Recovery Plan for Barrens topminnow

(*Fundulus julisia*)

Photo credit: Andrew Zimmerman, CFI

U.S. Fish and Wildlife Service

Southeast Region

Atlanta, Georgia

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PURPOSE AND DISCLAIMER This document presents the U.S. Fish and Wildlife Service's (Service) plan for the conservation of Barrens topminnow. The recovery plan is the second part of the Service's 3-part recovery planning framework and includes the statutorily required elements pursuant to section 4(f) of the Endangered Species Act (Act). This recovery plan is informed by the first part of the framework, a Species Status Assessment (SSA). The SSA report delivers foundational science for informing decisions related to the Act and includes an analysis of the best available scientific and commercial information regarding a species' life history, biology, and current and future conditions that characterizes the species' viability (i.e., ability to sustain populations in the wild over time) and extinction risk. We have also prepared a Recovery Implementation Strategy (RIS), the third part of the framework. The RIS is an easily updateable operational plan that is separate and complimentary to the recovery plan that details the on-the-ground recovery activities needed to complete the recovery actions contained in the recovery plan.

Recovery plans describe the envisioned recovered state for a listed species (when it should no longer meet the Act's definitions of a threatened species or endangered species) and include a recovery strategy, recovery criteria, recovery actions, and the estimates of time and cost needed to achieve it. Plans are published by the Service and are often prepared with the assistance of recovery teams, contractors, State agencies, and others. Recovery plans do not necessarily represent the views, official positions, or approval of any individuals or agencies involved in plan formulation, other than the Service. They represent the official position of the Service only after they have been signed by the Regional Director as approved. Recovery plans are guiding and planning documents only; identification of an action to be implemented by any public or private party does not create a legal obligation beyond existing legal requirements. Nothing in this plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in any one fiscal year in excess of appropriations made by Congress for that fiscal year in contravention of the Anti-Deficiency Act, 31 U.S.C. 1341, or any other law or regulation. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and completion of recovery actions.

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Regional Director, Region 4, U.S. Fish and Wildlife Service

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RECOMMENDED CITATION AND ELECTRONIC AVAILABILITY

U.S. Fish and Wildlife Service. 2024. Recovery plan for Barrens topminnow (*Fundulus julisia)*. U.S. Fish and Wildlife Service, Southeast Region, Atlanta, Georgia, USA. 16pp.

An electronic copy of this Final Recovery Plan will be made available at:

https://ecos.fws.gov/ecp/species/5045

I. INTRODUCTION

This recovery plan describes criteria for determining when the Barrens topminnow should be considered for delisting, lists site-specific actions that will be necessary to meet those criteria, and estimates the time and cost to achieve recovery. Additionally, a brief summary of information on the species' biology and status are included, along with a brief discussion of factors limiting its populations. A detailed discussion of these and other topics pertinent to the recovery of Barrens topminnow can be found in the Species Status Assessment. Detailed on the ground activities implementing recovery actions can be found in the Recovery Implementation Strategy. These supplemental documents are available at https://ecos.fws.gov/ecp/species/5045. The Recovery Implementation Strategy (RIS) and Species Status Assessment (SSA) are finalized separately from the Recovery Plan and will be updated on a routine basis. The Barrens topminnow was federally listed as an endangered species under the Act on November 20, 2019 (84 FR 56131). A Recovery Outline was released with the rule on November 20, 2019 that described the preliminary recovery strategy and actions while this plan was prepared.

The Barrens topminnow is a small, colorful killifish that grows to 98 millimeters (3.9 inches) that only lives in spring-fed streams on the Barrens Plateau in middle Tennessee. Individuals live up to four years of age and mature after their first year. Spawning takes place in aquatic vegetation multiple times over the summer months from April through August.

The species was previously known from the headwater tributaries of three river systems, the Caney Fork, the Elk, and the Duck Rivers. The Duck River genetic unit was extirpated by the 1960s, and the only known natural site in the Elk River watershed was extirpated in the early 2010s. Currently, representation of the Barrens topminnow consists of four genetic management units (GMUs) from two river basins: Witty Creek, Hickory Creek, and Upper Collins River in the Caney Fork River basin, and the Pond Spring unit in the Elk River basin. Within these GMUs, the species is only known from six sites: two naturally occurring and three the result of stocking, in the Caney Fork and Elk watersheds (See Figure 1).

