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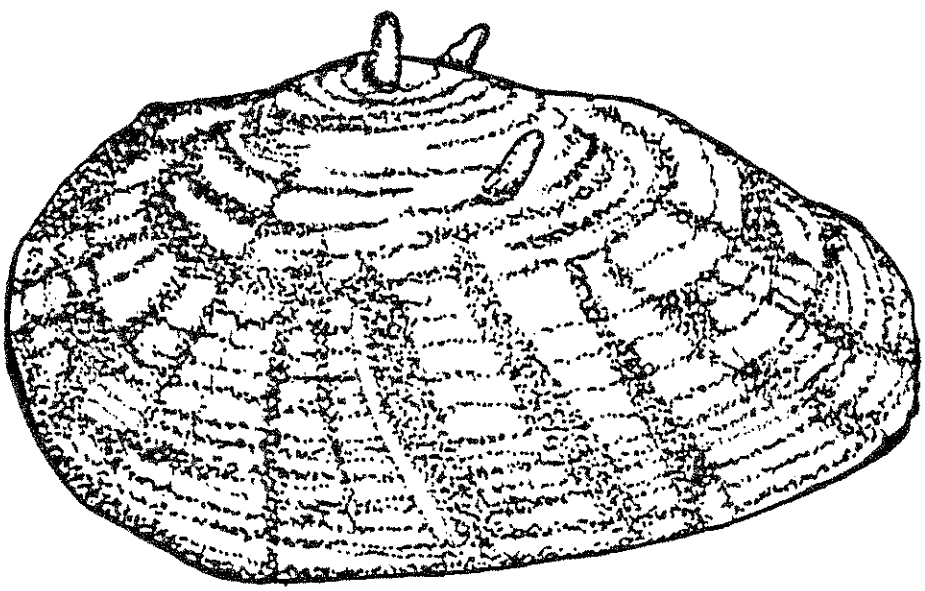
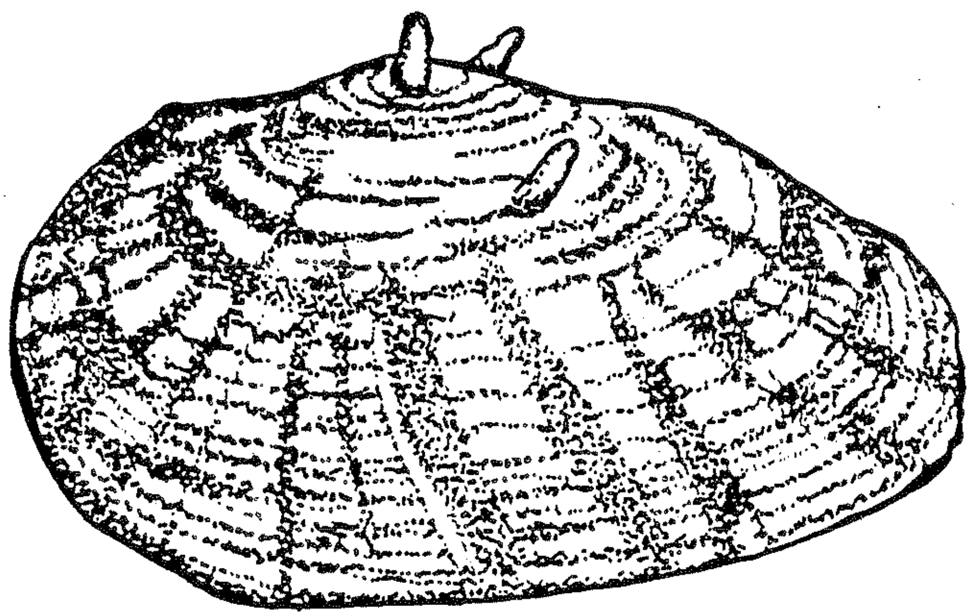
E. steinstansana (98)
Widlak 1987

Tar River Spiny Mussel



Recovery Plan

Tar River Spiny Mussel



Recovery Plan

28 pp.

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RECOVERY PLAN

for

Tar River Spiny Mussel
(*Elliptio* (*Canthyria*) *steinstansana*) Johnson and Clarke

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Date: January 16, 1987

DISCLAIMER

This is the completed Tar River Spiny Mussel Recovery Plan. It has been approved by the U.S. Fish and Wildlife Service. It does not necessarily represent official positions or approvals of cooperating agencies and does not necessarily represent the views of all individuals who played a role in preparing this plan. This plan is subject to modification as dictated by new findings, changes in species status, and completion of tasks described in the plan. Goals and objectives will be attained and funds expended contingent upon appropriations, priorities, and other constraints.

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RECOVERY PLAN EXECUTIVE SUMMARY

1. Point or condition when the species can be considered recovered.

   The primary objective of recovery is to protect the only known population of Elliptio steinstansana and to reestablish the species throughout its historic range in the Tar River in North Carolina.

   Downlisting from endangered to threatened status should occur when the following criteria are met: (1) the existing population shows evidence of reproduction, including at least two juvenile (age three or younger) age classes; (2) four additional subpopulations are discovered or reestablished within the species' historic range; (3) all populations and their habitats are protected from present and foreseeable threats; and (4) all populations remain stable or increase over a period of 15 to 20 years.

   Because of its extremely restricted distribution, the Tar River spiny mussel may be unable to reach the point where it can be delisted. However, when downlisting criteria are met, the species' status should be reassessed to determine if delisting is warranted.

2. What must be done to reach recovery?

   Delisting may be possible if the existing population is secure, subpopulations are reestablished, and all populations are protected and exhibit long-term stability.

