Appalachian Elktoe
(*Alasmidonta ravaneliana*)

Status Review:
Summary and Evaluation

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U.S. Fish and Wildlife Service
Southeast Region
Asheville North Carolina Ecological Services Field Office
Asheville, North Carolina

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STATUS REVIEW
Appalachian elktoe (*Alasmidonta ravaneliana*)

GENERAL INFORMATION

Current Classification: Endangered

Lead Field Office: Asheville, North Carolina, Ecological Services

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Date of original listing: November 23, 1994 (59 FR 60324)

Critical Habitat/4(d) rule/Experimental population designation/Similarity of appearance listing: Critical habitat final rule: September 27, 2002 (69 FR 61016).

Methodology used to complete the review: In accordance with section 4(c)(2) of the Endangered Species Act of 1973, as amended (Act), the purpose of a status review is to assess each threatened species or endangered species to determine whether its status has changed and if it should be classified differently or removed from the Lists of Threatened and Endangered Wildlife and Plants (50 CFR 424.11). The U.S. Fish and Wildlife Service (Service) evaluated the biology, habitat, and threats of the Appalachian elktoe to inform this status review.

We announced initiation of this review in the Federal Register on July 14, 2021 (86 FR 37178) with a 60-day comment period. During the public comment period we received one comment that expressed concern that the Appalachian elktoe had not met the criteria for delisting, with particular concern for the declines in the Little Tennessee River and South Toe Rivers. These comments are addressed in the review. The primary sources of information used in this analysis were the 1994 final listing rule (59 FR 60324), the 1996 recovery plan, peer-reviewed reports, agency reports, unpublished survey data and reports, and personal communication with recognized experts. This review was completed by the U.S. Fish and Wildlife Service, Asheville Ecological Services Field Office (AFO), Asheville, North Carolina. All literature and documents used for this review are on file at the AFO. All recommendations resulting from this review are the result of thoroughly reviewing the best available information on the Appalachian elktoe.

FR Notice citation announcing the species is under active review: July 14, 2021 (86 FR 37178)

Species' Recovery Priority Number at start of 5-year review (48 FR 43098):
5. This number indicates a high degree of threat, and a low recovery potential.

Review History:
Previous 5-year reviews recommending no change in status were published on March 3, 2009 (Service 2009) and August 28, 2017 (Service 2017).

REVIEW ANALYSIS

Listed Entity

Appalachian elktoe (*Alasmidonta ravaneliana*) Lea 1834

Taxonomy and nomenclature
We are not aware of any changes to the taxonomy of this entity, and it is still considered valid by the Service.

Distinct Population Segment (DPS) (61 FR 4722)
The Act defines species as including any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate wildlife. This definition limits listing of a DPS to only vertebrate species. Because the species under review is a not a vertebrate, the DPS policy does not apply.

Recovery Criteria

Recovery Plan or Outline
Recovery Plan for the Appalachian elktoe (*Alasmidonta ravaneliana*), August 26, 1996.

Recovery plans are not regulatory documents, but are intended to provide guidance to the Service, States, and other partners on methods of minimizing threats to listed species and on criteria that may be used to determine when recovery is achieved. If the recovery criteria defined in the plan are still valid, meeting recovery criteria can indicate that the species no longer requires protections under the Act. However, when recommending whether a listed species should be delisted, the Service must apply the factors in section 4(a) of the Act (84 FR 45020).

According to the 1996 Recovery Plan, the Appalachian elktoe will be considered for downlisting to threatened status when the likelihood of the species' becoming extinct in the foreseeable future has been eliminated by achievement of the following criteria:

(1) Through protection of both existing populations and successful establishment or discovery of additional populations, a total of four distinct viable populations exist within the species' historic range, with at least one each in the Little Tennessee, French Broad, and Nolichucky River systems;
(2) each of the four populations have at least three year classes present and show evidence of reproduction, including gravid females, and at least one juvenile age class (age 3 or younger);
(3) biological studies show that populations are increasing in density or extent in each of the 4 populations;

(4) where habitat has been degraded, noticeable improvements in water and stratum quality have occurred;
(5) all four populations and their habitats are protected from present and foreseeable threats; and,
(6) all four populations remain stable or increase over a period of 10 to 15 years.

