# RECOVERY PLAN

## *Tar Spinymussel*

U.S. Fish and Wildlife Service

# TAR SPINYMUSSEL RECOVERY PLAN

(*Elliptio* (*Canthyria*) *steinstansana*) Johnson and Clarke

FIRST REVISION

Original Approved: January 16, 1987
Original Prepared By: James C. Widlak

Revised by

John A. Fridell
Asheville Field Office
U.S. Fish and Wildlife Service
Asheville, North Carolina

for

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

Approved: 
Regional Director, U.S. Fish and Wildlife Service

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Recovery plans delineate reasonable actions which are believed to be required to recover and/or protect the species. Plans are prepared by the U.S. Fish and Wildlife Service, sometimes with the assistance of recovery teams, contractors, State agencies, and others. Objectives will only be attained and funds expended contingent upon appropriations, priorities, and other budgetary constraints. Recovery plans do not necessarily represent the views nor the official positions or approvals of any individuals or agencies, other than the U.S. Fish and Wildlife Service, involved in the plan formulation. They represent the official position of the U.S. Fish and Wildlife Service only after they have been signed by the Regional Director or Director as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

Literature citations should read as follows:

U.S. Fish and Wildlife Service. 1992. Revised Tar Spinymussel Recovery Plan. Atlanta, GA. 34 pp.

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# EXECUTIVE SUMMARY FOR THE TAR SPINYMUSSEL RECOVERY PLAN

**Current Status:** This North Carolina endemic is listed as endangered. Presently there are only three known remaining populations of the Tar spinymussel--two extremely small, apparently nonreproducing, populations in the main stem of the Tar River and a third, larger population, in Swift Creek, a tributary to the Tar River. The historic range of the species is unknown, but available information indicates it also once occurred in portions of the main stem of the Tar River from Franklin County to northern Pitt County, North Carolina.

**Habitat Requirements and Limiting Factors:** The preferred habitat of the Tar spinymussel appears to be relatively fast-flowing, well-oxygenated water, in sites with a substrate comprised of relatively silt-free, uncompacted gravel/coarse sand. Water quality and habitat degradation resulting from siltation and the runoff and discharge of agricultural, municipal, and industrial 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:** Downlisting. The species' extremely low population levels and restricted distribution may preclude full recovery.

**Recovery Criteria:** Downlisting from endangered to threatened status should occur when the following criteria are met: (1) all three existing populations show evidence of reproduction, including at least two juvenile (age 3 or younger) age classes; (2) two new, distinct viable populations 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 low numbers and restricted distribution, the Tar spinymussel may be unable to reach the point where it can be delisted. However, delisting may be possible if existing populations are secure, new populations are reestablished, and all populations are protected and exhibit long-term stability. When downlisting criteria are met, the species' status should be reassessed, and criteria for delisting should be established.

**Actions Needed:**

1. Utilize existing legislation/regulations to protect the species.
2. Elicit support through development and utilization of an information/education program.
3. Search for new populations and monitor existing populations.
4. Determine species' life history, habitat requirements, and threats to the species.

5. Implement management and alleviate threats to the species' existence.
6. Through augmentation, reintroduction, and protection, establish five 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 |
|---|---|---|---|---|---|---|---|---|
| 1992 | 5.5 | 18.0 | 6.0 | 25.0 | 0.0 | 30.0 | 12.5 | 97.0 |
| 1993 | 5.5 | 5.5 | 6.0 | 25.0 | 25.0 | 30.0 | 12.5 | 109.5 |
| 1994 | 5.5 | 3.0 | 4.0 | 25.0 | 25.0 | 30.0 | 12.5 | 105.0 |
| 1995 | 5.5 | 3.0 | 0.0 | 0.0 | 25.0 | 10.0 | 2.0 | 45.5 |
| 1996 | 5.5 | 3.0 | 4.0 | 0.0 | ? | 10.0 | 2.0 | 24.5* |
| 1997 | 5.5 | 3.0 | 0.0 | 0.0 | ? | 10.0 | 2.0 | 20.5* |
| 1998 | 5.5 | 3.0 | 5.5 | 0.0 | ? | 0.0 | 2.0 | 16.0* |
| 1999 | 5.5 | 3.0 | 0.0 | 0.0 | ? | 0.0 | 2.0 | 10.5* |
| 2000 | 5.5 | 3.0 | 5.5 | 0.0 | ? | 0.0 | 2.0 | 16.0* |
| 2001 | 5.5 | 3.0 | 0.0 | 0.0 | ? | 0.0 | 2.0 | 10.5* |
| 2002 | 5.5 | 3.0 | 5.5 | 0.0 | ? | 0.0 | 2.0 | 16.0* |
| Total: | 60.5 | 50.5 | 36.5 | 75.0 | 75.0* | 120.0 | 53.5 | 471.0* |

*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:** Total recovery is unlikely for this species, and the downlisting date cannot be estimated at this time. As mussels do not reproduce until about age 5, more than 10 years is needed to document reproduction and assess viability.

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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 spinymussel, Elliptio (Canthyria) steinstansana (Johnson and Clarke), formerly known as the Tar River spinymussel, is 1 of approximately 70 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 (U.S. Fish and Wildlife Service, 1985).