3. What specifically must be done to meet the needs of number 2 above?

   The known population of E. steinstansana has been estimated to contain 100 to 500 individuals. The key to recovery is to protect and increase this population. Once this is accomplished, new populations can be established. Artificial propagation may be the only means of providing individuals, but to date attempts have been unsuccessful. Techniques for propagating mussels must be developed. Resource agencies, industry, and landowners should cooperate to maintain water quality in the Tar River. Research on the species' biology and ecology should be conducted. The relationship between E. steinstansana and the introduced Corbicula fluminea should also be investigated.

4. What management/maintenance needs have been identified to keep the species recovered?

   If the Tar River spiny mussel is delisted, the populations will have to continue to be monitored to ensure that they are maintaining viability.

   Habitats occupied by Tar River spiny mussels should continue to be protected from alteration and water quality degradation.

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PART I

INTRODUCTION

The rivers and streams of the Southeastern United States contain a diverse naiad (freshwater mussel) fauna. There are over 150 species in this 11-state area, including species endemic to particular rivers or river systems (Burch 1975). Although the richest fauna occurs in the Tennessee and Cumberland River drainages, rivers throughout the region support healthy populations of some species. The Tar River spiny mussel, *Elliptio (Canthyria) steinstansana* (Johnson and Clarke), is 1 of 61 mussel species known from North Carolina (Dawley 1965) and one of only three known freshwater spiny mussel species in the world. It was listed as endangered on July 29, 1985 (FEDERAL REGISTER 50:26572-26575).

The Tar River spiny mussel was formally described as *Elliptio (Canthyria) steinstansana* by Johnson and Clarke (1983) from the Tar River, North Carolina. Clarke (1983) states that it is similar to *Pleurobema* (=*Fusconaia*) *collina* of the James River, Virginia, but bears a greater similarity to *Elliptio (Canthyria) spinosa* of the Altamaha River, Georgia. A taxonomic history, with reasons for generic and specific placement of the species, is provided in Clarke (1983) and Johnson and Clarke (1983).

Elliptio (Canthyria) steinstansana is a medium-sized mussel reaching about 60mm in length (Johnson and Clarke 1983). The shell is subrhomboidal with inequilateral, subinflated valves. The anterior end is regularly rounded and slightly broader posteriorly, ending in a blunt point. Umbos are slightly elevated above the hinge line and are located in the anterior third of the shell. The left valve contains two triangular pseudocardinal teeth. The right valve has two parallel pseudocardinals--one triangular and serrate (posterior) and one low and vestigial (anterior). Lateral teeth are straight, compressed, obliquely descending, double in the left valve, and single in the right valve. The pallial line is impressed anteriorly and faint posteriorly, and nacre color is yellowish or pinkish (anterior) and bluish-white (posterior). Young specimens have an orange-brown periostracum with narrow and wide greenish rays; adults are darker with inconspicuous rays. The shell surface is generally smooth and shiny with fine concentric sculpture and has from one to several short spines arranged in a radial row slightly in front of the posterior ridge. The spines project perpendicularly from the shell surface, and the tips are slightly bent (or angled) toward the ventral margin of the shell. On specimens less than 35mm long, the spines measure approximately 2.6mm in length and 1.5mm in basal width (Johnson and Clarke 1983). Large specimens may or may not have shell spines. These individuals may be confused with some forms of *Elliptio complanata*, a common Tar River species. *E. steinstansana* may be distinguished by its shiny periostracum and parallel pseudocardinal teeth.

Distribution

Elliptio (Canthyria) steinstansana has apparently always had a restricted distribution and is endemic to the Tar River in eastern North Carolina. The type locality is the Tar River in Edgecombe County. Historical collection records indicate that the Tar River spiny mussel once occurred from Falkland in Pitt County to Spring Hope in Nash County (Shelley 1972, Clarke 1983). The Fall Line apparently wasn't a barrier to upstream distribution of the Tar River spiny mussel (Figure 1), and it is possible that the species once occurred upstream from Spring Hope. Since 1966, the species' range has been reduced by about 50 percent (Clarke 1983) to approximately 12 miles of the Tar River in Edgecombe County. Clarke (1983) collected nine live Tar River spiny mussels, and Biggins (U.S. Fish and Wildlife Service [Service], personal communication) found three live specimens during surveys in 1982 and 1983. Clarke (1983) also conducted intensive surveys of four other rivers in eastern North Carolina. Collections from the Roanoke, Cashie, Neuse, and Trent Rivers contained no live or relic specimens of the Tar River spiny mussel. A recent survey of several of Clarke's sites by Service personnel during the fall of 1985 failed to find live E. steinstansana. An extensive survey of the river in Franklin, Nash, and Edgecombe Counties by personnel from the Service, U.S. Army Corps of Engineers, North Carolina Wildlife Resources Commission, Virginia Polytechnic Institute and State University, and Smithsonian Institution was conducted in the spring of 1986. Several relic shells were found, but no live E. steinstansana were collected. State and Service personnel resurveyed Clarke's sites in October 1986 and failed to collect live specimens or shells. Clarke (1983) estimated the population in the Tar River to be between 100 and 500 individuals. This estimate is not based on quantitative collections, but it does indicate that the Tar River spiny mussel is one of the rarest freshwater mussels in North America.

Life History and Ecology

The life history and ecological requirements of the Tar River spiny mussel are unknown. However, it probably follows one of the two life cycle strategies exhibited by all other North American unionids. Male mussels release sperm into the water column, and the sperm are taken in by females through their siphons during normal siphoning. Fertilized eggs are retained in the gills, which serve as brood pouches for the fully developed larvae, or glochidia. The glochidia are released into the water, and within three or four days must attach to an appropriate host fish. If attachment occurs, the glochidia metamorphose and drop from the fish as free-living juvenile mussels. Two reproductive modes are known. In tachytictic (short-term) breeders, eggs are fertilized in spring and glochidia are released in spring and summer. Fertilization occurs in summer and fall in bradytictic (long-term) breeders. Glochidia over-winter in the females' brood pouches and are released the following spring. Winter release of glochidia has also been observed for some bradytictic species (Zale 1980). Unionine (subfamily Unioninae) species, including the genus Elliptio, generally exhibit the tachytictic mode of reproduction. Ortmann (1911) reported gravid females of Elliptio species from late April through early August. It is likely that Elliptio steinstansana is also a short-term breeder. However, the glochidia of the Tar River spiny mussel are undescribed and the fish host is unknown.

