

**Recovery Plan
for the
Fluted Kidneyshell (*Ptychobranthus subtentus*)**



Photo courtesy of Brett Ostby, Virginia Polytechnic Institute and State University

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DISCLAIMER

Recovery plans delineate reasonable actions that are believed necessary to recover and/or protect the species. We, the U.S. Fish and Wildlife Service (Service), publish recovery plans, sometimes with the assistance of recovery teams, contractors, State agencies, and others. Plans are reviewed by the public and subject to additional peer review before they are adopted by the Service. Objectives of the recovery plan will be attained and funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not obligate other parties to undertake specific tasks. Recovery plans do not necessarily represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than the Service. They represent our official position only after they have been signed by the Director or Regional Director as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

By approving this document, the Regional Director certifies that the information used in its development represents the best scientific and commercial data available at the time it was written. Copies of all documents reviewed in development of the plan are available in the administrative record, located at the Service's Tennessee Ecological Services Field Office, Cookeville, Tennessee.

Approved: _____
Regional Director, U.S. Fish and Wildlife Service

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Recovery Plan for Fluted Kidneyshell (*Ptychobranhus subtentus*)

This Recovery Plan describes criteria for determining when the Fluted Kidneyshell (*Ptychobranhus subtentus*) should be considered for delisting, lists site-specific actions that will be necessary to meet those criteria, and estimates the time required and costs for implementing recovery actions necessary to achieve recovery. Additionally, cursory information on the species' biology and status are included, along with a brief discussion of factors limiting its populations. The Recovery Plan was informed by a Species Status Assessment (SSA) (USFWS 2021), which provides a more detailed account of the species' status, distribution, biology, and threats. A Recovery Implementation Strategy (RIS) has also been developed; it is the operational document that details on-the-ground activities for implementing recovery actions. The RIS and SSA are finalized separately from the Recovery Plan and will be updated on a routine basis.

Species Status: The Fluted Kidneyshell was federally listed as endangered on October 28, 2013 (78 FR 59269) under the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*) (Act). Critical Habitat was designated for the species on October 28, 2013 (78 FR 59555). The Fluted Kidneyshell is assigned a recovery priority of 2, which indicates the species faces a high degree of threat and a high recovery potential. Recovery potential is considered high because propagation techniques have been developed and the species has been successfully reintroduced into some portions of its historical range. However, alleviating the threats will require diligent and long-term efforts. The species is listed as endangered by state agencies in Alabama, Kentucky, Tennessee, and Virginia.

Habitat Requirements and Limiting Factors: The Fluted Kidneyshell is a Cumberlandian Region mussel, meaning it is restricted to the Cumberland (Kentucky and Tennessee) and Tennessee (Alabama, Kentucky, Tennessee, and Virginia) River drainages. The species occurs in medium-sized creeks to large rivers, inhabiting sand and gravel substrates in relatively shallow riffles and shoals with moderate to swift current (Williams *et al.* 2008). The host fishes for larval Fluted Kidneyshell also utilize these habitats for reproduction and feeding upon aquatic insects, underscoring the importance of free-flowing stream reaches with suitable substrates in meeting requirements for all of the species' life history stages (Luo 1993; Davis and Layzer 2012).

At the time of listing, the primary threats to Fluted Kidneyshell were associated with the destruction, modification, or curtailment of its habitat or range. Construction of several large impoundments from 1913 to 1976 inundated many river miles within the species' range, rendering habitats in these reaches unsuitable for Fluted Kidneyshell and severing connectivity between the remaining occupied reaches (USACE 2019; TVA 2020). These historical events have shaped the current distribution and fragmented the distribution of the Fluted Kidneyshell into isolated populations. Ongoing activities, especially gravel and coal mining, urban development, and agriculture, continue to degrade habitat within the species' range by contributing sediment and chemical contaminants to streams and by physically altering stream channels and riparian habitat. The fragmented and isolated distribution of current Fluted Kidneyshell populations leave them vulnerable to extirpation. Climate change is likely to

