Recovery Plan For The Appalachian Elktoe *(Alasmidonta raveneliana) Lea*

U.S. Fish and Wildlife Service
Southeast Region
Atlanta, Georgia

RECOVERY PLAN

for

Appalachian Elktoe (*Alasmidonta raveneliana*) Lea

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By approving this document, the Regional Director certifies that the data used in its development represents the best scientific and and commercial information available at the time it was written. Copies of all documents reviewed in the development of this recovery plan are available in the administrative record located at the Asheville, North Carolina, Field Office.

Literature citations should read as follows:

U.S. Fish and Wildlife Service. 1996. Appalachian Elktoe Recovery Plan. Atlanta, GA. 32 pp.

Additional copies of this plan may be purchased from:

Fish and Wildlife Reference Service
5430 Grosvenor Lane, Suite 110
Bethesda, Maryland 20814
Phone: 301/492-6403 or
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EXECUTIVE SUMMARY

Current Status: The Appalachian elktoe was federally listed as endangered on November 23, 1994. Only two populations of the species are known to survive. One population occurs in the main stem of the Little Tennessee River in Swain and Macon Counties, North Carolina. The second population is restricted to scattered locations along a short reach of the Toe River and the main stem of the Nolichucky River in Yancey and Mitchell Counties in North Carolina, extending downriver into Unicoi County, Tennessee. A single specimen of the Appalachian elktoe was also found in the Cane River, a major tributary to the Nolichucky River, in Yancey County, North Carolina. The complete historic range of the species is unknown, but available information indicates that it once had a fairly wide distribution throughout the Upper Tennessee River system in western North Carolina. In Tennessee the species in known only from its present range in the main stem of the Nolichucky River.

Habitat Requirements and Limiting Factors: The species has been reported from relatively shallow medium-sized creeks and rivers with cool, well-oxygenated, and moderate- to fast-flowing water. It has been observed in gravelly substrata, often mixed with cobble and boulders; in cracks in bedrock; and occasionally in relatively silt-free, coarse, sandy substrata. Water quality and habitat degradation resulting from impoundments, stream channelization projects, and point and nonpoint sources of siltation and other pollutants appear to be major factors in reducing the species' distribution and reproductive capacity. Unless new populations are found or created and existing populations are maintained, this species will likely become extinct in the foreseeable future.

Recovery Objective: Delisting.

Recovery Criteria: Downlist from endangered to threatened status when the following criteria are met: (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) all four populations and their habitats are protected from present and foreseeable threats; and, (4) all four populations remain stable or increase over a period of 10 to 15 years.

Delist when the following criteria are met: (1) Through protection of both existing populations and successful establishment or discovery of additional populations, a total of six 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 six 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) all six populations and their habitats are protected

from present and foreseeable threats; and, (4) all six populations remain stable or increase over a period of 10 to 15 years.

Actions Needed:

1. Utilize existing legislation/regulations to protect the species.
2. Elicit support through the development and utilization of an information/education program.
3. Search for new populations and monitor existing populations.
4. Determine the species' life history, habitat requirements, and threats.
5. Implement management and alleviate threats to the species' existence.
6. Through augmentation, reintroduction, and protection, establish six viable populations.
7. Develop and implement cryopreservation of the species.

Cost ($000s):

Year	Need 1	Need 2	Need 3	Need 4	Need 5	Need 6	Need 7	Total
1996	5.5	8.0	6.0	25.0	0.0	30.0	8.5	83.0
1997	5.5	5.5	6.0	25.0	25.0	30.0	8.5	105.5
1998	5.5	3.0	4.0	25.0	25.0	30.0	2.0	94.5
1999	5.5	0.0	0.0	0.0	25.0	10.0	2.0	42.5
2000	5.5	0.0	4.0	0.0	?	10.0	2.0	21.5*
2001	5.5	2.0	0.0	0.0	?	10.0	2.0	19.5*
2002	5.5	0.0	5.5	0.0	?	0.0	2.0	13.0*
2003	5.5	0.0	0.0	0.0	?	0.0	2.0	7.5*
2004	5.5	2.0	5.5	0.0	?	0.0	2.0	15.0*
2005	5.5	0.0	0.0	0.0	?	0.0	2.0	7.5*
2006	5.5	0.0	5.5	0.0	?	0.0	2.0	13.0*
Total	60.5	20.5	36.5	75.0	75.0*	120.0	35.0	422.5*

* Habitat improvement costs needed for the species' recovery will not be known until the magnitude of specific threats is determined through research.

Date of Recovery: The delisting and downlisting dates cannot be estimated at this time. As mussels do not reproduce until about age 5, more than 10 years are needed to document reproduction and assess viability.

