards created by past coal mining practices. Acid mine water and its effects on the main channel and tributaries of the New River were recognized as early as 1938 (Shoup 1940; Shoup and Peyton 1940). Historically, 13 mussel species were documented from the drainage, but the mussel fauna has been reduced to eight species that occur in isolated and widely spaced patches (Ahlstedt *et al.* 2017).

2.4.2 Overutilization for commercial, recreational, scientific or educational purpose:

The overutilization for commercial, recreational, scientific or educational purposes was not considered to be a limiting factor in the Recovery Plan or in the 2013 5-year review. We have no new information to indicate that this has changed.

2.4.3 Disease and predation:

The Recovery Plan stated that there is little data indicating that disease or predation are limiting factors for this species as did the 2013 5-year review. We have no other information to indicate that disease and/or predation are limiting factors for this species.

2.4.4 Inadequacy of existing regulatory mechanisms:

The Little-wing Pearlymussel 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), additional 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, as demonstrated under Factor A, population declines and degradation of habitat for this species are ongoing despite the protection afforded by these laws and corresponding regulations.

While they have resulted in some improvements in water quality and stream habitat for aquatic life, regulatory mechanisms have not been adequate to fully protect the Little-wing Pearlymussel. Sedimentation and nonpoint-source pollutants continue to be a significant problem.

The Little-wing Pearlymussel was designated as an endangered species in Tennessee (TWRA 2015), Kentucky (KDFWR 2013) and Virginia (VDGIF 2018). The state designations in Kentucky and Virginia convey 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 Act.

Since listing, section 7 of the Act has required Federal agencies to consult with the Service when projects they fund, authorize, or carry out may affect the species. However, the lack of Federal authority over the many actions likely impacting Little-wing Pearlymussel habitat has become apparent. Many of the threats (including those identified at the time of listing, during recovery planning, and since development of the Recovery Plan) involve activities that likely do not have a Federal nexus (such as water quality changes resulting from development, water withdrawals, or indiscriminate logging) and, thus, may not require section 7 consultation. Although the take prohibitions of section 9 of the Act do apply to these types of activities and their effects on the Little-wing Pearlymussel, enforcement of the section 9 prohibitions is difficult, at best. The Service is not informed when many activities are being considered, planned, or implemented and, therefore, has no opportunity to provide input into the design of the project or to inform project proponents of the need for a section 10 permit. Unlike higher profile species, the public may not be

aware that listed mussel species exist in nearby waters, making them less likely to report habitat destruction.

2.4.5 Factor E: Other natural and manmade factors affecting its continued existence:

Restricted Range and Isolation

Potentially suitable habitat for Little-wing Pearlymussel has been fragmented by impoundments and reaches of unsuitable habitat. The BSFCR population, likely the only remaining potentially viable population, is 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 spills include accidents involving vehicles transporting chemicals over road crossings of the main channel or tributaries, and accidental or intentional release of chemicals used in agricultural or residential applications. The lack of connection to other Little-wing Pearlymussel populations eliminates the possibility for recolonization into the BSFCR.

Another consequence of the Little-wing Pearlymussel's restricted range 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, 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 Little-wing Pearlymussel makes recovery of extirpated populations virtually impossible without human intervention.

Climate Change

In its Fifth Assessment Report, the Intergovernmental Panel on Climate Change (IPCC) concluded that warming of the climate system is unequivocal (IPCC 2014). Numerous long-term climate changes have been observed including changes in arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves, and the intensity of tropical cyclones (IPCC 2014). Climate change has the potential to increase the vulnerability of

the Little-wing Pearlymussel to random catastrophic events (McLaughlin *et al.* 2002, Thomas *et al.* 2004).