The Tar spinymussel 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 60 millimeters (mm) 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. Two or more linear ridges, originating within the beak cavity and extending to the ventral margin, can be found on the interior surface of the shell. The distance between these ridges widens toward the ventral margin. 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 35 mm long, the spines average approximately 2.6 mm in length and 1.5 mm in basal width (Johnson and Clarke 1983) with spines on some specimens measuring up to 5 mm in length (Alderman 1991). Juveniles may have as many as 12 spines, 6 on each

valve. However, adult specimens tend to lose their spines as they mature, and some large adult specimens may not have shell spines. These individuals may be confused with some forms of Elliptio complanata, a common Tar River species. Elliptio steinstansana may be distinguished by its shiny periostracum, parallel pseudocardinal teeth, and the linear ridges on the inside surface of the shell.

## Distribution

Elliptio (Canthyria) steinstansana has apparently always had a restricted distribution and is endemic to the Tar River drainage basin in eastern North Carolina. The type locality is the Tar River in Edgecombe County. Historically this species was collected only from the main stem of the Tar River from near Louisburg in Franklin County to the vicinity of Falkland in Pitt County (D. Stansbery, personal communication to Alderman, 1990; Shelley 1972; Clarke 1983). However, it is probable that E. steinstansana may have once occurred throughout much of the Tar River basin prior to settlement of the area during the 1700s. In 1982 and 1983, Clark (1983) conducted extensive surveys of the Tar River, as well as four other rivers in eastern North Carolina, including the Roanoke, Cashie, Neuse, and Trent Rivers, and located E. steinstansana in only a 12-mile stretch of the Tar River in Edgecombe County. During 1985 and early 1986, Clarke's collection sites, as well as additional sites on the main stem of the Tar River in Edgecombe, Nash, and Franklin Counties, were surveyed by personnel with the U.S. Fish and Wildlife Service (Service), U.S. Army Corps of Engineers, North Carolina Wildlife Resources Commission, Virginia Polytechnic Institute and State University, and Smithsonian Institution. Several relic shells were found, all in Edgecombe County, but no live E. steinstansana were collected. During the summer of 1986 through the summer of 1989, Alderman (1989) extensively surveyed the Tar River and its tributaries. During this period, Alderman found only four live E. steinstansana in the main stem of the Tar River. All four were adult specimens found scattered within a 1-mile stretch of the river in Edgecombe County. Then in 1990, Alderman (1991) collected a relatively fresh-dead adult specimen of E. steinstansana from the Tar River in Nash County. Based on these recent collections it appears that only isolated adult E. steinstansana remain in the main stem of the Tar River--one small population located in Edgecombe County and another possible small remnant population located in Nash County.

In 1987, Alderman (1989) discovered an additional population of E. steinstansana in Swift Creek, a tributary to the Tar River that flows from Vance County to its confluence with the Tar River in Edgecombe County. Alderman found three living E. steinstansana in Swift creek in 1988, four in 1989, and over two dozen fresh shells along the creek during the summer of 1989. Many of the spiny mussels collected from Swift Creek were juveniles, indicating that successful reproduction is or was occurring in this stream.

In August of 1990, a massive mussel kill occurred in Swift Creek (Alderman, personal communication, 1990). Approximately 100 dead E. steinstansana of all ages were collected immediately following this event. Organophosphate or carbonate pesticides have been implicated as the cause of this kill (U.S. Fish and Wildlife Service News Release, April 2, 1991). The overall effect of this mussel kill on the Swift Creek population is currently unknown; however, recent survey data suggest that a relatively healthy population of spinymussels continues to exist in Swift Creek (Alderman, personal communication, 1991).

## Life History and Ecology

Details of the life history and ecological requirements of the Tar spinymussel 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 3 or 4 days they 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; 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). Most native mussel 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 therefore likely that E. steinstansana is a tachytictic breeder. Further studies conducted by Hove and Neves (1989) determined that Pleurobema collina from the James River drainage in Virginia is a tachytictic breeder and that the species' glochidia may parasitize several fish species that are also part of the Tar River and Swift Creek fish fauna, including roseyside dace, bluehead chub, pumpkinseed, satinfin shiner, and rosefin shiner. Clarke and Neves (1984) suggested that E. steinstansana and P. collina may be closely related. If such is the case, it is probable that E. steinstansana and P. collina have similar reproductive biology and utilize similar fish hosts.

The preferred habitat of E. steinstansana in Swift Creek was described by Alderman (1989) as relatively fast-flowing, well-oxygenated, circumneutral pH water in sites prone to significant swings in water velocity, with a substrate comprised of relatively silt-free, uncompacted gravel and/or coarse sand. In the Tar River drainage basin, this habitat type presently occurs only in Swift Creek and a few other limited locations. Clarke (1983) reported collecting E. steinstansana in the main stem of the Tar River in sand

substrate ranging from fine to coarse. However, after Alderman's discovery of the Swift Creek population, it is believed that the specimens collected from the Tar River in fine sand substrates were likely either individuals displaced by heavy flows or individuals forced to utilize unsuitable or marginal habitat due to the absence of preferred habitat. Alderman (1989) described the habitat in the main stem of the Tar River where he collected live E. steinstansana as that which most closely approximates the above described preferred habitat.

