D.Y.

76-06-14

Recovery Plan

Dromedary Pearly Mussel (*Dromus dromas*)

Recovery Plan for the Dromedary Pearly Mussel

Dromus dromas (Lea, 1834)

Dromus dromas form caperatus (Lea, 1845)

November 1983

Prepared by

Steven Ahlstedt

For the

United States Fish and Wildlife Service

Southeast Region

Atlanta, Georgia

Approved: Robert E. Gilmore
Associate Director, U.S. Fish and Wildlife Service

Date: 1984

THIS IS THE COMPLETED DROMEDARY PEARLY 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 IT DOES NOT NECESSARILY REPRESENT THE VIEWS OF ALL INDIVIDUALS WHO PLAYED A KEY ROLE IN PREPARING THIS PLAN. THIS PLAN IS SUBJECT TO MODIFICATION AS DICTATED BY NEW FINDINGS AND CHANGES IN SPECIES STATUS AND COMPLETION OF TASKS ASSIGNED IN THE PLAN. GOALS AND OBJECTIVES WILL BE ATTAINED AND FUNDS EXPENDED CONTINGENT UPON APPROPRIATIONS, PRIORITIES, AND OTHER BUDGETARY CONSTRAINTS.

THE RECOVERY PLAN FOR THE MUSSEL AND FISH SPECIES OF THE TENNESSEE RIVER VALLEY HAVE BEEN DEVELOPED ON A SPECIES-BY-SPECIES BASIS. FOR IMPLEMENTATION PURPOSES, THE PLANS WILL BE CONSOLIDATED ON A WATERSHED BASIS, AND THE NEEDS OF ALL LISTED SPECIES IN THAT SYSTEM WILL BE ADDRESSED.

ALTHOUGH THIS PLAN WAS PREPARED BY STEVEN AHLSTEDT, AN EMPLOYEE OF THE TENNESSEE VALLEY AUTHORITY, THE VIEWS, OPINIONS, POLICIES, AND CONCLUSIONS EXPRESSED HEREIN DO NOT NECESSARILY REFLECT THE VIEWS, OPINIONS, POLICIES, AND CONCLUSIONS OF THE TENNESSEE VALLEY AUTHORITY.

LITERATURE CITATIONS SHOULD READ AS FOLLOWS:

U.S. Fish and Wildlife Service. 1983. Dromedary Pearly Mussel Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia, 58 pp.

ADDITIONAL COPIES MAY BE OBTAINED FROM:

FISH AND WILDLIFE REFERENCE SERVICE
1776 E. JEFFERSON STREET
4TH FLOOR
ROCKVILLE, MARYLAND 20852

CONTENTS

	Page
PART I	
INTRODUCTION	1
DISTRIBUTION	2
Historical	2
Present	3
ECOLOGY AND LIFE HISTORY	8
REASONS FOR DECLINE AND CONTINUED THREATS	11
Impoundment	11
Siltation	13
Pollution	15
PART II	
RECOVERY	20
Recovery Objectives	20
Step-down Outline	21
Narrative Outline	24
BIBLIOGRAPHY	37
PART III	
IMPLEMENTATION SCHEDULE	52
APPENDIX - List of Reviewers	56

CONTENTS

(Continued)

TABLE

	Page
1. Historical records for *Dromus dromas*, including the form *caperatus* prior to 1970, and subfossil records recorded to 1981	4

FIGURES

1. Tennessee River--Recent Locations for *Dromus dromas* (Lea, 1834)	46
2. Cumberland River--Recent Locations for *Dromus dromas* (Lea, 1834)	47
3. Clinch River--Recent Locations for *Dromus dromas* form *caperatus* (Lea, 1845)	48
4. Powell River--Recent Locations for *Dromus dromas* Form *caperatus* (Lea, 1845)	49
5. Typical naiad life cycle depicting the various stages . . .	50

PHOTOGRAPH

1. Photograph of *Dromus dromas*	51

PART I

INTRODUCTION

The tributary streams of the Tennessee and Cumberland River basins contain freshwater mussel species that are endemic to the southern Appalachian Mountains and the Cumberland Plateau region. Ortmann (1924) referred to these species as "Cumberlandian," and this region became known as one of the chief centers of freshwater mussel speciation. Of the 23 American freshwater mussel species listed as endangered by the U.S. Department of the Interior, 13 are members of the Cumberlandian faunal group. The dromedary pearly mussel (*Dromus dromas*) was proposed as an endangered species in September 1975 (*Federal Register* 40(188:44329-44333) and listed in June 1976 (*Federal Register* 41(115):24062-24067).

D. dromas was described by Lea in 1834 from the Harpeth and Cumberland Rivers, Tennessee. The headwaters form of *D. dromas* form *caperatus* was described by Lea in 1845 from the Clinch River, Tennessee. This species is commonly known as the dromedary mussel or the camel shell because of a distinct "hump" present near the umbo on big river specimens of *D. dromas* (Coker, 1915; Neel and Allen, 1964). Ortmann (1920) separated these forms of *D. dromas* using the presence or absence of the hump and the degree of inflation. *D. dromas* is a Cumberlandian species restricted to the Tennessee and Cumberland Rivers from the major headwater tributary streams downstream as far as Muscle Shoals in northern Alabama (Ortmann, 1925; Morrison, 1942; Hinkley, 1906; Isom, 1972).

DISTRIBUTION

Historical

Ortmann's 1918 monograph on the naiads of the upper Tennessee River is the most significant work on that region's freshwater mussel fauna prior to construction of impoundments on many of these streams. At the time of Ortmann's survey, a total of 66 species of mussels occurred in the Tennessee River between Chattanooga and Knoxville, Tennessee. Pardue (1981) reported only 23 species of mussels living in the lower Tennessee River during a survey conducted in 1978. Publications by Wilson and Clark (1912, 1914) and Neel and Allen (1964) on the mussels of the Cumberland River and its tributaries also offer an excellent historical account of that fauna prior to impoundment and extensive coal mining. A total of 79 species of freshwater mussels was reported by Wilson and Clark (1914), and 59 species were later reported by Neel and Allen (1964).