adversely affect the species by altering hydrologic cycles and temperature regimes, but the extent or magnitude of this threat has not been quantified at this time. Although disease was not identified as a substantial threat at the time of listing, research suggests that pathogens or other causal agents (i.e., bacteria, parasites) contributed to poor mussel health leading to the annual mussel die-offs in the Clinch River beginning in 2016 (Henley *et al.* 2019). Richard *et al.* (2020) identified a novel densovirus (Clinch densovirus 1) that was epidemiologically linked to morbidity in Clinch River mussels.

Recovery Strategy

The Fluted Kidneyshell is one of several species protected under the Act found in the Cumberland and Tennessee River systems. These systems contain the most diverse mussel fauna in North America (Haag 2010) but are under threat from many factors contributing to declines of mussel populations. Impoundments in the Cumberland and Tennessee River systems have converted free flowing rivers into fragmented stream reaches that function as less resilient and isolated refugia for the remaining Fluted Kidneyshell and other imperiled mollusks. This fragmented arrangement of remaining habitat impedes recolonization and genetic exchange between Fluted Kidneyshell populations, leaving them vulnerable to extirpation. Human activities associated with mining, urban development, and agriculture have degraded and continue to degrade water quality and stream habitat through point source and non-point source discharges of pollutants and physical alterations. In addition to these persistent threats, the most robust population of Fluted Kidneyshell (Clinch River) is currently experiencing a sharp decline in abundance likely due to a newly identified viral pathogen, as described above.

The overall recovery strategy will focus on securing enough resilient Fluted Kidneyshell populations throughout the Tennessee and Cumberland River drainages to maintain species representation and establish sufficient redundancy for species viability (Wolf *et al.* 2015). Reducing threats to populations is essential to increasing resiliency. It is essential that we improve our understanding of the needs of Fluted Kidneyshell individuals and populations and their responses to threats to guide implementation of specific recovery activities. This will be achieved through routine monitoring of existing populations, researching the habitat and water quality needs of individuals in relation to threats, and monitoring outcomes of population augmentations and reintroductions. Population augmentations and reintroductions will be accomplished through captive propagation and translocation of individuals. Researching genetic differences between populations and genetic diversity within populations will increase our understanding of species representation and guide augmentations and reintroductions. Adaptive management will be necessary to adjust recovery activities according to new information about the species and to respond to changing conditions.

Much of the land within watersheds currently or historically occupied by Fluted Kidneyshell is in private ownership. Land acquisition will, in some instances, be an effective tool for removing threats caused by land uses that contribute to erosion, nutrient enrichment, and stream bank instability. Additional actions will enhance these and other water quality threats at a scale sufficient for recovering the species. Thus, reducing threats posed by water quality and habitat degradation will require a watershed-level approach involving public outreach and communication with landowners, other agencies, and stakeholder groups. Coordination and

cooperation will be necessary to develop and implement effective recovery activities amenable to stakeholders' missions, objectives, and aspirations. Activities to reduce threats to the Fluted Kidneyshell will promote conservation of aquatic diversity within the species' range, including multiple other species listed under the Act. Population augmentations will likely be necessary to increase resiliency of Fluted Kidneyshell populations that are currently too small to be viable and allow more time to implement other conservation activities. Reintroductions into extirpated portions of historically occupied habitats will increase species redundancy, enabling the species to better withstand catastrophic events.

We expect the recovery of the Fluted Kidneyshell to require long-term human intervention to alleviate threats, strengthen existing populations, and establish new populations. Planning and implementation of conservation activities to recover the Fluted Kidneyshell should be a part of a broader effort to conserve the native mussel fauna in the Tennessee and Cumberland River drainages. These efforts will require close coordination with partners and stakeholders and the engagement and dedication of those partners and stakeholders to efficiently and effectively recover the Fluted Kidneyshell.