## Reasons for Decline and Threats to Its Continued Existence

The Tar and Neuse River basin comprises 8,893,000 acres of the Piedmont and Coastal Plain physiographic regions in eastern North Carolina. In 1980, land use within this 29-county area was characterized as being 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, activities within the basin have had profound effects on the aquatic fauna, including E. steinstansana. A report issued by the North Carolina Department of Environment, Health, and Natural Resources (NCDEHNR 1985) indicates that biological and water quality in the Tar River basin is fair to good, but several significant problems still exist. The following sections discuss activities in the Tar and Neuse River basin and other Southeastern river systems and how they are thought to have contributed to the decline of freshwater mussels in the Southeastern United States, including the Tar spinymussel. It should be noted that populations 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 spinymussel may become extinct in the foreseeable future.

### Pollution

Pollution from private, municipal, industrial, silvicultural, and agricultural sources is believed to be one of the most significant factors contributing to the past and continuing decline of E. steinstansana. 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).

Both point and nonpoint sources of pollution are believed to have had a severe effect on E. steinstansana and other mussel populations in the Tar River basin. The upper and middle portions of the Tar River experience high pesticide and nutrient loading from agricultural and silvicultural activities (NCDEHNR 1985); and, as previously mentioned, the runoff or discharge of pesticides into Swift Creek has

been implicated as the cause of a massive mussel die-off, including approximately 100 Tar spinymussels, that occurred in the stream in 1990. Recent faunal changes in the Tar River near Tarboro and Rocky Mount probably resulted, in a large part, from sewage and other municipal pollution (Clarke 1983). 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 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 recovery of mussel populations may not occur for up to 2 miles below the discharge points of chlorinated sewage effluent. During surveys conducted in the mid-1980s, Service personnel noted a decline in mussel populations for approximately 1 mile below the Tar River Regional Wastewater Treatment Plant operated by the City of 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 appeared suitable. The wastewater treatment plant at Rocky Mount was constructed in 1982 and has had a continuous history of National Pollution Discharge Elimination System Permit compliance problems since it opened (North Carolina Environmental Defense Fund [NCEDF] and Pamlico-Tar River Foundation [P-TRF] 1990a). Several other wastewater treatment facilities that discharge into the Tar River or its tributaries, above the existing population of the E. steinstansana in the Tar River, have also been implicated as violating the water quality standards of their National Pollution Discharge Elimination System Permits during recent years, including the plants at Franklinton, Littleton, Louisburg, Oxford, Scotlandneck, and Tarboro (NCEDF and P-TRF 1990b). Some of these plants have since been upgraded, and the North Carolina Division of Environmental Management plans to upgrade and incorporate uniform and up-to-date pollution reduction requirements at all sewage treatment facilities within the Tar and Pamlico River basin (NCEDF and P-TRF 1990a).

Clarke (1983) stated that mussel populations may become reestablished as a result of improved water quality. However, recolonization by mussels will probably take many years, and the fact that Elliptio steinstansana is one of the rarest species of mussels makes natural reestablishment of the species highly unlikely.

Siltation

Siltation, resulting from poorly implemented land use practices during construction, agricultural, and forestry activities is another serious threat to the continued existence and recovery of E. steinstansana. It has been estimated that 15.3 million tons (16.8 million metric tons) of soil erode from land in the Tar and 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 estimated at 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. Reduction in mussel abundance in the Stones River in Tennessee was thought to be a partial result of siltation from gravel dredging during summer low-flow conditions (Schmidt 1982). Likewise, the recent decline of a previously large mussel bed in Swift Creek is believed to be the result of sedimentation associated, at least in part, with recent logging activities on adjacent lands (Alderman, personal communication, 1991). Suspended sediment can clog the gills of filter-feeding mussels and eventually suffocate them, so mussels often respond by closing their valves (Ellis 1936). Ellis (1936) also determined that siltation from soil erosion reduced light penetration, altered heat exchange in the water, and allowed organic and toxic substances to be carried to the bottom where they were retained for long periods of time. This results in further oxygen depletion and possible absorption of these toxicants by mussels (Harman 1974).

The SCS (1980) estimated that two-thirds of the annual gross erosion in the Tar and Neuse River basin occurs on cropland. In addition, erosion resulting from improper logging activities (760,000 tons per year) represents an increase of 85 percent in erosion over and above normal expected erosion within the basin (SCS 1980). Sedimentation has been cited as a cause of water quality problems in all tributaries of the Tar River within the range of the Tar spinymussel (NCDEHNR 1985). *Elliptio steinstansana* occurs in gravel/coarse 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, the abundance of mussels, including *E. steinstansana*, will undoubtedly continue to decrease.

Impoundments

Impoundments on rivers in the Southeast have also been responsible for the decline of mussel populations. The most unique locality for freshwater mussels, with respect to species diversity and abundance, was Muscle Shoals, Alabama. This habitat 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 (U.S. Fish and Wildlife 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 species, 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 has impounded the Tar River for several miles. This impounded river section no longer provides suitable habitat for the Tar spinymussel because of silt deposition and reduction of flow. Also, hypolimnetic discharge from the impoundment has altered the conditions in the tailwater (Clarke 1983), possibly making the affected section of the river below the dam unsuitable for E. steinstansana or its fish host(s). In addition, the dam acts as an effective barrier to natural upstream expansion or recruitment 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. Once it is eliminated from the river above these impoundments, natural expansion of the Tar spinymussel into this portion of its historical range would not be possible.