D. dromas, including the headwaters form *caperatus*, had a wide distribution in the upper Tennessee and Cumberland River drainage. Interestingly, this species has not been reported from the Duck, Buffalo, or Paint Rock Rivers (tributaries to the lower Tennessee River). Bogan and Parmalee (1983) recently documented the occurrence of *D. dromas* in the Little Tennessee River, based on prehistoric archaeological specimens. Relict specimens of *D. dromas* have also been reported from the Caney Fork (Cumberland River system) by John Schmidt (personal communication). Neel and Allen (1964) noted that *D. dromas* was probably more abundant in the Cumberland River than in the Tennessee River. Morrison (1942) and Bogan and Parmalee's (1983) work on archaeological shell middens indicates that, at least prehistorically, *D. dromas* was one of the most abundant species in the Tennessee

River. Historical records for D. dromas, including the headwaters form caperatus prior to 1970, are summarized in Table 1.

Present

D. dromas, including the headwaters form caperatus, is presently known only from the Tennessee (Figure 1), Cumberland (Figure 2), Clinch (Figure 3), and Powell Rivers (Figure 4).

Recent freshwater mussel surveys of the Tennessee River were conducted by TVA personnel in 1978 (TVA, 1978; Pardue, 1981). The 1978 TVA survey of the Tennessee River was a dive/float survey at numerous collecting sites below Kentucky and Pickwick Dams and the upstream reservoir areas between Pickwick and Chickamauga Dams. Numerous collecting sites in Wilson, Wheeler, Guntersville, and Nickajack Reservoirs and the upstream portions of the Tennessee River in Chickamauga and Watts Bar Reservoirs were included in this survey. Based on this survey, D. dromas must be considered extremely rare in the Tennessee River since only three live specimens represented by one individual each were found in Chickamauga Reservoir below Watts Bar Dam at TRM 520.8, TRM 520.5, and TRM 520.2 by TVA biologists in 1978 (Pardue, 1981). This species had not been previously found alive in the Tennessee River since Ortmann (1918) reported it 3 miles below Knoxville, Tennessee.

A total of two live specimens of D. dromas was found while sampling for freshwater mussels in the Cumberland River at the proposed Hartsville Nuclear Power Plant site (TVA, 1976). The two specimens were found at Bartlett's Bar CRM 296.8 as a result of diving, brailing, and searching commercial cookout camps in a 35-mile reach of the Cumberland River between CRM 270.0 and CRM 305.5. A live specimen of D. dromas was also found in a commercial musseling boat at CRM 293, and an undetermined

Table 1. Historical records for Dromus dromas, including the form caperatus prior to 1970, and subfossil records recorded to 1981.

River	Source
Tennessee River	Conrad (1836) Lewis (1871) Pilsbry and Rhoads (1896) Hinkley (1906) Ortmann (1918, 1925) Hickman (1937) van der Schalie (1939) Morrison (1942) Stansbery (1964) Isom (1972) Warren (1975)
Limestone Creek, Alabama	Ortmann (1925)
Flint River, Alabama	van der Schalie (1939)
Elk River	Conrad (1836) Ortmann (1925)
Holston River	Lewis (1871) Pilsbry and Rhoads (1896) Boepple and Coker (1912) Ortmann (1918)
Clinch River	Lea (1845) Ortmann (1918) Cahn (1936) Hickman (1937)
Powell River	Pilsbry and Rhoads (1897) Ortmann (1918) Hickman (1937)
Little Tennessee River	Bogan and Parmalee (1983) archaeological specimens
Cumberland River	Lea (1834) Conrad (1836) Wilson and Clark (1912, 1914) Ortmann (1918, 1925) Shoup, Peyton, and Gentry (1941) Neel and Allen (1964) Stansbery (1969)

Table 1. Continued.

River	Source
Harpeth River	Lea (1834) Conrad (1836)
Caney Fork	University of Michigan Museum, Record #98572 John Schmidt (personal communication) relict specimens collected in 1981
Obey River	Shoup, Peyton, and Gentry (1941)
Big South Fork Cumberland River	Wilson and Clark (1914) TVA (1978) subfossil specimen

number of freshly dead specimens was observed in a commercial clammer's cookout camp at a stone quarry near Rome Landing, Tennessee. A single live specimen of D. dromas, as well as five dead individuals and two single valves, was observed in a commercial clammer's cull and stockpiles during the summers of 1977-1979 (Bogan and Parmalee, 1983; Parmalee et al., 1980).

The headwaters form of D. dromas form caperatus has been reported from the Clinch River by Neves et al. (1980), TVA (1979a), Bates and Dennis (1978), and Stansbery (1973). Sampling by TVA in 1978 at six sites on the Clinch River between CRM 172.3 and CRM 183.5 produced 1 live and 34 freshly dead specimens of D. dromas. The greatest number of D. dromas was observed at CRM 178.2 and CRM 178.7, where 15 and 11 freshly dead specimens, respectively, were found in muskrat middens (TVA, 1978). During 1979, a total of eight live or freshly dead specimens of D. dromas was found during a 170-mile float survey of the Clinch River from Cedar Bluff (CRM 322.6) to State Highway 25E (CRM 153.8) (TVA, 1979a). Further, one live specimen of D. dromas has recently been collected by Richard Neves (personal communication) from the Clinch River at Pendleton Island, Virginia (CRM 226.3). This is the first report of D. dromas being found in the Virginia portion of the Clinch River. Based on these data, D. dromas must be considered rare in the Clinch River. The largest populations probably occur in a 23-mile reach of the Clinch above the backwaters of Norris Reservoir between Manning Ferry (CRM 166.4) and Kyles Ford, Tennessee (CRM 189.6).

D. dromas has also been found in the Powell River by Dennis (1981), Ahlstedt and Brown (1980), Neves et al. (1980), and TVA (1979c). Freshwater mussel sampling in the Powell River from 1975 to 1979 produced 6 live and 43 freshly dead specimens of D. dromas (Ahlstedt and Brown, 1980). In Ahlstedt and Brown's report, the largest population of D. dromas in the Powell River probably exists at Buchanan Ford (PRM 99.2), where approximately 30 freshly dead specimens and 2 live individuals were found from 1975 to 1979. Three live and thirty-six freshly dead specimens of D. dromas were found by TVA (1979c) during a 102-mile float survey of the Powell River between Olinger (PRM 167.4) and State Highway 25E (PRM 65.1). Recent freshwater mussel sampling in the Powell River by TVA biologists during May and June 1981 produced 3 live specimens of D. dromas at Fletcher Cliff (PRM 117.9) and 10 live specimens at McDowell Ford (PRM 106.5). D. dromas is considered rare in the Powell River and is probably limited to a 49-mile reach of the upper Powell above Norris Reservoir between Cosby Bridge (PRM 78.7) and White Shoals (PRM 127.2).