The published SSA (Service, 2017) for Barrens topminnow includes an in-depth, scientific review of the species' biological threats and how they contribute to the five categorical factors (A-E) outlined in section 4(a)(1) of the Act. A summary of the biological threats Barrens topminnow and their relation to the five factors are as follows:

Western mosquitofish (Factor C)

Competition and predation from Western mosquitofish (*Gambusia affinis*) poses the greatest threat to populations of Barrens topminnows. While the mosquitofish is native to Tennessee, it is not naturally found on the Barrens Plateau where Barrens topminnows are endemic. These fish were first introduced in the 1960s to control mosquitoes and have expanded through most of the native range of the Barrens topminnow. The mosquitofish use the same peripheral, slow-moving habitat as the topminnow, and is a more aggressive species. Mosquitofish will prey upon eggs and juvenile topminnows and harass adults to the point of reduced body condition. Once mosquitofish gain access to an area, topminnows are typically extirpated within three to five

years. Invasion from mosquitofish segregates topminnow populations into isolated headwaters, creating less resilient populations. These isolated populations are also prevented from exchanging genes, reducing representation within the metapopulation. As populations are lost, the overall redundancy of the species decreases.

Livestock influence (Factor A)

Many of the springs historically occupied by Barrens topminnows are used as water sources for cattle. Access of livestock to surface waters tends to result in sediment transport, with associated deposition on substrate and vegetation. Increased nutrient levels and reduced visibility are typical of these areas, with impacts to topminnow spawning displays. Topminnows require clear water for their spawning displays to be successful and clean vegetation for egg laying. This widespread threat reduces habitat quality, resulting in a decline in population resiliency and a competitive advantage for mosquitofish due to their tolerance of poor habitats.

Riparian vegetation removal (Factor A)

One activity often associated with livestock operations is vegetation clearing up to spring edges and runs that topminnows rely on. Trees and shrubs are cleared to allow for easier access by cattle, to increase available pasture, or to provide views of the stream. Riparian vegetation acts to stabilize banks, reduce overland runoff, and maintain cool water temperatures. However, a fully shaded stream will reduce the filamentous algae and other submerged vegetation needed as habitat for the Barrens topminnow. Without appropriate spawning habitat and stable bank conditions, recruitment and population resiliency are negatively impacted.

Drought (Factors A and E)

The Barrens topminnow is a spring specialist only found in springhead pools and runs, so any impacts to the spring systems can directly impact the species. Springhead discharges decrease during drought, which leads to a reduction of available habitat. Fish can be stranded if springs dry up completely, as well as extremely vulnerable to predation. While climate models for Middle Tennessee do not predict significant overall change in precipitation, increased variability is expected, which could lead to more droughts and flooding. Groundwater withdrawal for irrigation in an area with a concentration of nursery and sod agriculture may exacerbate the flow reductions from drought. In conjunction with livestock access, drought-reduced spring discharge can result in a high concentration of animal waste in topminnow habitats affecting water quality. Summitville Mountain Spring, the topminnow type locality, has dried completely during droughts on multiple occasions, necessitating the capture and housing of topminnows until conditions allow them to be returned to the spring pool. Since 2006, type locality fish have been captured and returned at more than seven times due to drought, and in 2022, the spring dried completely before action could be taken and only a few fish were salvaged. Prior to human alteration of Barrens topminnow habitat, the topminnows were able to move out of drying springs during drought to more permanent water and then re-colonize the springs once conditions improved. Manmade barriers and invasive mosquitofish in the lower reaches of streams inhabited by topminnows now prevent successful re-colonization in these situations. As populations decrease and suffer reduced resiliency during drought, they become more susceptible to other threats, and as populations are lost, the overall redundancy of the species declines. Even

if a population is rescued during a drought, the resulting bottleneck can cause a loss of genetic representation within the population.