Exotic Species

The Asiatic clam, Corbicula fluminea, may also be a threat to the Tar spinymussel. C. fluminea 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 1972 the species could be found in most of the major river systems throughout the United States (Fuller and Powell 1973). C. fluminea has become well established in the Tar River and has recently begun to expand into Swift Creek (Alderman, personal communication, 1991). The extent of the threat that C. fluminea presents to the Tar spinymussel 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 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, E. steinstansana may be unable to withstand vigorous competition.

The zebra mussel (Dressena polymorpha) is another exotic freshwater mussel species that may pose a significant threat to E. steinstansana. D. 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 Great Lakes and is rapidly expanding into the surrounding river basins, including those of the South Atlantic Slope (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).

D. polymorpha is a prolific breeder, and 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).

Die-offs/Kills

Since 1982, biologists and commercial mussel fishermen 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 and Tennessee), Tennessee River (Tennessee), 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 of these kills 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 discovered a massive mussel die-off/kill of unknown origin in the Tar River in April 1986. Thousands of freshly dead and recently dead juvenile and adult mussels were observed at two locations below Rocky Mount. In August of 1990, another die-off/kill occurred in Swift Creek. An organochlorine or a carbonate pesticide was implicated as the cause of this kill. In both the Tar River and Swift Creek die-offs, all mussel species present within the affected stream reaches appeared to be impacted, including E. steinstansana. If die-offs of this nature continue, the capacity of all mussel populations in the Tar River to maintain themselves will be severely reduced. Preventing the loss of any E. steinstansana is critical to the species' survival; continual mussel die-offs/kills will very likely result in the 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 surviving populations of E. steinstansana in the Tar River drainage basin of North Carolina and to protect its remaining habitat from present and foreseeable threats. There are only three known surviving populations of this species--two in the main stem of the Tar River and one in Swift Creek. Of these, only the Swift Creek population appears to be reproducing. Lack of proper protection and management of these populations, particularly the Swift Creek population, will preclude recovery of the Tar spinymussel and will ultimately lead to the species' 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 basin 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 Tar spinymussel may not be possible. The species has a very restricted distribution, and much of the habitat within its known historic range may be unsuitable for reintroductions.

The Tar spinymussel 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. All three existing populations of E. steinstansana in both the Tar River and Swift Creek show evidence of reproduction and recruitment; i.e., gravid females and host fish must be present and populations must contain at least two year classes, including one year class at age 4 or younger.

2. The reestablishment or the discovery of two additional viable populations has occurred (excluding the Tar River populations in Edgecombe and Nash Counties and the Swift Creek population). These populations should occur in two additional sections of the Tar River (or other streams if new information identifies them as historical habitat of the species), one each in Franklin and Pitt Counties, North Carolina--areas historically supporting populations of E. steinstansana. 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. Each population should contain at least three subpopulation centers (a continuous river segment or a series of closely spaced river segments containing habitat and E. steinstansana as a breeding unit) dispersed such that a single catastrophic event would not eliminate the Tar spinymussel from newly reestablished locations. The subpopulation centers should 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 population units and their habitats are protected from any present and foreseeable threats that would jeopardize their continued existence.

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

5. Monitoring of all population units indicates no downward trends over a period of 15 to 20 years.

When these criteria are met, the species will be considered for downlisting to threatened, and the criteria for delisting will be established.

C. Narrative Outline

1. Maintain the existing populations and habitat of the Tar spinymussel in the Tar River and Swift Creek. At present, E. steinstansana is restricted to two small sections of the Tar River in Edgecombe and Nash Counties, North Carolina, and to Swift Creek, a tributary to the Tar River. 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 in the Tar River and protect and secure the Swift Creek population, the species will likely be extinct in the very 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 habitats. Prior to and during implementation of this recovery plan, the present populations can be protected only by full enforcement of existing laws and regulations. Unless this objective is met, any recovery activities would be essentially moot. Habitat and water quality degradation has severely reduced the species' range and continues to threaten the only remaining populations. Immediate action is necessary to identify and bring actions and activities operating in violation of existing environmental statues into compliance and to prevent future violations. Complete compliance with Federal and State laws and regulations designed to protect water and habitat quality must be ensured if the Tar spinymussel 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 with the potential to adversely affect the species and its habitat. Once impacts have been identified, regulatory/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 habitats. Assistance and support of conservation groups, local governments, and regional and

local planners will be essential in meeting the goal of recovering the Tar spinymussel. Also, support of local industrial, business, and farming 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 educated as to why and how they should protect the river. 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 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 establishment of mussel sanctuaries, high-quality water designations, stream buffer zones, and other protection strategies as a means of protecting present and reintroduced populations. The U.S. Fish and Wildlife Service should work with the appropriate State agencies in North Carolina to have special status assigned to river and stream reaches inhabited by the species that would provide increased protection to the Tar spinymussel.