The habitat of E. steinstansana was described by Clarke (1983). Live specimens were collected in sand substrate ranging from fine to coarse in water 0.1 to 1.2 meters deep. Stream width at these locations ranged from 48 to 57 meters and maximum current velocity was 0.26 to 0.5 m/sec. Biggins (personal communication) collected E. steinstansana in water with similar depth and current conditions and hard-packed sand substrate; one specimen, however, was found in soft sand. Clarke (1983) suggested that unpolluted, well-oxygenated water of moderate hardness with substantial volume and flow over sandy substrate and the presence of the appropriate host fish are essential habitat features.

Several authors have speculated on the function of spines on the three species of Elliptio. Johnson (1970) thought that spines on young E. spinosa served as devices to stabilize the mussels in the substrate. However, Clarke (1978, unpublished) stated that because E. steinstansana occurs in fine sediment in areas of slow current, spines are more likely a morphological response to intense selection within mixed species communities. Placement of spines on the shells may also be significant. One hypothesis is that spines function to maintain valve alignment, because the single spine on the left valve articulates with the space between spines on the right valve. This would have some value to juvenile mussels with weak adductor muscles (Clarke 1978, unpublished).

Reasons for Decline

The Tar-Neuse River basin comprises 8,893,000 acres of the Piedmont and Coastal Plain physiographic regions in eastern North Carolina. Land use within this 29-county area is: 47 percent forest, 20 percent cropland, 3.5 percent urban, and 11.4 percent other uses; water comprises 18.1 percent of the area (U.S. Soil Conservation Service [SCS] 1980). Major population centers in the Tar River basin are Rocky Mount (41,283), Greenville (35,740), Henderson (13,522), and Tarboro (8,634). Although the area is largely undeveloped and the river, for the most part, is physically unaltered, activities within the basin have had profound effects on the aquatic fauna, including E. steinstansana. A recent report issued by the North Carolina Department of Natural Resources and Community Development (NCDNRCD 1985) indicated that biological and water quality in the Tar River basin is fair to good, but problems still exist. The following sections discuss activities in the Tar-Neuse River basin and other river systems and how they are thought to have contributed to the decline of freshwater mussels in the Southeastern United States, including the Tar River spiny mussel. It should be noted that the population of this species may already be at a critically low level, and it is unlikely that natural recovery is possible. Loss of any individuals due to factors discussed here greatly increases the probability that the Tar River spiny mussel may go extinct in the foreseeable future.

Siltation resulting from poorly implemented land use practices during agricultural and forestry activities may be the most significant factor contributing to water quality problems and decline of E. steinstansana in the Tar River. It has been estimated that 15.3 million tons (16.8 million metric tons) of soil erode from land in the Tar-Neuse River basin annually. Of this, approximately 4 million tons (4.4 million metric tons) (26 percent) reaches the waterways (SCS 1980). The Tar River basin above Louisburg is one of the most severely eroded areas in North Carolina (SCS 1980). The average erosion rate is 23.3 tons (25.6 metric tons) per acre annually. For every 100 tons of gross annual erosion, 32 tons are delivered to the streams (SCS 1980), resulting in a total of 551,240 tons entering these streams. 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 levels in Kentucky streams within coal mining areas were reported to be up to 30 times higher than in streams outside those areas, resulting in declines in abundance of the benthic fauna (Branson and Batch 1972). Reductions in mussel abundance in the Stones River in Tennessee were thought to be a partial result of siltation from gravel dredging during summer low flow conditions (Schmidt 1982). Suspended sediment can clog the gills of filter feeding mussels and eventually suffocate them, so mussels often respond by closing their valves (Ellis 1936). Kitchel et al. (1981) reported reduced siphoning activity, and consequently reduced feeding, by mussels placed in aquaria with suspended coal fines. Indications are that siltation can stress mussels severely and lead to chronic effects. It has been estimated that two-thirds of the annual gross erosion in the Tar-Neuse River basin occurs on cropland. Sedimentation has been cited as the cause of water quality problems in all tributaries of the Tar River within the range of the Tar River spiny mussel (NCDNRCD 1985). In addition, erosion resulting from improper logging activities (760,000 tons/year) represents an increase of 85 percent in erosion over and above normal expected erosion within the basin (SCS 1980). Erosion from poor land use is expected to increase over the next 40 years. Elliptio steinstansana occurs in sand substrate and is not found in areas of silt deposition. It is apparently not a silt tolerant species and may be sensitive to lower amounts of silt than other species. If siltation in the Tar River basin continues at present rates or increases, abundance of mussels, including E. steinstansana, will undoubtedly continue to decrease.