Freshwater mussel surveys by numerous individuals have failed to find D. dromas living in any streams other than the Tennessee, Cumberland, Clinch, and Powell Rivers. The species must be considered rare in the Tennessee River since freshwater mussel surveys conducted by Ellis (1931), van der Schalie (1939), Scruggs (1960), Bates (1962, 1975), Stansbery (1964), Williams (1969), Yokley (1972), and Isom (1969, 1971a, 1972) failed to document the presence of D. dromas in the Tennessee River.

Numerous freshwater mussel surveys of the tributary streams to the Tennessee River system have also failed to identify D. dromas living in the Holston River (TVA, 1981); the North, South, and Middle Forks of the Holston River (Neves et al. 1980; Stansbery, 1972; Stansbery and Clench, 1974, 1975, 1978; TVA, 1976), Big Moccasin Creek (Neves and Zale, 1982); Copper Creek (Ahlstedt, 1981a); Nolichucky River (TVA, 1980c); French Broad River (TVA, 1979d); Paint Rock River (Isom et al. 1973b; TVA, 1980d); Elk River (Isom et al. 1973a; Ahlstedt, 1983); Flint River (Isom et al. 1973b); Buffalo River (van der Schalie, 1973; TVA, 1980b); and Duck River

(Ortmann, 1924; Isom and Yokley, 1968; van der Schalie, 1973; TVA, 1979b; Ahlstedt, 1981b).

Freshwater mussel surveys in the Cumberland River by Sickle (1982) and Stansbery (1969, 1970) and tributary streams to include Little South Fork Cumberland River by Starnes and Bogan (1982), Rockcastle River (Blankenship and Crockett, 1972), and the Stones River (Tucker, 1972; Stansbery et al., 1983; Schmidt, 1982) have failed to find *D. dromas* living in these streams. Very little of the Cumberland River has been searched since it was impounded.

Thus it can be assumed that only a small portion of the Tennessee and Cumberland Rivers contains the big river form of *D. dromas*, and the headwater tributary streams to the Tennessee River (Clinch and Powell Rivers above Norris Reservoir) contain the largest known populations of the headwaters form *caperatus*. However, the upper Cumberland River and headwater tributary streams are relatively unknown. Freshwater mussel surveys in the Big South Fork Cumberland River, Buck Creek, Obed, Obey, and the Caney Fork may produce living populations of *D. dromas*. Further, intensive freshwater mussel sampling in the French Broad River, Emory River, and the Sequatchie River (tributaries to the Tennessee River) may also reveal living populations of *D. dromas*.

ECOLOGY AND LIFE HISTORY

Cumberlandian freshwater mussels are most often observed in clean, fast-flowing water in substrates that contain relatively firm rubble, gravel, and sand substrates swept free from siltation. These mussels are usually found buried in the substrate in shallow riffle and shoal areas.

Since freshwater mussels are quite long lived--up to 50 years or more for some species--and rather sedentary by nature, they are especially vulnerable to stream perturbations. Of particular concern are the Cumberlandian species, which have suffered severe population declines. Of the 22 Cumberlandian species recorded from the Tennessee River (Ortmann 1925) in 1924 before the impoundment of Wilson Reservoir, all but 6 were apparently eliminated (Stansbery, 1964; Isom, 1969). TVA's recent mollusk investigations on the Tennessee River in 1978 produced only three Cumberlandian species (TVA, 1978; Pardue, 1981). Neel and Allen's (1964) survey of the upper Cumberland Basin before impoundment documented an almost total elimination of the genus Dysnomia (=Epioblasma), of which six of the eight species reported were Cumberlandian forms. Representatives of the genus Dysnomia are typically found in silt-free riffles and shoals.

D. dromas is a Cumberlandian species with a typical swollen big river type and a compressed headwater form caperatus. D. dromas is categorized as a riffle species because it is typically found in shallow, fast-flowing water with stable, clean substrate. However, this species has been found alive in approximately 18 feet of water in the Cumberland River at Bartlett's Bar. In this case, although a shallow riffle or shoal was not present, fast-flowing water over stable, relatively silt-free gravel and sand substrates enabled D. dromas to survive these depths. However, the specimens collected were old and eroded, suggesting that the population may not be reproducing. This portion of the Cumberland River is affected by water releases from Cordell Hull Dam.

D. dromas (see photo) is a medium-sized species, rounded to subtriangular or subelliptical in outline with full, high beaks set forward. Valves are generally solid and inflated. Beak sculpture consists of a series of fine ridges running parallel with the growth lines. The outer surface of the shell near the median line has a strong concentric ridge or hump with a curved row of smaller knobs near the midline extending from the umbo area to the ventral margin. The outer covering of the shell (periostracum) is generally yellowish-green in color with broken green rays covering the shell. Further, numerous smaller narrow rays of dots or broken lines mixed with wider green rays or blotches cover the surface of the shell. Inside coloration of the shell (nacre) is generally white or pinkish in color (especially the big river form), while the nacre of the headwaters form caperatus is whitish pink, salmon, or reddish in color.

The life history of D. dromas is presumed similar to that of most unionids and is briefly illustrated in Figure 5. Males produce sperm that are discharged into the surrounding water and dispersed by water currents. Any female D. dromas downstream from the males obtains these sperm during the normal process of siphoning water during feeding and respiration (Stein, 1971). Fertilization of the eggs by sperm occurs within the gills of the female. The fertilized eggs are retained in the posterior section of the outer gills, which are modified as brood pouches. The marsupium consists of numerous ovisacs along the larger posterior section of the outer gill, leaving a small anterior portion of the gill nonmarsupial (Bogan and Parmalee, 1983). The family Unionidae is separated into two groups based on the length of time glochidia remain in the female (Ortmann, 1911). By Ortmann's definitions, bradytictic bivalves (long-term breeders) breed from midsummer through fall or early winter; embryos develop in the female over winter and are released the following spring or summer. Tachytictic bivalves (short-term breeders) breed in spring and release glochidia by mid to late summer of the same year. D. dromas is a bradytictic species, with gravid females having been observed in September (Bogan and Parmalee, 1983).

