U.S. FISH AND WILDLIFE SERVICE
SPECIES ASSESSMENT
AND LISTING PRIORITY ASSIGNMENT FORM

SCIENTIFIC NAME: *Lasmigona holstonia*

COMMON NAME: Tennessee Heelsplitter

LEAD REGION: R4 (Southeast)

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DATE INFORMATION CURRENT AS OF: December 13, 2022

STATUS/ACTION

_x__ Species petitioned for listing which we have determined does not warrant listing (does not meet the definition of a threatened or endangered species)

Petition Information:
_x__ Petitioned; Date petition received: April 20, 2010
90-day "substantial" finding: September 27, 2011 (76 FR 59835)

PREVIOUS FEDERAL ACTIONS:
On April 20, 2010, we received a petition from the Center for Biological Diversity, Alabama Rivers Alliance, Clinch Coalition, Dogwood Alliance, Gulf Restoration Network, Tennessee Forests Council, and West Virginia Highlands to list 404 aquatic, riparian, and wetland species, including Tennessee Heelsplitter (*Lasmigona holstonia*), as endangered or threatened species under the Act. On September 27, 2011, we published a 90-day finding (76 FR 59836) that the petition contained substantial information indicating listing may be warranted for the species. This document constitutes our 12-month finding on the April 20, 2010, petition to list Tennessee Heelsplitter under the Act.

ANIMAL GROUP AND FAMILY/PLANT GROUP, ORDER AND FAMILY: CLAMS, Unionoida, Unionidae

BIOLOGICAL INFORMATION

Species Description

The Tennessee Heelsplitter (*Lasmigona holstonia*) is a small, thin-shelled freshwater mussel occurring along river margins and in small headwater streams in Virginia, Tennessee, Georgia, Alabama, and historically in North Carolina. Individuals become reproductively active at approximately three years, have a lifespan of 20-30 years, and grow up to 3 inches (75 mm) in length. Adults are yellowish to greenish brown, becoming darker brown with age (Figure 1).

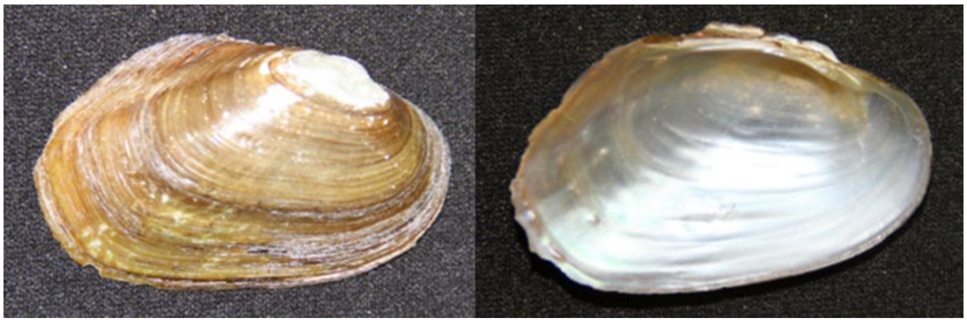

Figure 1. Tennessee Heelsplitter specimen (GDNR).

For more information on the species description, see section 2.1 of the SSA Report (Service 2022, pp. 4-5).

Taxonomy

The Tennessee Heelsplitter (*Lasmigona holstonia*) is in the phylum Mollusca, class Bivalvia. Recent studies indicate the genus *Lasmigona* is polyphyletic, which means it is derived from more than one common ancestor, and some species currently in the genus may be reassigned in the future based on reproductive traits (King et al. 1999, p. S65; Breton et al. 2011, p. 1653).

There is some taxonomic uncertainty regarding the Tennessee Heelsplitter populations in the Cumberland River system, as well as in populations of the upper Duck and Elk River drainages within the Tennessee River system (Campbell and Harris 2006, p. 7). These possibly represent a closely related undescribed species with morphological and slight life history differences. Specimens collected from these populations of Tennessee Heelsplitter are often referred to as the Barrens Heelsplitter or Toesplitter in some reports and publications (*Lasmigona* sp. or *Lasmigona* sp. cf. *holstonia*) (Layzer et al. 1993, p. 67; Neves et al. 1997, p. 50; Ahlstedt et al. 2017, p. 50). This potential differentiation is not formally described, nor does it have genetic data to support recognition. The Barrens Heelsplitter is also not currently accepted as a species by the scientific community; as such, we include this variant as a form of the Tennessee Heelsplitter (Williams et al. 2017, p. 41).

Another species, *Lasmigona diversa*, was described from the Tennessee River system by Timothy Conrad in 1856. While the Barrens Heelsplitter may represent the Tennessee Heelsplitter, *Lasmigona diversa* is currently not recognized as a valid species or synonym of the Tennessee Heelsplitter. The Etowah Heelsplitter (*Lasmigona etowaensis*), which was formerly considered a subspecies of the Tennessee Heelsplitter (*Lasmigona holstonia etowahensis*), was recently separated from the Tennessee Heelsplitter based on distribution and genetic analyses; it was elevated to species status (Williams et al. 2017, p. 50). The Etowah Heelsplitter is now recognized as a different species, and occurs only in the Mobile Basin, where it replaces the Tennessee Heelsplitter (Williams et al. 2008, p. 405).

Life History/Habitat

The Tennessee Heelsplitter becomes reproductively active at approximately age three (Barton 2011, p. 24). The lifespan of the Tennessee Heelsplitter is at least 24 years, and while the species might live longer, older females may have lower fecundity compared to younger individuals (Barton 2011, pp. 14-16). The species is likely bradytictic (Bogan 2017, p. 60), meaning the timing of spawning and brooding is long-term (Watters et al. 2001, pp. 544-545), with females gravid for several months between August and the following May (Neves 1991, p. 268; EPA 2008, p. 45; Womble and Rosenberger 2021, p. 21). Gravid specimens have been reported beginning in August; however, some populations, such as those in the Cumberland drainage, may begin spawning in the fall (Clarke 1985, p. 9; Pinder et al. 2002, p. 201). Long-term brooding species have advantages over short-term brooders in that their spawning period is much longer and females may have multiple broods. The Tennessee Heelsplitter is not considered to be sexually dimorphic, but because it is a long-term brooding species, gravid females may be found year-round or in most seasons. It is possible to discern gravid females, but not non-gravid females, from males. Sex ratios are therefore considered unknown, but it is assumed that sexes are equal in abundance in a population.

Tennessee Heelsplitter individuals, like most freshwater mussel species, broadcast free larvae called glochidia (Barnhart et al. 2008, p. 374). Reproduction begins with males releasing sperm into the water column, which females siphon to fertilize their eggs (McMahon and Bogan 2001, p. 342). Females brood the fertilized eggs in their gills until they become mature glochidia (Kat 1984, p. 190). Mature glochidia may be released when the female is disturbed by an appropriate host fish, attaching to the fins or gill filaments until they transform into juvenile mussels (Barnhart et al. 2008, p. 371). The Tennessee Heelsplitter has limited dispersal capability and broadcast glochidia into the water column to encounter a suitable fish host (Steg and Neves 1997, p. 34). The Tennessee Heelsplitter has been the subject of several fish host trials and has a high transformation rate on numerous fish species (see Appendix 1, Service 2022, p. 64). While broadcasting is considered a more ancestral reproductive strategy among mussels, high transformation rates on multiple fish species likely improves dispersal success.

