U. S. Fish and Wildlife Service

Draft Recovery Plan

for

The Rabbitsfoot
(*Quadrula cylindrica cylindrica*, Say 1817)

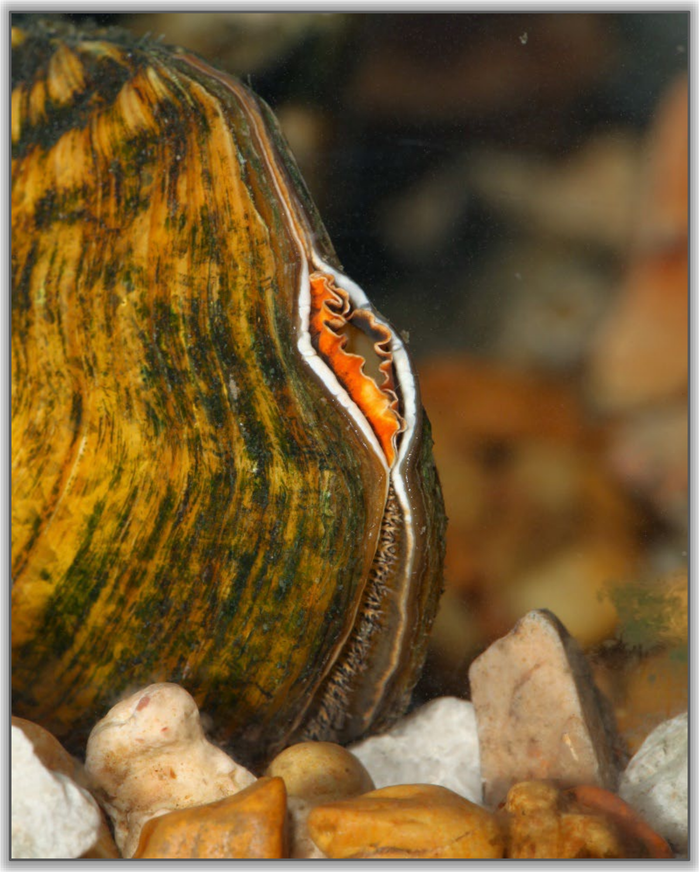

Photo: Dr. Chris Barnhart, Missouri State University

October 2022

ACKNOWLEDGMENTS

Rebecca Peak (U.S. Fish and Wildlife Service [Service], Arkansas Ecological Services Field Office) prepared this document. Dan Fitzgerald (Service, Branch of SSA Science Support) provided analyses to identify a portfolio of watersheds to inform development of quantitative recovery criteria. The following individuals reviewed and provided comments on draft recovery criteria: Chris Davidson, Andy Ford, Matthew Mangan, Richard Novak, Bryan Simmons, and Matthew Wagner (Service); Brant Fisher (Indiana Department of Natural Resources); Brian Metzke (Illinois Department of Natural Resources); Sarah Douglass (Illinois Natural History Survey); Monte McGregor (Kentucky Department of Fish and Wildlife Resources); Keri Lejeune and Charles Battaglia (Louisiana Department of Wildlife and Fisheries); Robert Ellwanger (Mississippi Museum of Natural Sciences); Steve McMurray (Missouri Department of Conservation); John Navarro (Ohio Department of Natural Resources); Dan Hua and Jason Wisniewski (Tennessee Wildlife Resources Agency).

DISCLAIMER

Recovery plans delineate reasonable actions believed necessary to recover and/or protect the species. We, the 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 we adopt them. Actions 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 activities. 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. Recovery plans represent our official position 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 completion of recovery activities. 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 Arkansas Field Office, Conway, Arkansas.

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

Date: ________________________________

Suggested citation:
U.S. Fish and Wildlife Service. 2022. Recovery Plan for the Rabbitsfoot (*Quadrula cylindrica cylindrica*). Atlanta, Georgia. 11 pp.