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PART I

INTRODUCTION

The Appalachian elktoe (*Alasmidonta raveneliana*) was listed as an endangered species on November 23, 1994 (U.S. Fish and Wildlife Service [Service] 1994). This freshwater mussel inhabits relatively shallow medium-sized creeks and rivers with cool, well-oxygenated, and moderate- to fast-flowing water. The Appalachian elktoe is endemic to the upper Tennessee River system in the mountains of western North Carolina and eastern Tennessee. It once had a fairly wide distribution in western North Carolina but has been eliminated from the majority of its historic range (including the French Broad River, the Little River [French Broad River system], the Pigeon River [French Broad River system], the Swannanoa River [French Broad River system], and Talula Creek [Little Tennessee River system]). It has been reduced to short reaches of the Little Tennessee River, Nolichucky River, Toe River, and Cane River in North Carolina. In Tennessee, the species is known only from its present distribution in the Nolichucky River. The species' range has been seriously reduced by impoundments and the general deterioration of habitat and water quality resulting from siltation and other pollutants contributed by poor land-use practices and toxic discharges.

Description, Ecology, and Life History

The Appalachian elktoe (*Alasmidonta raveneliana*) (Lea 1834) has a thin, but not fragile, kidney-shaped shell, reaching up to about 3.2 inches in length, 1.4 inches in height, and 1 inch in width (Clarke 1981). Juveniles generally have a yellowish brown periostracum (outer shell surface), whereas the periostracum of the adults is usually dark brown in color. Although rays are prominent on some shells, particularly in the posterior portion of the shell, many individuals have only obscure greenish rays. The shell nacre (inside shell surface) is shiny, often white to bluish white, changing to a salmon, pinkish, or brownish color in the central and beak cavity portions of the shell; some specimens may be marked with irregular brownish blotches (adapted from Clarke 1981). A detailed description of the species' shell, with illustrations, is contained in Clarke (1981). Soft parts are discussed in Ortmann (1921).

Because of its rarity, little is known about the autecology of the Appalachian elktoe. The species has been reported from relatively shallow medium-sized creeks and rivers with cool, well-oxygenated, and moderate- to fast-flowing water. It has been observed in gravelly substrata, often mixed with cobble and boulders; in cracks in bedrock (Gordon 1991); and occasionally in relatively silt-free, coarse, and sandy substrata (J. Alderman, North Carolina Wildlife Resources Commission, personal communication, 1992; personal observations, 1989, 1991). Like other freshwater mussels, the Appalachian elktoe feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The reproductive cycle of the Appalachian elktoe is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration.

The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. They then detach from their fish host and sink to the stream bottom where they continue to develop, provided they land in a suitable substratum with the correct water conditions. Recent studies funded by the U.S. Forest Service and conducted by personnel with the Tennessee Technological University at Cookeville, Tennessee, have identified the banded sculpin (*Cottus carolinae*) as a host species for glochidia of the Appalachian elktoe (M. Gordon, Tennessee Technological University, personal communication, 1993). The mussel's life span and many other aspects of its life history are unknown.

Distribution and Threats to Its Continued Existence

The Appalachian elktoe is known to be endemic to the upper Tennessee River system in western North Carolina and eastern Tennessee. Historical records for the species in North Carolina exist for the Little Tennessee River system (Talula Creek, Graham County) and the French Broad River system, including the Nolichucky River (county unknown), the Little River (Transylvania County), the Swannanoa River (county unknown), the Pigeon River (Haywood County), and the main stem of the French Broad River (Buncombe County and an unknown county) (Clarke 1981). An additional historical record of the Appalachian elktoe in the North Fork Holston River in Tennessee (S. S. Haldeman collection) is believed to represent a mislabeled locality (Gordon 1991).

Surveys of the French Broad River and its tributaries in Transylvania, Henderson, Haywood, Buncombe, and Madison Counties, North Carolina, failed to locate any specimens of the Appalachian elktoe (R. Biggins, U.S. Fish and Wildlife Service, personal communications, 1989, 1991; Alderman, personal communication, 1990; Gordon, personal communications, 1991, 1992; personal observations, 1986 through 1991). The species has also been extirpated from Talula Creek in the Little Tennessee River system (personal observations, 1987, 1992) and could not be found in any of the other major tributaries to the Little Tennessee River (Gordon, personal communication, 1991; S. Ahlstedt, Tennessee Valley Authority, personal communication, 1992). If the historic record for the species in the North Fork Holston River in Tennessee was a good record, then the species has been eliminated from this river as well.

Only two populations of the species are known to survive. The healthiest of these populations, discovered in 1987 by Tennessee Valley Authority biologists (Steven Ahlstedt and Charles Saylor), exists in the main stem of the Little Tennessee River between Emory Lake at Franklin, Macon County, North Carolina, and Fontana Reservoir in Swain County, North Carolina (Tennessee Valley Authority 1987; J. Widlak, U.S. Fish and Wildlife Service, personal communication, 1988; Biggins 1990; Gordon 1991; personal observations, 1988, 1991, 1992, 1993). This population was likely reduced in size by the impoundment of these two reservoirs. The second population occurs in the Nolichucky River system. This population appears to be restricted to scattered pockets within a short reach of the Toe River in Yancey and Mitchell

Counties in North Carolina (personal observations, 1991, 1992) and the main stem of the Nolichucky River, Yancey and Mitchell Counties, North Carolina (Alderman, personal communication, 1991; personal observation, 1992, 1993), extending downriver into the vicinity of Erwin, Unicoi County, Tennessee (personal observation, 1992). A single specimen of the Appalachian elktoe was also found in the Cane River, above its confluence with the Nolichucky River, Yancey County, North Carolina (C. McGrath, North Carolina Wildlife Resources Commission, personal communication, 1992).