The Tennessee Heelsplitter most often occurs in small streams that, unless a mussel population was previously documented, are infrequently surveyed for mussels. As a result, there is a lack of literature and reports citing Tennessee Heelsplitter population extirpation. In some situations, mainstem populations may be considered extirpated, but the Tennessee Heelsplitter persists in tributaries (Johnson et al. 2012, p. 88). Based on historical information from museum collections, there are locations where the species was collected pre-impoundment that no longer are suitable to support the Tennessee Heelsplitter, although habitat to support the species exists at the HUC-10 level; for this reason, none of the analysis units (AUs) are considered “extirpated” in our analysis.

For more information on the life history and habitat of the Tennessee Heelsplitter, see sections 2.4 and 2.5.1 of the SSA Report (Service 2022, pp. 6-9).

Historical and Current Range/Distribution

For information on the historical range of the Tennessee Heelsplitter, see section 2.5 of the SSA Report (Service 2022, pp. 7-9). The current distribution of the Tennessee Heelsplitter is consistent with historical distribution. The species occurs within three drainages: Tennessee, Cumberland, and New (Figure 2).

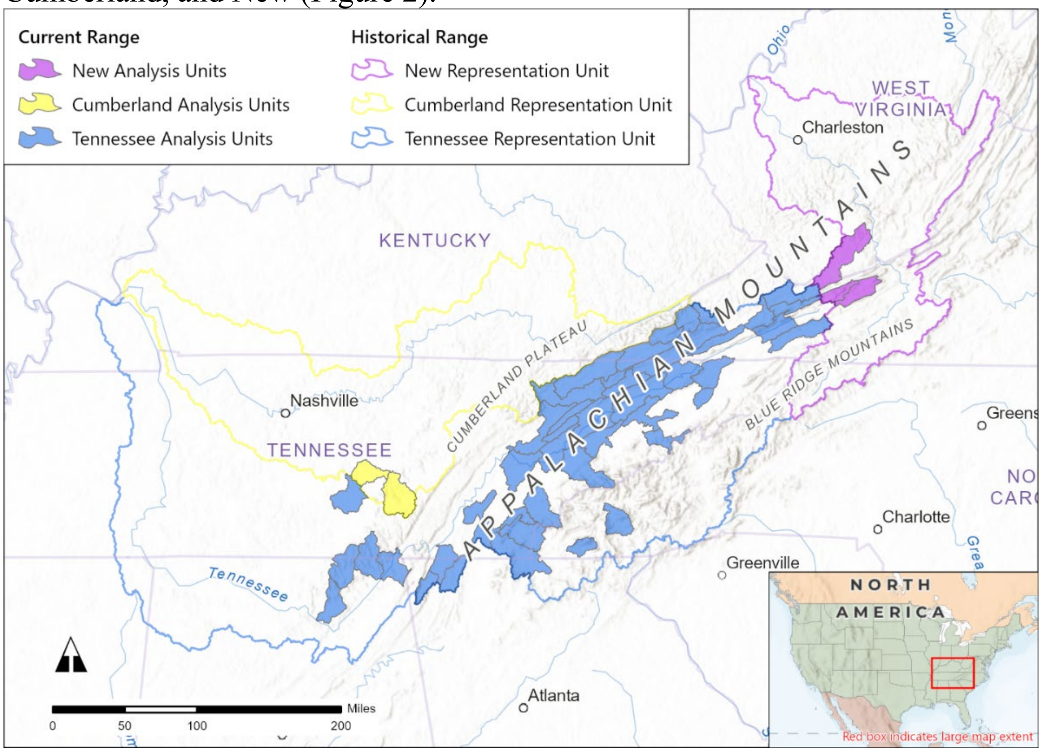

Figure 2. Map of current range of the Tennessee Heelsplitter.

Resource Needs

Resources influencing the successful completion of each life stage for Tennessee Heelsplitter individuals include abundant host fish, stable substrate, proximity to breeding individuals, small or headwater streams, water with neutral pH and little to no contaminants, spring-fed streams with low to moderate water flow, and water temperature range that allows for life history functions (Service 2016a, p. 12). Successful completion of each life stage affects the ability of populations to withstand stochastic events (resiliency), the species to withstand catastrophic events (redundancy) as well as adapt to changing environmental conditions by way of genetic exchange or respond to environmental diversity between occupied streams (representation).

The population and species-level resource needs of the Tennessee Heelsplitter include sufficient juvenile and breeding adult abundances with broad distributions, suitable and abundant host fish, and habitat connectivity. Resiliency of Tennessee Heelsplitter populations (which we defined as occupied stream reaches within AUs), as well as representation and redundancy of the species, are influenced by access to necessary resources.

For more information about individual, population, and species resource needs, see Chapter 3 of the SSA Report (Service 2022, pp. 10-15).

<u>SUMMARY OF BIOLOGICAL INFORMATIONFOR FEDERAL REGISTER</u>

The Tennessee Heelsplitter is a small freshwater mussel usually less than 50 millimeters (2 inches) long. The species is a freshwater mussel native to the New, Cumberland, and Tennessee River basins in Virginia, Tennessee, Georgia, Alabama, and historically North Carolina.

The Tennessee Heelsplitter predominantly inhabits spring-fed creeks and small headwater streams with stable substrates and good water quality. Resources influencing the successful completion of each life stage for Tennessee Heelsplitter include abundant host fish, stable substrate, proximity to breeding individuals, small or headwater streams, water with neutral pH and little to no contaminants, spring-fed streams with low to moderate water flow, and water temperature range that allows for life history functions (Service 2016a, p. 12). Successful completion of each life stage affects the ability of populations to withstand stochastic events (resiliency) and catastrophic events (redundancy), adapt to changing environmental conditions by way of genetic exchange, or respond to environmental diversity between occupied streams (representation).

The population and species-level resource needs of the Tennessee Heelsplitter include sufficient juvenile and breeding adult abundances with broad distributions, presence of suitable and abundant host fish, and habitat connectivity. Resiliency of Tennessee Heelsplitter populations (which we defined as occupied stream reaches within analysis units), as well as representation and redundancy of the species, are influenced by access to necessary resources.

FACTORS INFLUENCING THE STATUS

The Act directs us to determine whether any species is an endangered species or threatened species because of any factors (or threats) affecting its continued existence (i.e., whether it meets the definition of a threatened species or an endangered species). We use the term “threat” to refer to actions or conditions that are known to or are reasonably likely to negatively affect individuals of a species. The term “threat” includes actions or conditions that have a direct impact on individuals as well as those that affect individuals through alteration of their habitat or required resources. The term “threat” may encompass—either together or separately—the source of the action or condition, or the action or condition itself.

However, the mere identification of any threat(s) does not necessarily mean that the species meets the statutory definition of an “endangered species” or a “threatened species.” In determining whether a species meets either definition, we must evaluate all identified threats by considering the expected response by the species, and the effects of the threats—in light of those actions and conditions that will ameliorate the threats—on an individual, population, and species level. We evaluate each threat and its expected effects on the species, then analyze the cumulative effect of all the threats on the species as a whole. We also consider the cumulative effect of the threats in light of those actions and conditions that will have positive effects on the species—such as any existing regulatory mechanisms or conservation efforts. The Secretary determines whether the species meets the definition of an "endangered species" or a "threatened species" only after conducting this cumulative analysis and describing the expected effect on the species now and (if evaluating whether a species is a threatened species) in the foreseeable future.