INTRODUCTION

The Service's recovery planning process entails developing a recovery plan and recovery implementation strategy (RIS). This document provides the Service's plan for the conservation and recovery of the Rabbitsfoot (*Quadrula cylindrica cylindrica)*. It describes the recovery vision, strategy, and required elements per section 4(f)(1)(B) of the Act, which are criteria, actions, and overall time and cost estimates to recovery. The RIS is a separate document from the recovery plan and is developed in cooperation with partners. It serves as an operational document for stepping down the recovery actions into specific activities needed to achieve recovery and details how, when, and where they will be accomplished. The specifics of the RIS are updated as new information becomes available through recovery implementation, a 5-year review, or some other relevant feedback.

To develop this recovery plan, we prepared a Species Status Assessment (SSA) report (Service 2021). The contents of the report are as follows: (1) summary of the subspecies' biology at the individual, population, and subspecies levels; (2) description of the influences on resource needs and viability within the framework of the three factors that contributed to listing; (3) discussion of conservation actions implemented to benefit this mussel and its habitat; (4) description of the subspecies' current condition in terms of resiliency, representation, and redundancy; (5) calculation of projected future risk of extirpation or low condition; and (6) identification of a portfolio of watersheds that maximize viability of the Rabbitsfoot. The SSA report is available at https://ecos.fws.gov/ecp/species/5165.

RECOVERY VISION

The Rabbitsfoot occurs in continuous flowing water such as rivers, streams, and creeks, which provide the resources it needs to survive and reproduce: suitable physical habitat and water quality conditions, food, and host fish species (Service 2021 pp. 14–17). This freshwater mussel subspecies historically occurred within at least 434 watersheds located throughout the lower Great Lakes and lower Mississippi river sub-basins and Ohio, Cumberland, Tennessee, White, Arkansas, and Red river systems in 15 states (Figure 1; Service 2021 pp. 44). It is presumed extirpated from 288 of those watersheds, a reduction of between 63% and 70% of its historical range (Figure 1; Service 2021 pp. 44). Losses of many populations of freshwater mussels prior to the 1950s are directly associated with the acute effects of destruction of riverine habitat from construction of dams, channelization, and pollution from chemical spills or municipal and industrial effluents (Service 2021 pp. 19–32). More recently, biologists identify the chronic effects of these threats e.g., fragmentation of habitat and isolation of populations, as well as interactions among them as a cause for the continued decline in populations (Strayer et al. 2004, p. 435; Galbraith et al. 2010, entire). Yet, the decline in freshwater mussel species remains enigmatic as the chronic effects of these threats do not fully explain declines in their populations (Haag et al. 2019, entire).

Recovery of the Rabbitsfoot is contingent upon its viability, defined as its ability to sustain healthy populations in natural river systems within a biologically meaningful timeframe (Service 2021, p. 5). In our SSA analysis, we used the conservation principles of resiliency, redundancy, and representation to assess viability of the Rabbitsfoot at specific points in time (Wolf et al.

2015, p. 204; Service 2021 pp. 39–52). For populations to be resilient to stochastic events such as normal variation in temperature and rainfall as well as ongoing threats such as the effects of anthropogenic activities e.g., altered hydrology and fragmentation of riverine habitat, they need to occur in stream reaches with a sufficient spatial extent to support an abundance of individuals of multiple age classes and with evidence of reproduction and recruitment of juveniles into the population (Service 2021 pp. 17–18). Redundancy is characterized by a species having multiple, resilient populations distributed across its historical range relative to the spatial occurrence of catastrophic events such as widespread droughts and flooding as well as connectivity among populations to increase the ability of a species to withstand or recover from catastrophic events (Service 2021 pp. 17–18). To have sufficient representation, resilient populations should be distributed across the historical range of a species (Service 2021 pp. 17–18). The vision of recovery for the Rabbitsfoot is to work cooperatively with partners to conserve watersheds with multiple, resilient populations across the historical range to the maximum extent possible and with connectivity maintained among watersheds whereby this mussel subspecies has a high probability of persistence for the foreseeable future and no longer requires protections afforded by the Act.