The glochidia of D. dromas might be called bean-shaped and are of the hookless type. The hookless type of glochidia has a more delicate shell, the valves of which are shaped like the bowl of a very blunt spoon and are most frequently parasitic on the gill filaments of fish (Coker and Surber, 1911; Lefevre and Curtis, 1910). The fish host(s) for D. dromas are unknown (Ortmann, 1912, 1921).

REASONS FOR DECLINE AND CONTINUED THREATS

Historically, D. dromas was widespread in the Tennessee and Cumberland Rivers, including major tributary streams. Neel and Allen (1964) noted that D. dromas was probably more abundant in the Cumberland than the Tennessee River. Morrison (1942), and Bogan and Parmalee's (1983) work on archaeological shell middens indicate that, at least prehistorically, D. dromas was once one of the most abundant species in the Tennessee River. Ortmann (1918) reported the headwaters form caperatus to be abundant in the Holston River, where it integrated with the big river form.

D. dromas has become increasingly rare throughout its range. The reason for this decline is not totally understood; but impoundments, siltation, and pollution are speculated by various authors to be the major causes.

Impoundment

Possibly the single greatest factor that has contributed to this species' decline, as well as other members of the Cumberlandian faunal group, is the alteration and destruction of stream habitat due to impoundment of the Tennessee and Cumberland Rivers and their headwater tributary streams for flood control, navigation, hydroelectric power production, and recreation. Since the early 1930s and 1940s, the Tennessee Valley Authority, Aluminum Company of America (Alcoa), and the U.S. Army Corps of Engineers have constructed numerous dams on the Tennessee and Cumberland River systems. A total of 51 dams is integrated into the TVA water control system. TVA has 36 dams in the Tennessee River basin, of which 9 are located on the main river (Tennessee), and the rest on tributary streams. Five major impoundments are also located on the Cumberland River, with six additional dams located on tributary streams.

Stream impoundment affects species composition by eliminating those species not capable of adapting to reduced flows and altered temperatures. Tributary dams typically have storage impoundments with hypolimnial discharges and sufficient storage volume to cause the stream below the dam (reservoir tailwater) to differ significantly from both preimpoundment conditions in the same area and from comparable reaches above the reservoir. Possible effects of a hypolimnial discharge include: altered temperature regimes, extreme water level fluctuations, reduced turbidity, seasonal oxygen deficits, and high concentrations of certain heavy metals (TVA, 1980a). Biological responses attributable to these types of environmental changes typically include restricted fish and benthic macroinvertebrate communities (Isom, 1971b). Hickman (1937) recorded numerous species of mussels and snails in the vicinity of the Norris Dam construction site prior to the impoundment of that reach of the Clinch River and predicted that the Norris Dam flood control project would have a deteriorating effect on the molluscan fauna. A. R. Cahn (1936) collected mussels extensively in the dewatered riverbed following closure of Norris Dam. Forty-five species of freshwater mussels and nine species of river snails were found in this reach of the Clinch River. In a return visit to the area below the dam 4 months later, not a single live mussel could be found.

Siltation

A second factor that has severely affected freshwater mussels, especially Cumberlandian species, is siltation. In rivers and streams the greatest diversity and number of mussels are usually associated with gravel and/or sand substrates. These two types of substrate are most common in running water (Hynes, 1970). Increased silt transport into our waterways due to strip mining, coal washing, dredging, farming, logging, and road construction are some of the more obvious results of human alteration of the landscape. Hynes (1974) states that there are two major effects of inorganic sediments introduced into aquatic ecosystems. The first is an increase in the turbidity of the water with a consequent reduction in the depth of light penetration, and the second is a blanketing effect on the substrate. High turbidity levels due to the presence of suspended solids in the water column have a mechanical or abrasive action that can irritate, damage, or cause clogging of the gills or feeding structures of mollusks (Loar et al., 1980). Additionally, high levels of suspended solids may reduce or inhibit feeding by filter-feeding organisms such as mussels, causing nutritional stress and mortality (Loosanoff, 1961). Freshwater mussels are quite long lived and rather sedentary by nature. Many species have been unable to survive in a layer of silt greater than 0.6 cm in depth (Ellis, 1936). Since most freshwater mussels, especially the Cumberlandian forms, are riverine species that require clean, flowing water over stable, silt-free rubble, gravel, and sand shoals, the smothering action by siltation is often severe. Fuller (1977) reported that siltation associated with poor agricultural practices and deforestation of much of North America was probably the most significant factor impacting mussel communities. The reproductive life cycle of the mussel can be affected indirectly by siltation by impacting host-fish populations, either by smothering and killing fish eggs and larvae, reducing food availability, or filling of interstitial spaces in a gravel and rubble substratum, thus potentially eliminating both spawning bed and habitat critical to the survival of young fishes (Loar et al., 1980).

Coal production in the Appalachian region, which includes headwater tributary streams to the Cumberland and Tennessee Rivers, has increased drastically in the last few decades. This change has been brought about largely by the necessity to provide relatively inexpensive coal supplies for the production of more than 80 percent of the electricity consumed in the eastern United States. The majority of this coal has traditionally been mined by auger and deep-mining techniques; however, strip mining is on the increase. By 1985, it is estimated that 67 percent of coal extraction will be accomplished by strip mining (Minear and Tschantz, 1976). Branson (1974) stated that the entire upper Kentucky River basin as well as that of the Cumberland River looks very bleak because mining operations are being intensified to meet the growing demand for coal. This will result in increased silt runoff and escalate impacts to the freshwater mussel fauna, especially the headwater tributary streams to the Cumberland River and the Powell and Clinch Rivers of the Tennessee River system. Vaughan (1978) reported that so much land has been disturbed by mining in the New River watershed (a tributary stream in eastern Tennessee) that finding an unaffected stream to study fish and diatoms was extremely difficult. Branson (1974) reported silt (as a by-product of strip mining) is the most widespread form of pollution in North America. Branson and Batch (1972) found a 90 percent reduction in total benthic population size and number of species as a result of increased siltation. Mussel populations in the upper reaches of the Powell River (including tributary streams such as North Fork Powell, Callahan Creek, and Pigeon Creek) are already heavily impacted by silt and coal fines from coal washing operations and active and abandoned strip mines (Ahlstedt and Brown, 1980). On numerous occasions since 1975, the Powell River has been observed running black for long periods of time by TVA biologists and concerned fishermen. During the week of March 31, 1979, a biologist with the Tennessee Department of Public Health notified TVA biologists that the Powell River was running black near the head of Norris Reservoir, a distance of over 130 river miles downstream from its source at a coal preparation plant in Appalachia, Virginia. This was confirmed that same week by a TVA biologist. Unless strong, corrective measures are taken, the threat posed by coal-related siltation to endangered species in aquatic ecosystems of southwestern Virginia can be expected to grow in the future as coal production increases.