Threats

Several influences affect the Tennessee Heelsplitter and may work synergistically to enhance or limit the species' viability. We focus on the influences included in the diagram below that were identified as having the greatest impact to current habitat suitability according to the literature and species experts, these include aquatic nuisance species, siltation/sedimentation, pollution and toxic spills, drought and floods, and impoundments (Figure 3). All influences listed in the diagram, apart from conservation actions, have adverse effects on habitat factors.

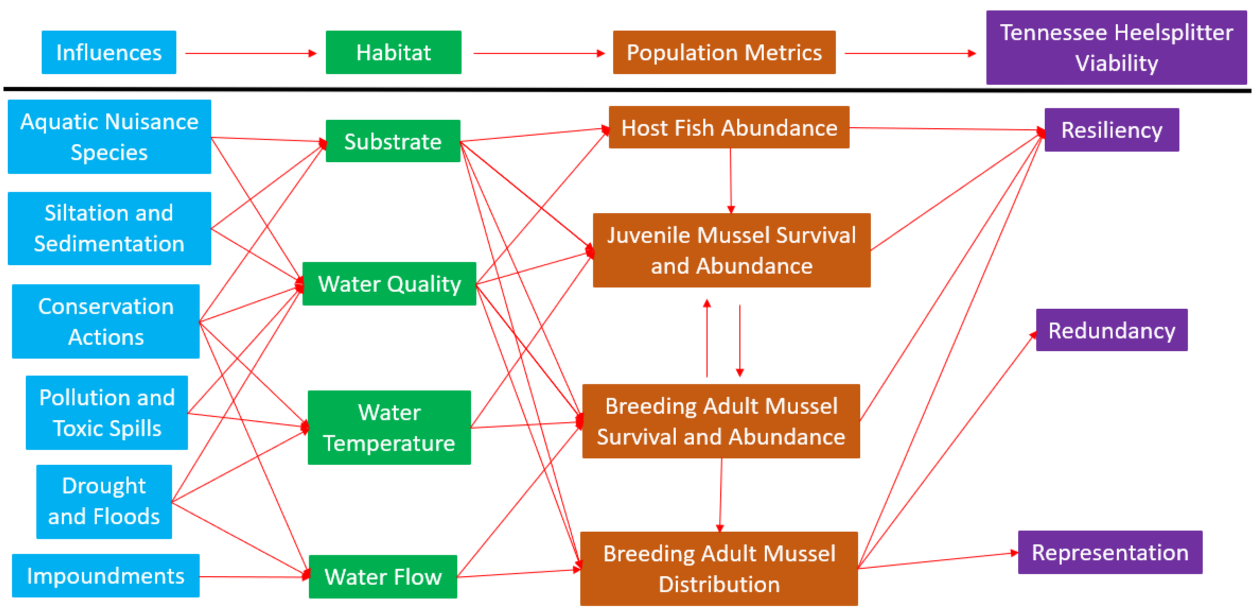

Figure 3. Influence diagram for the Tennessee Heelsplitter.

For details about the influences on Tennessee Heelsplitter viability, see Chapter 4 of the SSA Report (Service 2022, pp. 16-28). To communicate how some of the primary influences affect Tennessee Heelsplitter throughout the range, we developed a threat calculation matrix to characterize the risk for a given stressor (see CSAS 2014, entire). We considered the primary effect of the influence to the species, the spatial threat extent, the threat frequency, and the estimated overall level of impact.

These are broad categorizations intended to summarize current negative influences on the Tennessee Heelsplitter at the individual and population levels. These influences are evaluated individually and cumulatively since they may also be acting synergistically on some populations, which would be expected to increase the level of impact. However, all influences are not considered to be acting on all Tennessee Heelsplitter populations concurrently. While the magnitude of these threats may differ across Tennessee Heelsplitter populations, they likely affect populations similarly at the range wide level. Examples include timing of toxic spills, which are extremely difficult to predict; or rate of spread and densities of aquatic nuisance species, which can vary substantially and are driven by multiple biotic and abiotic factors, including repeated human introduction.

Aquatic Nuisance Species
Aquatic nuisance species (ANS) such as Asian clams affect the Tennessee Heelsplitter through competition for resources (Hakenkamp et al. 2001, pp. 495-497; Benson and Williams 2021, entire). Asian clams are found throughout the range, persist in native mussel habitat, and can reproduce much faster than Tennessee Heelsplitter. They have a widespread spatial extent, therefore have the potential to affect most Tennessee Heelsplitter populations. While the presence of Asian clam likely reduces overall resilience, they co-occur with Tennessee Heelsplitter in many locations. Therefore, we rated the level of impact as moderate.

Siltation and Sedimentation
Siltation and sedimentation degrade Tennessee Heelsplitter habitat. This species appears to be more tolerant of fine substrates than other species of freshwater mussels and can be found in depositional areas (Cordiero 2004, entire; Williams et al. 2008, p. 405). However, excessive sediment buildup can suffocate mussels, affect reproduction, or even affect groundwater availability (see Section 4.2, Service 2022, pp. 17-18). The spatial extent of this threat is widespread, affecting nearly all populations of Tennessee Heelsplitter, and the temporal frequency is considered continuous, or without interruption, thus this threat has a moderate level of impact, reducing species resilience, but populations are withstanding effects.

Pollution and Toxic Spills
Pollution and toxic spills contaminate Tennessee Heelsplitter habitat. These events are considered spatially localized, thus likely affect less than 50% of the populations in any given event (EPA 2022a, unpaginated). They also are considered temporally recurrent. For example, in the North and South Fork Holston River mainstems within the Tennessee River basin, toxic spills occur every year or frequently over long timeframes (Neves 1991, p. 268; EPA 1995, p. 7; WJHL 2022, entire). The Tennessee Heelsplitter persists in tributaries within these AUs and may have never been common in chronically affected river reaches. Acute events have a moderate level of impact, meaning they reduce resilience, but their effects can be difficult to measure and only through consistent surveys and dedicated research efforts are we able to track trends in mussel decline or recovery. This information is not generally available for Tennessee Heelsplitter populations (see section 2.5, Service 2022, pp. 7-9). Persistence of populations within the HUC (hydrologic unit code, or watershed) is considered an indication of resiliency.

Droughts and Floods
Droughts and floods have the potential to affect both Tennessee Heelsplitter habitat and population size. The spatial extent is localized, as any given drought or flood may not affect all populations due to underlying geology, and differ in timing, severity, or duration. Droughts can result in mussel stranding, and floods may result in either stranding or displacement (Vannote and Minshall 1982, p. 4,105; Tucker 1996, p. 435; Hastie et al. 2001, pp. 107–115; Peterson et al. 2011, unpaginated). However, the Tennessee Heelsplitter is frequently associated with spring-fed streams, which have a continuous source of groundwater and relatively stable flow regimes, so the species may be less affected by drought and floods due to preferred habitat. This threat is temporally considered recurrent, or happening periodically, and is least likely to reduce resilience, but highly dependent on the severity of the event and the location.

Impoundments
Impoundments, or dams, result in habitat loss, fragmentation, restricted host fish movement, and alteration of flow conditions (Haag 2009, p. 107). Impoundments affect habitat sometimes for large distances and on multiple tributaries, and isolate Tennessee Heelsplitter populations. Unregulated and free-flowing rivers and streams in the New, Cumberland, and Tennessee rivers are uncommon. Dams are widespread throughout the range of the species, but their effects on populations are linearly related to habitat alteration downstream and habitat loss due to lentic conditions upstream of the impoundment. These effects vary substantially depending on the location or size of the impoundment and a single dam may affect multiple rivers and streams.