The decline of this species throughout its range has been attributed to several factors, including siltation resulting from past logging, mining, agricultural, and construction activities; the run-off and discharge of organic and inorganic pollutants from industrial, municipal, agricultural, and other point and nonpoint sources; habitat alterations associated with impoundments, channelization, and dredging; and other natural and human-related factors that adversely modify the aquatic environment.

Land-clearing/disturbance activities carried out without proper sedimentation control pose a significant threat to freshwater mussels. Mussels are sedentary and are not able to move long distances to more suitable areas in response to heavy silt loads. Natural sedimentation resulting from seasonal storm events probably does not significantly affect mussels, but human activities often create excessively heavy silt loads that can have severe effects on mussels and other aquatic organisms. Siltation has been documented to adversely affect native freshwater mussels both directly and indirectly. Siltation degrades water and substrata quality, limiting the available habitat for freshwater mussels (and their fish hosts), thereby limiting their distribution and potential for expansion and maintenance of their populations. It also irritates and clogs the gills of filter-feeding mussels, resulting in reduced feeding and respiration, and smothers mussels if sufficient accumulation occurs. Siltation increases the potential exposure of the mussels to other pollutants (Ellis 1936, Marking and Bills 1979, Kat 1982). Ellis (1936) found that less than 1 inch of sediment deposition caused high mortality in most mussel species. Sediment accumulations that are less than lethal to adults may adversely affect or prevent recruitment of juvenile mussels into the population. Also, sediment loading in rivers and streams during periods of high discharge is abrasive to mussel shells. Erosion of the outer shell allows acids to reach and corrode underlying layers (Harman 1974).

Mussels are also known to be sensitive to numerous other pollutants, including, but not limited to, a wide variety of heavy metals, high concentrations of nutrients, and chlorine--pollutants that are commonly found in many domestic and industrial effluents (Havlik and Marking 1987). In the early 1900s Ortmann (1909) noted that the disappearance of unionids (mussels) is the first and most reliable indicator of stream pollution. Keller and Zam (1991) concluded that mussels are more sensitive to metals than commonly tested fish and aquatic insects. The life cycle of native mussels makes the reproductive stages especially vulnerable to pesticides and other pollutants (Ingram 1957, Stein 1971, Fuller 1974, Gardner *et al.* 1976). Effluent from sewage treatment facilities can be a significant source of pollution that can severely affect the diversity and abundance of aquatic mollusks. The toxicity of chlorinated sewage effluents to aquatic life

is well documented (Brungs 1976, Tsai 1975, Bellanca and Bailey 1977, U.S. Environmental Protection Agency 1985, Goudreau *et al.* 1988), and mussel glochidia (larvae) rank among the most sensitive invertebrates in their tolerance to toxicants present in sewage effluents (Goudreau *et al.* 1988). Goudreau *et al.* (1988) found that the recovery of mussel populations may not occur for up to 2 miles below the discharge points of chlorinated sewage effluent.

The effects of impoundments on mussels are also well documented. The closure of dams changes the habitat from a lotic to a lentic condition. Depth increases, flow decreases, and silt accumulates on the bottom. Hypolimnetic discharge lowers water temperatures downstream. Fish communities change, and host fish species may be eliminated. Mussel communities change; species requiring clean gravel and sand substrate are lost (Bates 1962). In addition, the construction of dams results in the fragmentation and isolation of the species' populations, and these dams act as effective barriers to natural upstream expansion or recruitment of mussel and fish species.

The available evidence demonstrates that habitat deterioration resulting from sedimentation and pollution from numerous point and nonpoint sources, when combined with the effects of other factors (including habitat destruction/alteration resulting from impoundments, channelization projects, etc.), has played a significant role in the decline of the Appalachian elktoe. The Service believes this is particularly true of the extirpation of the species from the Pigeon, Swannanoa, and French Broad Rivers. These factors likely also contributed to the extirpation of the species from the Little River and Talula Creek, though habitat loss and alteration resulting from impoundments, channel modification projects, and excavation activities within the stream channel (particularly in the case of Talula Creek) are believed to have had a severe adverse effect on the species in these streams.