Pollution

A third factor that must be considered, although on a much broader scale, is the impact caused by various forms of pollutants. An increasing number of streams throughout the United States have been subject to municipal, agricultural, and industrial waste discharges. The damage suffered varies according to a complex of interrelated factors, that include the characteristics of the receiving stream and the nature, magnitude, and frequency of the stress or stresses applied. Often the degradation has been so severe and of such duration that the streams are no longer considered valuable in terms of their biological resources (Hill et al., 1974). Usually, these areas will not recover if there are residual effects from the pollutant, which makes the area unsuitable for aquatic organisms, or if there is an inadequte pool of organisms for recruitment and recolonization (Cairns et al., 1971).

The absence f freshwater mussels can logically be an indication of environmental disruption only when and where their former presence can be demonstrated (Fuller, 1974). It is very rare that the composition and size of the mussel fauna can be quantitatively and/or qualitatively correlated with a specific disruption, be it chemical or physical (Ingram, 1956). However, documentation is available concerning the adverse impacts of some pollutants on freshwater mussels. Simpson (1899) mentioned the adverse effect of sawdust upon mussels as a false streambed. Wilson and Danglade (1914) noted that bark dislodged from logs driven downstream coated the bottom substrate of the Prairie River of Minnesota. Neel and Allen (1964) reported that coal mine acids in the major headwater tributaries of the Cumberland River have practically eliminated the most diverse known assemblage of species belonging to the genus Epioblasma (=Dysnomia). This decline in the genus Epioblasma is typical of what has happened to many Cumberlandian species. A combination of toxic wastes, gravel dredging, and increased fertilizer and pesticide use has reduced the freshwater mussel fauna in the Stones River from 45 to 30 species of freshwater mussels (Schmidt, 1982). Ortmann (1918), in his studies of the freshwater mussels of the upper Tennessee drainage, reported numerous streams to be already polluted and the mussel fauna gone. These streams included the Powell River, for a certain distance below Big Stone Gap, Virginia (wood extracting plant); the North Fork Holston River for some distance below Saltville, Virginia (salt and plaster of paris industries); French Broad River at Asheville, North Carolina; Big Pigeon River from Canton, North Carolina, all the way to its mouth (wood pulp and paper mill); and the Tellico River below Tellico Plains, Tennessee (wood pulp and extracting mill).

The North Fork Holston River in southwestern Virginia is one stream that has suffered greatly from chronic pollution. From 1894 to 1972, a chemical plant located along the North Fork Holston River near Saltville, Virginia, effectively eliminated stream life in much of the lower 80 miles of the river (Hill et al., 1974). Chemicals discharged into the river included sodium hydroxide, sodium carbonate, sodium bicarbonate, hydrozine, chlorine, and dry ice. Additional wastes consisting of sand, limestone particles, and mercury were also discharged into the river and later into settling lagoons located along the banks of the river (TVA, 1968). This plant ceased operation in 1972 because it could not economically comply with water quality standards. Activities have been completed to correct this problem.

Ortmann (1918) reported 42 species and forms of freshwater mussels from the North Fork Holston River at and below Saltville, Virginia. More recent surveys in the North Fork indicate a good mussel fauna occurring above Saltville; however, the mussel fauna below Saltville had largely been extirpated (Neves et al., 1980; Stansbery and Clench, 1974; and TVA, 1976). C. C. Adams (1915) in his study of the pleurocerid river snail *Io fluvialis* indicated the North Fork Holston River *I. fluvialis* population had suffered greatly from the outfall of the chemical industry at Saltville since before 1900. No living native populations of *I. fluvialis* are now known to exist anywhere in the Holston River system (Stansbery, 1972; Stansbery and Clench, 1974).

Mussel surveys in the North Fork near the Virginia-Tennessee State line by TVA biologists in 1981 revealed eight species of mussels naturally occurring in this section of the river, giving an indication of gradual faunal recovery. Several mussel species and the spiny river snail (I. fluvialis) were transplated from the Clinch River into the North Fork Holston River from 1975 to 1978 (Ahlstedt, 1980) are still surviving, and in some cases may be reproducing. Although young mussels were found at the transplant site, these mussels could be individuals from the initial transplants, the progeny of the transplanted mussels, or the result of small but recovering resident populations. Another documented impact to the freshwater mussel fauna in the upper Tennessee River system occurred in the free-flowing reaches of the Clinch River above Norris Reservoir during two separate chemical spills that occurred in 1967 and 1970. In June 1967, a dike surrounding a fly ash settling lagoon collapsed, releasing a highly caustic alkaline slurry (pH 12) into the Clinch River below the Appalachian Power Company (APCo) generating facility at Carbo, Virginia. During this period, an estimated 162,000 fish were killed in the Virginia portion of the Clinch River (66 miles), and an additional 54,000 fish were killed in 24 miles of the Clinch in Tennessee, where the polluted mass was diluted (TVA, 1967). The Virginia State Water Control Board conducted a bottom fauna survey to assess the damage to fish food organisms. Their observations indicated that: (1) bottom-dwelling fish food organisms appeared to have been completely eliminated for a distance of approximately 3.0 or 4.0 miles below the spill, (2) a reduction in the number and kinds of bottom-dwelling fish food organisms occurred in the Clinch River for 77.0 miles below the spill, and (3) freshwater mussels and snails were eliminated for 11.5 miles below Carbo, Virginia. In June 1970, a second industrial spill occurred at the plant involving the release of an undetermined amount of sulfuric acid which killed approximately 5,300 fish. Representatives of the Virginia State Water Control Board indicated that stream damage began approximately 1 mile below the APCo power plant and extended a distance of almost 18 miles downstream to St. Paul, Virginia. Fish populations sampled on the Clinch River near St. Paul, Virginia, following the fish kills (Raleigh et al., 1978) indicated rapid recovery of the fauna. Cairns et al. (1971) reported that recovery was apparently rapid for all faunal groups except mollusks. Recent freshwater mussel surveys of the Clinch River by Neves et al. (1980), TVA (1979a), and Bates and Dennis (1978) documented an almost total elimination of the freshwater mussel fauna from Carbo, Virginia (CRM 264.2) to Miller Yard (CRM 243.0). TVA's 1979 float survey of the Clinch River produced 12 species of freshwater mussels above the APCo generating facility at Carbo. Only two species of mussels were found in a 20-mile reach below Carbo (TVA, 1979a). One can only speculate as to why the molluscan fauna has failed to recolonize this stretch of the Clinch. This may be, in part, due to the continued discharges of some effluents from the plant. In addition, coal fines have also been observed entering the Clinch River from Lick Creek, a tributary stream located above St. Paul, Virginia. This stream was observed to be running black with coal fines in August 1979 by the U.S. Fish and Wildlife Service (USFWS) and TVA biologists.