RECOVERY STRATEGY

Because genetic structure of populations of the Rabbitsfoot is lacking, we used the two sub-basins and six river systems that represent the historical range as the foundation for grouping watersheds that occupy geographically and ecologically comparable areas into nine representation units (Figure 1; Service 2021, p. 40). We used demographic and distributional criteria to assign each extant watershed an ordinal classification of resilience of low, medium, or high condition (Service 2021, pp. 40–42). To estimate representation and redundancy, we tallied the number of watersheds classified in each current condition across the nine representation units (Service 2021, pp. 40–42). Because of the substantial reduction in its historical range, number of watersheds classified as low condition, and isolation of watersheds classified as high and medium condition from each other, resilience, redundancy, and representation for the Rabbitsfoot i.e., current condition, is low (Service 2021, pp. 44–47).

The fundamental objective in developing a recovery strategy for a species is to maximize its viability i.e., achieve the recovery vision. To develop our strategy, we applied a three-part optimization approach (Beyer et al. 2016, entire; Service 2021, pp. 56–63). We framed our approach in terms of identifying watersheds that maximize probability of persistence (i.e., resilience) and geographic extent (i.e., representation) for a specific number of watersheds (i.e., redundancy). Accomplishment of this strategy is contingent upon availability of funds and cooperation among private, local, state, and federal partners with expertise in the ecology of the Rabbitsfoot and improvement and maintenance of its habitat.

The first part of the approach focuses on maintaining resilience in all watersheds that are currently classified as high condition. This part may be the most important as projected probability of a watershed being classified as extirpated or low condition at 2050 was more likely than not (95% CI >0.5) for all extant watersheds (Service 2021, p. 52). Natural resource professionals can achieve this part by eliminating or abating threats to the persistence of the Rabbitsfoot through activities that protect and/or improve habitat. These activities include