1.5 Consider the use of land acquisition as a means of protecting the species' essential habitat. Land acquisition could provide long-term protection to present and reintroduced populations of the species and should be fully explored.

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, time of year they are released, and the required fish host(s). Fertilization rate should also be investigated. 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 Tar spinymussel are also 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 the runoff and discharge of agricultural, municipal, and industrial pollutants appear to be major factors in the reduction of the species' range in the Tar River. In Swift Creek, runoff or discharge of pesticides has been implicated as the cause of a major mussel kill affecting the Swift Creek population in 1990. Increased siltation of the stream due to recent logging activities is believed to be further affecting this population. The impoundments on the Tar River have also likely had an impact on the species, and the recent disposal of fly ash adjacent to the Tar River (Alderman, personal communication, 1991) may be further affecting the Tar River populations. 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 introduction/spread. Of rising concern among malacologists is the potential effect of the introduced

Asiatic clam, Corbicula fluminea, on native freshwater mussels. Another exotic clam, the zebra mussel (Dreissena polymorpha), has recently invaded the Great Lakes and adjacent river systems. Adverse impacts to endemic mussels have been noted. The zebra mussel has not yet been observed in the Tar River basin. However, the species has spread rapidly from the Great Lakes area into surrounding drainage basins, and it is expected to invade other basins in the near future. The relationship between these nonnative mollusks and the native fauna should be thoroughly investigated, and (where feasible) measures should be implemented to minimize their impact and control their expansion.

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 Tar spinymussel's habitat 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. Theoretical considerations by Franklin (1980) and Soulé (1980) indicate that 500 breeding individuals represents a minimum population level (effective population size) that would contain sufficient genetic variation to enable that population to evolve and respond to natural habitat changes. The actual population size in a natural ecosystem necessary to provide 500 breeding individuals can be expected to be larger, possibly by as much as 10 times. The factors that will influence population size include sex ratio, length of the species' reproductive life, fecundity, and extent of exchange of genetic material within the population, plus other life history aspects. Some of these factors can be addressed under Task 2.1, while others will need to be addressed as part of this task.

3. Search for additional populations and/or habitat suitable for reintroduction efforts. Distributional studies of this species have been completed (Clarke 1983, Alderman 1989 and 1991), and some areas within the species' historical range that may be suitable for transplants have been identified (Alderman, personal communication, 1991). However, it is possible that some relic populations were missed, and further study may yield additional populations and additional potential transplant sites. Also, surveys should be continued 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 three known remaining populations of the Tar spinymussel--two small populations in the main stem of the Tar River (one in Edgecombe County and the other in Nash County) and a third, larger population, in Swift Creek, a tributary to the Tar River. The historic range of the species is unknown, but available information indicates it also once occurred in portions of the main stem of the Tar River from Franklin County to northern Pitt County, North Carolina. The two known existing populations in the Tar River are believed to be extremely small, and no evidence of successful reproduction has been observed in either of these populations within the last decade. For the species to survive in the Tar River, it will likely be necessary that these populations be supplemented to enable them to reach a viable size. Also, there may be areas within the species' historic range that could support reestablished populations. Areas for potential transplants will be selected based on present and future habitat and water quality. However, since the Swift Creek population is presently 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 Determine the need, appropriateness, and feasibility of augmenting and expanding existing populations. The Swift Creek population of the species may be able to expand naturally if environmental conditions are improved and maintained. However, even if conditions are improved in the Tar River, the Tar River populations are believed to be too small to expand naturally and will likely need to be supplemented in order to continue to survive and reach a viable size. Implementation of this task will be based on population size, habitat quality, and the likelihood of long-term benefits from the task.

   4.2 Develop a successful technique for reestablishing and augmenting populations. Sufficient specimens of E. steinstansana are not currently available to allow for 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 most easily protected from further threats.

4.4 Augment existing populations where needed, establish new populations within the species' historic range, and evaluate success. Using 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. Two of three remaining populations of the Tar spinymussel are apparently not reproducing and are continuing to decline. Artificial propagation techniques may be able to provide juvenile mussels for transplants. However, present habitat conditions may not be suitable in the Tar River at this time for reintroduction to succeed. Cryogenic preservation of the Tar spinymussel could maintain genetic material (much like seed banks for endangered plants) from all the extant populations until 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 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 to determine if reproduction and recruitment are occurring. This should be conducted on a biennial schedule.

7. Annually assess 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
FWE - Fish and Wildlife Enhancement (Division of U.S. Fish and Wildlife Service)
LE - Law Enforcement (Division of U.S. Fish and Wildlife Service)
NCDEM - North Carolina Department of Environmental Management
NCNHP - North Carolina Natural Heritage Program
NCWRC - North Carolina Wildlife Resources Commission
SCS - U.S. Soil Conservation Service
TNC - The Nature Conservancy