Small Population Sizes, Restricted Range, and Low Genetic Diversity (Factor E)

The Barrens topminnow range has become more restricted due to losses of natural populations in the Duck River and Elk River watersheds and multiple populations in the Caney Fork River watershed. Habitat fragmentation has subjected the small populations to genetic isolation, reduced space for reproduction, and reduced adaptive capabilities, thereby increasing the likelihood of extinction. Small, isolated populations are also vulnerable to the Allee effect (a positive relationship between individual fitness and either numbers or density of conspecifics). The fragmentation and small population sizes have also led to increased risk from genetic bottlenecking and inbreeding depression. This reduced allelic representation impedes the species ability to adapt to future threats such as climate change or diseases.

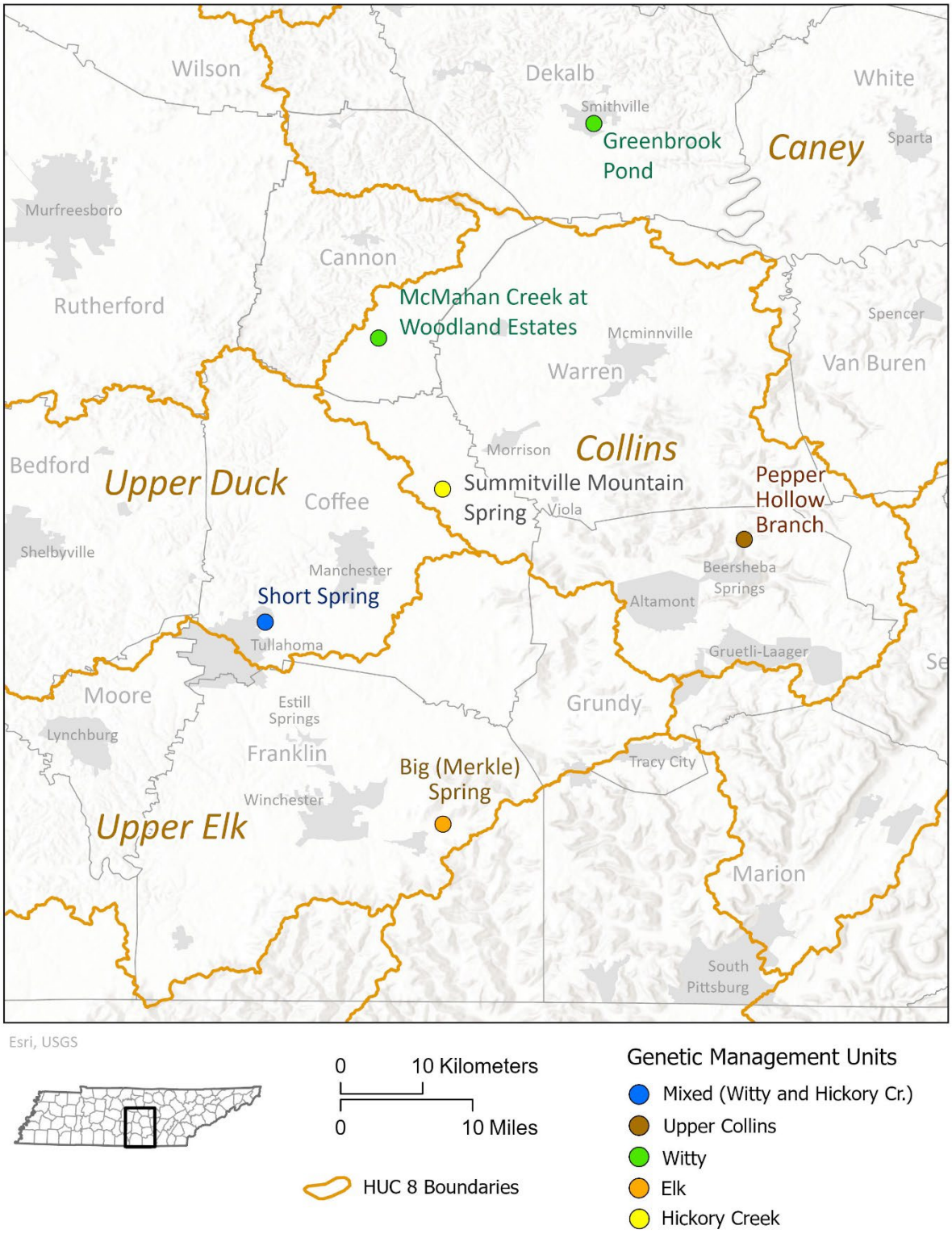

Figure 1: Map of extant Barrens topminnow sites and their respective GMUs

II. RECOVERY STRATEGY

The recovery strategy provides a concise overview of the envisioned recovered state for Barrens topminnow, describes the Service's chosen approach to achieve it, and includes the rationale for why the approach was chosen. Specifically, the recovery strategy articulates how the plan's statutory elements (e.g., recovery criteria, recovery actions, and estimates of time and cost) will work together to achieve Barrens topminnow's recovery.