At present none of the remaining populations of Appalachian elktoe demonstrate all of these criteria with high confidence. A more thorough update on each population is available below in the Biology and Habitat Summary section of this document. There is at least one functioning population in each river system mentioned in the criteria and at least 4 total, but long-term viability is questionable in all populations due to observed declines in some populations due to uncertain combinations of factors. Most of these populations show signs of recruitment and some are either stable or increasing in extent. Habitat improvements are present in some populations. Due to the large size of the watersheds involved and the myriad of factors affecting the populations, the protection from threats all foreseeable threats would likely require re-establishment of the species beyond its present range to provide redundancy to the threat of habitat degradation due to land use in the watersheds and that is a present focus of species management. At least 4 of the populations can be demonstrated to have remained stable for 15 years, but fine scale data required to be confident in population dynamics would require additional targeted data than is presently available.

Note: Appalachian elktoe will be considered for delisting when the above criteria have been met for six populations (as opposed to the four populations necessary for downlisting).

Biology and Habitat Summary

A detailed description of each population is available in previous 5-year reviews (Service 2009, 2017). Freshwater mussels like the Appalachian elktoe are difficult subjects to study due to their complicated life history and their residence in stream substrates where they are difficult to observe in large numbers without negative effects to the habitat. The viability of a population is hard to assess due to the difficulty of producing repeatable results in a complex environment. Many species populations, including Appalachian elktoe, exhibit natural fluctuation in observed density that may result from actual changes in density within normal bounds or may result from observation biases. In the case of Appalachian elktoe, a species with moderately long life, estimated to be around 12 years (Pandolfi et al. 2022), accounting for natural background fluctuation in populations requires detailed and repeated observation over a long time and this data is typically not available in sufficient detail to support statistical analysis. Currently known distribution falls into eight populations as defined by different river reaches and are shown in Figure 1 and described in the table and text below.