In major rivers and many streams where there are a series of impoundments, mussel habitat is restricted to short linear reaches below the dam. The frequency of this threat is continuous because their presence continues to affect habitat long after construction. Of all threats to native freshwater mussels, the effects of dams are perhaps best documented, and it is indisputable they have a high level of impact. Where they are constructed, the population is not considered to be able to withstand the effect, although there may be a recovery gradient further downstream. Tennessee Heelsplitter population persistence despite the presence of dams throughout the range of the species is potentially a result of the species' preference for the headwaters of river systems, where impoundments are generally less common. The species also occurs in spring-fed streams, which are often ditched or used for farm pond construction, and the population is not able to withstand the permanent effects of changes from lotic (rapidly moving) to lentic (still) flow conditions. It is worth noting that leaky check dams constructed for flood control are the exception when considering impacts of dams, as they slow the flow and provide suitable habitat for Tennessee Heelsplitter (Watson, B. 2022, pers. comm).

<u>Conservation Measures and Existing Regulatory Mechanisms</u>
The Tennessee Heelsplitter is currently found in the New, Cumberland, and Tennessee River basins within the states of Alabama, Virginia, Georgia, and Tennessee. It has not been collected since 2002 in North Carolina and the state currently considers the status as unknown. Of the states where the Tennessee Heelsplitter occurs, it is protected by state law as endangered in

Virginia. Virginia has blanket protective regulatory measures for all native freshwater mussels, prohibiting take or possession without a scientific collector's permit.

A variety of additional designations or status descriptions are assigned to the Tennessee Heelsplitter in other states, making it unlawful for anyone to take, possess, transport, export, process, sell, offer for sale or ship, and for any contract carrier to knowingly transport or receive for shipment. However, these designations are typically accompanied by wildlife management agency mandates and are not state statutory protections.

The states of Alabama and Tennessee have designated river reaches where it is unlawful to take, catch, or kill freshwater mussels, and the degradation of aquatic habitat is prohibited. The actual protection afforded to mussels through these sanctuaries is limited without considerable enforcement and trained regulatory personnel. While these sanctuaries provide some indirect protection to mussels in the Clinch, Powell, and Duck River mainstems, they do not provide protection in tributaries where the Tennessee Heelsplitter commonly occurs. The Tennessee Heelsplitter is most often located in tributaries and small streams on private lands; commercial harvest is not considered a threat to the species.

Section 401 of the Federal Clean Water Act (CWA) requires Federal license or permit applicants to provide certification that any discharges from the facility will not degrade water quality or violate water-quality standards, including those established by states. Section 404 of the CWA establishes a program to regulate the discharge of dredged and fill material into waters of the United States. Permits to fill wetlands and fill, culvert, bridge, or re-align streams or water features are issued by the U.S. Army Corp of Engineers (USACE) under Nationwide Permits, Regional General Permits, or Individual Permits. These regulatory programs benefit Tennessee Heelsplitter by protecting water quality and instream habitat needs of the species.

Current State regulations regarding pollutants are designed to be protective of aquatic organisms; however, freshwater mussels may be more susceptible to some pollutants than the test organisms commonly used in bioassays (measurement of the concentration of a substance by its effects on living cells), and water quality criteria may not incorporate data available for freshwater mussels (March et al. 2007, pp. 2,066–2,067). A multitude of bioassays conducted on 16 mussel species show that freshwater mollusks are more sensitive than previously known to some chemical pollutants, including chlorine, ammonia, copper, fungicides, and herbicide surfactants (Augspurger et al. 2007, pp. 2,025–2,028).

The ANS Task Force, co-chaired by the Service and the National Oceanic and Atmospheric Administration (NOAA), encourages state and interstate planning entities to develop management plans describing detection and monitoring efforts of aquatic nuisance and nonnative species, prevention efforts to stop their introduction and spread, and control efforts to reduce their impacts. Management plan approval by the ANS Task Force is required to obtain funding under Section 1204 of the ANS Prevention and Control Act. These plans are a valuable and effective tool for identifying ANS problems and concerns under many jurisdictions and other interested entities. Each state within the current range of the Tennessee Heelsplitter has a plan. These plans have raised state-level awareness of the severity of ecological damage that nonnative and nuisance species are capable of, but many are in early stages of implementation.

The Reservoir Release Improvement (RRI) Program was initiated by Tennessee Valley Authority in 1988 at many large impoundments within the range of the Tennessee Heelsplitter. The RRI focuses on improvements in dissolved oxygen concentrations below dams, including initiating minimum flows (Higgins and Brock 1999, p. 4). The RRI program has resulted in improved dissolved oxygen, decreased bank erosion, and stabilized habitat in several river systems in the Tennessee River basin (Scott et al. 1996, p. 5). Despite these improvements, habitat conditions and thermal regimes below hydropower dams continue to be limiting for most mussel species (Layzer and Scott 2006, p. 475).

Cumulative Effects

We note that, by using the SSA framework to guide our analysis of the scientific information documented in the SSA report, we have analyzed the cumulative effects of identified threats and conservation actions on the species. To assess the current and future condition of the species, we evaluate the effects of all the relevant factors that may be influencing the species, including threats and conservation efforts. Because the SSA framework considers not just the presence of the factors, but to what degree they collectively influence risk to the entire species, our assessment integrates the cumulative effects of the factors and replaces a standalone cumulative-effects analysis.

The Tennessee Heelsplitter is exposed to a variety of stressors that can interact to affect the species synergistically, meaning that the effects of two or more stressors are more harmful than the effects of each stressor acting alone. Several significant interacting stressors can act in combination to cause shifts and declines in native aquatic communities through the introduction of invasive species, habitat loss, disease, and changing climate (Kernan 2015, pp. 326–330).

For example, an increase in water temperature can occur from an increase in air temperature. Increasing water temperatures and changes in precipitation can affect the quality of instream habitat. Water quality can also be negatively affected by an increase in precipitation and flood events. In addition, these stressors reduce the quality of instream habitat for the benthic community. Further, the range expansion of an invasive species (Asian clam), as the habitat becomes more suitable for invasive species from increasing temperatures and as more frequent flood events increase the spread of these species, can lead to an increase in competition with the Tennessee Heelsplitter. These synergistic effects are considered when assessing current and future conditions.

CURRENT CONDITION

To assess current condition, Tennessee Heelsplitter occurrence information was organized so multiple spatial scales could inform resiliency, redundancy, and representation analyses. In the absence of genetic information, we arranged occurrences into populations by occupied river or stream. For resiliency and redundancy, analysis units (AUs) were defined and displayed at the HUC-10 level. The AUs are the fundamental basis for our current condition analysis and discussion. For representation, we identified three representation units (RUs) for the Tennessee Heelsplitter corresponding with river drainages of occurrence: Cumberland, New, and Tennessee. Each RU contributes to the adaptive capacity of the species and are important components of assessing overall species' viability (Shaffer and Stein 2000, entire; Service 2016b, p. 23). We also evaluated species' adaptive capacity by scoring 36 attributes that describe the Tennessee Heelsplitter's ability to "persist in place" (Thurman et al. 2020, entire).