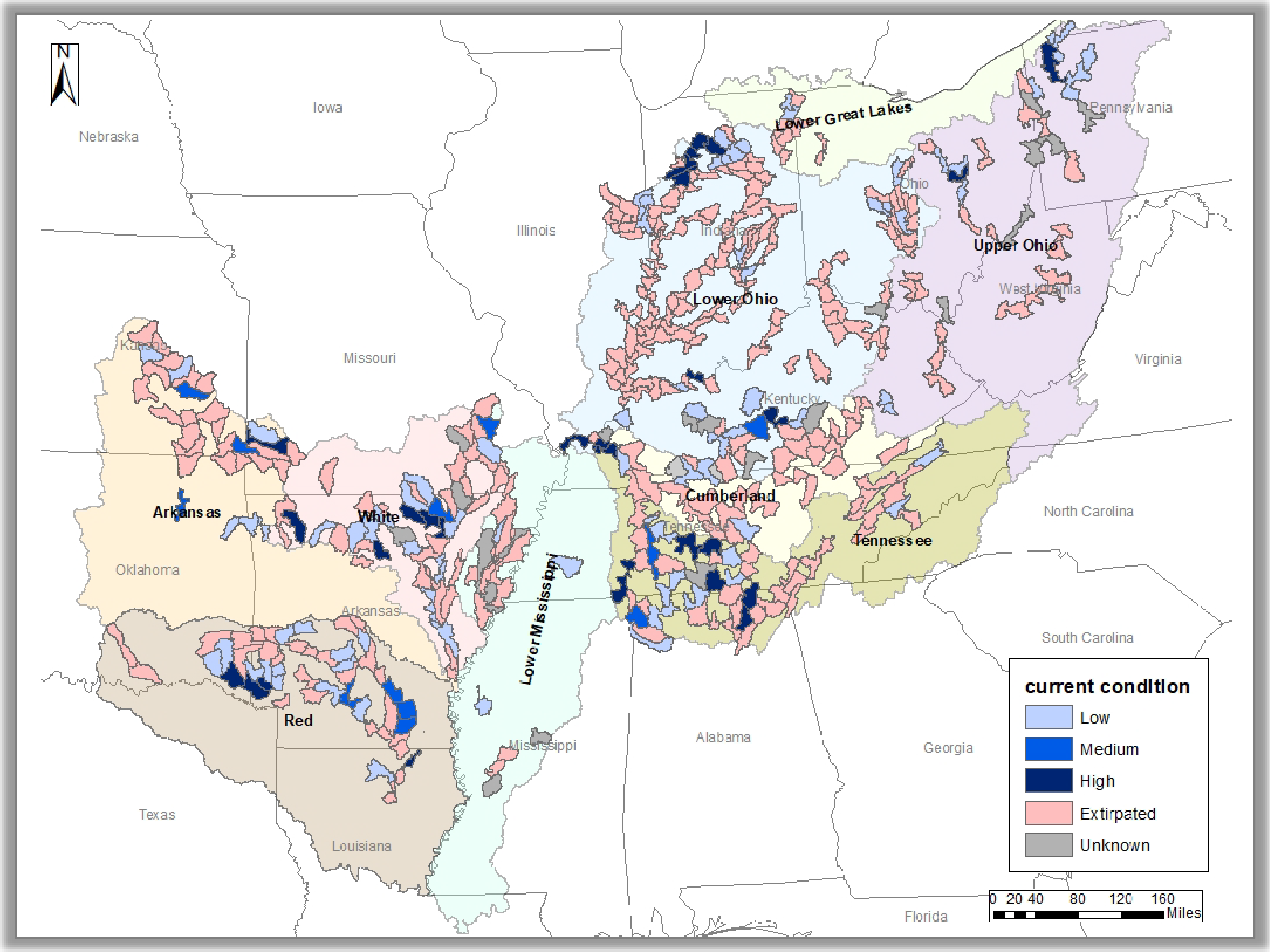

Figure 1. Current condition of the Rabbitsfoot by watershed distributed across the nine representation units.

developing conservation easements, using existing legislation, programs, and regulations or encouraging development of new ones that are protective of freshwater mussels and their habitat (e.g., protecting water quality), removing non-functional, aging, and unsound low-head dams, planting riparian vegetation to stabilize stream banks and decrease water temperature, and replacing culverts and bridges that restrict fish passage with new ones that allow passage and accommodate increased flows (Service 2021, pp. 32–36). A total of 27 watersheds across nine representation units are currently classified in high condition (Figure 1; Service 2021, pp. 122–125).

The second part of the approach focuses on increasing resilience in watersheds currently classified as low and medium condition with the lowest projected risk of extirpation at 2050 (Service 2021, pp. 52–55). Natural resource professionals should first eliminate or abate threats by implementing activities such as those described in the first part until populations demonstrate increasing numbers and recruitment over a specified number of years. When possible, natural resource professionals should prioritize improving habitat in watersheds that include tributaries of mainstem rivers with extant watersheds that originate from underground springs to provide the spatial complexity and habitat needs necessary to facilitate recovery of populations from stochastic events such as normal variation in temperature and rainfall and catastrophic events such as widespread droughts and flooding. After known threats are eliminated or abated, natural resource professionals may utilize augmentation to increase genetic diversity and the species' ability to adapt to environmental changes or to increase population numbers above depensation thresholds related to Allee effects and environmental stochasticity (Strayer et al. 2019, p. 3). We identified a total of 41 watersheds across nine representation units within which to protect and/or improve habitat to increase resilience (Service 2021, pp. 122–125).