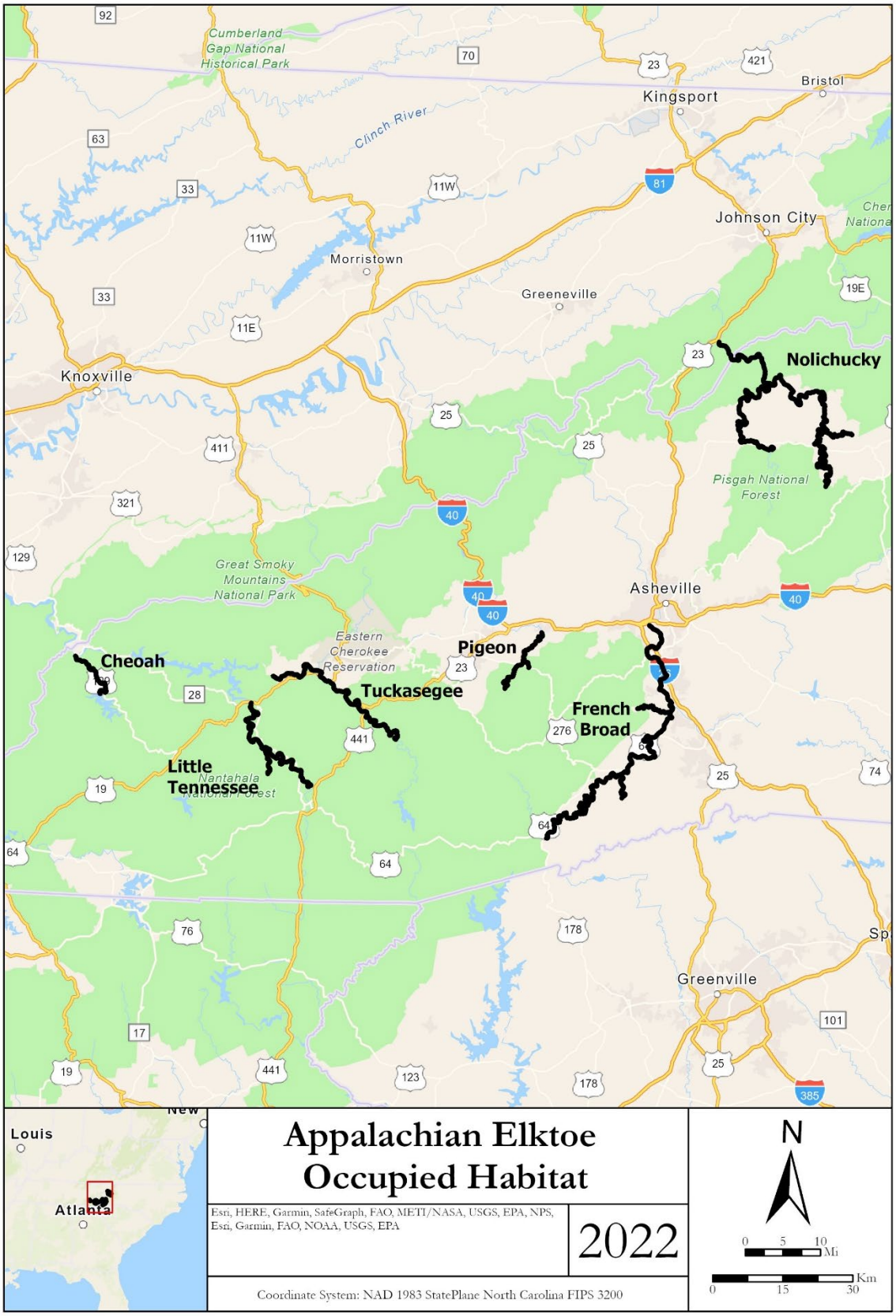

Figure 1. Appalachian Elktoe Distribution Map

The Service and other biologists commonly use Catch Per Unit Effort (CPUE) data to assess the relative abundance of mussels. This method is calculated by dividing the number of individuals observed by the number of person hours expended during the effort. CPUE data is susceptible to observation bias and so must be used within its ability to inform decisions. The data in Table 1 represents the average of all efforts within populations of Appalachian elktoe where the effort and catch were known with certainty. The effort over years varied and the site selection heavily influenced the catch rate. This data can be used to give a general sense of the density commonly observed within a population and helps to rank them relative to each other.

Table 1. Average Catch Per Unit Effort of live adult Appalachian elktoe observed.

Population	Waterway	2016	2017	2018	2019	2020	2021	2022	Average
Little Tennessee	Burningtown Creek				5.7	7.8	13.9	22.6	12.5
Little Tennessee	Little Tennessee		0.1	0.1	0.3	0.3	0.2		0.2
Tuckaseegee	Tuckaseegee River	22.7	30.5	2.0	8.9	1.0	2.2	3.6	10.1
Cheoah	Cheoah River			4.9		0.5	1.3		2.2
French Broad	French Broad River	0.3	0.4	0.8	0.1	0.7			0.4
Little River	Little River			43.2	27.2	59.6	44.2	15.0	37.8
Mills River	Mills River				0.4	0.4	0.3		0.4
Pigeon River	Pigeon River	1.4	1.4	1.8		10.2	13.8		5.7
Nolichucky River	Nolichucky River		0.3	6.0					3.1
Nolichucky River	North Toe River		2.0	0.4	0.2				0.9
Nolichucky River	South Toe River	1.0	8.3	10.0		5.6	76.0		20.2
Nolichucky River	Cane River	3.0		1.7	0.6	0.4	8.0		3.4

By looking at CPUE data through time and combining that with information with assessments of habitat quality and land use changes, we have developed a sense of general trends that are provided in Table 2, however, these observations are mostly qualitative unless there is repeat data available. Details about each of the populations are provided below.

Table 2. Population Summary and Qualitative Trends

Population	Occupied Length (km)	Density	Threat Level	Trend Notes
Little Tennessee - Burningtown Creek	5	High	Low	Newly found in 2019, potentially increasing/stable.
Little Tennessee	40	Low	Medium	This population suffered collapse starting in 2005, since then the population has remained very low. This population should be considered to be unstable.
Tuckaseegee	49	Medium	Medium	This population appears to be decreasing, but the data is not conclusive. Large construction projects in the watershed appear to have reduced the density of the population, but they remain extant throughout much of the 49km reach.
Cheoah	15	Low	Low	Population remains small, but the population is under hatchery management and watershed has moderate protection, potentially stable.
French Broad	102	Low	Medium	Population is low density but spread out over a large area, appears to be slowly increasing since 2005, potentially stable.
Little River	4	High	Medium	Arguably the densest known population with very high recruitment, but largely confined to a short reach of river.
Mills River	9	Low	Medium	This population has always been very low density, but the species remains extant. Stability of this population is unknown.
Pigeon River	23	Medium	Medium	This population is affected by rural and agricultural activity in its watershed, but the population appears to be stable and reproducing.
Nolichucky - Nolichucky River	21	Low	High	This subpopulation is extant but appears to be decreasing due to land use and potentially high temperature. Considered to be decreasing.
Nolichucky - North Toe River	42	low	High	Subpopulation of the Nolichucky River Population.
Nolichucky - South Toe River	33	High	Low	This is one of the best remaining subpopulations. The lower end of the South Toe River experienced a population decrease in its lower 10 km, but the upper 23 km has remained stable and may be increasing in density.
Nolichucky - Cane River	40	Low	High	Stream suffered a chemical spill in 2008, population is extant but not robust.