The Service's Species Range Project (SRP) developed a nationwide species distribution modeling platform specific to aquatic species using a variety of stream network and both catchment- and watershed-level abiotic landscape metrics. The SRP developed a model determining the amount of suitable aquatic habitat within the Tennessee Heelsplitter range. Using this model, we selected all HUC-10s, or AUs, that had known Tennessee Heelsplitter occurrences. Occurrences were incorporated if a live individual or fresh dead specimen was collected since 2000, or collections of the species were made in the 1990s with no recent negative mussel survey data to dispute that the species still occurs within the water body. The model determined the percent river miles per catchment that were deemed suitable habitat for the Tennessee Heelsplitter based on 12 predictor variables that are biologically relevant for the species and serve as proxies for the threats identified in Chapter 4 of the SSA Report (Service 2022, pp. 16-28). Thus, the habitat suitability accounts for the presence of all of the stressors to the species, except for ANS and dams, because they are not reflected in the model's environmental variables.

Current condition for each AU is determined by a combination of percent of river miles predicted as potentially suitable habitat and time since last confirmed observation; the "point values" of each suitability and observation level result in a combined score that ranks the overall current condition of each AU. AUs with recent species observations scored higher than those that have not yet been surveyed or do not have recent surveys. While all AUs have suitable habitat (and thus, some level of resiliency and redundancy), this amount varies across the range of the species. Therefore, current condition for each AU is ranked as moderate, high, or most resilient in terms of habitat suitability for the species. All AUs have some level of suitable habitat, which is why the lowest rank is "moderate." Current condition is represented by moderate to high to most resiliency in terms of suitable habitat available to the species, with the "high" and "most" resiliency categories having confirmed species presence.

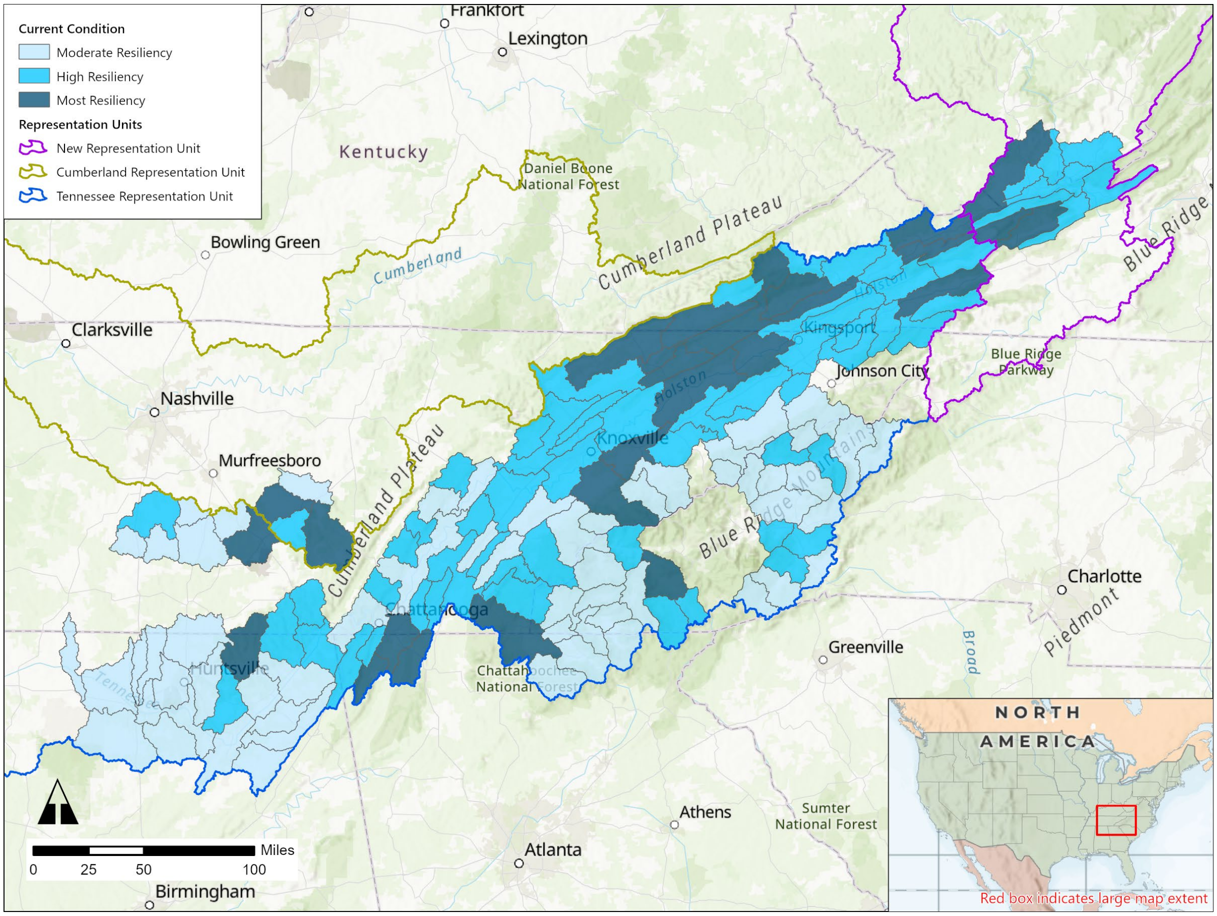

Figure 4. Current condition of AUs for the Tennessee heelsplitter throughout the range.

Across the range, there are varying levels of suitable habitat to help the species maintain viability (Figure 4). Our model indicates the Tennessee Heelsplitter in all RUs has the capability to withstand stochastic events. AUs with a current condition level of high or most resilient (60%, n=88) indicate large percentages of suitable habitat, or high estimated resiliency. In the Cumberland RU, three AUs (75%, n = 4), 75 AUs in the Tennessee RU (57%, n = 132), and all the AUs in the New RU (100%, n = 10) are in high or most resilient condition level. There are also moderately resilient AUs in the Cumberland RU (25%, n = 1) and Tennessee RU (43%, n = 57).

The areas for the Tennessee Heelsplitter, considered strongholds due to their numerous occurrences, are in the New and northeast Tennessee RUs, and most AUs with "high" or "most" resiliency have some level of connectivity of suitable habitat which is essential for species viability. Redundancy, or the number and distribution of AUs with suitable habitat, is high, as our analysis indicates that suitable habitat exists throughout the range of the Tennessee Heelsplitter. Representation is maintained across all three RUs of historical and current occurrence, the Cumberland, New, and Tennessee. Additionally, available information indicates the species' adaptive capacity will ensure survival despite predicted climate impacts (see section

5.5.3 and Appendix 4 of SSA Report (Service 2022, pp. 40-41, 72-75), particularly because of the strong association with spring-fed streams that can act as cold-water and drought refugia in the face of climate change.

For more details on the current condition analysis, see Chapter 5 of the SSA Report (Service 2022, pp. 29-42).

FUTURE CONDITIONS

We focused our future conditions analysis on how land use/land cover (LULC) changes, as well as climate change, impact resiliency, redundancy, and representation in the future. Outlined in Chapter 4 of the SSA Report, primary factors influencing the viability of the Tennessee Heelsplitter include siltation and sedimentation; pollution and toxic spills; drought and floods; aquatic nuisance species, particularly the Asian clam; and impoundments. These influences may be affected by LULC, or climate change, which in turn indicate future habitat suitability for the Tennessee Heelsplitter.

All AUs currently have suitable habitat, but land use change may reduce current levels of suitable habitat (i.e., resiliency) in the future. As such, future condition includes a ranking of “reduced” resiliency in addition to “moderate”, “high”, or “most” resiliency. In our analysis, we considered two 20-year intervals, and an estimated future time frame of 40 years (out to 2060). This timeframe was chosen based on data availability and our understanding of the heelsplitter’s response to these threats in the future.