The third part of the approach focuses on increasing representation and redundancy through reintroduction in watersheds currently classified as extirpated or unknown condition and with the greatest probability of being classified in medium or high condition at 2050 (Service 2021, pp. 57–63). Again, this part will first require implementation of activities that eliminate or abate threats that caused extirpation. The result of this part will include the establishment of multiple high and medium condition watersheds distributed across the historical range although some watersheds may be in low condition if connectivity is restored or maintained among them and high or medium condition watersheds (Service 2021, pp. 56–58). We identified a total of 43 watersheds across nine representation units for reintroduction to increase representation and redundancy (Service 2021, pp. 122–125).

Williams et al. (2017) synonymized the two freshwater mussel subspecies, Rabbitsfoot (*Quadrula cylindrica cylindrica*) and Rough Rabbitsfoot (*Quadrula cylindrica strigillata*) into a single species, *Theliderma cylindrica.* This taxonomic change was based on limited genetic data (Serb et al. 2003; Sproules et al. 2006) and has far-reaching management implications for the species. The Service is cooperating with Virginia Polytechnic Institute and State University to conduct a study to evaluate the taxonomic validity of the two subspecies to inform how we move forward with recovery planning and implementation. The results of the taxonomic study will provide the foundation for a larger study to evaluate genetic structure within and among populations of the Rabbitsfoot to determine if there are genetically distinct populations, or additional subspecies- or species-level entities (Sproules et al. 2006, entire, Lopes-Lima et al.

2019, entire). Results of such studies also are essential to inform reintroduction and augmentation efforts through propagation associated with parts two and three of the approach.

Currently, demographic trends for most populations of the Rabbitsfoot are not well known. Furthermore, the biology of the Rabbitsfoot, particularly in response to threats also is not well known. Since we need this information to guide implementation of specific recovery activities, we will develop and implement a standardized monitoring program for collecting data to assess population trends and habitat quality, estimate abundance and recruitment, and evaluate recovery efforts. We also will develop and implement monitoring and control programs for invasive, non-native mussel and fish species that compete with and are predators of native freshwater mussels and encourage programs to minimize their spread. We will develop a database that will be used to prioritize watersheds, threats, and needed recovery actions as well as track recovery efforts and document when threats to each watershed have been eliminated or abated.

RECOVERY CRITERIA

We are defining reasonable recovery criteria for what constitutes a recovered freshwater mussel species based on the best available information for the Rabbitsfoot. As new information becomes available, criteria will be re-evaluated and updated accordingly. The Rabbitsfoot will be considered for delisting when the following criteria are met:

1. Watersheds identified in Criterion 3 support the resource needs necessary for each life history stage of the Rabbitsfoot, such as appropriate flows, water quality, spawning temperatures, substrate for juvenile settlement and adult survival, food availability, and sufficient abundance of host fish necessary for recruitment (Service 2021 pp. 14–17; Factors A, D, and E).

2. Range-wide threats identified in the Species Status Assessment (Service 2021, pp. 20-33) have been addressed to the extent that hydrologic alteration, erosion and sedimentation, climate change, nutrient and chemical pollution, and density of developed land use, as well as local scale threats such as mining and invasive species, have been eliminated and/or abated to the extent necessary to maintain resiliency, redundancy, and representation (Service 2021, pp. 57-63; Factors A, D, and E). Examples of addressing and measuring current and foreseeable threats to the Rabbitsfoot include:

    a. <u>Hydrologic Alteration:</u> flows in regulated rivers with designated critical habitat are managed according to conditions well suited for recruitment and survival of the Rabbitsfoot.

    b. <u>Erosion and Sedimentation:</u> environmentally sensitive best management practices for erosion control, stormwater control, and riparian habitat protection are widely adopted with a successful track record for implementation in watersheds necessary for recovery.

    c. <u>Nutrient and Chemical Pollution:</u> regulatory thresholds for water quality that are protective of freshwater mussels are enacted and enforced; water quality classifications are changed to prevent future adverse effects to critical habitat; mining effects are mitigated to levels necessary to support recruitment and survival of the Rabbitsfoot.

d. Climate Change: sufficient data, data collection tools, and predictive models are in place to allow for accurate forecasting of climate (e.g., precipitation and water temperature) conditions relevant to recruitment and survival of the Rabbitsfoot; robust predictive models and appropriate actions are incorporated into management and regulatory mechanisms for the Rabbitsfoot.

e. Density of Developed Land Use: sufficient data, data collection tools, and predictive models are in place to allow for accurate forecasting of future land use conditions related to recruitment and survival of the Rabbitsfoot; occupied habitats that are most vulnerable to future urbanization of land use effects are identified and protected; local ordinances are enacted and enforced in developing watersheds with critical habitat to buffer against adverse effects associated with urbanization.