Thomas *et al.* (2004) report that frequency, duration, and intensity of droughts are likely to increase in the Southeast as a result of global climate change. According to Kaushal *et al.* (2010), stream temperatures in the Southeast have increased roughly 0.2–0.4ºC (0.4–0.7ºF) per decade over the past 30 years, and as air temperature is a strong predictor of water temperature, stream temperatures are expected to continue to rise. Estimates of the effects of climate change using available climate models typically lack the geographic precision needed to predict the magnitude of effects at a scale small enough to discretely apply to the range of a given species. However, data on recent trends and predicted changes for Kentucky and Tennessee (Girvetz *et al.* 2009), and, more specifically, the Cumberland and Tennessee River drainages (Alder and Hostetler 2019), provide some insight for evaluating the potential threat of climate change to the Little-wing Pearlymussel. Alder and Hostetler (2019) use different emission scenarios to calculate estimates of average annual increases in maximum and minimum temperature, precipitation, snowfall, and other variables. These scenarios, called "representative concentration pathways" (RCPs) are plausible pathways toward reaching a target radiative forcing (the change in energy in the atmosphere due to greenhouse gases) by the year 2100 (Moss *et al.* 2010). According to this model, air temperatures and precipitation are expected to increase in the Cumberland and Tennessee River drainages (Alder and Hostetler 2019).

There is uncertainty about the specific effects of climate change (and their magnitude) on the Little-wing Pearlymussel; however, species with limited ranges, fragmented distributions, and small population size 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 Little-wing Pearlymussel.

2.5 Synthesis

The Little-wing Pearlymussel was historically a widespread Cumberlandian mussel species. Its range included four physiographic provinces (Interior Plateau, Ridge and Valley, Blue Ridge, and Southeastern Plain) and five States (Alabama, Kentucky, North Carolina, Tennessee, and Virginia). In the Cumberland River drainage, it occurred in 15 different streams and rivers (Table 1). The Little-wing Pearlymussel is now considered extirpated from the entire Cumberland River system, except for a few miles of the BSFCR upstream and downstream of the Tennessee and Kentucky border and one short reach of Cane Creek in Tennessee. In the Tennessee River system, it was known from 17 streams and rivers, but is now likely extirpated from the system. The last known living Little-wing Pearlymussel in the Tennessee River system was

found in the Clinch River near Pounding Mill, Tazewell County, Virginia, in the late 1990s.

Reintroduction of the species to previously occupied streams within its range will be necessary to meet the recovery criteria. Species propagation has had limited success to date. Propagation techniques and understanding of the reproductive biology must be improved to create a successful program. Moreover, we need to increase our understanding of the species' specific habitat needs and response to threats to inform species introductions.

Threats to the species remain similar to those presented in the recovery plan and consist primarily of industrial and municipal pollution, oil extraction, coal mining, acid mine drainage, and siltation resulting from mining, agriculture, and construction activities (USFWS 1989). Past unregulated activities from coal and oil and gas extraction were believed to have contributed to the species' decline, especially in Horse Lick Creek, BSFCR, Little South Fork Cumberland River, Clinch River, and Cane Creek. Except for BSFCR and Cane Creek, all of these populations are now extirpated.

The threats to the species continue to exist at some level. Moreover, no specific information is available to indicate a single factor, or combination of factors, caused the decline of the species. There is only one potentially viable population of this species known (population in BSFCR), rendering the species vulnerable to stochastic events. Because of its restricted distribution and continued vulnerability to threats, 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.

3 RESULTS

Recommended Classification: Remain Endangered

The recovery criteria listed in Section 2.2 above have not been met for delisting or downlisting the species. Little-wing Pearlymussel is known to occur in two isolated populations and continues to be vulnerable to the previously identified threats. Our knowledge of the biology of the species is insufficient to understand the species' specific habitat needs and its response to threats. Species population reintroductions within its historical range will be necessary to meet recovery criteria. Some successful propagation of the species has occurred, but there is currently no propagation program in place to accomplish this. For these reasons, 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).

4 RECOMMENDATIONS FOR FUTURE ACTIONS

The following actions are generally ordered based on priority, with the higher priority actions listed towards the top.