We considered climate and development future scenarios using the EPA’s Integrated Climate and Land-Use Scenarios (ICLUS), which explore future changes in global emissions and human population, housing density, and impervious surface for the U.S. through shared socioeconomic pathway scenarios (SSPs) (EPA 2022b, unpaginated). The different population and land use change scenarios stem from global population and development assumptions underlying different future trajectories from the SSPs. We considered two scenarios (SSP2 and SSP5) to bracket the lower emission and higher emission scenarios at timesteps 2040 and 2060 (Service 2022, p. 44). We assumed that increases in future development would include changes in both stochastic and catastrophic events that could affect the species and its habitat.

Our analysis of future conditions for the Tennessee Heelsplitter projects slight changes to levels of suitable habitat and overall resiliency throughout the range of the species (Figures 5 and 6). Under SSP2, habitat suitability decreases in 7 AUs by 2040, and 13 AUs by 2060. Under this lower emission future scenario, in 40 years (2060), it is projected that 91% of AUs (n=133) will maintain varying levels of suitable habitat for the Tennessee Heelsplitter. However, 5% of AUs (n=7) are projected to have less suitable habitat than under current conditions, and 4% of AUs (n=6) (all located in the Tennessee RU), will no longer have suitable habitat.

Under SSP5, habitat suitability decreases in 19 AUs by 2040, and 32 AUs by 2060. Under this higher emission future scenario, in 40 years (2060), 77% of AUs (n=113) will maintain varying levels of suitable habitat for the Tennessee Heelsplitter. However, 9% of AUs (n=13) will have less suitable habitat than under current conditions, and 14% of AUs (n=20) will no longer have suitable habitat for the species. Decreases in suitable habitat could mean reduced resiliency for the Tennessee Heelsplitter; however, our analysis shows that by 2060, 77-91% of the Tennessee Heelsplitter's range is predicted to maintain varying levels of suitable habitat to sustain the species.

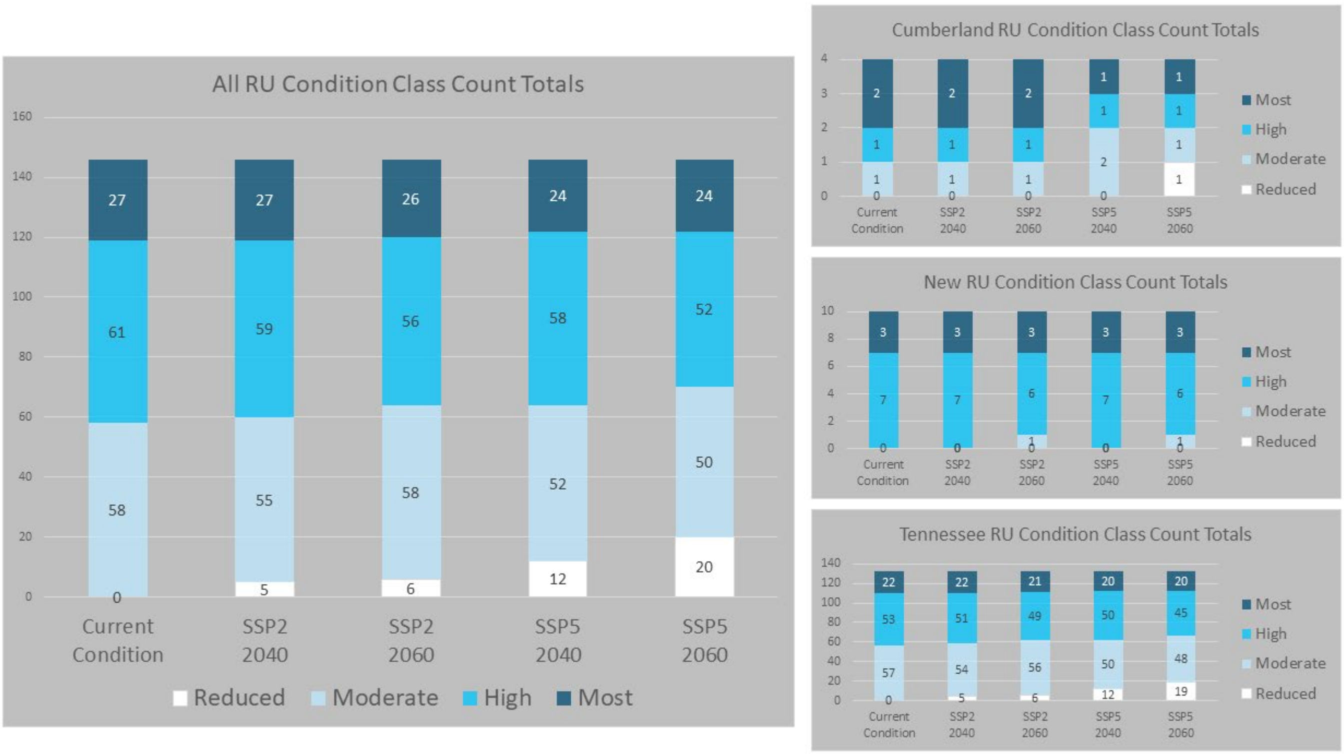

Figure 5. Resiliency totals (combined and by RU) for current condition and at timesteps 2040 and 2060, under two future scenarios SSP2 and SSP5.