The Asiatic clam, Corbicula fluminea (sometimes referred to as Corbicula manilensis), is 1 of 204 introduced mollusk species in North America (Dundee 1969). It was first discovered in the United States in the Columbia River, Oregon, in 1939. By 1956 it had spread to the Southwestern United States, to the Tennessee and Cumberland Rivers by 1961, and by 1964 it was reported in the Ohio and Mississippi River systems and into Florida (Dundee 1969). The first record of the species in the Atlantic drainage was in 1971 from the Altamaha River in Georgia. In 1972 live specimens were found in the Savannah River, Georgia; Pee Dee River, South Carolina; and Delaware River, Pennsylvania and New Jersey (Fuller and Powell 1973). Once established in a river, Corbicula fluminea populations achieve high densities and expand rapidly. Sickel (1973) reported 10 to 15 adults/ft^2 in streams of the Southern Atlantic Slope region of Georgia. Densities of 1,000/m^2 in the New River, Virginia (Rodgers et al. 1977), and Tar River (Clarke 1983) and 10,000/m^2 in the Altamaha River in Georgia (Gardner et al. 1976) have been reported. Rodgers et al. (1977) estimated that Corbicula traversed 138 river miles (rm) (222.6 km) in 15 years, or 9.2 rm/yr (14.8 km/yr). Parmalee (1965) reported rapid dispersal in Illinois, and Neves (Virginia Polytechnic Institute and State University, personal communication) and Clarke (Ecosearch, Inc., personal communication) stated that Corbicula has spread rapidly in a short time in the North Fork Holston River, Virginia, and Tar River, respectively. Malacologists have recently become concerned about the possibility of a competitive interaction between Asiatic clams and native bivalves. The average filtration rate of Corbicula was estimated to be 347 ml/hr/clam (Buttner and Heidinger 1981), and Clarke (1983) hypothesized that in a river 1 meter deep flowing 1 mi/hr, 250 C. fluminea/m^2 would filter 95 percent of the phytoplankton out of the water over 24 river miles.

Disturbance of watersheds also plays a role in the expansion of the Asiatic clam. Corbicula fluminea predominates in rivers altered by human activities, excluding native unionids even when suitable habitat exists. Because it is hermaphroditic, requires no fish host, and has a long spawning season, C. fluminea may be competitively superior to native mussels in disturbed habitats. In unaltered areas, native mussels become increasingly dominant and may outcompete Asiatic clams for food and space (Fuller and Powell 1973, Sickel 1973, Fuller and Imlay 1976, Kraemer 1979). However, even in undisturbed areas, Corbicula may ultimately gain a competitive advantage by producing larger broods (Kraemer 1979). Competition may not occur among adults but rather at the juvenile stage (Neves et al., in press). The present range of E. steinstansana is in the area of the Tar River disturbed by an urban center and agricultural activity. Corbicula appeared in this area within the past five years and is now well established (Clarke, personal communication). The population will probably continue to grow and may eventually replace some of the native mussels. Clarke (1986) stated that Corbicula is a direct threat to the continued survival of the Tar River spiny mussel.

Because of its restricted distribution, the species may be unable to withstand vigorous competition and may be in imminent danger of extinction as Asiatic clam populations increase in the Tar River.

Impoundments on rivers in the Southeast have been responsible for the decline of mussel populations. The most unique locality for freshwater mussels, with respect to species diversity and abundance--Muscle Shoals, Alabama--was destroyed after closure of Wilson Dam (Ortmann 1925). Fifty additional dams have eliminated mussel populations from large sections of the Tennessee and Cumberland Rivers in Tennessee and Kentucky (Service 1984a, 1984b, 1984c, 1984d). The effects of impoundments on mussels are well documented. Closure of dams changes the habitat from lotic to lentic conditions. Depth increases, flow decreases, and silt accumulates on the bottom. Hypolimnetic discharge lowers water temperatures downstream. Fish communities change and host fish species, particularly anadromous, may be eliminated. Mussel communities change; species requiring clean gravel and sand substrate are replaced by silt tolerant species (Bates 1962). Construction of a dam near Rocky Mount (Figure 1) has impounded the Tar River for several miles, and hypolimnetic discharge has altered the conditions in the tailwater (Clarke 1983). The impounded river section no longer provides suitable habitat for the Tar River spiny mussel because of silt deposition and reduction of flow. Lowered water temperatures below the dam may have eliminated the fish host. In addition, the dam acts as an effective barrier to natural upstream expansion of this and other mussel species in the Tar River. Two smaller dams built in the vicinity in the early 1900s have blocked upstream expansion for over 50 years. Mussels above these dams have survived and reproduced, but E. steinstansana no longer occurs in that section of the river. Natural expansion of the Tar River spiny mussel into this portion of its historical range is no longer possible.

Pollution of inland waters is one of the most important environmental concerns in the United States. Many rivers have been severely impacted by pollution from municipal, industrial, and agricultural sources. Aquatic populations have been reduced and in some cases completely extirpated from lakes and streams. Pollution from a chlor-alkali plant eliminated fish and mussels from 80 miles of the North Fork Holston River, Virginia. Spills in the Clinch River, Virginia, in 1967 and 1971 killed the aquatic fauna for 11 miles (fly ash) and 18 miles (sulfuric acid) (Cairns et al. 1971, Raleigh et al. 1978). Although fish populations have subsequently recovered, those river sections are still devoid of mussels. Declines in abundance of mussel populations in the Cumberland River drainage have been attributed to acid mine drainage (Neel and Allen 1964) and organic wastes (Schmidt 1982). Salanki and Varanka (1978) found that insecticides have significant effects on mussels. Low concentrations of lindane (.006 g/l), phorate (.008 g/l), and trichlorfon (.02 g/l) caused a 50 percent reduction in siphoning activity and 1 g/l phorate or 1 ml/l trichlorfon were lethal concentrations. Preliminary findings of an ongoing study at Virginia Polytechnic Institute to determine the effects of chlorinated effluent from sewage treatment plants on aquatic mollusks indicate that sewage effluents affect the diversity and abundance of this invertebrate group. Recovery of populations may not occur for up to 4,000m below the discharge point (Neves, personal communication). Because freshwater mussels accumulate such pollutants as heavy metals and pesticides, they have been suggested as potential biomonitors of streams (Imlay 1982). In the Tar River, municipal pollution has affected aquatic organisms, and recent faunal changes near Tarboro and Rocky Mount probably resulted from pollution (Clarke 1983). The upper and middle portions of the river experience high pesticide and nutrient loading, primarily from agricultural lands (NCDNRCD 1985). These point and non-point sources of pollution have likely affected E. steinstansana and other mussels. During a recent survey, Service personnel noted a decline in mussel populations for approximately 1 mile below a sewage treatment plant in Rocky Mount. Mussels were abundant above the plant and again several miles below, but the river immediately below the outfall was devoid of mussels although the habitat was suitable. Sewage treatment facilities have been upgraded, and Clarke (1983) stated that mussel populations may become reestablished as a result of improved water quality. However, the Rocky Mount water treatment plant (Figure 1) still uses chlorination as a backup to the upgraded ozonization system. Recolonization by mussels will probably take many years, and the fact that Elliptio steinstansana is one of the rarest species of mussels may make natural reestablishment of the species highly unlikely.