Through protection and/or improvement of habitat in extant watersheds, successful establishment of reintroductions in watersheds currently classified as extirpated or unknown condition or the discovery of additional extant watersheds, seven of nine representation units contain 95 to 103 watersheds that maximize the probability of persistence (resiliency; Table 1) and geographic extent (representation) for specific watersheds (redundancy) (Service 2021, pp. 57–63; Factors A and E). This criterion is based on the best available information and professional judgment of species experts. It may be revised based on additional biological, demographic, or genetic information obtained through recovery actions.

3.1 Arkansas River

3.1.1 Seven of nine Neosho River watersheds downstream of John Redmond Reservoir are in medium or high condition.

3.1.2 Three of five Spring River and North Fork Spring River watersheds are in medium or high condition, with at least one watershed in high condition.

3.2 Cumberland River

3.2.1 Three of four Red River watersheds in medium or high condition, with at least two in high condition.

3.2.2 Two watersheds on Rockcastle River closest to its confluence with the Cumberland River in at least medium condition.

3.3 Lower Great Lakes

3.3.1 Upper St. Joseph's River watersheds in at least medium condition, with Fish Creek watershed in high condition.

3.4 Lower Mississippi River

3.4.1 At least one watershed in high and four in medium condition in the St. Francis River.

3.5 Lower Ohio River

3.5.1 Green River with at least two high condition watersheds, four medium condition watersheds, and two low condition watersheds. At least three watersheds in four of the Green River tributary watersheds (Nolin, Rough, and Barren rivers, and Russell Creek) in medium or high condition.

3.5.2 Ohio River from Green River confluence upstream to Cannelton Lock and Dam with at least one watershed in high and one in medium condition.

3.5.3 Ohio River from Smithland Lock and Dam to Lock and Dam 53 with at least two watersheds in high and one watershed in medium condition.

3.5.4 The North Fork Vermilion and Middle Branch North Fork Vermilion rivers in high or medium condition.

3.5.5 At least five watersheds in the Tippecanoe River in high condition.

3.5.6 At least three watersheds in the Scioto River, Olentangy River, and/or Big Darby and Little Darby creeks in at least medium condition.

3.6 Upper Ohio River

3.6.1 French Creek watershed in high condition, and LeBoeuf and Muddy creek watersheds, tributaries of French Creek, in at least low condition.

3.6.2 Upper and lower Allegheny River watersheds are in at least medium condition.

3.6.3 Both Shenango River watersheds in at least medium condition.

3.6.4 Walhonding River watershed in high condition, including the Mohican River and Muskingum River watershed at the convergence with the Walhonding River in at least medium condition and Tuscarawas River watersheds in at least medium condition.

3.6.5 Pymatuning Creek watershed in at least medium condition.

3.7 Tennessee River

3.7.1. Tennessee River watersheds downstream of Pickwick Landing and Kentucky Lake dams in high condition.

3.7.2 Two of five Duck River watersheds in high condition and two in medium condition and the Lower Buffalo River watershed, a tributary of the Duck River, in at least medium condition.

3.7.3 At least one Elk River watershed in high condition and two of three remaining watersheds in medium condition.

3.7.4 Paint Rock River watersheds in high condition.

3.7.5 Bear Creek watershed at its confluence with the Tennessee River in high condition and the other in medium condition.