Recovery Goal: The goal of this Recovery Plan is to ensure the long-term viability of the Fluted Kidneyshell in the wild to the point that it can be removed from the Federal List of Endangered and Threatened Wildlife (50 CFR 17.11). Therefore, this Recovery Plan establishes delisting criteria for the species. Criteria will be reevaluated as new information becomes available.

Recovery Criteria: Recovery criteria are objective, measurable conditions that, when met, indicate that a species may warrant delisting. The Fluted Kidneyshell will be considered for delisting when the following conditions are met:

Criterion 1

At least 12 populations demonstrate a stable or increasing trend, natural recruitment, and multiple age classes over a 15-year period. At least 3 of these populations occur in each of the following drainages: Cumberland River, lower Tennessee River, and upper Tennessee River. An additional 3 populations are necessary for species redundancy, but these populations can be distributed among any of the 3 historic drainage basins (Cumberland River, Upper Tennessee River, and Lower Tennessee River).

Criterion 2

Threats have been addressed and/or managed to the extent that water quality, instream habitat, and connectivity between and among populations will be maintained at levels meeting life history requirements of the species. Additionally, pathogen prevalence and disease incidence should occur at sufficiently low levels such that effects on population growth and demography are insignificant.

Justification for Recovery Criteria

The proposed recovery criteria reflect the best available information on the Fluted Kidneyshell. These criteria address the five factors described in section 4(a)(1) of the Act and

incorporate the conservation principles of representation, resiliency, and redundancy (Schaffer and Stein 2000; Wolf *et al.* 2015).

Populations must exhibit a stable or increasing trend, natural recruitment, and multiple age classes across a 15-year monitoring period to be demographically resilient to stochastic events. Fifteen years represents a period of 2 reproductive generations (the time it takes for a new cohort to produce a reproductive cohort). The Fluted Kidneyshell mussel reaches sexual maturity by 6 to 7 years of age (Davis and Layzer 2012). Provided that threats to the species are effectively managed and these populations demonstrate 15 years of stable or increasing trends, and are able to maintain a moderate to high resilience level into the foreseeable future, the redundancy provided by 12 resilient populations would reduce the risk of extinction such that protection under the Act would no longer be necessary. Additionally, threats to the Fluted Kidneyshell identified in both the 2013 listing rule (78 FR 59269) and the SSA (USFWS 2021), need to be ameliorated to recover and delist the species. To the extent necessary to support recovery, regulations and programs need to be in place to ensure that water quality parameters will be maintained at levels meeting the life history requirements of the Fluted Kidneyshell, habitat degradation and stream impairment needs to be effectively managed or abated to a degree that does not impair the basic functions of feeding, breeding, and sheltering, and connectivity between populations and among habitats is restored or mitigated to allow appropriate genetic flow and exchange.

The distribution of resilient populations needs to be representative of geographic, genetic, and ecological variation that exists across the species' historical range for the Fluted Kidneyshell to adapt to changing conditions. It is expected that restoring or maintaining at least 3 populations in each of the Cumberland, Upper Tennessee, and Lower Tennessee drainage basins would provide representation of local adaptations to geographic and ecological variation that the species may possess although range-wide genetics information for the Fluted Kidneyshell is lacking. The additional 3 populations should be distributed across these historic drainage basins for added redundancy. Increasing the redundancy of resilient populations across each of these drainage basins will provide adaptive variation to respond to changing environmental conditions. This will also decrease the species' vulnerability to catastrophic events by spreading risk among multiple populations. In combination with actions to manage threats, achieving this criterion will reduce the risk of extinction to the point that protection under the Act is no longer necessary.