Since 1982 biologists and commercial musselmen have reported extensive mussel die-offs in rivers and lakes throughout the United States. Kills have been documented from the Clinch River (Virginia), Powell River (Virginia, Tennessee), Tennessee River (Tennessee), the Upper Mississippi River (Wisconsin to Iowa), and rivers in Illinois, Kentucky, and Arkansas. Lake St. Clair (Michigan), and Chatauqua Lake (New York) have also been affected. The cause is unknown, but numerous species of mussels are involved including several commercially important and federally listed species.

Personnel involved in a survey for E. steinstansana in April 1986 discovered a massive die-off in the Tar River. Thousands of freshly dead and recently dead juvenile and adult mussels were observed at two locations below Rocky Mount. All species appeared to be affected and several shells (spineless) of what were believed to be Tar River spiny mussels were found. If these die-offs continue, the capacity of all mussel populations in the Tar River to maintain themselves will be severely reduced. Loss of any Elliptio steinstansana is critical to the species' survival; continual mussel kills will very likely result in extinction of this species in a short time.

PART II

RECOVERY

A. RECOVERY OBJECTIVES

The immediate goal of this recovery plan is to maintain the only known population of *E. steinstansana* in the Tar River of North Carolina, and protect its habitat from present and foreseeable threats. The Tar River spiny mussel may be one of the most critically endangered species presently on the Federal list (Clarke 1983). Its extremely low population level and restricted distribution may preclude recovery of the species to the point that it no longer requires protection under the Endangered Species Act.

Although *E. steinstansana* may be nearing the point of extinction, the intermediate goal of this recovery plan is to restore and maintain *E. steinstansana* throughout a significant portion of its historic range in the Tar River and downlist the species from endangered to threatened status. 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. The Tar River spiny mussel will be considered for downlisting to threatened status when the following criteria are met:

1. The population of *E. steinstansana* in Edgecombe County, North Carolina, at the nine collection sites reported by Clarke (1983), shows evidence of reproduction and recruitment; i.e., three year classes, including at least two year classes age three or younger, are present. This population should also include one year class age ten or older.

2. Through reestablishment or discoveries of additional subpopulations, excluding Edgecombe County, viable subpopulations* exist in two sections of the Tar River, one each in Nash and Pitt Counties, North Carolina--areas historically supporting populations of *E. steinstansana*. Each river section should contain at least three subpopulation

*Viable subpopulation - a population containing a sufficient number of reproducing adults to maintain genetic variability and in which annual recruitment is adequate to maintain viability.

centers** dispersed such that a single catastrophic event would not eliminate the Tar River spiny mussel from newly reestablished locations. The author recommends that subpopulation centers be at least 1 river mile apart. These new subpopulations should also show evidence of reproduction and recruitment as described for criterion 1.

3. The species and its habitats are protected from any present and foreseeable threats that would jeopardize the survival of any of the subpopulations.

4. Monitoring of all subpopulations indicates no downward trends over a period of 15 to 20 years.

When these criteria are met, the species' status will be reassessed to determine if delisting is warranted.

B. STEP-DOWN OUTLINE

1. Maintain the population and habitat of *E. steinstansana* in the Tar River in Edgecombe County.

   1.1 Identify current and future threats to species' survival.

      1.1.1 Work with appropriate agencies to identify and assess projects that could have negative effects on the species or its habitat.

      1.1.2 Determine the effects of threats to the species such as siltation, pesticide contamination, and municipal and industrial effluents.

      1.1.3 Investigate relationships with nonnative bivalves (*Corbicula*).

   1.2 Conduct intensive surveys and habitat analyses.

      1.2.1 Determine species' current distribution, range, and population size.

      1.2.2 Identify characteristics of habitat essential to the various life history stages.

2. Seek support for mitigation of threats to and protection of the species.

**Subpopulation center - a continuous river segment or a series of closely spaced river segments containing habitat and *E. steinstansana* as a breeding unit.

2.1 Meet with local government officials and industry representatives to solicit support for protection of the species and mitigation of impacts to the species and its essential habitats.

2.2 Meet with landowners along the river to seek support for species protection.

2.3 Determine most appropriate method for protecting species' essential habitat.

2.4 Develop an educational program to stress the need to protect this endangered species and its habitats.

3. Conduct life history studies and identify ecological requirements of the species.

3.1 Investigate gametogenic cycle and identify fish hosts.

3.2 Investigate species' ecological requirements and associations.

4. Determine the feasibility of reestablishing populations within the species' historic range and, if feasible, introduce the species into such areas in the Tar River.

4.1 Develop techniques for holding and propagating freshwater mussels in laboratory or culture facilities.

4.2 Utilize techniques from 4.1 to protect the species from extinction and secure the existing populations.

4.3 Select suitable sites for reestablishing populations.

4.4 Develop methods for establishing new populations, such as transplants, release of infected host fish, or introduction of juveniles.

4.5 Determine minimum number of mussels needed to maintain viable populations.

4.6 Carry out reintroduction program.

5. Periodically monitor existing populations and all introduced populations in the Tar River.

6. Evaluate the success of recovery activities and make revisions as necessary.

C. NARRATIVE OUTLINE

1. Maintain the population and habitat of the Tar River spiny mussel in the Tar River in Edgecombe County. At present, *E. steinstansana* is restricted to 12 miles of the Tar River in Edgecombe County, North Carolina. If the species is to survive and expand its range, protection of this population and river section is vital.