3.8 Red River

3.8.1 The two Little River watersheds immediately upstream of Millwood Lake are in high condition and at least one other watershed in medium condition. At least two Little River tributary watersheds (Glover, Rolling Fork, Cossatot, and Saline rivers) are in low condition.

3.8.2 Two of five Ouachita River watersheds between Malvern and Camden, Arkansas, in high condition; two of five watersheds in medium condition. Two lower Little Missouri River watersheds in medium condition.

3.8.3 Three of six Saline River watersheds in high condition; two of six watersheds in medium condition.

3.8.4 Bayou Bartholomew watershed in Louisiana in high condition.

3.9 White River

3.9.1 War Eagle Creek watershed in high condition.

3.9.2 Two of four Buffalo River watersheds in high condition; two of four in medium condition.

3.9.3 Lower Middle Fork Little Red River watershed in high condition.

3.9.4 Strawberry River watersheds in high condition.

3.9.5 Lower Spring River watershed in high condition; South Fork Spring River watershed in medium condition.

Table 1. Demographic and distributional criteria used to assign resilience within watersheds and to assess their current condition (Service 2021 p. 43, Table 5.1).

<table>
<tr><th>Condition</th><th>Abundance</th><th>Reproduction</th><th>Distributional Criterion</th><th>Probability of Persistence[†]</th></tr>
<tr><td rowspan="2">High</td><td>100s of individuals</td><td>Evidence of reproduction or stable/increasing at 5-yr review</td><td rowspan="2">Occurs in more than 50 river km</td><td rowspan="2">> 0.75</td></tr>
<tr><td>10s of individuals</td><td>Evidence of reproduction or increasing status at 5-yr review</td></tr>
<tr><td rowspan="3">Medium</td><td>100s of individuals</td><td>Decreasing trend at 5-yr review</td><td rowspan="3">Occurs in 10–50 river km</td><td rowspan="3">0.25–0.75</td></tr>
<tr><td>10s of individuals</td><td>Unknown or stable at 5-yr review</td></tr>
<tr><td>Fewer than 10 individuals</td><td>Evidence of reproduction or increasing status at 5-yr review</td></tr>
<tr><td rowspan="3">Low</td><td>10s of individuals</td><td>Decreasing trend at 5-yr review</td><td rowspan="3">Occurs in fewer than 10 river km</td><td rowspan="3">< 0.25</td></tr>
<tr><td>Fewer than 10 individuals</td><td>Unknown or stable at 5-yr review</td></tr>
<tr><td>Presence-absence data</td><td>Unknown or stable at 5-yr review</td></tr>
<tr><td>Unknown</td><td colspan="2">Historical records of occurrence in watershed with no surveys in past 30 years</td><td>Not Applicable</td><td>Not Applicable</td></tr>
<tr><td>Extirpated</td><td colspan="2">No individuals collected in surveys within the past 30 years</td><td>No areas occupied</td><td>Not Applicable</td></tr>
</table>

[†]Probability of persistence represents expected risk of extirpation over 30 years. It reflects authors' judgments and is provided only to reduce linguistic uncertainty in verbal category descriptions, following best practices for communicating risk.

ACTIONS NEEDED

The actions identified in the table below are those we believe are necessary to recover the Rabbitsfoot, based on the best available science. Recovery actions are assigned numerical priorities to address the most significant threats first to achieve the most recovery in the least amount of time (48 FR 43098). Priority 1 actions are defined as those actions that must be taken to prevent extinction or to prevent the subspecies from declining irreversibly in the foreseeable future. Priority 2 actions are those that must be taken to prevent a significant decline in population size or habitat quality or some other significant negative impact. Priority 3 actions are all other actions that are necessary to provide for full recovery of the subspecies.

ESTIMATED COST OF RECOVERY:

The estimated costs of implementing recovery actions for delisting are $20,630,000. Some costs are not determinable at this time, and therefore the total cost may be higher than this estimate. Some costs relate to habitat conservation that benefits multiple species and enhances ecosystem services to people (e.g., drinking water protection, open space for recreation); as such, some of these actions and their associated costs may be implemented aside from this plan.