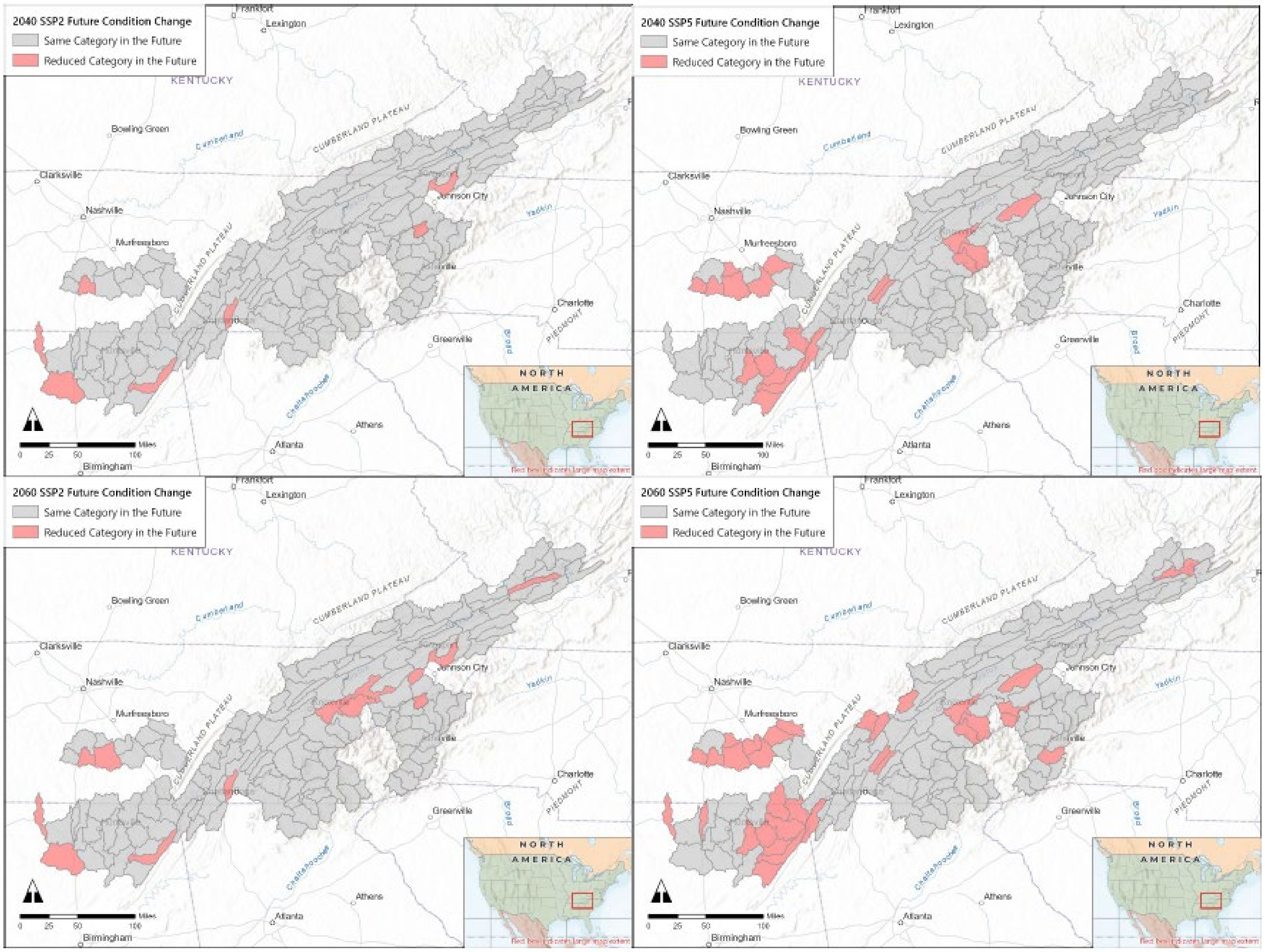

Figure 6. Future habitat suitability change by AU (defined by watershed), at timesteps 2040 and 2060, under two future scenarios SSP2 and SSP5.

With resiliency, or suitable habitat, maintained rangewide, it is also projected that the concentration of AUs with high resiliency in the southwestern Virginia and northeastern Tennessee strongholds will remain intact. Connectivity of these resilient AUs within the upper Tennessee RU bolster the likelihood of Tennessee Heelsplitter persistence into the future. In the future, stochastic events associated with threats to the species will likely affect suitable habitat in portions of the range, and these are more likely to occur or be observed in developed areas. However, our future condition projections indicate Tennessee Heelsplitter resiliency is sufficient to withstand environmental stochasticity, due to prevalent suitable habitat and life history traits that reduce risk currently and into the future.

The New and Tennessee RUs currently have the largest number of most resilient AUs. All RUs maintain at least 91% AUs with high suitable habitat condition under future condition SSP2 and 77% AUs with high suitable habitat condition under SSP5 future condition projections. Multiple

AUs maintain resiliency in future condition projections across RUs and are likely to help buffer changes in environmental conditions through 2040 and 2060.

The Tennessee Heelsplitter has several life history traits that allow it to adapt to changing conditions, such as the capability to transform on a wide variety of common host fish species, occurring in varying stream sizes, as well as tolerance of silty and sandy substrates and depositional areas with low flows. Spring-fed streams where the Tennessee Heelsplitter is most frequently located are ubiquitous throughout the species range and have year-round groundwater contributions with continuous flow and comparatively stable temperature regimes. These characteristics are expected to help the Tennessee Heelsplitter persist in most AUs throughout the range into the future and withstand projected climate effects.

Additionally, the Tennessee Heelsplitter can be locally abundant, and therefore when considering its occurrence in headwater streams, the result could potentially be large populations in multiple tributary streams within AUs. The dendritic populations in small headwater streams increases the species redundancy and may enable the species to withstand stochastic and potentially catastrophic events such as contaminant spills, which are likely to increase in developed land use areas in the future.

As noted above, our representation analysis indicates that there are many aspects of Tennessee Heelsplitter life history and ecology that will enable the species to persist in place in the future, and that representation in RUs will be maintained throughout the range. We do not expect future representation, or adaptive capacity, to change through 2060. As such, future predicted resiliency and redundancy will continue to be high, and representation for the Tennessee Heelsplitter will be maintained through 2040 and 2060.

For more details on the future conditions analyses, see Chapter 6 of the SSA Report (Service 2022, pp. 43-52).

FINDING

<u>Regulatory Framework</u>
Section 4 of the Act (16 U.S.C. 1533) and its implementing regulations (50 CFR part 424) set forth the procedures for determining whether a species is an "endangered species" or a "threatened species." The Act defines an endangered species as a species that is "in danger of extinction throughout all or a significant portion of its range," and a threatened species as a species that is "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." The Act requires that we determine whether any species is an "endangered species" or a "threatened species" because of any one or a combination of the following factors:

(A) The present or threatened destruction, modification, or curtailment of its habitat or range;

(B) Overutilization for commercial, recreational, scientific, or educational purposes;

(C) Disease or predation;
(D) The inadequacy of existing regulatory mechanisms; or
(E) Other natural or manmade factors affecting its continued existence.

These factors represent broad categories of natural or human-caused actions or conditions that could affect a species' continued existence. In evaluating these actions and conditions, we look for those that may have a negative effect on individuals of the species, as well as other actions or conditions that may ameliorate any negative effects or may have positive effects.

The Act does not define the term "foreseeable future, which appears in the statutory definition of "threatened species." Our implementing regulations at 50 CFR 424.11(d), as revised in 2019, set forth a framework for evaluating the foreseeable future on a case-by-case basis. The term "foreseeable future" extends only so far into the future as we can reasonably determine that both the future threats and the species' responses to those threats are likely. In other words, the foreseeable future is the period of time in which we can make reliable predictions. "Reliable" does not mean "certain"; it means sufficient to provide a reasonable degree of confidence in the prediction. Thus, a prediction is reliable if it is reasonable to depend on it when making decisions.

It is not always possible or necessary to define the foreseeable future as a particular number of years. Analysis of the foreseeable future uses the best scientific and commercial data available and should consider the timeframes applicable to the relevant threats and to the species' likely responses to those threats in view of its life-history characteristics. Data that are typically relevant to assessing the species' biological response include species-specific factors such as lifespan, reproductive rates or productivity, certain behaviors, and other demographic factors.

Status Assessment

Status Throughout All of Its Range
After evaluating threats to the species and assessing the cumulative effect of the threats under the section 4(a)(1) factors, we assessed the current status of the Tennessee Heelsplitter to determine if it is in danger of extinction throughout its range. The Tennessee Heelsplitter's current distribution has not substantially changed from its known historical distribution. The species maintains multiple resilient AUs (60% of units categorized with high or most resiliency) distributed throughout each river basin. The strongholds for the Tennessee Heelsplitter, where we know there are numerous occurrences, are in the New and northeast Tennessee RUs, and most AUs with "high" or "most" resiliency have some level of connectivity of suitable habitat, which is essential for species viability. Redundancy, or the number and distribution of AUs with suitable habitat, is high, as our analysis indicates that suitable habitat exists throughout the range of the Tennessee Heelsplitter. Representation is maintained across all three RUs of historical and current occurrence, the Cumberland, New, and Tennessee. Additionally, available information indicates the species' adaptive capacity will ensure survival despite predicted climate impacts,

particularly because of the strong association with spring-fed streams that can act as cold-water and drought refugia in the face of climate change. The effects of siltation and sedimentation, pollution and toxic spills, drought and floods, aquatic nuisance species, and impoundments occur in minor portions of the current Tennessee Heelsplitter range and may have contributed to some habitat degradation. However, these threats appear to have been mostly localized in extent and have had only moderate impact; the current risk of extinction is low. Therefore, after assessing the best available information, we conclude that the Tennessee Heelsplitter is not in danger of extinction throughout all of its range.