Both areas where the Appalachian elktoe still survives appear to have escaped the large-scale pollution from point sources that have occurred in the past in other areas within the species' historic range, and both river reaches still supporting the species were rated by the North Carolina Department of Environment, Health, and Natural Resources (NCDEHNR), Division of Environmental Management, as having excellent water quality (NCDEHNR 1985). There are relatively few major point source discharges in the upper Nolichucky River system, and the river reach that still supports the Appalachian elktoe is located over 20 miles from the nearest of these discharges. The Little Tennessee River system also currently has relatively few major point source discharges. While the City of Franklin recently expanded their wastewater treatment facility and discharge into Lake Emory, directly above the occurrence of the Appalachian elktoe (as well as two other federally listed aquatic species--the endangered little-wing pearly mussel and the threatened spotfin chub), they upgraded their treatment system to advance treatment (because of the local community's interest in protecting the quality and uses of the river below Franklin). This discharge is not believed to pose a major threat to the health of the Little Tennessee River ecosystem.

The most immediate threats to both remaining populations of the species appear to be associated with sedimentation and other pollutants (i.e., fertilizers, pesticides, heavy metals, oil, salts, organic wastes, etc.) from nonpoint sources. Much of the Nolichucky River in North Carolina contains heavy loads of sediment from past land-disturbance activities within its watershed, and suitable habitat for the Appalachian elktoe appears to be limited in this river system. The species has not been found in the Nolichucky River system in substrata with accumulations of silt and shifting sand; the species appears to be restricted to small, scattered pockets of stable, relatively clean, and gravelly substrata. The same is true of the population surviving in the Little Tennessee River. While there have been a few observations of the Appalachian elktoe in the Little Tennessee River in coarse sandy substrata, they were lone individuals that were observed following periods of heavy rain, when they were likely displaced from more suitable habitat by storm flows. These individuals were not observed in subsequent visits to these sites. The river channel above Lake Emory (above the reach of the river supporting the Appalachian elktoe) carries a high load of unstable sediments and is devoid of mussels. It is believed that Lake Emory has served in the past, and continues to serve to a lesser degree, as a sediment trap, which has helped to protect the integrity of the river below the Town of Franklin. However, the lake is rapidly filling with sediment, and large sediment accumulations in the river below the lake are becoming increasingly common.

Many of the industries, landowners, developers, builders, etc., in the watersheds of these two river systems are to be commended for implementing measures for controlling the run-off of sediment and other pollutants into the rivers and tributaries. Landowners along the Nolichucky River, where the Appalachian elktoe still survives, have indicated that in recent years they have noted improvements (decreases) in the amount of sand and sediment in the lower Toe and Nolichucky Rivers. These improvements are, no doubt, in a large part due the efforts of industries and landowners within the watershed of the Nolichucky River. However, there are still large quantities of sand and other unstable sediments within this river system, and there are still activities occurring within both the Little Tennessee and Nolichucky River watersheds that continue to contribute to the problem.

While the Service does not have the authority under the Endangered Species Act to require or enforce implementation of erosion- or sedimentation-control measures, the Service strongly encourages the use of "best management practices" and "stream-side management zones." Implementation of such measures benefits the landowners by helping to control the run-off of topsoil, fertilizers, pesticides, etc., and by helping to maintain the quality of a river's ecosystem--its biological, recreational, and aesthetic values. Also, the Service and other Federal and State agencies have programs available for assisting landowners with the development and implementation of corrective measures at problem sites. For instance, the Service's Partners for Wildlife Program (Partners) has the potential to provide funding to interested and willing industries and landowners to help restore degraded areas; fence livestock out of streams; and provide alternative water sources, plant filter strips, restore eroding stream banks, etc. The Service, in cooperation with the Natural Resources Conservation Service, Resource Conservation and Development Council, and Little Tennessee River Watershed Association, is currently involved in Partners projects with four landowners in the Little Tennessee River watershed.

Another potential threat to the Appalachian elktoe is the introduction and/or invasion of exotic species. For example, the Asiatic clam, *Corbicula fluminea*, one of 204 introduced mollusk species in North America (Dundee 1969), was first discovered in the United States in the Columbia River in Oregon in 1939. By 1972 the species could be found in most of the major river systems throughout the United States (Fuller and Powell 1973). While *C. fluminea* has not been observed in the stretch of the Little Tennessee River still inhabited by the Appalachian elktoe, it has become well established in portions of the Toe and Nolichucky Rivers. The extent of the threat that *C. fluminea* presents to the elktoe and other native mussel populations is presently unknown and requires further study. Many malacologists are concerned about the possibility of a competitive interaction for space, oxygen, and food between *C. fluminea* and native bivalves. Competition may not occur among adults but, rather, at the juvenile stage (Neves and Widlak 1987). Because of its restricted distribution, the Appalachian elktoe may not be able to withstand vigorous competition.