PART II

RECOVERY

A. Recovery Objectives

The ultimate objective of this Recovery Plan is to maintain and restore viable populations* of D. dromas to a significant portion of its historic range and remove the species from the Federal list of endangered and threatened species. This can be accomplished by (1) protecting and enhancing habitat containing D. dromas populations and (2) establishing populations in rivers and river corridors that historically contained D. dromas. This species shall be considered recovered, i.e., no longer in need of Federal Endangered Species Act protection, when the following criteria are met:

1. A viable population of D. dromas exists in the Clinch River from the backwaters of Norris Reservoir upstream to approximately CRM 226 and in the Powell River from the backwaters of Norris Reservoir upstream to approximately PRM 130. These two populations are dispersed throughout each river so that it is unlikely that any one event would cause the total loss of either population.
2. Through reestablishments and/or discoveries of new populations, viable populations exist in three additional rivers. Each of these rivers will contain a viable population that is

---

*Viable population - a reproducing population that is large enough to maintain sufficient genetic variation to enable it to evolve and respond to natural habitat changes. The number of individuals needed to meet this criterion will be determined as one of the recovery tasks.

distributed such that a single event would be unlikely to eliminate *D. dromas* from the river system.

3. The species and its habitat are protected from present and foreseeable human-related and natural threats that may interfere with the survival of any of the populations.

4. Noticeable improvements in coal-related problems and substrate quality have occurred in the Powell River, and no foreseeable increase in coal-related siltation occurs in the Clinch River. If the Cumberland River, including its tributaries, is selected for transplants or new populations are discovered, then these improvements in coal-related problems and substrate quality also apply to these streams.

B. Step-down Outline

Prime Objective: Recover the species to the point it no longer requires Federal Endangered Species Act protection.

1. Preserve populations and presently used habitat of *D. dromas* with emphasis on the Clinch, Powell, Tennessee, and Cumberland Rivers.

    1.1 Continue to utilize existing legislation and regulations (Federal and State endangered species laws, water quality requirements, stream alteration regulations, etc.) to protect the species and its habitat.

1.2 Conduct population and habitat surveys.

1.2.1 Determine species' present distribution and status.

1.2.2 Characterize the habitat, ecological associations, and essential elements (biotic and abiotic factors) for all life history stages.

1.2.3 Determine the extent of the species' preferred habitat.

1.2.4 Present the above information in a manner that identifies essential habitat and specific areas in need of protection.

1.3 Determine present and foreseeable threats to the species and strive to minimize and/or eliminate them.

1.3.1 Determine impacts of coal industry-related pollution on nonendangered species.

1.3.2 Investigate and inventory other factors negatively impacting the species and its environment.

1.3.3 Solicit information on proposed and planned projects that may impact the species.

1.3.4 Determine measures that are needed to minimize and/or eliminate any adverse impacts and implement where necessary.

1.4 Solicit help in protecting the species and its essential habitat.

1.4.1 Meet with local government officials and regional and local planners to inform them of our plans to attempt recovery and request their support.

1.4.2 Work with local, State, and Federal agencies to encourage them to utilize their authorities to protect the species and its river habitat.

1.4.3 Meet with local mining and industry interests and solicit their support in implementing protective actions.

1.4.4 Meet with landowners adjacent to the species' population centers and inform them of the project and get their support in habitat protection measures.

1.4.5 Develop an eductional program using such items as slide/tape shows and brochures. Present this material to business groups, civic groups, youth groups, church organizations, etc.

1.5 Investigate the use of Scenic River Status, mussel sanctuaries, land acquisitions, and/or other means or combinations to protect the species.

2. Determine the feasibility of introducting the species back into rivers within its historic range and introduce where feasible.

2.1 Survey rivers within the species' range to determine the availability and location of suitable transplant sites. This can include areas for population expansion within rivers where the species presently exists.

2.2 Identify and select sites for transplant.

2.3 Investigate and determine the best method of establishing new populations; i.e., introduction of adult mussels, juveniles, infected fish, artificially cultured individuals, or other means or combinations.

2.4 Introduce species within historic range where it is likely they will become established.

2.5 Implement the same protective measures for these introduced populations as outlined for established populations in numbers 1.2 through 1.4 above.

3. Conduct life history studies not covered under section 1.2 above; i.e., fish hosts, age and growth, reproductive biology, longevity, natural mortality factors, and population dynamics.

4. Determine the number of individuals required to maintain a viable population.

5. Investigate the necessity for habitat improvement and, if feasible and desirable, identify techniques and sites for improvement to include implementation.

6. Develop and implement a program to monitor population levels and habitat conditions of presently established populations as well as introduced and expanding populations.

7. Assess overall success of recovery program and recommend action (delist, continued protection, implement new measures, other studies, etc.).