1.1 Identify current and future threats to species' survival. Unless this objective is met, any recovery activities would be essentially moot. Habitat alteration and degradation has reduced the species' range in the Tar River and may be threatening the only remaining population.

1.1.1 Work with appropriate agencies to identify and assess projects that could have negative effects on the species or its habitat. The implementation of the Federal Water Pollution Control Act and the State Capacity Use Act should improve water quality in the future by restricting discharge of pollutants into surface water and controlling invasion by brackish water in the aquifer system (SCS 1980). The Fish and Wildlife Coordination Act requires Federal agencies to consider the effect of projects they carry out or fund on fish and wildlife and their habitats. Section 7 of the Endangered Species Act requires agencies to consult with the Fish and Wildlife Service to ensure that their activities do not jeopardize the survival of listed species. Regulations included in these acts provide a measure of protection for the Tar River spiny mussel and its habitat. A study of the Tar and Neuse River basins (SCS 1980) has identified siltation as a major problem in those rivers, but other problems should be identified and brought to the attention of Federal and State regulatory agencies. Cooperation is needed among agencies to evaluate potential effects to the species or its habitat from construction, channelization, development, and flood control projects and to consider environmental concerns early in the planning stages.

1.1.2 Determine the effects of threats to the species such as siltation, pesticide contamination, and municipal and industrial effluents. Studies should be conducted to quantify acute and chronic effects of contaminants on the species at both individual and population levels.

1.1.3 Investigate relationships with nonnative bivalves (Corbicula). Of rising concern among malacologists is the potential effect of the introduced Asiatic clam, *Corbicula fluminea*, on native freshwater mussels. This relationship should be thoroughly investigated through laboratory and field-oriented studies.

1.2 Conduct intensive surveys and habitat analyses. The entire range of this species should be determined.

1.2.1 Determine species' current distribution, range, and population size. Intensive surveys should be continued in the Tar River to determine the species' range, abundance, and density, and to record and monitor future range reductions or the discovery of new populations or subpopulations. Surveys are recommended for river sections in Granville, Vance, Franklin, Nash, Edgecombe, and Pitt Counties.

1.2.2 Identify characteristics of habitat essential to the various life history stages. Physical, chemical, and biological components that characterize preferred habitat should be defined. Habitat analyses should be conducted concurrently with life history investigations so that potential habitat differences among life history stages are identified.

2. Seek support for mitigation of threats to and protection of the species. If recovery of the species is to succeed, it is important for local residents and landowners to ensure that environmental quality be maintained in their areas. An information program should be developed to inform the public of the importance of the river as the only refuge for the species.

2.1 Meet with local government officials and industry representatives to solicit support for protection of the species and mitigation of impacts to the species and essential habitats. Local civic leaders and regulatory agencies should be informed about recovery activities and kept apprised of projects that could affect the species or its habitat. Industry representatives should be encouraged to comply with their discharge permits and to cooperate with the populace in improving environmental quality.

2.2 Meet with landowners along the river to seek support for species' protection. Support from owners of riparian land is vital to the species' recovery. These landowners should be made aware of the species' presence in the river and the importance of protecting this habitat. They should be encouraged to take steps to improve water quality and report sources of pollution and point source violations.

2.3 Determine most appropriate method for protecting species' essential habitat. The possibility of protecting the species and its habitat through acquisition, management agreements, registry, or other means should be explored.

2.4 Develop an educational program to stress the need to protect endangered species and their habitats. It is important for the public to be informed about the need to protect endangered species and their role in providing that protection. This could be accomplished through slide-tape shows, brochures, and presentations to local school, church, and civic groups. The information and education section of the North Carolina Wildlife Resources Commission should be contacted and encouraged to publish articles about the species in its popular magazine. For the protection of the species, this task should be carried out in a way that would avoid giving specific locations where individuals have been collected.

3. Conduct life history and ecological research on the species. Without accurate data on the species' biology and ecological requirements, recovery efforts are likely to fail. All life stages should be investigated.

3.1 Investigate gametogenic cycle and identify fish hosts. 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 when they are released. Fertilization rate should also be investigated. This factor undoubtedly affects survival of the population. A description (size, shape, valve structure) of *E. steinstansana* glochidia should be provided and comparison made to glochidia of other Tar River mussels, particularly the other *Elliptio* species. Life history studies should also include identification of host fish. Most North American unionids rely on certain fish species for completion of their life cycles. Knowledge of the fish host would facilitate completion of Task 4.3. Another factor needing further investigation is species' morphology. Some specimens having no evidence of spines on the shell have been collected. Proportions of spined to spineless individuals should be determined. This is absolutely necessary for accurate data collection under Task 1.2.

3.2 Investigate species' ecological requirements and associations. This could be accomplished in conjunction with Task 1.2.2. In addition, community structures of associated mussel and fish species should be investigated.

4. Determine the feasibility of reestablishing populations within the species' historic range and, if feasible, introduce the species into such areas in the Tar River. The present range of the Tar River spiny mussel is much smaller than it was historically. There may be areas within the species' former range that could support reestablished populations. Since E. steinstansana is endemic to the Tar River, introductions into other rivers would not be advisable, but there may be areas in the Tar River that would be suitable for transplants to establish new populations. Clarke (1983) indicated that river sections in Franklin, Vance, and Granville Counties may support populations. These areas should be considered for possible transplant sites. However, since the existing population will be the only source of individuals for transplants, it is vital that this population be protected to increase its size before any transplants are attempted.