The zebra mussel (*Dreissena polymorpha*) is another exotic freshwater mussel species that may pose a significant threat to the Appalachian elktoe. *Dreissena polymorpha*, a native of the drainage basins of the Black, Caspian, and Aral Seas, was first introduced into Lake St. Clair in the mid- to late 1980s. In only a few years it colonized all five of the Great Lakes and is rapidly expanding into the surrounding river basins (O'Neill and MacNeill 1991). Many biologists believe the species may ultimately infest most areas of North America south of central Canada and north of the Florida Panhandle (O'Neill and MacNeill 1991). *Dreissena polymorpha* is a prolific breeder; once established in an area, it attaches in large numbers to any firm nontoxic surface, including other living organisms (i.e., crayfish, snails, other mussels, etc.) (O'Neill and MacNeill 1991). Numerous live and dead native mussels have been observed, covered with extensive growths of *D. polymorpha*, and there are signs that native mussel populations in Lake St. Clair are disappearing rapidly coincident with the *D. polymorpha* colonization (O'Neill and MacNeill 1991). Aside from the direct interactions between *D. polymorpha* and native benthic organisms, there is concern that the tremendous filtering activity exerted by high-density populations of the species could disrupt the natural food chain and affect the entire aquatic communities of infested lakes and streams (Hebert *et al.* 1991, O'Neill and MacNeill 1991, Weigmann *et al.* 1991).

The introduction of nonindigenous fish species can also result in the significant disruption of aquatic communities. The effects of predation on endemic species and/or competition for food and breeding habitat between nonindigenous and native fish species can result in drastic declines in, or even the elimination of, the native fish fauna, including the species necessary for the Appalachian elktoe and other endemic mussels to complete their reproductive cycles.

Predation may also pose a threat to the continued existence of the Appalachian elktoe. Shells of the Appalachian elktoe are often found in muskrat middens along the reach of the Little Tennessee River where the species still exists and occasionally in middens along the Nolichucky River. The species also is presumably consumed by other mammals, such as racoon and mink. While predation is not thought to be a significant threat to a healthy mussel population, it could, as suggested by Neves and Odum (1989), limit the recovery of endangered mussel species or contribute to the local extirpation of mussel populations already depleted by other factors.

PART II

RECOVERY

A. Recovery Objectives

The immediate goal of this recovery plan is to maintain the only known surviving populations of *A. raveneliana* and to protect its remaining habitat from present and foreseeable threats. There are only two known surviving populations of this species--one in a short reach of the Little Tennessee River in North Carolina and one in a short reach of the upper Nolichucky River system in North Carolina, extending a short distance into Tennessee. Lack of proper protection and management of these populations will preclude recovery of the Appalachian elktoe and will ultimately lead to the species' extinction.

The intermediate goal of this recovery plan is to restore and maintain *A. raveneliana* throughout a significant portion of its historic range in the Little Tennessee, French Broad, and Nolichucky River systems and to downlist the species from endangered to threatened status.

Though the ultimate goal is to recover the species to the point where it can be removed from the Federal List of Endangered and Threatened Wildlife and Plants, full recovery of the Appalachian elktoe may not be possible. The species appears to have a very restricted distribution, and much of the habitat within its known historic range may not be suitable for reintroductions.

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 existing populations and through successful establishment of reintroduced populations or the discovery of additional populations, a total of four distinct viable populations exist. A viable population is defined as a naturally reproducing population that is large enough to maintain sufficient genetic variation to enable it to evolve and respond to natural environmental changes. The number of individuals needed to reach a viable population will be determined as one of the recovery tasks. These four populations shall be distributed throughout the species' historic range, with at least one each in the Little Tennessee, French Broad, and Nolichucky River systems. Also, these populations must be extensive enough that it is unlikely that a single event would eliminate or significantly reduce one or more of these populations.

2. Three distinct naturally reproduced year classes exist within each of the four populations. One of these year classes must have been produced within the 3 years prior to the time the

species is reclassified from endangered to threatened. Within the year prior to the downlisting date, gravid females and host fish must be present in each populated river and/or stream reach.

3. Biological and ecological studies have been completed and any required recovery measures developed and implemented from these studies are beginning to show signs of success, as evidenced by an increase in population density and/or an increase in the length of the river reach inhabited by each of the four populations.

4. Where habitat has been degraded, noticeable improvements in water and stratum quality have occurred.

5. Each of these four populations and their habitats are protected from any present and foreseeable threats that would jeopardize their continued existence.

6. All four populations remain stable or increase over a period of 10 to 15 years.

The Appalachian elktoe will be considered for removal from Endangered Species Act protection when the likelihood of the species' becoming threatened in the foreseeable future has been eliminated by the achievement of the following criteria:

1. Through protection of existing populations and through successful establishment of reintroduced populations or the discovery of additional populations, a total of six distinct viable populations exist. These populations shall be distributed throughout the species' historic range, with at least one each in the Little Tennessee, French Broad, and Nolichucky River systems. Also, these populations must be extensive enough that it would be unlikely that a single event would eliminate or significantly reduce one or more of them.

2. Three distinct naturally reproduced year classes exist within each of the six populations. One of these year classes must have been produced within the 5 years prior to the recovery date and another year class within the 3 years prior to the recovery date. Within the year prior to the recovery date, gravid females and host fish must be present in each river.

3. Studies of the mussel's biological and ecological requirements have been completed and recovery measures developed and implemented from these studies have been successful, as evidenced by an increase in population density and/or an increase in the length of the river reach inhabited by each of these six populations.

4. Where habitat has been degraded, noticeable improvements in water and stratum quality have occurred.

5. Each of these six populations and their habitats are protected from any present and foreseeable threats that would jeopardize their continued existence.