Our goal is to maintain the existing populations at moderate resilience or higher, increase the number of resilient populations in each management unit, and establish mechanisms to manage threats into the future. At this time, redundancy is low for the Barrens topminnow, since the four GMUs are restricted to six isolated sites occupied by small populations, only one may have high resiliency.

Resiliency

For Barrens topminnow populations to withstand normal variation in environmental conditions and demographic processes, as well as periodic disturbances from drought, it will be necessary to reduce threats that are currently limiting population growth. Resilient populations of topminnows need large numbers of individuals, consistent recruitment of juveniles, and to inhabit multiple, connected springs for spatial complexity. These habitats must be drought resistant and free of invasive mosquitofish. Once established, resilient sites need to provide sufficient habitat (clean, clear water with stable temperatures, aquatic vegetation suitable for egg laying, and presence of surrounding riparian vegetation) to support a population of topminnows independent of regular stocking.

We will work with partners to catalog site-specific threats, deny mosquitofish access to springs, maintain ark populations for the four management units, provide wells to maintain water levels during drought, and reduce habitat degradation from livestock and development. It is a high priority to create mosquitofish passage barriers with the help of the Tennessee Wildlife Resources Agency (TWRA), Great Smoky Mountains National Park (GSMNP), and the Natural Resources Conservation Service (NRCS), where practical, to protect existing and create additional mosquitofish-free sites from invasion. These barriers should be situated with an effort to maintain connectivity to allow for natural recolonization and access to refugia during droughts within spring systems, where possible. At drought affected sites, it is high priority to work with NRCS, TWRA and Tennessee Tech University (TTU) to establish wells to maintain water levels and prevent future extirpation of those sites. Additionally, the maintenance of ark populations for each management unit, in cooperation with Dale Hollow and Wolf Creek National Fish Hatcheries (NFHs), Tennessee Aquarium Conservation Institute (TNAQUA) and Conservation Fisheries, Inc. (CFI), is another priority action to support Barrens topminnow resiliency by providing a suitable source of fish to augment or reestablish various sites in the case of a stochastic event. Habitat improvements, such as livestock exclusion, and bank stabilization will also be necessary at some sites, though less of a priority. To inform decisions about the relative priority of implementing or modifying specific actions for individual populations and the species

overall, we will work with TWRA and others to monitor existing topminnow populations and assess additional potential sites to determine the effectiveness of actions taken to reduce threats and determine where new sites should be established.

Redundancy

Redundant populations inhabit multiple, connected springs for spatial complexity allowing for a species to withstand catastrophic events. In the case of the Barrens topminnow, likely events include extreme droughts across the range of the species, floods overtopping barriers allowing mosquitofish access, or stochastic events that may impact only a sub watershed. To provide effective redundancy, existing populations and others that are discovered or established through recovery efforts in the future must be resilient to variability in demographic processes and environmental conditions, primarily drought events. To maximize benefits of redundancy, habitats will be managed to enhance connectivity of sites within each management unit to maintain gene flow and increase the likelihood for natural recolonization of sites from which the species has been lost.

Topminnows have been historically collected from more than 30 natural sites across their known range and it is likely that without mosquitofish, such a distribution of interconnected sites would provide sufficient redundancy for the species if they could move freely within the each of the watersheds. Currently, there are only six isolated sites extant across the four GMUs, and to achieve recovery more sites will be required in each. Within the Elk River watershed, the species was only known from Pond Spring, which is a very large (0.8 hectares, >2 acres) site with high quality and complex habitat. Without re-establishing a population at Pond Spring, or a similarly large and complex site, multiple smaller sites will be needed to support redundancy and ensure persistence of the Elk River GMU. Within the other GMUs, connectivity will need to be established between sites allowing for the species to withstand catastrophic events. Reestablishing interconnected streams, either naturally or human facilitated, will assure that recolonization will occur after potential future extirpation events.