Little Tennessee River Populations

The Little Tennessee River population consists of separate population segments in the Little Tennessee, Tuckaseegee and Cheoah rivers. These population segments are separated by impoundments that limit further upstream migration and prevent downstream gene flow between the populations.

Little Tennessee River

Total occupied habitat: 40.6 km from the mouth at Fontana Lake to Emory Dam near Franklin, North Carolina

Burningtown Creek occupied length 5-7km from the mouth up to the township of Burningtown, North Carolina

The Little Tennessee River population, considered the best remaining population in terms of density and extent at the time of listing, suffered a decline starting in 2005 resulting in that population size is very small and maybe vulnerable to future extirpation. The cause or causes of this decline remain unknown but coincide with the after-effects of unusually high flood flows in the fall of 2014 associated with hurricanes Frances and Ivan. Appalachian elktoe were disrupted across their range by this event, but in most areas the populations rebounded in several years following the flood event, but in the Little Tennessee River the population continued to decline. The cause of this decline is likely multifold, but other populations of Appalachian elktoe seem to have declined as a result of chronic turbidity, and the flooding of 2004 is hypothesized to have increased chronic turbidity by causing numerous landslides and destabilizing large portions of the river's banks throughout the watershed. The result of bank instability in the watershed could have resulted in continued effects due to further bank destabilization during moderate rain events for years after the initial flooding as stream banks continued to be undermined and slough into the river. In 2019, 4 Appalachian elktoe were observed in the mainstem Little Tennessee River after failing to find any in 2015. In 2019 a sub-population of Appalachian elktoe were found in Burningtown Creek, a small tributary to the Little Tennessee River. This subpopulation is small compared to the past population in the Little Tennessee River; however, it represents a valuable source of individuals for the eventual re-establishment of Appalachian elktoe in the Little Tennessee River either naturally by emigration into the Little Tennessee or by population augmentation as part of recovery activities planned by the NCWRC (Owensby, 2021).

Tuckaseegee River

Total occupied habitat: 48.9 km from its mouth at Fontana Lake near Bryson City, North Carolina to Cullowhee Dam in Cullowhee, North Carolina, with most of the population in the middle portion between the confluence with the Oconaluftee River and the confluence with Savannah Creek.

The Tuckaseegee River still supports a moderately abundant population spread over a long length of river, but the density of Appalachian elktoe in the Tuckaseegee has always been lower than some other occupied rivers considered to have a thriving population. Most of the population occurs in the middle portion of the occupied habitat, The stability of this population needs more study, but it seems the Tuckaseegee population is reasonably stable over the previous five years. This population is threatened by development within the watershed and several hydropower operations that cause the water to rise and fall rapidly and

discharge cold water into the habitat. Anecdotal evidence suggests that the population has declined in the last few years. This may be due to observed chronic turbidity in the Tuckaseegee and several major tributaries.

Cheoah River

Total occupied habitat: 14.8km from the mouth up to Santeetlah Dam, however most of the population is confined to the upper 5 km

The Cheoah River supports a very small population of Appalachian elktoe that is concentrated in the upper five km of the occupied habitat. The population is being actively managed by the NCWRC through population augmentation. This population is threatened by low population level, but the Cheoah River is well regulated by minimum flows from a hydropower dam and close association with the Nantahala National Forest making the threat level of the Cheoah lower than other streams where most of the watershed is in private ownership. This population is too small to consider viable presently.

French Broad River Populations

The French Broad River Populations are not separated by hard barriers like dams, but may be isolated by areas of degraded habitat. It is unknown if gene flow is presently occurring between population segments. The three recognized populations are in the mainstem French Broad River and 2 tributaries: the Little and Mills rivers.