6. All six of the populations remain stable or increase over a period of 10 to 15 years.

C. Narrative Outline

1. Maintain the existing populations and habitat of the Appalachian elktoe. At present there are only two known surviving populations of *A. raveneliana*--one in a relatively short reach of the Little Tennessee River in Swain and Macon Counties, North Carolina, and one in a relatively short reach of the upper Nolichucky River system in Yancey and Mitchell Counties, North Carolina, extending a short distance into Unicoi County, Tennessee. If the species is to survive and expand its range, protection of the existing populations and remaining areas of suitable habitat is vital. Unless immediate steps are taken to stop the decline of the species and protect and secure these relict populations, the species will likely be extinct in the near future.

   1.1 Utilize existing legislation and regulations (Federal Endangered Species Act, Federal and State water quality regulations, stream alteration regulations, surface mining laws, etc.) to protect the species and its habitat. Prior to and during implementation of this recovery plan, the present populations can be protected only by the full enforcement of existing laws and regulations. Unless this objective is met, any recovery activities would be essentially moot. Habitat and water quality degradation have severely reduced the species' range and continue to threaten the only remaining populations. Complete compliance with Federal and State laws and regulations designed to protect water and habitat quality must be ensured if the Appalachian elktoe is to survive.

   1.2 Work with appropriate Federal and State regulatory and review agencies to identify and assess projects and/or activities that could have negative effects on the species and to ensure incorporation of measures for protecting the species and its habitat into such activities. Through Section 7 of the Endangered Species Act, the Fish and Wildlife Coordination Act, Clean Water Act, etc., Federal and State regulatory and review agencies must work together to carefully evaluate and identify actions and activities that could potentially have an adverse effect on the species and its habitat. Once impacts have been identified, regulatory and/or permitting agencies must be encouraged to utilize their authorities to ensure that the species and its habitat are adequately protected from such activities.

   1.3 Solicit help in protecting and enhancing the species and its essential habitat. The assistance and support of conservation groups, local governments, and regional and local planners will be essential in meeting the goal of recovering the Appalachian elktoe. Also, the support of local industrial, business, silvicultural and agricultural communities, as well as local residents, will be needed. Construction, forestry, and agricultural "best management practices" must be implemented by all landowners, and National Pollution Discharge Elimination System Permit compliance must be encouraged and enforced. Local land-use planning is needed to protect water resources, and individuals need to be informed as to why and how they should protect

creeks and rivers. Efforts such as the Service's Partners for Wildlife Program and programs offered through Federal and State departments of agriculture must be utilized to encourage and assist landowners with the restoration of degraded areas that are contributing to sedimentation or water pollution problems. Without a commitment from the local people who have an influence on habitat quality in the streams inhabited by the species, recovery efforts will be met with little success.

1.3.1 Meet with local government officials and regional and local planners to inform them of our plans to attempt recovery and solicit their support for protection of the species and its essential habitat.

1.3.2 Meet with local business, farming, logging, mining, and industry interests and elicit their support in implementing protective actions.

1.3.3 Develop an educational program using such items as slide/tape shows, brochures, etc. Present this material to business and industrial groups, civic groups, schools, church organizations, etc. Educational material outlining the recovery goals and emphasizing the benefits of maintaining and upgrading habitat quality will be extremely useful in informing the public of our actions and implementing Tasks 1.3.1 and 1.3.2 above.

1.4 Encourage the establishment of mussel sanctuaries, protective water quality designations, stream buffer zones, and other protection strategies as a means of protecting present and reintroduced populations. The Service should work with the Environmental Protection Agency and appropriate State agencies in North Carolina and Tennessee to have special status assigned to river reaches inhabited by the species that would provide increased protection to the Appalachian elktoe and the quality of the rivers in which it survives.

2. Determine threats to the species, conduct research necessary for the species' management and recovery, and implement management where needed.

2.1 Conduct life history research on the species (reproduction, food habits, age and growth, and mortality rates) and characterize the species' habitat requirements (relevant physical, biological, and chemical components) for all life history stages. Research should be done to determine the time and duration of the spawning season, when fertilization occurs, how long glochidia are held in the females' marsupia, and the time of year they are released. Fertilization rates should also be investigated. While there is some information indicating that the banded sculpin serves as a fish host to the Appalachian elktoe, further studies are necessary to determine if other fish species may also serve as hosts to the elktoe's glochidia and the status of fish host(s) species within the mussel's range. Detailed knowledge of the habitat requirements of the species; community structures of associated mussel and fish species; and how

these biotic and abiotic factors affect reproduction, growth, and mortality rates of the Appalachian elktoe is needed in order to focus management and recovery efforts on specific problems within the species' habitat. Unless the life cycle and environmental requirements of all life history stages of the species are defined, recovery efforts may be inconsequential or misdirected.