IMPLEMENTATION SCHEDULE

| PRIORITY # | TASK # | TASK DESCRIPTION | TASK DURATION (Years) | RESPONSIBLE PARTY | | | COST ESTIMATES ($000'S) | | | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | FWS | | | | | | |
| | | | | Region | Division | Other | FY 1992 | FY 1993 | FY 1994 | |
| 1 | 1.1 | Utilize existing legislation and regulations to protect species and its habitat. | Continuous | 4 | LE, FWE | EPA, COE, NCDEM, NCWRC | 3.0 | 3.0 | 3.0 | |
| 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 | 4 | FWE | COE, EPA, NCDEM, NCNHP, NCWRC, SCS | 2.0 | 2.0 | 2.0 | |
| 2 | 1.3.1, 1.3.2 | Meet with local governmental officials and business interests and elicit their support for recovery. | 3 | 4 | FWE | COE, EPA, NCDEM, NCNHP, NCWRC, SCS, TNC | 3.5 | 2.5 | 2.5 | |
| 2 | 1.3.3 | Develop information and education program and present. | Ongoing | 4 | FWE | NCNHP, NCWRC, TNC | 15.0 | 10.0 | 2.0 | Task duration: 1 year to develop, then continuous. |

IMPLEMENTATION SCHEDULE

| PRIORITY # | TASK # | TASK DESCRIPTION | TASK DURATION (Years) | RESPONSIBLE PARTY | | | COST ESTIMATES ($000'S) | | | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | FWS | | | | | | |
| | | | | Region | Division | Other | FY 1992 | FY 1993 | FY 1994 | |
| 2 | 5 | Develop and utilize cryo-preservation techniques. | Ongoing | 4 | FWE | Con-tract | 12.5 | 12.5 | 12.5 | |
| 2 | 6 | Develop and implement a monitoring program. | Ongoing | 4 | FWE | NCWRC, NCNHP | --- | --- | 4.0 | Biennial. |
| 3 | 7 | Annually assess recovery program and modify program and plan where required. | Ongoing | 4 | FWE | NCWRC, NCNHP | 0.5 | 0.5 | 0.5 | |

IMPLEMENTATION SCHEDULE

| PRIORITY # | TASK # | TASK DESCRIPTION | TASK DURATION (Years) | RESPONSIBLE PARTY | | | COST ESTIMATES ($000'S) | | | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | FWS | | | | | | |
| | | | | Region | Division | Other | FY 1992 | FY 1993 | FY 1994 | |
| 1 | 1.4 | Encourage establishment of mussel sanctuaries, high-quality resource water designations, and other protective strategies as a means of protecting present and reintroduced populations. | Ongoing | 4 | FWE | EPA, COE, NCDEM, NCNHP, NCWRC, SCS, TNC | ??? | ??? | ??? | |
| 2 | 1.5 | Consider use of land acquisition to protect the species. | Ongoing | 4 | FWE | NCNHP, NCWRC, TNC | ??? | ??? | ??? | |
| 2 | 2.1, 2.2, 2.3 | Conduct research necessary for species management and recovery; i.e., habitat requirements, biology, and threat analysis. | 3 | 4 | FWE | NCWRC | 25.0 | 25.0 | 25.0 | Life history and threat analysis study, conducted by NCWRC, began in 1991. |
| See comments. | 2.4 | Based on biological and threat analysis, | 2 | 4 | FWE | EPA, COE, NCDEM | --- | 25.0 | 25.0 | Priority 1, 2, or 3, depending on result of |

IMPLEMENTATION SCHEDULE

| PRIORITY # | TASK # | TASK DESCRIPTION | TASK DURATION (Years) | RESPONSIBLE PARTY | | | COST ESTIMATES ($000'S) | | | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | FWS | | | | | | |
| | | | | Region | Division | Other | FY 1992 | FY 1993 | FY 1994 | |
| | | investigate need for management and and implement where needed. | | | | NCWRC, NCNHP, SCS | | | | 2.1, 2.2, and 2.3. |
| 2 | 2.5 | Determine number of individuals required to maintain viable population. | 1 | 4 | FWE | Contract | --- | --- | ??? | |
| 2 | 3 | Search for additional populations and suitable habitat. | Ongoing | 4 | FWE | NCWRC or contract | 6.0 | 6.0 | --- | |
| 2 | 4 | Develop techniques, select sites, reintroduce the species back into historic habitat, and evaluate and protect any populations established. | Ongoing | 4 | FWE | Contract or NCWRC | 30.0 | 30.0 | 30.0 | Task duration: 3 years (protection continues). |

## PART IV

## LIST OF REVIEWERS

Mr. Bradley S. Barker
Executive Director
Region J Council of Governments
100 Park Drive, Box 12276
Research Triangle Park, NC 27709

Mr. John H. Sutton
Executive Director
Region M Council of Governments
P.O. Drawer 1510
Fayetteville, North Carolina 28302

Mr. John MacGuire, Manager
Raleigh Regional Office
North Carolina Department of Environment,
Health, and Natural Resources
P. O. Box 27687
Raleigh, North Carolina 27611

Mr. Richard Bishop, Manager
Fayetteville Regional Office
North Carolina Department of Environment,
Health, and Natural Resources
Suite 714, Wachovia Building
Fayetteville, North Carolina 28301

Dr. William Cobey, Jr., Secretary
North Carolina Department of Environment,
Health, and Natural Resources
P.O. Box 27687
Raleigh, North Carolina 27611