- Conduct research to understand genetic diversity between and within extant populations to inform reintroductions and long-term management.
- Continue to develop propagation techniques to support population reintroductions and augmentations.
- Continue efforts to monitor the population in BSFCR and introduce propagated juveniles to expand the population into formerly occupied reaches (i.e., from the known occupied reach downstream to the backwaters of Lake Cumberland).
- Take appropriate actions to eliminate or reduce threats to this species in the BSFCR and Cane Creek. Regulations that apply to coal mining and oil extraction activities should to be strictly enforced to prevent the loss of these populations.
- Conduct additional surveys for the species in the Caney Fork basin to establish the current distribution. Identify opportunities for population reintroduction/ augmentation.
- 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): Tennessee River system – Tennessee tributary tailwaters: Elk River, AL and TN; lower French Broad/Holston Rivers, TN, upper Clinch River, TN; Nolichucky River, TN; Duck River, TN; Emory River, TN; Obed River, TN; South Fork Holston River, VA; upper French Broad River, TN; lower Pigeon River, TN; Hiwassee River, TN; Copper Creek., VA; Fountain Creek, TN. Cumberland River system – Rockcastle River, KY; Middle Fork Rockcastle River, KY; Sinking Creek, KY; Buck Creek., KY; Roundstone Creek; Clear Fork, TN; Collins River, TN; Big Hickory Creek, TN; Little South Fork, KY; Kennedy Creek, KY; East Fork Stones River, TN; Harpeth River, TN; Red River, KY/TN; Whippoorwill Creek., KY.
- Continue to educate the public about water quality, biodiversity protection, and the value of freshwater mussels.

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Table 1. Occurrences of the Little-wing Pearlymussel.

Stream or River	County(s)	State	Physiographic Province[1]	Last Year Observed
Cumberland River Drainage				
Rockcastle River	Laurel, Rockcastle	KY	IP	1967
Horse Lick Creek	Jackson, Rockcastle	KY	IP	2010
Buck Creek	Pulaski	KY	IP	1975
Pitman Creek	Pulaski	KY	IP	1985
Whippoorwill Creek	Logan	KY	IP	1988
West Fork Red River	Todd	KY	IP	<1981
Begley Branch	Pickett[2]	TN	IP	Unknown
Big South Fork Cumberland River	Scott McCreary, Wayne	TN KY	IP	2017
Little South Fork Cumberland River	McCreary, Wayne	KY	IP	1986
Stones River	Rutherford	TN	IP	1966
Caney Fork River	Van Buren	TN	IP	<1981
Cane Creek	Van Buren	TN	IP	2019
Collins River	Warren	TN	IP	1986
Hickory Creek	Warren	TN	IP	1969
Hills Creek	Warren	TN	IP	1968
Tennessee River Drainage				
South Fork Holston River	Washington	VA	RV	1974
South Fork Holston River	Sullivan	TN	RV	1974
North Fork Holston River	Smyth	VA	RV	1971
North Fork Holston River	Washington	TN	RV	1924[3]
Big Moccasin Creek	Scott	VA	RV	1914
Middle Fork Holston River	Smyth	VA	RV	1968
Holston River	Sullivan	TN	RV	1914
French Broad River	Unknown	TN	RV	1880[4]
Powell River	Lee, Scott	VA	RV	1918
Wallen Creek	Lee	VA	RV	1914
Clinch River	Tazewell	VA	RV	2002[5]
Clinch River	Scott	VA	RV	1999[5]
Copper Creek	Scott	VA	RV	1979[6]
Valley River	Cherokee	NC	BR	2005
Little Tennessee River	Swain	NC	BR	2005[7]
Elk River	Limestone	AL	HR	1918
Elk River	Franklin	TN	HR	1918
Blue Water Creek	Lauderdale	AL	HR	1918
Duck River	Marshall, Bedford	TN	RV	1888
Fountain Creek	Maury	TN	IP	Archeological
Tennessee River	Hardin	TN	SP	1942
Tennessee River[8]	Knox	TN	RV	Unknown

Data from museum records available online in Invertebase (http://www.invertebase.org/portal/collections) and from the McClung Museum of Natural History and Culture, University of Tennessee, and from Haag and Cicerello (2016), Warren and Haag (2005), Stansbery (1976), Clarke (1981), Parmalee and Klippel (1986), Parmalee and Bogan (1998), Ahlstedt (1986), Ahlstedt *et al.* (2013), Williams *et al.* (2008), and personal communications from J. Simmons (TVA), M. McGregor (KDFWR), S. Ahlstedt (USGS, retired), J. Jones (USFWS), B. Ostby (Daguna Consulting, LLC), T. Lane (VDGIF), and R. Schapansky (NPS).

[1] IP = Interior Plateau, RV = Ridge and Valley, BR = Blue Ridge, SP = Southeastern Plains.