French Broad River Mainstem

Total occupied habitat: 102.8 km from the confluence with Hominy Creek near Asheville North Carolina up to the confluence with the East Fork of the French Broad near Rosman North Carolina

Appalachian elktoe appear to be increasing in extent and density in approximately 102.8km of the river upstream of Asheville NC. The density of Appalachian elktoe remains low throughout, but the large extent and seemingly increasing frequency of observation is a good sign for viability of this population.

Little River

Total occupied habitat: 7.9km from the mouth up to Cascade Lake Dam, however recent surveys suggest only the 4.1km from the Little River's confluence with Crab Creek up to Cascade Lake Dam is a reproducing population

The Little River Appalachian elktoe population is small in extent, but its high density and excellent habitat quality make it a standout location for the species. This population is in the tailrace of a non-functional hydropower dam that appears to be benefitting the habitat quality substantially. Habitat quality upstream of the dam is high gradient and is a relatively small stream for Appalachian elktoe. Sediment inputs upstream of the dam are captured by the reservoir. The reservoir may also serve to warm up the temperature and help in the processing of excess nutrients into high quality food for mussels. The land surrounding the reservoir and the tailrace are mostly undeveloped and are still owned by the family of the previous owners of Cascade Power. The habitat quality for mussels is exceptional in this area, but with increasing distance from the dam, sediment and nutrient inputs begin to degrade the habitat substantially. This population has some of the highest mussel densities in the region; however, within about four kilometers from the dam, the influence of tributary streams with degraded

water quality begin to negatively influence the Little River and mussel density drops to zero for some distance before its confluence with the French Broad mainstem. This degraded habitat may be a barrier between these two populations, but it is possible there is occasional gene flow, especially during flooding events when Little River individuals may be washed downstream into the French Broad where they can add to that population. The viability of this population is currently considered high with habitat stability provided by the dam which has likely resulted in recent surveys documenting reproduction in the 4.1km of the occupied habitat immediately downstream of the dam.

Mills River

Total occupied habitat: 9.8km from the mouth of the river upstream to the confluence of the east and west forks

The population of Appalachian elktoe in the Mills River has been very small since the time of its first discovery in 2002. Since that time Appalachian elktoe have been seen sporadically but have never been abundant. However, the Mills River supports a dense population of a closely related mussel species, slippershell (*Alasmidonta virdis*). It is unknown what environmental condition causes the slippershell to be numerous and for the Appalachian elktoe to be a minor part of the mussel fauna of the Mills River. At present it can only be stated that Appalachian elktoe is still present, but the population dynamics of this population are unknown.

Pigeon River Population

Total occupied habitat: 22.9km from Canton North Carolina upstream to Lake Logan on the West Fork Pigeon

The Pigeon River is hydrologically part of the French Broad River Sub-basin; however, because it is geographical isolation from the French Broad River it is considered a standalone population. Survey data suggests Appalachian elktoe are relatively abundant in places. They are prevented from downstream expansion by the Evergreen paper mill in Canton, NC, which, despite marked improvement over the last few decades, still appears to create an environment unsuitable for Appalachian elktoe due to waste heat and tannic effluent. Upstream distribution in the West Fork Pigeon is blocked by Lake Logan dam, a small recreational reservoir; however, due to steep topography it is possible that the Appalachian elktoe is already at or near its highest possible upstream extent in this tributary. In the East Fork Pigeon Appalachian elktoe are present in low numbers in the lower reaches of the tributary, but rural and agricultural land use in this watershed appears to limit their density and extent.

Nolichucky River Populations

Total occupied habitat: 136.4km, includes all three major tributaries and the mainstem river down to Erwin Tennessee

The Nolichucky River Sub-basin supports a population of Appalachian elktoe that is large in extent, and has areas of high density, but the majority of the Sub-basin is characterized by patchy distribution and low density. The North Toe, South Toe and Cane watersheds make up the major tributaries of the upper Nolichucky Sub-basin. The North Toe and South Toe come together and the resulting combined waterway continues to be shown on maps as the North Toe River until its confluence with the Cane River, beyond which it is known as the Nolichucky River. Within a short distance the Nolichucky River flows through a gorge which descends steeply off of the Blue Ridge physiographic province where it habitats and conditions change and potentially

becomes unsuitable to Appalachian elktoe. There are no physical barriers in the sub-basin; however, habitat conditions and long distances are likely creating isolation between some of the tributaries. For ease of discussion the Nolichucky River Population is broken into 4 sub-populations described below.