Mr. John Morris, Director
Water Resources Office
North Carolina Department of Environment,
Health, and Natural Resources
P.O. Box 27687
Raleigh, North Carolina 27611

Mr. Alan W. Klimek, P.E.
Environmental Engineer
Division of Environmental Management
North Carolina Department of Environment,
Health, and Natural Resources
P.O. Box 27687
Raleigh, North Carolina 27611

State Clearinghouse
North Carolina Division of Policy Development
116 West Jones Street
Raleigh, North Carolina 27603

Mr. William deBuys, Director
North Carolina Nature Conservancy
P.O. Box 805
Chapel Hill, North Carolina 27514

Dr. George Everett, Director
Environmental Management Division
North Carolina Department of Environment,
Health, and Natural Resources
P.O. Box 27687
Raleigh, North Carolina 27611

Mr. David W. Sides, Director
Soil and Water Conservation Division
North Carolina Department of Environment,
Health, and Natural Resources
P.O. Box 27687
Raleigh, North Carolina 27611

Director
North Carolina State Museum of Natural History
P.O. Box 27647
Raleigh, North Carolina 27611

Mr. Bobbye Jack Jones
State Conservationist
U.S. Soil Conservation Service
Room 535, Federal Building
310 New Bern Avenue
Raleigh, North Carolina 27601

Mr. Charles R. Fullwood
Executive Director
North Carolina Wildlife Resources Commission
512 N. Salisbury Street
Raleigh, North Carolina 27604-1188

Dr. Phillip K. McKnelly, Director
Parks and Recreation Division
North Carolina Department of Environment,
Health, and Natural Resources
P.O. Box 27687
Raleigh, North Carolina 27611

Dr. David Lindquist
University of North Carolina - Wilmington
Biological Sciences Department
601 South College Road
Wilmington, North Carolina 28403

Mr. William R. Roberson, Jr.
Secretary
North Carolina Department of Transportation
P.O. Box 25201
Raleigh, North Carolina 27611

Mr. Dennis Rankin
Environmental Protection Specialist
Distribution and Transmissions Branch
Rural Electrification Administration
USDA South Building, Room 3307
Washington, DC 20250

Colonel Walter S. Tulloch
District Engineer
U.S. Army Corps of Engineers
Wilmington District
P.O. Box 1890
Wilmington, North Carolina 28401-1890

Ms. Margaret Plemmons
North Carolina Department of Environment,
Health, and Natural Resources
8003 Silas Creek Parkway Ext.
Winston-Salem, North Carolina 27106

Mr. Lindsay W. Cox
Piedmont Triad Council of Governments
2216 W. Meadowview Road
Wilmington Building, Suite 201
Greensboro, North Carolina 27407-3480

Mr. Doug Lewis, Director
Planning and Assessment Office
North Carolina Department of Environment,
Health, and Natural Resources
P.O. Box 27687
Raleigh, North Carolina 27611

Mr. James A. Graham, Commissioner
North Carolina Department of Agriculture
P.O. Box 27647
Raleigh, North Carolina 27611

Dr. W. James Fleming, Leader
North Carolina Cooperative Fish and
Wildlife Research Unit
Department of Zoology
North Carolina State University
Box 7617
Raleigh, North Carolina 27695-7617

Dr. Walter Courtenay, Jr.
American Society of Ichthyologists
and Herpetologists
Department of Biological Sciences
Florida Atlantic University
Boca Raton, Florida 33431

Dr. Carter R. Gilbert, Editor
Southeastern Fishes Council Proceedings
Florida State Museum
University of Florida
Gainesville, Florida 32611

Mr. Ed Pickering
Water Resources Division
Office of Environmental Affairs
U.S. Geological Survey, Mail Stop 423
760 National Center
Reston, Virginia 22092

Dr. Wallace Evans
Supervisory Environmental Scientist
Minerals Management Service
Mail Stop 650
National Center
Reston, Virginia 22091

Mr. T. J. Granito
Environmental Impact Branch
U.S. Coast Guard Headquarters (G-WP-4)
Room 1114-B
2100 - 2nd Street, SW.
Washington, DC 20591

Mr. Dean Shumway, Chief
Biological Resources Branch
Federal Energy Regulatory Commission
825 N. Capitol Street, NE., RB305
Washington, DC 20426

Mr. Fred Regetz
Office of Environment and Energy
Department of Housing and Urban Development
Room 5136, HUD Building
451 Seventh Street, SW.
Washington, DC 20410

Mr. Jack E. Ravan
Regional Administrator
Environmental Protection Agency
345 Courtland Street, NE.
Atlanta, Georgia 30365

Ms. Jane Sharp
Conservation Council of North Carolina
307 Granville Road
Chapel Hill, North Carolina 27514

Mr. D. R. Huff, Jr.
President
North Carolina Association of Soil and
Water Conservation Districts
Route 1, Box 130
Aberdeen, North Carolina 28315

Mr. Kenneth L. Bellamy
Division Administrator
Federal Highway Administration
310 New Bern Avenue, Suite 410
Raleigh, North Carolina 27601

Dr. Phil Doerr, Chairman
Rare and Endangered Wildlife Committee
Wildlife Society, Southeastern Section
c/o Department of Zoology
North Carolina State University
Raleigh, North Carolina 27607