4.1 Develop techniques for holding and propagating freshwater mussels in laboratory or culture facilities. The author believes that immediate action may be necessary to prevent extinction of the Tar River spiny mussel. After considering alternatives it was decided that the only practical means of preventing extinction would be to bring as many individuals as possible to a holding facility. Once there, attempts could be made to propagate the mussels to provide a pool of individuals for transplant back into the Tar River. However, no facility has ever attempted to hold mussels for more than several months or been successful at rearing juveniles past four months of age. Therefore, there is an immediate and urgent need to develop techniques for holding mussels for prolonged periods and rearing juveniles to a size at which they can be transplanted. If Tasks 1.1 and 1.2.1 indicate the need for immediate action, facilities should be ready, so the work should be done in conjunction with those tasks using common mussel species. Successful completion of this task would be of great benefit to Elliptio steinstansana as well as all other listed mussel species.

4.2 Utilize techniques developed under Task 4.1 to protect the species from extinction and secure the existing populations. At present the population of E. steinstansana may not contain enough individuals to maintain reproductive viability. Since the survival of the species depends solely on this population, it is vital that steps be taken to protect and secure it. Successful propagation would provide individuals for transplant back to the Tar River within the present range of the species to augment and secure the existing population. Genetic variability could be maintained through periodic exchange of adults held at the culture facility for new individuals brought in from the river. Once the existing population is secure, transplants to other areas of the Tar River could begin.

4.3 Select suitable sites for reestablishing populations. Upon completion of life history studies and habitat analyses, a list of potential sites for transplants can be developed. These sites should provide the physical, chemical, and biological components required by the species for survival. Factors to be considered in site selection include substrate, water quality, and the presence of the species' fish hosts.

4.4 Develop methods for establishing new populations, such as transplants, release of infected host fish, or introduction of juveniles. There are at present two ongoing projects, by the Tennessee Valley Authority (TVA) and the Virginia Cooperative Fish and Wildlife Research Unit at Virginia Polytechnic Institute, to introduce mussel populations by (1) introduction of adult mussels and (2) release of fish artificially infected with glochidia. An artificial culture medium developed by TVA (Isom and Hudson 1982) offers potential for rearing juveniles in the laboratory for later release. Comparative analyses of these techniques is needed to determine the best method to use in a particular stream.

4.5 Determine minimum number of mussels needed to maintain viable populations. Of prime concern in establishing new populations is the minimum number of individuals needed to maintain the genetic health of an introduced population. Recovery plans developed for other endangered mussels have proposed 500 individuals as a minimum number required to maintain genetic variability and evolutionary potential (Service 1984a, 1984b, 1984c, 1984d).

4.6 Carry out reintroduction program.

5. Periodically monitor existing populations and all introduced populations in the Tar River. The population in Edgecombe County should be closely monitored. Sites should be visited at least once every year and twice if possible. Quantitative samples should be taken to determine densities of adults and juveniles. A concerted effort should be made to find gravid females and juveniles to determine if reproduction and

recruitment are occurring. Once recovery efforts are underway, a regular monitoring schedule should be developed for all introduced populations.

6. Evaluate the success of recovery activities and make revisions as necessary. This recovery plan is based on the best information available. It should be reviewed periodically and revised as needed as new information becomes available and recovery activities progress.

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PART III

KEY TO IMPLEMENTATION SCHEDULE COLUMNS 1 AND 4

General Category (Column 1):

Information Gathering - I or R (Research)

1. Population status
2. Habitat status
3. Habitat requirements
4. Management techniques
5. Taxonomic studies
6. Demographic studies
7. Propagation
8. Migration
9. Predation
10. Competition
11. Disease
12. Environmental contaminant
13. Reintroduction
14. Other information

Acquisition - A

1. Lease
2. Easement
3. Management agreement
4. Exchange
5. Withdrawal
6. Fee title
7. Other

Other - O

1. Information and education
2. Law enforcement
3. Regulations
4. Administration

Management - M

1. Propagation
2. Reintroduction
3. Habitat maintenance and manipulation
4. Predator and competitor control
5. Depradation control
6. Disease control
7. Other management

Priorities within this section (Column 4) have been assigned according to the following:

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

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.

Priority 3 - All other actions necessary to provide for full recovery of the species.

Tar River spiny mussel
(Elliptio (Canthyria) steinstansana)

Implementation Schedule

General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency: FWS Region	Responsible Agency: FWS Division	Responsible Agency: Other	Estimated Fiscal Year Costs: FY 1	FY 2	FY 3	Comments/Notes
M-3	Maintain the population of E. steinstansana in the Tar River in Edgecombe County.	1	1	Continuous	4	SE	North Carolina Wildlife Resources Commission (NCWRC)	---	---	---	Existing program funds.
I2, II2, I14	Identify and assess projects that could have negative impacts on the species or its habitat.	1.1.1	1	Continuous	4	SE, ES	NCWRC	---	---	---	Existing program funds.
R12	Determine effects of siltation, pesticides, and effluents.	1.1.2	1	3+ years	4	SE	Contract	25,000	25,000	25,000	A study involving components of this task is ongoing (FY 86) at the Virginia Cooperative Fisheries Research Unit, Blacksburg, Virginia.
R1,R3, R6,R10	Investigate relationships with nonnative bivalves (Corbicula).	1.1.3	1	3+ years	4	SE	Contract	20,000	20,000	20,000	
R1,R3	Determine species' current distribution and range and habitat requirements.	1.2.1 and 1.2.2	1	2 years	4	SE	NCWRC	27,000	27,000	---	Funding is presently (FY 86) being provided for surveys and life history studies (see Task 3.1).
O1,O4	Seek support from local government, industry and landowners for species' protection.	2.1 and 2.2	3	Continuous	4	SE, ES	NCWRC	---	---	---	Existing program funds.
A3,A4, A6	Determine appropriate methods for protecting species' habitat.	2.3	3	Continuous	4	SE	NCWRC and The Nature Conservancy (TNC)	---	---	---	Possible acquisition, registry, or management agreements.