2.2 Identify and eliminate current and future threats to the species' survival. Water quality and habitat degradation resulting from siltation and other pollutants from numerous point and nonpoint sources appear to be major factors in the reduction of the species' range. The nature of and mechanisms by which these and other factors impact the species are not entirely understood. The extent to which the species can withstand these adverse impacts is unknown. To minimize and eliminate these threats (where necessary to meet recovery), the information gathered in Task 2.1 must be utilized to target and correct specific problem areas and determine the specific causative agent(s).

2.3 Investigate relationships with nonnative bivalves and prevent their introduction/spread. Of concern among malacologists is the potential effect of the introduced Asiatic clam (*Corbicula fluminea*) and the zebra mussel (*Dreissena polymorpha*) on native freshwater mussels. Introductions of nonindigenous fish may also pose a significant threat the Appalachian elktoe. The relationship between these nonindigenous species and the native fauna should be thoroughly investigated, and measures should be implemented (where feasible) to prevent and/or minimize their expansion and impact.

2.4 Based on the biological data and threat analysis, investigate the need for management, including habitat improvement. Implement management where needed to secure viable populations. Specific components of the Appalachian elktoe's habitat or biological needs may be lacking, and this may limit the species' potential expansion. Habitat improvement programs may be needed to alleviate limiting factors.

2.5 Determine the number of individuals required to maintain a viable population and the genetic viability of existing populations. Long-term management of Appalachian elktoe populations will require knowledge of the genetic composition of each population, the number of individuals necessary to maintain genetic viability, and an understanding of the factors that affect viability. Such studies should develop and use techniques that minimize the sacrifice of individuals from natural populations (examples include salvage and analysis of individuals killed incidentally or collected from fresh muskrat middens, nonlethal analysis of individuals using small excised tissue samples, production of an experimental cultured population, and development of such techniques using more common surrogate species).

3. Search for additional populations and/or habitat suitable for reintroduction efforts. Distributional studies of this species have been completed. However, it is possible that some relic populations were missed, and further study may yield additional populations and/or suitable habitat for reintroductions. Also, surveys are needed to record and monitor any future range reductions or expansions.

4. Determine the feasibility of augmenting extant populations and reestablishing populations within the species' historic range and reintroduce where feasible. Presently there are only two known remaining populations of the Appalachian elktoe--the Little Tennessee River and Nolichucky River populations. For the species to survive, it may be necessary at some point in the future for these populations to be supplemented to enable them to reach or maintain a viable size. Also, recovery of the Appalachian elktoe cannot be achieved without the reestablishment of the species throughout a significant portion of its historic range, and there may be areas within the species' historic range that could support reestablished populations. Because the majority of the areas from which the species has been eliminated are isolated from existing populations, natural reestablishment of these areas by the species is impossible and will require human assistance. However, before reintroduction activities can be carried out with any confidence that they can be successful, additional research is necessary to determine the range of environmental requirements of the species and successful techniques for reintroducing it. Further, artificial propagation of the species may be necessary in order to obtain sufficient numbers of the species for successful reintroductions. It appears that the existing populations, especially the Nolichucky River population, are too small to support reintroductions.

   4.1 Determine the need, appropriateness, and feasibility of augmenting and expanding existing populations. The Nolichucky River population of the species may be able to expand naturally if environmental conditions are improved and maintained. However, the Little Tennessee River population is sandwiched between two reservoirs and presently has no potential for expansion except within presently unsuitable areas within the river reach and its tributaries between these two reservoirs. It may be necessary at some point in the future to supplement both of these populations in order for them to continue to survive and/or reach and maintain a viable size. Implementation of this task will be based on population size, habitat quality, and the likelihood of long-term benefits.

   4.2 Develop a successful technique for reestablishing and augmenting populations. It is likely that sufficient specimens of the Appalachian elktoe are not currently available to allow for the translocation of enough individuals of the species to reestablish viable populations. There is an immediate and urgent need to develop techniques for propagating and holding mussels for prolonged periods and rearing juveniles to a size and age at which they can be successfully transplanted. Reintroduction techniques must also be developed to ensure success.

4.3 Coordinate with appropriate Federal and State agency personnel, local governments, and interested parties to identify habitat suitable for augmentation and reintroductions and those sites most easily protected from future threats.

4.4 Augment existing populations where needed, establish new populations within the species' historic range, and evaluate success. Using the techniques developed in Task 4.2, introduce and monitor success.

4.5 Implement the same protective measures for any introduced populations as outlined for established populations.

5. Develop and implement cryogenic techniques to preserve the species' genetic material until such time as conditions are suitable for reintroduction. In the future, artificial propagation techniques may be able to provide juvenile mussels for transplants. At this time, however, artificial propagation techniques have meet with only limited success. Also, habitat conditions within the species' historic range may not be suitable for reintroduction to succeed. Cryogenic preservation of the Appalachian elktoe could maintain genetic material from all the extant populations (much like seed banks for endangered plants) until successful propagation techniques have been developed and habitat is suitable for reestablishment of the species. Additionally, if a population were lost to a catastrophic event, such as a toxic chemical spill, cryogenic preservation could, if the techniques can be developed, allow for the eventual reestablishment of the population using genetic material preserved from that population.