We will collaborate with TWRA, TNAQUA, CFI, TTU, Tennessee Department of Environment and Conservation (TDEC), and private landowners to survey historical sites, as well identify potential new sites for topminnows, and assess habitat availability and threat prevalence, with the aim of establishing additional populations. Some sites will require restoration before topminnows can be reestablished. Where mosquitofish are present, we will work with TWRA and GSMNP to remove mosquitofish and create barriers to prevent recolonization. Higher priority will be given to maintaining existing populations over establishing new ones. The highest priority for rediscovering or reestablishing sites is to find or reestablish an additional Elk River population. We will coordinate with the NFHs, TNAQUA, and CFI to maintain ark populations for the four GMUs (Hickory Creek, Witty Creek, Upper Collins River, and Elk River) to provide a ready source for reintroductions and augmentations. In addition to managed arks at hatcheries and aquaria, it may be beneficial to create self-sustaining, artificial refugia, such as livestock watering tanks within the native range of the species. To fully realize the benefit of increased redundancy, we will work to increase connectivity for Barrens topminnows between sites within

spring systems, providing a natural mechanism for reestablishing populations lost to stochastic events.

Representation

To recover the species, it will be necessary to maintain representation of the four GMUs to avoid further erosion of the limited genetic variation available for the species to adapt to environmental change. Under current climatic models, Middle Tennessee is projected to experience a slight warming trend with increased precipitation extremes (*i.e.,* both more extreme droughts and more flooding) in the future. The species has experienced multiple bottleneck events in both recent and historic periods due to reduced connectivity and isolated headwater habitat resulting in a loss of genetic diversity. The isolated populations must be managed for gene flow to minimize the chances of inbreeding depression and genetic drift. Additionally, the unique four GMUs must each be maintained to maximize the genetic diversity of the species as a whole.

To maintain the representation of the Barrens topminnow in order to sufficiently adapt to changing environmental conditions over time, we will work with the NFHs, TWRA, TNAQUA, CFI, TDEC, and private landowners to preserve the four GMUs on the ground and as ark populations. Maintaining ark populations is a high priority activity for preventing the loss of any of these representative units, especially the Elk River and Hickory Creek units, where the limited number of populations creates a high risk of extinction for each management unit. To ensure genetic diversity and the effective population sizes are being sustained, we will prioritize collaboration with these partners as well as TTU researchers to conduct genetic monitoring of the ark and in situ populations, and based on the results, facilitate gene flow between individual sites within the management units, if prudent. We will also investigate the utility of incorporating the genes from individuals in the aquarium hobby in Europe into the controlled breeding program if appropriate with the help of our TTU colleagues.

Data Gaps and Uncertainty

At this time, there is still uncertainty on the conditions that may allow for resilient populations of Barrens topminnows to persist in contact with mosquitofish, if possible, but further research into the species needs as recommended in this Strategy and in the Actions will help answer this. It is also unclear to what extent water withdrawals contribute to reduced spring discharge during droughts, but studies of the aquifers contributing to the Barrens topminnow's spring habitat will help address this potential threat. In order to manage the wild and ark populations for the extant GMUs, further, ongoing genetic analysis will be necessary and will help inform the genetic management plan suggested in the Actions.

III. RECOVERY CRITERIA

Recovery criteria are statutorily required objective, measurable descriptions of a recovered state for Barrens topminnow, as described in 4(f)(1)(b)(ii) of the Act. Recovery criteria describe the conditions of resiliency, redundancy, representation, and threat abatement that indicate when Barrens topminnow may no longer meet the Act's definitions of an endangered species or

threatened species. Recovery criteria present our best estimate of a species' recovered condition at the time of recovery plan development. Changes in available information, technologies, and our understanding of the species over time might mean that the recovered state envisioned by the recovery criteria differs from our assessment in a later status determination.

Given the landscape scale distribution of mosquitofish within the limited and disconnected headwater habitat of the Barrens topminnow, recovery of the species will be contingent on continued, intensive human management and monitoring. With this in mind, it is necessary that we establish systems to ensure that maintenance activities necessary to the persistence and genetic health of Barrens topminnow populations continue into the future.