Dr. Robert Stern, Director
Office of Environmental Compliance
Department of Energy
Forrestal Building, Room 4G-064
1000 Independence Avenue, SW.
Washington, DC 20585

Director
North Carolina Natural Heritage Program
P.O. Box 27687
Raleigh, North Carolina 27687

Mr. Michael Corcoran
Executive Director
North Carolina Wildlife Federation
Box 10626
Raleigh, North Carolina 27605

Dr. Joe Bailey
Department of Zoology
Duke University
Durham, North Carolina 27706

Dr. Ed Menhinick
Department of Biology
University of North Carolina at Charlotte
UNC-C Station
Charlotte, North Carolina 28223

Ms. Debra Owen
Woolpert Consultants
8731 Red Oak Boulevard
Charlotte, North Carolina 28217-3958

Dr. G. Thomas Watters
Museum of Zoology
Ohio State University
1813 N. High Street
Columbus, Ohio 43210-1394

U.S. Forest Service
Wildlife, Fisheries, and Range
1720 Peachtree Road, NW.
Atlanta, Georgia 30367

Ms. Peggy Olwell
Center for Plant Conservation
Missouri Botanical Garden
P.O. Box 299
St. Louis, Missouri 63166

Fish and Wildlife Reference Service
5430 Grosvenor Lane, Suite 110
Bethesda, Maryland 20814

Dr. Richard Neves
Virginia Cooperative Fish and
Wildlife Research Unit
Virginia Polytechnic Institute and
State University
106 Cheatham Hall
Blacksburg, Virginia 24061

Mr. Kramer Jackson
County Manager
Pitt County Office Building
1717 West 5th Street
Greenville, North Carolina 27834

Mr. Sam W. Noble
City Manager
City of Tarboro
P.O. Box 220
Tarboro, North Carolina 27886

Mr. Ellis Williford
County Manager
P.O. Box 10
Tarboro, North Carolina 27886

Mr. Raymond Boutwell
County Manager
P.O. Box 529
Louisburg, North Carolina 27549

Mr. Harold Blizzard
County Manager
P.O. Box 906
Oxford, North Carolina 27565

Mr. Randolph Holoman
County Manager
Courthouse, Room 104
Nashville, North Carolina 27856

Mr. William Batchelor
City Manager
City of Rocky Mount
P.O. Box 1180
Rocky Mount, North Carolina 27802

Mr. John Alderman
Division of Wildlife Management
North Carolina Wildlife Resources
Commission
512 N. Salisbury Street
Raleigh, North Carolina 27611

Mr. Bill Adams
Environmental Division
U.S. Army Corps of Engineers
P.O. Box 1890
Wilmington, North Carolina 28402-1890

Mr. Steve Beleu
Oklahoma Department of Libraries
U.S. Government Information Division
200 N.E. 18th Street
Oklahoma City, Oklahoma 73105-3298

CBSG
12101 Johnny Cake Ridge Road
Apple Valley, Minnesota 55124

Mr. Peter D. McKone
Freese and Nichols, Inc.
811 Lamar Street
Fort Worth, Texas 76102

Wildlife Biologist
Eufaula National Wildlife Refuge
Route 2, Box 97-B
Eufaula, Alabama 36027-9294

Mr. Andy Moser
Annapolis Field Office
U.S. Fish and Wildlife Service
1825B Virginia Street
Annapolis, Maryland 21401

Mr. Michael Bean, Chairman
Wildlife Program
Environmental Defense Fund
1616 P Street, NW.
Washington, DC 20036

Mr. Ted Tyndall
CZR, Inc.
4709 College Acres Drive, Suite 2
Wilmington, North Carolina 28403

Mr. Fred C. Schmidt, Head
Documents Department - KS
The Libraries
Colorado State University
Fort Collins, Colorado 80523

Ms. Jayne Brim
U.S. Fish and Wildlife Service
National Fisheries Research Center
7920 N.W. 71st Street
Gainesville, Florida 32606

Mr. Robert M. Todd
Commercial Musseling Coordinator
Tennessee Wildlife Resources Agency
Ellington Agricultural Center
P.O. Box 40747
Nashville, Tennessee 37204

Mr. Ben Hafer
2117 Andy Holt Avenue, #1527
Knoxville, Tennessee 37916

Mr. Alan Smith
P.O. Box 887
Mars Hill, North Carolina 28754

Federal Highway Administration
Office of Environmental Policy
Environmental Analysis Division
400 Seventh Street, SW., Room 3240
Washington, DC 20590

Directorate for Biological, Behavioral,
and Social Sciences
National Science Foundation
1800 G Street, NW., Room 215
Washington, DC 20550

Mr. Julius T. Johnson
Director of Public Affairs
Tennessee Farm Bureau Federation
P.O. Box 313
Columbia, Tennessee 38401

Dr. James Layzer
U.S. Fish and Wildlife Service
Tennessee Cooperative Fishery
Research Unit
Tennessee Technological University
Box 5114
Cookeville, Tennessee 38505

Dr. Mark Gordon
U.S. Fish and Wildlife Service
Tennessee Cooperative Fishery
Research Unit
Tennessee Technological University
Box 5114
Cookeville, Tennessee 38505