6. Develop and implement a program to monitor population levels and habitat conditions of existing populations, as well as newly discovered, introduced, or expanding populations. During and after recovery actions are implemented, the status of the species and its habitat must be monitored to assess any progress toward recovery. Quantitative samples should be taken to determine densities of adults and juveniles. A concerted effort should be made to find gravid females and juveniles in order to determine if reproduction and recruitment are occurring. Monitoring should be conducted on a biennial schedule.

7. Annually assess the overall success of the recovery program and recommend action (changes in recovery objectives, delist, continue to protect, implement new measures, other studies, etc.). The recovery plan must be evaluated periodically to determine if it is on track and to recommend future actions. As more is learned about the species and as conditions change, recovery objectives may need to be modified.

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PART III

IMPLEMENTATION SCHEDULE

Priorities in column one of the following Implementation Schedule are assigned as follows:

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

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

3. Priority 3 - All other actions necessary to meet the recovery objective.

Key to Acronyms Used in This Implementation Schedule

COE - U.S. Army Corps of Engineers
EPA - U.S. Environmental Protection Agency
TE - Endangered Species Division of the U.S. Fish and Wildlife Service
FS - U.S. Forest Service
FWS - U.S. Fish and Wildlife Service
LE - Law Enforcement Division of the U.S. Fish and Wildlife Service
R4 - Region 4 (Southeast Region), U.S. Fish and Wildlife Service
NRCS - U.S. Natural Resources Conservation Service
SCA - State Conservation Agencies - In North Carolina, these are the North Carolina Department of Agriculture; North Carolina Department of Environment, Health, and Natural Resources; North Carolina Division of Parks and Recreation, and North Carolina Wildlife Resources Commission. In Tennessee, the Tennessee Department of Environment and Conservation, Tennessee Wildlife Resources Agency, and Tennessee Department of Agriculture.
TNC - The Nature Conservancy
TVA - Tennessee Valley Authority

APPALACHIAN ELKTOE IMPLEMENTATION SCHEDULE

Priority	Task Number	Task Description	Task Duration	Responsible Agency		Cost Estimates ($000s)			Comments
				FWS	Other	FY1	FY2	FY3	
1	1.1	Utilize existing legislation and regulations to protect species and its habitat.	Continuous	R4/TE and LE	COE, EPA, SCA, FS, TVA	2.5	2.5	2.5	
1	1.2	Work with appropriate Federal and State agencies to identify actions that could negatively affect the species and incorporate protective measures into such actions.	Continuous	R4/TE	COE, EPA, SCA, NRCS, FS, TVA	3.0	3.0	3.0	
1	1.4	Encourage establishment of outstanding resource water designations and other protective strategies as a means of protecting the species.	Ongoing	R4/TE	COE, EPA, SCA, NRCS, TNC, FS, TVA	???	???	???	
1	2.1, 2.2, 2.3	Conduct research necessary for species' management and recovery; i.e., habitat requirements, biology, and threat analyses.	3 years	R4/TE	SCA, FS, TVA	25.0	25.0	25.0	
2	1.3.1, 1.3.2	Meet with local government officials and business interests and elicit their support for recovery.	3 years	R4/TE	COE, EPA, SCA, NRCS, TNC, FS, TVA	3.0	2.0	1.0	
2	1.3.3	Develop information and education program and present.	Ongoing	R4/TE	COE, EPA, SCA, NRCS, TNC, FS, TVA	5.0	3.5	2.0	Task duration: 1 year to develop, then continuous.
See comments	2.4	Based on biological and threat analyses, investigate need for management and implement where needed.	2 years	R4/TE	COE, EPA, SCA, NRCS, FS, TVA	---	25.0	25.0	Priority 1, 2, or 3, depending on result of 2.1, 2.2, and 2.3.

APPALACHIAN ELKTOE IMPLEMENTATION SCHEDULE (continued)

Priority	Task Number	Task Description	Task Duration	Responsible Agency FWS	Responsible Agency Other	Cost Estimates ($000s) FY1	FY2	FY3	Comments
2	2.5	Determine number of individuals required to maintain viable population.	1 year	R4/TE and LE	Contract	---	---	???	
2	3	Search for additional populations and suitable habitat for reintroduction.	Ongoing	R4/TE	SCA, FS, or Contract	6.0	6.0	---	
2	4	Develop artificial holding and propagation techniques; reintroduce species into historic habitat; and, if needed, augment existing populations.	Ongoing	R4/TE	Contract	30.0	30.0	30.0	
2	5	Develop and utilize cryopreservation techniques.	Ongoing	R4/TE	Contract	8.5	8.5	2.0	
2	6	Develop and implement a monitoring program.	Ongoing	R4/TE	SCA, FS, TVA	---	---	4.0	Biannual.
3	7	Annually assess recovery program and modify program and plan where required.	Ongoing	R4/TE	SCA, COE, EPA, NRCS, FS, TVA	0.5	0.5	0.5	

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