RECOVERY CRITERIA

The following recovery criteria for delisting, when met collectively, would indicate that Barrens topminnow may no longer need the protections of the Act:

Recovery Criterion 1:

1. Three to five sites for each of the recognized genetic management units exhibit consistent recruitment (two or more age classes with young of the year present) and stable or increasing trends in monitoring scores (habitat quality, abundance, threats) over a 12-year period (Factors A and E).

Rationale for Criterion 1

For this species, four GMUs are maintained as separate metapopulations. The individual occupied sites are isolated from one another and are counted as separate populations for the purpose of recovery, and the number of populations needed my vary by GMU based on size of individual sites. These populations may be augmented from other populations or arks within the same GMU to reduce the possibility of genetic drift. At this time, there are six sites occupied within the four GMUs. To maintain species level representation, each GMU must have redundant populations with proven resiliency, and it will be necessary to measure this resiliency over the at least 12 years, based on the repeated patterns of measurable population change for the species studied by Ennen et al. (2021, p. 463). Site resiliency should be assessed using a standardized monitoring framework, such as used by Kuhajda et al. (2014, p.5).

Recovery Criterion 2:

2. Threats to populations from mosquitofish, drought and water withdrawal, habitat degradation, and genetic degradation are managed across all GMUs with durable conservation management agreements and a framework for measuring the implementation of these efforts (Factors A, C, D, and E).

Rationale for Criterion 2

Invasive species, drought, and habitat modification are the greatest threats to the survival of Barrens topminnows. The isolated nature of the springs can result in genetic drift and inbreeding depression if not managed. In order for existing populations to persist, and for new populations to meaningfully contribute to the recovery of the species, threats have to be addressed with a plan for continuity for a management dependent species like the topminnow. Management plans and agreements must have committed partners, sources of funding for continued work, and the ability to ensure such agreements are maintained. Agreements and plans must be binding, such that necessary conservation actions for the species continue after removal of ESA protection, with a reliable way to measure their implementation.

Recovery Criteria 3:

3. Ark populations or self-sufficient artificial refugia are established for each genetic management unit and maintained in accordance with a species propagation and reintroduction plan developed with partners. Support for the maintenance of these arks and/or refugia should be insured to continue until these external populations are no longer necessary for the continuation of the species. (Factors C and E).

Rationale for Criterion 3

In addition to the need for ongoing management of threats, the isolated nature of Barrens topminnow habitat requires that safeguards against catastrophic events be established. The establishment of self-sustaining, *ex situ* populations has proven useful for other spring endemic species. Such populations can act as broodstock sources for future reintroductions or refugia during extreme conditions. These can take the form of cattle watering tanks isolated from main water courses, purpose-built mesocosms, or directly managed ark populations. These refugia must be established and maintained to standards that ensure sufficient genetic mixing and population stability. These standards should be determined in coordination with the partners who will be establishing and managing such populations. In addition, sufficient, long-term funding sources, such as endowments, dedicated to the maintenance of these populations must be established in order to ensure continued efforts following delisting, or until no longer needed for the persistence of the species.

IV. PRIORITIZED RECOVERY ACTIONS

Recovery of Barrens topminnow will be accomplished through implementation of the site-specific recovery actions summarized in Table 1. We assign recovery action priority numbers (1-3) to each action. The assignment of priorities does not imply that some recovery actions are of low importance, but instead implies that lower priority items may be deferred while higher priority items are being implemented.

Actions will reduce or eliminate the stressors identified in the listing rule (as derived from the SSA; not all stressors identified in the SSA may affect whether the species should be endangered or threatened). Completing the actions should contribute to meeting the quantitative measures set in the recovery criteria.

Table 1. Summary of recovery actions.