South Toe River

Total occupied habitat: 32.1 km from the mouth to the community of Celo, North Carolina with most of the population in 23.1 km between the confluence with Little Crabtree Creek near Micaville, North Carolina and Celo

The South Toe River contains the best population segment of Appalachian elktoe remaining in the Nolichucky Sub-basin. This subpopulation has also been studied better than most others due to three masters thesis published since the last five year review (Rondell 2019, Thompson 2020, Pandolfi et. al 2022). Beginning in 2015 it was noticed that the Appalachian elktoe downstream of a large road construction project began to decrease in density and is perhaps extirpated and that the population has remained stable in upstream of the road construction. Due to these studies taking place after the majority of the effects had already taken place it is difficult to state with certainty that the road construction was the primary causative factor, but the most plausible interpretation is that chronic turbidity resulting from large scale construction in the watershed caused nearly complete loss of Appalachian elktoe in about 10km of the South Toe River (Rondell 2019, Thompson 2020, Pandolfi et al. 2022).

North Toe River

Total occupied habitat: 42.9 km from the confluence with Cane River to the confluence with Snow Creek near Penland, North Carolina

The North Toe River appears to have suffered a population decline over the last decade. Appalachian elktoe are still extant but are difficult to find and aggregates of more than a few animals are not commonly seen. The effects of mines and other discharges from the town of Spruce Pine, NC, appear to be leading contributors to habitat degradation. The mines include: Sibelco NA Quartz, Sibelco NA Schoolhouse, Sibelco NA Crystal, Sibelco NA Red Hill, The Quartz Corp K-T Feldspar Corp., and The Quartz Corp and The Feldspar Corp. These facilities discharge ore mining waste water into the North Toe River. As an example of a known instance of impacts, in July of 2018, Quartz Corp illegally discharged hyrdoflouric acid into the North Toe River causing a fish kill. This instance likely impacted Appalachian elktoe in the same reach. Waste water spills and illegal mining discharges have been documented in the past and are expected to continue a common occurrence in this area. The cumulative effect of mine activity and other land uses appears to be having a negative effect on Appalachian elktoe in this river and it is unknown if they will continue to persist in the North Toe River long-term.

Cane River

Total occupied habitat: 39.5 km from the mouth to the confluence of Bowlens Creek

The Cane River formerly contained a functional subpopulation of Appalachian elktoe but following a chemical spill in 2008 associated with the Town of Burnsville Wastewater Treatment Plant near the upper end of distribution for Appalachian elktoe in the Cane River, the population died off and has not recovered. The wastewater plant has continued to have spills of raw sewage and equipment failures that likely contributes to the lack of rebound in

the population. Gravel mining further up the river may also contribute to limited recovery of this subpopulation. This subpopulation is currently part of reintroduction efforts by the NCWRC, but the population viability remains in question due to habitat degradation.

Nolichucky River
Total occupied habitat: 21.5 km from Chestoa Pike Road to the confluence with the Cane River
The Nolichucky River portion of the population is the downstream reach of the North Toe River after its confluence with the Cane River. The problems affecting the North Toe River also affect the Nolichucky River. Much of the Nolichucky River flows through a steep gorge where stream velocity may be naturally limiting in many places. Appalachian elktoe were formerly found in the Nolichucky River down to the outskirts Erwin, TN, but recent surveys have failed to find them downstream of the gorge for the last few efforts. It is possible that Appalachian elktoe are still extant in the lower reaches of the Nolichucky, but it is unlikely that they have sufficient numbers to be considered viable. Surveys of the Nolichucky gorge and the river in the vicinity of Erwin are necessary to make further judgement about this population segment.

Threats (Five-Factor Analysis) Summary

The status of a species is determined from an assessment of factors specified in section 4(a)(1) of the Act, including: Factor A: the present or threatened destruction, modification, or curtailment of its habitat or range; Factor B: overutilization for commercial, recreational, scientific, or educational purposes; Factor C: disease or predation; Factor D: the inadequacy of existing regulatory mechanisms; Factor E: other natural or manmade factors affecting its continued existence. A summary of this assessment is detailed below.