Recovery Action	**Estimated Cost**	**Priority**
1. Protect and improve habitat to maintain and increase resiliency.	$15,150,000	1
2. Maximize viability by reintroduction and augmentation efforts through propagation.	$4,100,000	2
3. Increase knowledge of the biology of the species and the ecological factors affecting it.	$750,000	1
4. Evaluate taxonomic uncertainty and genetic structure of populations.	$130,000	2
5. Monitor population and habitat conditions across historical range.	$500,000	1
6. Develop and implement strategies to prevent the spread of invasive nonnative species.		3
7. Periodically review recovery progress and update recovery plan as needed.		3
Total Estimated Cost:	$20,630,000	

DATE OF RECOVERY

If all actions are fully funded and implemented as outlined, including full cooperation of all partners needed to achieve recovery, we anticipate delisting could be achieved after the span of at least 30 years (three generations) following adoption of this plan, 2065.

LITERATURE CITED

Beyer, H. L., Y. Dujardin, M. E. Watts, and H. P. Possingham. 2016. Solving conservation planning problems with integer linear programming. Ecological Modelling 328:14-22.

Galbraith, H. S., D. E. Spooner, and C. C. Vaughn. 2010. Synergistic effects of regional climate patterns and local water management on freshwater mussel communities. Biological Conservation 143:1175–1183.

Haag, W. R. 2019. Reassessing enigmatic mussel declines in the United States. Freshwater Mollusk Biology and Conservation 22:43–60.

Lopes-Lima, M., L. Burlakova, A. Karatayev, A. Gomes-dos-Santos, A. Zieritz, E. Froufe, and A. E. Bogan. 2019. Revisiting the North American freshwater mussel genus *Quadrula sensu lato* (Bivalvia Unionidae): phylogeny, taxonomy, and species delineation. Zoologica Scripta 48:313–336.

Serb, J. M., J. E. Buhay, and C. Lydeard. 2003. Molecular systematics of the North American freshwater bivalve genus *Quadrula* (Unionidae: Ambleminae) based on mitochondrial ND1 sequences. Molecular Phylogenetics and Evolution 28:1–11.

[Service] U.S. Fish and Wildlife Service. 2021. Species Status Assessment Report for Rabbitsfoot (*Quadrula cylindrica cylindrica*), Version 1.0. Conway Ecological Services Field Office, Conway, Arkansas. 125 pages

Sproules, J. P., Grobler, N. Johnson, J. W. Jones, R. J. Neves, and E. M. Hallerman. 2006. Genetic analysis of selected populations of the Rabbitsfoot Pearlymussel (*Quadrula cylindrica cylindrica*) (Bivalvia: Unionidae). Report to the U.S. Fish and Wildlife Service, Frankfort, Kentucky. 16 pages.

Strayer, D. L., J. A. Downing, W. R. Haag, T. L. King, J. B. Layzer, T. J. Newton, and S. J. Nichols. 2004. Changing perspectives on pearly mussels, North America's most imperiled animals. BioScience 54:429–439.

Strayer, D. L., J. Geist, W. R. Haag, J. K. Jackson, and J. D. Newbold. 2019. Essay: Making the most of recent advances in freshwater mussel propagation and restoration. Conservation Science and Practice 1:e53.

Williams, J. D., A. E. Bogan, R. S. Butler, K. S. Cummings, J. T. Garner, J. L. Harris, N. A. Johnson, and G. T. Watters. 2017. A Revised List of the Freshwater Mussels (Mollusca: Bivalvia: Unionida) of the United States and Canada. Freshwater Mollusk Biology and Conservation 20:33–58.

Wolf. S., B. Hartl, C. Carroll, M. C. Neel, and D. N. Greenwald. 2015. Beyond PVA: why recovery under the Endangered Species Act is more than population viability. BioScience 65:200-207.