Related Recovery Criterion/a ID Number	Recovery Action Priority Number	Recovery Action ID Number	Recovery Action Summary	Recovery Action Description	Potential Partners	Estimated cost
All	1	1	Establish a reintroduction and management framework throughout the species range and continue to manage ark populations for the species.	To reintroduce the Barrens topminnow onto private lands and manage those habitats, we need a plan to manage the efforts as well as agreements to provide assurances to landowners and guarantees of continuity to managers, such as in the form of a Conservation Benefit Agreement, landowner agreements, or similar. Ark populations should be maintained at multiple facilities to provide fish for reintroduction and preventing extinction.	TWRA, FAC, land trusts, CFI, TNAQUA, TNWR, landowners	$3,500,000
1 and 2	1	2	Install mosquitofish barriers	Where suitable, barriers should be installed to prevent mosquitofish invasion, or create the opportunity to remove mosquitofish from existing areas. A repeatable framework should be developed to	TWRA, TDEC, FAC, GSMNP, TNWR, TDEC, landowners	$1,750,000

				assess, design, and install these barriers		
2	1	3	Install emergency water supplies	Where sites are threatened by drought, install wells or other alternative water supplies.	USGS, NRCS, FAC, TDEC, landowners	$28,000
1 and 2	1	4	Survey existing and potential sites	Annually monitor existing Barrens topminnow sites using standardized methodology to determine trends and identify threats. Survey for new populations and potential reintroduction locations. These efforts would benefit from the aid of habitat modeling and rapid sampling methods such as environmental DNA.	TWRA, CFI, TNAQUA, TTU, landowners	$400,000
All	1	5	Reintroduce topminnows into prepared sites	Where topminnows have been eliminated, or at unoccupied locations within the historic range, after the site has been protected from mosquitofish and the hydrology determined to be suitable, propagated Barrens topminnows should be reintroduced to create new occupied sites	TWRA, CFI, TNAQUA, FAC, landowners	$1,000,000
All	1	6	Conduct genetic monitoring and management	Monitor wild, hatchery, and *ex situ* populations for genetic drift to inform broodstock management every 3 years. Translocate adults between sites within GMUs to reduce genetic drift. If analysis supports, incorporate overseas individuals into to the Hickory Creek GMU	TTU, FAC, CFI, TNAQUA, possibly international partners	$450,000

All	2	7	Conduct landowner outreach	Contact landowners about participating in reintroduction and species recovery activities.	TWRA, land trusts, NRCS, CFI, TNAQUA, FWS, TTU	$200,000
All	2	8	Research species needs	Investigate species habitat needs to better prioritize reintroduction and habitat enhancement projects, and determine carrying capacity of sites to inform population dynamics	TTU, TNAQUA, CFI, TWRA, FAC, USGS	$500,000
2 and 3	2	9	Establish *ex situ* refugia	Establish self-sustaining populations on public or private land fully isolated from mosquitofish and with reliable water sources, such as livestock watering tanks or raceways. Research is needed to inform the best way to create sustainable populations needing limited intervention.	FAC, TTU, TWRA, TNAQUA, CFI	$50,000
All	3	10	Secure long-term funding for managing ark populations and wild populations	Secure endowment to fund survival dependent management activities for the species, such as site, ark population and genetic management, beyond the potential delisting of the species.	All	$1,5000,000
All	3	11	Public outreach and education	Community ownership in the well-being of this narrowly endemic species is necessary for full recovery. Without local eyes and ears, we may never know of additional sites and unexpected threats that occur.	All	$40,000
Total estimated Cost						**$8,918,000**

Partner Abbreviations: Tennessee Wildlife Resources Agency (TWRA), Tennessee Aquarium (TNAQUA), Conservation Fisheries, Inc. (CFI), Tennessee Tech University (TTU) U.S Fish and Wildlife Service (FWS), FWS branch of Fisheries and Aquatic Conservation (FAC), Tennessee National Wildlife Refuge (TNWR), National Resources Conservation Service (NRCS), U.S. Geological Survey (USGS), Tennessee Department of Environment and Conservation (TDEC), Great Smoky Mountains National Park (GSMNP).

Estimated Cost of Delisting: The estimated costs associated with implementing recovery actions for delisting are $8,918,000. Cost estimates reflect costs for specific actions needed to achieve Barrens topminnow recovery. Some costs for recovery actions are not determinable at this time; therefore, the total cost for recovery may be higher than this estimate.

Date of Recovery: The estimated date of recovery is 2065. If new sites and funding for reintroduction can be consistently found, renovated with a barrier and stocked every two to three years, then monitored, the criteria should be reachable in 40 years. As more is learned about this species and its threats and recovery actions are implemented and funded with the close cooperation of partners, the Service will carefully monitor and assess progress toward recovery to ensure that recovery goals are tracked, evaluated, and modified, if necessary.

V. Literature Cited

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