C. Narrative Outline

1. Preserve populations and presently used habitat of D. dromas with emphasis on the Clinch, Powell, Tennessee, and Cumberland Rivers. The greatest known concentrations of *D. dromas*, especially the headwaters form *caperatus*, occurs in the Clinch and Powell Rivers. Lesser known populations of big river *D. dromas* occur in the Tennessee and Cumberland Rivers. The protection of these

populations is essential for the continued survival of the species. Preservation of these mussel populations including transplanted populations of *D. dromas* will be required to meet the recovery objective.

1.1 Continue to utilize existing legislation and regulations (Federal and State endangered species laws, water quality requirements, stream alteration regulations, etc.) to protect the species and its habitat. Prior to and during implementation of this Recovery Plan the species can be protected by the full enforcement of existing laws and regulations.

1.2 Conduct population and habitat surveys. Most needed surveys have already been completed by TVA as part of the Cumberlandian Mollusk Conservation Program (Jenkinson, 1981) and other TVA projects since 1970. However, additional freshwater mussel surveys are recommended for the upper Clinch River between Cleveland, Virginia (CRM 272), and below Craft Mill, Virginia (CRM 219.2); the Harpeth, Sequatchie, French Broad, and Emory Rivers in Tennessee; and the Flint River in northern Alabama. Further, the Cumberland River below Cordell Hull Dam, Tennessee, and the headwater tributary streams to include the Big South Fork Cumberland River, Obed, Obey, Caney Fork (below Center Hill Dam), and Buck Creek are also recommended for freshwater mussel surveys.

1.2.1 Determine species' present distribution and status. Intensive dive/float surveys will be used where possible.

1.2.2 Characterize the habitat and ecological association and determine essential elements (biotic and abiotic factors) of its habitat for all life history stages. Some of the work necessary for the characterization of habitat has been accomplished for *Conradilla caelata* as part of TVA's Cumberlandian Mollusk Conservation Program. The final report on this is expected in 1983. However, it will be necessary to have intimate knowledge of *D. dromas* habitat requirements if actions are taken to protect the species.

1.2.3 Determine the extent of the species' preferred habitat. After the types and quality of habitat are defined, it will be necessary to determine the extent of such habitat.

1.2.4 Present the above information in a manner that identifies essential habitat and specific areas in need of protection.

1.3 Determine present and foreseeable threats to the species and strive to minimize and/or eliminate them. Many factors presently adversely affect the species and its habitat, and other problems associated with future development are likely to occur. These negative impacts must be identified and remedied if recovery is to be reached.

1.3.1 Determine impacts of coal industry-related pollution on the species. Coal-related pollution (coal washing, strip mining, and orphan mines) appears to be a major problem in the headwater tributary streams of the Cumberland River and the Powell and Clinch Rivers of the Tennessee River system. The present anticipated impacts of the problem need to be assessed. This could be accomplished with present State and Federal research facilities utilizing both field and laboratory research. Studying impacts on nonendangered mussels as experimental organisms is suggested.

1.3.2 Investigate and inventory factors negatively impacting the species and its environment. Factors such as road construction, dredging, herbicide and pesticide spraying, and chlorinated effluents may be having a substantial impact on the species. The effect of toxic spills in the Clinch are well documented, but other less obvious factors may be damaging this and other river systems. Other factors to consider are the impacts of commercial musseling on endangered species.

1.3.3 Solicit information on proposed and planned projects that may impact the species. Projects that are now planned or proposed could have a serious impact on the recovery of the species. Before delisting could be accomplished, anticipated negative impacts on the species must be addressed.

1.3.4 <u>Determine measures that are needed to minimize and/or eliminate any adverse impacts and implement where necessary</u>. Once the problem areas are identified, measures must be developed and implemented to minimize and/or where necessary eliminate those impacts that could likely jeopardize the continued existence of the species.

1.4 <u>Solicit help in protecting the species and its essential habitat</u>. All local, State, and Federal developmental and enforcement agencies and land use groups should be notified of our recovery efforts and the sensitivity of certain areas to prevent any modification or impacts that might prove harmful to the species and its habitat. These impacts typically include strip mining, oil and gas drilling, coal slurry pipelines, industrial development, road and bridge construction, installation of sewage treatment plants and their operation, and the use of herbicides along roads and powerline corridors as well as pesticides and fertilizers for farm crops. Some of this work has already been completed for the Clinch and Powell watersheds by the USFWS.

1.4.1 <u>Meet with local government officials and regional and local planners to inform them of our plans to attempt recovery and request their support</u>. The support of local government officials and planners will be essential if the river habitat is going to receive sufficient protection to reach recovery.

000682-B

1.4.2 <u>Work with local, State, and Federal agencies to encourage them to utilize their authorities to protect the species and its river habitat</u>. Local, State, and Federal agencies (Soil Conservation Service, U.S. Army Corps of Engineers, Office of Surface Mining, etc.) presently have sufficient laws and regulations to affect a measurable change in the quality of these rivers.

1.4.3 <u>Meet with local mining and industry interests and solicit their support in implementing protective actions</u>. Mining and industry along the rivers can have a substantial impact on the river's quality. Cooperation of these groups is essential in meeting the recovery goals.

1.4.4 <u>Meet with landowners adjacent to the species' population centers and inform them of the project and get their support in habitat protection measures</u>. Land use adjacent to the river greatly influences habitat quality. Much of this land is owned privately. Landowner agreements and/or land purchases can be used to protect these sites.

1.4.5 <u>Develop an educational program using such items as slide/tape shows and brochures. Present this material to business groups, civic groups, youth groups, church organizations, etc</u>. In spite of existing perturbations, the Clinch and Powell Rivers are probably two of the most biologically diverse river systems remaining in the southeastern United States. Further, the Cumberland River system contained (at least historically) an extremely rich freshwater mussel fauna. A brief informative program or pamphlet is needed to point out the basic problems, uniqueness of the river systems, the rarity of the resources at risk, the potential value of undisturbed systems, and the penalties for its abuse. This material could help to eliminate some of the misconceptions about the value of preserving endangered species and their habitat. Educational efforts should also include all local, State, and Federal agencies, wildlife officers and wildlife-oriented clubs. These programs could also be developed for television and local newspaper coverage.