[2] Specimen in Delaware Museum of Natural History (lot no. 0505584) gives locality as Pickett County, TN and coordinates that are for Begley Creek, a direct tributary to the Wolf River. If valid, this is a new subdrainage record (Obey River drainage).
[3] Specimen from North Fork Holston was collected by Calvin Goodrich and is undated. Goodrich collected and catalogued specimens of other species from the North Fork Holston River in 1924; thus, it is presumed his specimen(s) of the Little-wing Pearlymussel from North Fork Holston River were collected in 1924.
[4] Specimen from French Broad River in Tennessee was collected and catalogued at MCZ by R.E. Call, who collected in the Holston River in 1880. No date of collection is given for the specimen of the Little-wing Pearlymussel collected by Call in the French Broad River; thus, it is presumed this specimen was collected in 1880.
[5] The Little-wing Pearlymussel was last found alive in the Clinch River in 1999. Tim Lane (VDGIF) and Jess Jones (USFWS) report dead shells from the Clinch River in the early 2000s.
[6] The Little-wing Pearlymussel was last found alive in Copper Creek in 1979. Tim Lane (VDGIG) and Jess Jones (USFWS) report dead shells have been found in lower Copper Creek periodically since 2010 in the vicinity of the confluence with Lark Creek.
[7] A very weathered shell was found in 2018 by NCWRC in the Little Tennessee River, Swain County, North Carolina. The specimen has been catalogued at the NCSM.
[8] Specimen in the Florida Museum of Natural History (Lot no. 1134568) is from Knoxville, Knox County, TN and was collected by Mary Andrews. This may be the same person as Mrs. George Andrews, a well-known collector of land mollusks from the same time period who collected around Knoxville in the late 1800s and early 1900's. From this, it is likely the specimen came from the main channel Tennessee River.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Little-wing Pearlymussel (*Pegias fabula*)

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

__X__ No change is needed

Review Conducted By: Jessica Miller, Kentucky Field Office, with assistance from Gerald Dinkins, University of Tennessee

FIELD OFFICE APPROVAL:

Lead Field Supervisor, U.S. Fish and Wildlife Service, South Atlantic-Gulf Region

Approve VIRGIL ANDREWS Digitally signed by VIRGIL ANDREWS Date: 2019.12.02 16:08:18 -05'00' Date_____

REGIONAL OFFICE APPROVAL:

for Cooperating Regional Director, U.S. Fish and Wildlife Service,
North Atlantic - Appalachian Region

__X__ Concur _____ Do Not Concur

Signature Paula Trost Date 1/8/20

APPENDIX A: Summary of peer review for the 5-year review of the Little-wing Pearlymussel (*Pegias fabula*)

A. Peer Review Method: The draft document was peer-reviewed by Steve Ahlstedt (U.S. Geological Survey (retired)), Monte McGregor (Kentucky Department of Fish and Wildlife Resources), Jeff Simmons (Tennessee Valley Authority), and Brian Witcher (Big South Fork National River and Recreation Area).

B. Peer Review Charge: Melissa Lombardi in the Service's Arkansas Field Office assisted in completing the independent peer review and asked peer reviewers to read the 5-year review and provide any comments, both editorial and content related. The Service did not ask peer reviewers to comment on the recommendation regarding listing status.

C. Summary of Peer Review Comments/Report: The peer reviewers considered the revised 5-year review to be biologically sound and generally agreed with the species' status information and proposed conservation actions. They agreed that the 5-year review was based on the best available scientific information. One peer reviewer (Brian Witcher) corrected the year of the last collection record in BSFCR. Another peer reviewer (Jeff Simmons) provided additional information about surveys in BSFCR and Cane Creek. He also suggested conducting genetic studies of the species and surveying and reintroducing/augmenting populations in the Caney Fork basin as recommendations for future actions. Another peer reviewer (Monte McGregor) provided additional information about the species obtained by the Kentucky Department for Fish and Wildlife Resources's Center for Mollusk Conservation.

D. Response to Peer Review: We changed the year of the last collection record of the species in BSFCR from 2016 to 2017. We added that the overall mussel fauna in BSFCR downstream from the reach currently occupied by Little-wing Pearlymussel appears to be recovering from acid mine pollution. We added that mussel surveys in Cane Creek have not been sufficient to assess its current status. We added the following as recommendations for future actions: conducting genetic studies and surveying and reintroducing/augmenting populations in the Caney Fork basin. We added a description of the glochidia, an additional host fish, and densities from surveys in BSFCR.