Next, we proceed with determining whether Tennessee Heelsplitter is likely to become endangered within the foreseeable future throughout all of its range. In considering the foreseeable future as it relates to the status of the Tennessee Heelsplitter, we considered the relevant risk factors (threats) acting on the species and whether we could draw reliable predictions about the species' response to these factors into the future. The Tennessee Heelsplitter faces a variety of stressors from declines in water quality, impoundments, aquatic nuisance species, and deterioration of instream habitats. We assessed the future viability of Tennessee Heelsplitter by assessing land use and climate change, which we used as proxies for the stressors affecting the Tennessee Heelsplitter.

Based on projected habitat suitability for the two future scenarios, future resiliency for Tennessee Heelsplitter is expected to decrease slightly but overall 77% to 91% of AUs will remain in a high condition, depending on scenario. Multiple AUs maintain resiliency in future condition projections across the range and are likely to help buffer changes in environmental conditions through 2040 and 2060. Further, the concentration of resilient AUs in the southwestern Virginia and northeastern Tennessee strongholds are projected to remain intact. Connectivity of these resilient AUs within the upper Tennessee RU bolster the likelihood of persistence into the future.

In the future, stochastic events associated with threats to the species will likely affect population resilience in portions of the range, and these are more likely to occur or be observed in developed areas. However, our future condition projections indicate Tennessee Heelsplitter resiliency is sufficient to withstand disturbance and environmental stochasticity, due to prevalent suitable habitat and life history traits that reduce risk currently and into the future. The Tennessee Heelsplitter has several life history traits that allow it to adapt to changing conditions, such as the capability to transform on a wide variety of common host fish species, occurring in varying stream sizes, as well as tolerance of silty and sandy substrates and depositional areas with low flows. Spring-fed streams where the Tennessee Heelsplitter is most frequently located are ubiquitous throughout the species range and have year-round groundwater contributions with continuous flow and comparatively stable temperature regimes. These characteristics are expected to help the Tennessee Heelsplitter persist in most AUs throughout the range into the future and withstand projected climate effects. After assessing the best available information, we conclude that Tennessee Heelsplitter is not likely to become an endangered species within the foreseeable future throughout all of its range.

Status Throughout a Significant Portion of Its Range

Under the Act and our implementing regulations, a species may warrant listing if it is in danger of extinction or likely to become so in the foreseeable future throughout all or a significant portion of its range. Having determined that the Tennessee Heelsplitter is not in danger of extinction or likely to become so in the foreseeable future throughout all of its range, we now consider whether it may be in danger of extinction or likely to become so in the foreseeable future in a significant portion of its range—that is, whether there is any portion of the species' range for which it is true that both (1) the portion is significant; and (2) the species is in danger of extinction now or likely to become so in the foreseeable future in that portion. Depending on the case, it might be more efficient for us to address the "significance" question or the "status" question first. We can choose to address either question first. Regardless of which question we address first, if we reach a negative answer with respect to the first question that we address, we do not need to evaluate the other question for that portion of the species' range.

In undertaking this analysis for Tennessee Heelsplitter, we chose to address the status question first. We identified portions of the range where the biological status of the species may be different from its biological status elsewhere in its range. For this purpose, we considered information pertaining to the geographic distribution of (a) individuals of the species, (b) the threats that the species faces, and (c) the resiliency condition of populations.

We evaluated the range of the Tennessee Heelsplitter to determine if the species is in danger of extinction now or likely to become so in the foreseeable future in any portion of its range. The range of a species can theoretically be divided into portions in an infinite number of ways. We focused our analysis on portions of the species' range that may meet the definition of an endangered species or a threatened species. For Tennessee Heelsplitter, we considered whether the threats or their effects on the species are greater in any biologically meaningful portion of the species' range than in other portions such that the species is in danger of extinction now or likely to become so in the foreseeable future in that portion. We examined the following threats: aquatic nuisance species, siltation/sedimentation, pollution, drought and floods, impoundments, including cumulative effects.

We looked across the range of the Tennessee Heelsplitter and identified the three representation units (RUs) – Cumberland, New, and Tennessee drainages – to evaluate the effect of threats on the species. As described above, the threats are present across all AUs within the range, but some are localized in effect, though most have a low to moderate level of impact on the species. The habitat in New and Cumberland RUs currently consists of large percentages (100% and 75%, respectively) of suitable habitat, thus high estimated current resiliency. Our future conditions analysis indicates that none of the AUs in the New RU, and only one of the AUs in the Cumberland RU is predicted to no longer have suitable habitat to support the species. As such, the amount and distribution of suitable habitat in resilient AUs are predicted to be maintained 40 years in the future in both the New and Cumberland RUs, and we determined that the Tennessee heelsplitter is not in danger of extinction now or likely to become so in the foreseeable future in the Cumberland RU or the New RU.

The Tennessee RU is comprised of 132 AUs with varying levels of suitable habitat; 57% of the AUs have current condition level of high or most resilient, and 47% with a level of moderate resilience. Our future conditions analysis indicates that 4-14% of the AUs in the Tennessee RU could lose habitat suitability within the next 40 years. Despite this potential loss of habitat suitability, between 86-96% of the AUs are projected to maintain suitable habitat, with widespread distribution throughout the Tennessee RU portion of the range. The Tennessee heelsplitter is expected to have sufficient resiliency in this RU. Thus, we found that the Tennessee heelsplitter is not in danger of extinction now or likely to become so in the foreseeable future in the Tennessee RU.

We found no portion of the Tennessee Heelsplitter range where threats are impacting individuals differently from how they are affecting the species elsewhere in its range, or where the biological condition of the species differs from its condition elsewhere in its range such that the status of the species in that portion differs from its status in any other portion of the species' range.

Therefore, we find that the species is not in danger of extinction now or likely to become so in the foreseeable future in any significant portion of its range. This does not conflict with the courts' holdings in *Desert Survivors v. Department of the Interior*, 321 F. Supp. 3d 1011, 1070-74 (N.D. Cal. 2018), and *Center for Biological Diversity v. Jewell*, 248 F. Supp. 3d 946, 959 (D. Ariz. 2017) because, in reaching this conclusion, we did not apply the aspects of the Final Policy on Interpretation of the Phrase "Significant Portion of Its Range" in the Endangered Species Act's Definitions of "Endangered Species" and "Threatened Species" (79 FR 37578; July 1, 2014), including the definition of "significant" that those court decisions held to be invalid.

Determination of Status
Our review of the best available scientific and commercial information indicates that the Tennessee Heelsplitter does not meet the definition of an endangered species or a threatened species in accordance with sections 3(6) and 3(20) of the Act. Therefore, we find that listing the Tennessee Heelsplitter is not warranted at this time.

COORDINATION WITH STATES
While conducting our SSA for the Tennessee Heelsplitter, we coordinated and received information from all States within the species' current and historical range of Virginia, Tennessee, Georgia, Alabama, and North Carolina. A draft of the SSA Report was provided to all States within the species' range, and we received comments from Tennessee and Virginia.

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All SAFs supporting 12-month findings or candidate notices of review will be signed by the Director. SAFs should continue to be surnamed by Regional and Headquarters staff and leadership.

WENDI WEBER

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Date: 2023.08.11 16:45:37 -04'00'

Date:
Wendi Weber,
Acting Director,
U.S. Fish and Wildlife Service

Date of annual review: December 13, 2022
Conducted by: Sarah McRae