The final listing rule described threats to the Appalachian elktoe as a result of impoundments and general deterioration of habitat and water quality resulting from siltation and other pollutants contributed by poor land use practices and toxic discharges (Factor A; Service 1994). These threats led to declines of the Appalachian elktoe prior to listing and resulted in this species being lost from a large portion of its range, resulting in very limited distribution of this species and its isolation into disconnected habitat units limiting gene flow and preventing natural range expansion in most areas. All populations are currently threatened of habitat destruction and modification are and subject to the threat of poor demographic and genetic health due to isolation. This species appears to be especially sensitive to large scale erosive factors which can be happening at any place within the watersheds they reside in. Any alteration on the landscape that contributes to elevated turbidity during normal rain events within the occupied habitat appear to have an impact on the population by decreasing feeding efficiency and respiration in adults and may be especially harmful to juveniles leading to recruitment failure and population decline. Anecdotal evidence also suggests that elevated temperatures and alteration of water quality parameters are also damaging and likely result in synergistic effects with siltation that cause rapid population decline as seen in the Little Tennessee, Cane, South Toe and North Toe River populations/subpopulations.

The Appalachian elktoe does not have any recognized commercial value. At present there does not appear to be a significant threat from overutilization of the species (Factor B).

Disease in freshwater mussels is presently a topic of study (Factor C). It is possible that populations of Appalachian elktoe can be affected by diseases but there is no conclusive evidence that this is a primary factor in observed population declines. In each case of decline in this species there are obvious plausible factors that are sufficient to explain the decline without hypothesizing that a disease is a primary factor, but it cannot be ruled out that alterations to the habitat weaken the population to a tipping point where diseases my become relevant and then contribute to losses. This is a topic that needs additional study (Haag 2019, Richard et al. 2020).

Predation (Factor C) of Appalachian elktoe by mammals does appear to be a factor that affects their population locally. Shell middens left behind by mammals such as muskrat, mink or otters do occasionally have shells of Appalachian elktoe present and at times the number of shells is in the dozens. The number preyed upon in any given location appears to be correlated with the number of Appalachian elktoe present in the adjacent water body, meaning that areas with more Appalachian elktoe present in the stream are likely to have more Appalachian elktoe represented in the shell material in the middens. During times of exceptionally low water, it is hypothesized that mussels may be preyed upon more effectively by species that are not primarily aquatic, such as raccoons, who prey opportunistically on mussels left on dry stream bed by receding flows. It is possible that predation does have an effect under certain circumstances, but the effect seems to be minor and there is no evidence that predation alone causes observed declines in healthy populations. However, in populations where the numbers of Appalachian elktoe are already low due to other factors, predation may have a measurable effect, especially during times of drought (Neves and Odum 1989, Walters and Ford 2013, Edelman et al. 2015).

Present regulatory mechanisms at the federal and state level protect the Appalachian elktoe from intentional harm and appear to be effective at reducing take; however, the protection of the watersheds where Appalachian elktoe remain is inadequate to ensure its continued persistence (Factor D). The Appalachian elktoe can be affected by activities a significant distance from its occupied locations. Land disturbance anywhere in the watershed can contribute to habitat alteration far downstream and is suspected to have contributed to all observed declines so far: Little Tennessee River (agricultural land use and poor riparian protection); South Toe River (construction of a large highway), Cane River (chemical spill); North Toe River (discharges from mines and poor land use). In each of these cases the suspected primary cause took place a significant distance upstream from the effects and were not prevented by existing regulatory mechanisms. The riverine habitat that supports the Appalachian elktoe is a complex environment and it is difficult to remove all threats in the watershed, but the primary threat in each of the remaining populations appears to be erosion caused by land disturbing activities and, despite regulations intended to minimize erosion into waterways, this effect is widespread and common. Many activities contributing to erosion and turbidity in waterways are not adequately monitored for compliance with existing regulations and often when complaints are lodged the remedy is insufficient to protect the quality of downstream habitat. This may be the single biggest threat to this species.