Tar River spiny mussel
(*Elliptio* (*Canthyria*) *steinstansana*)

Implementation Schedule

General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency: FWS Region	FWS Division	Other	Estimated Fiscal Year Costs: FY 1	FY 2	FY 3	Comments/Notes
O1	Develop an educational program to stress needs for species' protection.	2.4.	3	1 year	4	SE		2,000	---	---	
R3,R6, R14	Conduct life history studies including gametogenic cycle, fish host identification and ecological requirements.	3.1 and 3.2	1	2 years	4	SE	NCWRC	---	---	---	Funding included in Tasks 1.2.1 and 1.2.2.
R7	Develop techniques for holding and propagating mussels.	4.1	1	3+ years	4	SE	Contract	45,000	45,000	45,000	
M1	Utilize techniques to protect species from extinction.	4.2	1	Continuous	4	SE	Contract	---	25,000	25,000	
R13,M2	Select suitable transplant sites and develop methods for establishing new populations.	4.3 and 4.4	1	3+ years	4	SE	Contract	12,000	12,000	12,000	
I13,R13	Determine minimum numbers needed for a viable population.	4.5	1	3+ years	4	SE	Contract	10,000	10,000	10,000	
M2	Carry out reintroduction.	4.6	1	3+ years	4	SE	NCWRC	---	10,000	10,000	
I1,I2	Monitor existing and introduced populations.	5	2	Continuous	4	SE	NCWRC	5,000	5,000	5,000	
O4	Evaluate success of recovery activities.	6	2	Continuous	4	SE	NCWRC	---	---	---	Existing program funds.

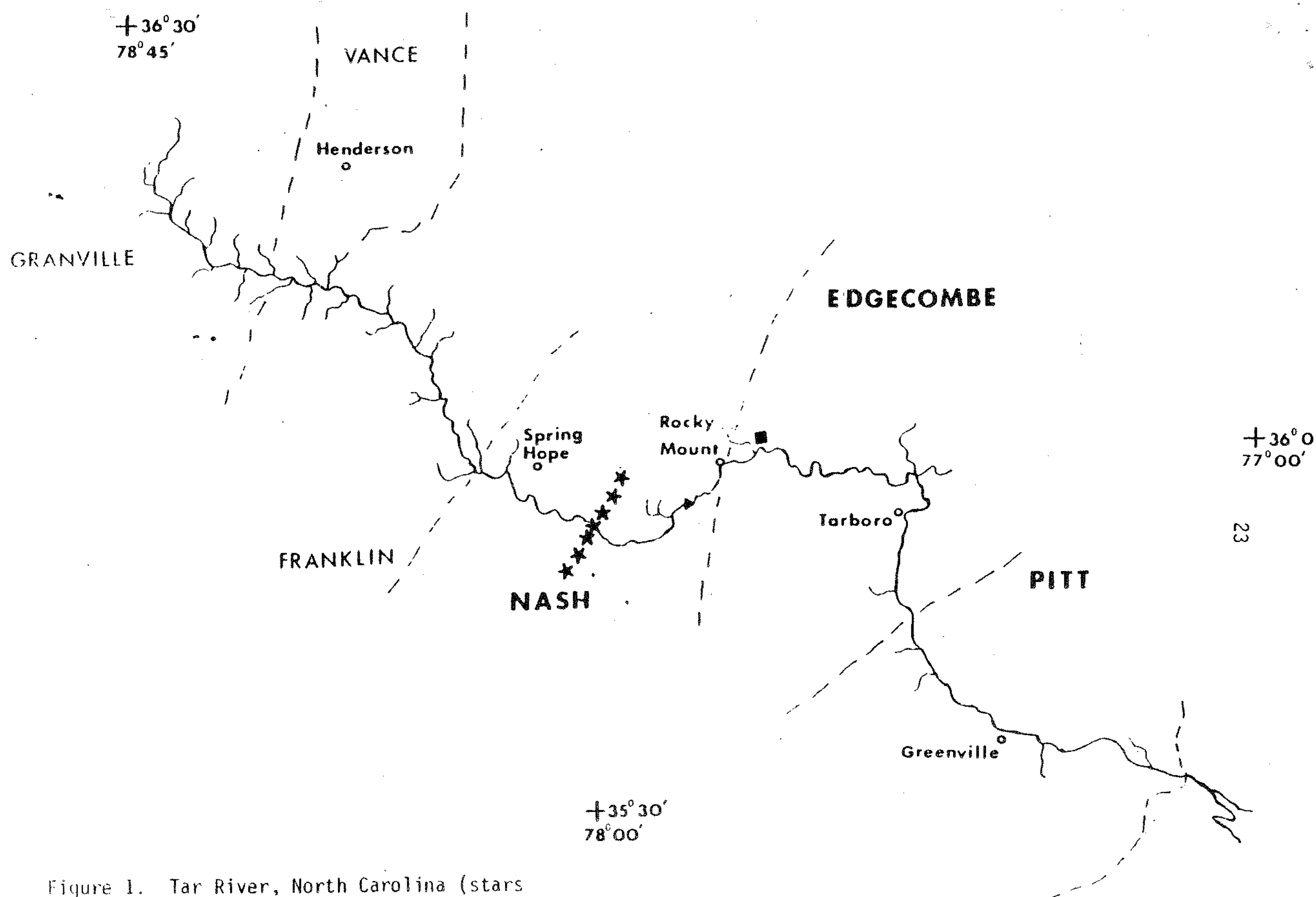

Figure 1. Tar River, North Carolina (stars indicate the Fall Line).

■ = Rocky Mount Water Treatment Plant

▲ = Dam

★ = Fall Line

Site visit April 28-29, 1986
no live C. stenistansona
die-off just ended