For the Fluted Kidneyshell to adapt to changing conditions, the distribution of resilient populations needs to be representative of geographic, genetic, and ecological variation that exists across the species' historical range. Lacking range-wide genetics information for the Fluted Kidneyshell, it is expected that restoring or maintaining at least 3 populations in each of the Cumberland, Upper Tennessee, and Lower Tennessee drainage basins would provide representation of local adaptations to geographic and ecological variation that the species may possess. The additional 3 populations should be distributed across these historic drainage basins for added redundancy. Increasing the redundancy of resilient populations across each of these drainage basins will provide adaptive variation to respond to changing environmental conditions. This will also decrease the species' vulnerability to catastrophic events by spreading risk among multiple populations. In combination with actions to manage threats, achieving this

criterion will reduce the risk of extinction to the point that protection under the Act is no longer necessary.

Recovery criteria correspond to the five factors upon which determinations to list, reclassify, and delist a species are based. Although not every identified threat needs to be completely eliminated to remove a species from the federal endangered species list, current and foreseeable threats must be abated to the point where a recovered species is unlikely to become in danger of extinction again within the foreseeable future.

The population resiliency analyses in the SSA uses information and analyses to demonstrate whether a population exhibits a desirable demographic structure and that threats are abated to a degree that the population would be expected to maintain resilience in the future. Resiliency conditions in the SSA consider population and habitat elements. Population elements include an assessment of population abundance (numbers of individuals within a population), continuity (length of continuously occupied habitat within each population), and spatial complexity of occupied habitats (number of occupied tributaries within a population). The habitat elements include water quality (amount of stream classified as impaired by 305b and 303d of the Clean Water Act), habitat quality (percent developed or agriculture within a population watershed was used as a surrogate for in-stream habitat quality), and connectivity (amount dams and barriers within a population watershed).

Actions Needed:

The recovery actions identified in the table below are those we believe are necessary to recover the Fluted Kidneyshell, based on the best available science.

Recovery Action	Estimated Cost¹	Priority²
1. Increase knowledge of the biology of the species, particularly its response to threats.	\$500,000	1
2. Conduct research on species' population genetics.	\$90,000	1
3. Consistently monitor the status of existing populations.	\$4,530,000	1
4. Utilize existing regulations, voluntary conservation practices, removal of barriers, and land acquisition to protect extant populations by reducing threats and maintaining, enhancing, and restoring habitat in their watersheds.	\$50,000,000	1
5. Continue propagation and augment populations, as appropriate.	\$2,000,000	2
6. Reduce threats in currently unoccupied watersheds within the range of the species.	\$25,000,000	3
7. Reintroduce new populations to unoccupied habitat within the historical range of the species.	\$1,000,000	3
8. Search for undocumented populations and undocumented occupied reaches within the range of the species.	\$200,000	3

9. Conduct outreach to local communities in the range of the species to gain support of conservation efforts and foster stewardship of watersheds.	\$150,000	3
10. Conduct periodic review of recovery progress and strategy.	-	3
Total Estimated Cost: \$83,470,000		

¹ Costs covered under existing programs are not included in this table.

² Recovery actions are assigned numerical priorities to highlight the relative contribution they may make toward species recovery (48 FR 43098):

Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly.

Priority 2 – An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

Priority 3 – All other actions necessary to provide for full recovery of the species.

Estimated Cost of Delisting: The estimated costs associated with implementing recovery actions for delisting are \$83,470,000. Cost estimates reflect costs for specific actions needed to achieve Fluted Kidneyshell recovery. Some costs for recovery actions, especially actions 4 and 7, are difficult to estimate at this time, because identifying specific activities under these actions depend on the outcomes from actions 1, 2, and 3. Because some costs are not determinable at this, the total cost for recovery will likely be higher than this estimate. Some of the costs specified for delisting the Fluted Kidneyshell will be shared with recovery programs for other federally listed freshwater mussel species within its range.

Date of Recovery: The estimated date of recovery is 2070. As we learn more about this species and its threats and recovery actions are implemented and funded with close cooperation of all partners, we will carefully monitor and assess progress toward recovery to ensure we are on track.

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