Perhaps one of the biggest factors affecting the recovery of Appalachian elktoe is both geographic and demographic (Factor E). The human mediated factors that led to the Appalachian

elktoe being confined to isolated, small populations have also resulted in a lack of gene flow between populations. Prior to dam building and habitat alteration it is suspected that all populations of Appalachian elktoe were connected by some level of gene flow that served to homogenize the population and allow for adaptation over long periods of time. As one location became unsuitable it was possible for the populations to move around to adapt and eventually repopulate areas as needed. Presently the populations have very limited ability to adapt to changing conditions. Additionally, the establishment of new subpopulations or populations and human mediated emigration of genes between populations is a necessary component of the species recovery that are presently limited by regulation and availability of resources. To compound the risk to the specie is that many of the populations are linear-in nature and a chemical spill could potentially extirpate the population and due to isolation recovery would only be accomplished through human-mediated efforts.

Synthesis

The Appalachian elktoe is a kidney-shaped yellowish-brown mussel native to relatively shallow, medium-sized creeks and rivers in the Upper Tennessee River system of North Carolina and Tennessee. The Appalachian elktoe is a species that is intimately tied to the health of the river system that it inhabits and due to its life history, is vulnerable to a wide variety of disturbances that can take place anywhere within the watershed it resides in. The remaining eight populations are disconnected and susceptible to genetic consequences of low demographics and reduced gene flow because of the populations' isolation from one another. The threat of population decline due to degradation of habitat quality is still significant for all populations, evidenced by recent declines in some of the populations that are associated with human activity within the watershed. Because of the continued threats to the species, evidence of population declines and a life history that results in slow recovery, we believe the species continues to meet the definition of an endangered species.

RECOMMENDED FUTURE ACTIVITIES

Continued assessment of the health of the remaining populations is critical to further recovery planning.

- The Tuckaseegee River population is a crucial component of the greater Little Tennessee River population, and it is important to take proactive measures to ensure this population is actively managed so that it remains viable. This may require additional efforts to establish the Appalachian elktoe in the Oconaluftee River in cooperation with the Eastern Band of Cherokee Indians.
- The upper portion of the South Toe River supports the last robust sub-population in the Nolichucky River System. This population should be used to re-populate the Cane River and the upper North Toe portions of this greater population so the species is better protected from potential threats to the South Toe River.
- In the Pigeon River, the West Fork Pigeon supports a much greater number of Appalachian elktoe than the East Fork Pigeon River. It would benefit the Pigeon River population to establish a study plot of Appalachian elktoe in the East Fork Pigeon River to investigate its potential to support additional Appalachian elktoe so the species is better protected from threats only affecting one of the forks.

- In the French Broad River, the population in the Little River is crucial to the long-term stability of this greater population, but the Little River is heavily influenced by the presence of Cascade Lake Dam. Efforts should be made to use the Little River population as a source population for establishing better demographics in the French Broad River mainstem, Mills River and possibly additional populations in other tributaries of the French Broad River while Cascade Lake Dam continues to protect water quality in the reaches downstream. Efforts should be made to assess options to continue protecting water quality in the Little River in the future, e.g., protecting riparian zones upstream and in areas where Appalachian elktoe occur and decreasing point source and non-point source population.
- If possible, agreements should be made with the State of North Carolina and other partners entities so that re-establishment of Appalachian elktoe throughout its historical range is more readily accomplished.
- Continued cooperation with the NCWRC Conservation Aquaculture Center (CAC) in Marion, NC, is crucial to the recovery of the species. The CAC has been instrumental in research on the life history of Appalachian elktoe and have been a primary partner in developing the technology necessary to manage the species. Future recovery activities will rely heavily on the CAC for support.

RESULTS / SIGNATURES

U.S. Fish and Wildlife Service
Status Review of Appalachian Elktoe

Status Recommendation:

On the basis of this review, we recommend the following status for this species. A 5-year review presents a recommendation of the species status. Any change to the status requires a separate rulemaking process that includes public review and comment, as defined in the Act.

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist:
____ *The species is extinct*
____ *The species does not meet the definition of an endangered or threatened species*
____ *The listed entity does not meet the statutory definition of a species*
_**X**__ No change needed

FIELD OFFICE APPROVAL:

Field Supervisor, Asheville Ecological Services Field Office, Fish and Wildlife Service

GARY PEEPLES Digitally signed by GARY PEEPLES Date: 2022.07.29 14:30:43 -04'00'

Approve _____

** Since 2014, Field Supervisors in the Region have been delegated authority to approve 5-year reviews that do not recommend a status change.*

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