1.5 Investigate the use of Scenic River Status, mussel sanctuaries, land acquisitions, and/or other means or combinations to protect the species. Both the Clinch and Powell Rivers appear eligible for Scenic River Status under the National Wild and Scenic Rivers Act (USDI, 1976). Such a designation would provide some additional protection for the species and its habitat. The State of Tennessee has designated portions of the Tennessee and Cumberland Rivers and the Clinch and Powell Rivers as mussel sanctuaries, but the headwaters for each of these streams originate in adjoining States such as Kentucky and Virginia. No protection is offered those mussel populations occurring in Kentucky and Virginia. Such protection is needed to prohibit collecting of mussels and fish for commercial or scientific purposes except with permits granted by State or Federal permitting offices. The Nature Conservancy is actively pursuing land acquisition at one location in the upper Clinch River to protect probably the greatest freshwater mussel diversity found anywhere in the southeastern United States. Protection of the upper Clinch and Powell Rivers from unwarranted collecting and environmental impacts is of the highest priority.

2. Determine the feasibility of introducing the species back into rivers within its historic range and introduce where feasible. The protection and preservation of the Clinch and Powell River populations would be a significant step toward recovery, especially for the headwaters form of *D. dromas* (*caperatus*). Big river *D. dromas* in the Tennessee and Cumberland Rivers are apparently found in such low numbers that reproduction may not be possible. The introduction of the headwaters form *caperatus* (from the Clinch or Powell River) using specimens that show some degree of "humping" similar to that of specimens found in the Tennessee and Cumberland Rivers is recommended. However, it is unlikely that removal from the list of Federal endangered or threatened species could be achieved without the establishment of populations in other rivers and the expansion of populations in the Clinch and Powell Rivers. The factors that caused extinction or population

reductions at potential transplant sites must be identified and remedied prior to attempts at establishing additional populations.

2.1 Survey rivers within the species' range to determine the availability and location of suitable transplant sites. This can include areas for population expansion within rivers where the species presently exists. Before the river system can be restocked with the species, the availability of suitable habitat containing all the essential elements for the species' survival and reproduction must be determined. In some cases the physical habitat may be available for adults, but juvenile habitat or the proper fish host might not be present.

2.2 Identify and select sites for transplants. After the suitability of a particular river system has been determined, specific sites for transplants within that river must be identified. TVA, as part of their Cumberlandian Mollusk Conservation Program, has studied 15 potential transplant sites for another endangered freshwater mussel *C. caelata*. The current distribution for *C. caelata* overlaps with that of *D. dromas* in the Clinch and Powell Rivers. As part of that program, each of the 15 sites was evaluated as potential transplant sites based on a correlation of stream characteristics with habitats of known populations of the species. Upon completion of all data analysis, four sites were chosen to receive *C. caelata* during the fall of 1982. One of these sites chosen is within the known historic range for *D. dromas* in the Tennessee River system (i.e., North Fork

Holston River). This site could also serve as a potential transplant site for D. dromas. Further studies are required in the main Tennessee and Cumberland Rivers for possible transplant sites including tributary streams to those rivers. Those tributary streams suggested for study include the (1) Holston River, (2) North and Middle Forks Holston River, (3) French Broad River, (4) Sequatchie River, and (5) the Elk River of the Tennessee River system and the (1) Big South Fork Cumberland River, (2) Caney Fork, (3) Obed, (4) Obey, and (5) Buck Creek of the Cumberland River system.

2.3 Investigate and determine the best method of establishing new populations, i.e., introduction of adult mussels, juveniles, infected fish, artificially cultured individuals, or other means or combinations. Some of these methods are currently being tested by TVA as part of the Cumberlandian Mollusk Conservation Program. Adult mussels, including gravid female C. caelata, were introduced in the fall of 1982 into river systems where they formerly occurred. Laboratory experiments were also conducted to determine specific fish hosts for C. caelata and Quadrula cylindrica. Another possible introduction method would be to release host fish infected with D. dromas glochidia. Isom and Hudson (1982) were successful in artificially culturing some species of freshwater mussels, but the young individuals survived only 60 days. Further investigations and experimentations are required for determining which method(s) should be used for D. dromas.

2.4 Introduce species within historic range where it is likely they will become established. If habitat is available and the introductions are likely to succeed, the introduction of the species to other rivers within its historic range should be initiated.

2.5 Implement the same protective measures for these introduced populations as outlined for established populations in numbers 1.2 through 1.4 above.

3. Conduct life history studies not covered under section 1.2 above; i.e., fish hosts, age and growth, reproductive biology, longevity natural mortality factors, and population dynamics. Knowledge of the many varied aspects of the species life history will be needed to understand the species and protect its future. Life history studies for *Conradilla* have indicated that at least two species of darters, *Etheostoma zonale* and *E. blenniodes*, serve as fish host(s) for *Conradilla*. Data on other potential fish host(s) is also needed.

4. Determine the number of individuals required to maintain a viable population. Theoretical considerations by Franklin (1980) and Soulé (1980) indicate that 500 individuals represent 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 can be expected to be larger, possibly by as much as 10 times. The factors that will influence actual population size include sex ratio, length of the species' reproductive life, fecundity, extent of exchange of genetic

material within the population, plus other life history aspects of the species. Some of these factors can be addressed under Task 1.2.2, while others will need to be addressed as part of this task on a need-to-know basis.

5. Investigate the necessity for habitat improvement and, if feasible and desirable, identify techniques and sites for improvement to include implementation. Low-level check dams should be considered in silt-prone areas in the upper tributary streams of the Cumberland and Powell Rivers and tributary streams to the Powell River, which includes the North Fork Powell, Callahan Creek, and Pigeon Creek. This would help to control silt and coal fines from entering these stream systems from coal preparation plants and silt from active and abandoned strip mines. Routine maintenance dredging would be recommended, and spoil could be deposited away from the river or buried in landfills. Although these are temporary measures for controlling silt loads in silt-prone areas such as the upper Cumberland and Powell, these structures are deemed necessary until massive reclamation programs have been established in the watershed basins. Additionally, a green belt corridor at least 40 feet wide is recommended between adjacent farmland and the edge of the streambank or riverbank. This would prevent farming up to the riverbank, construction activities, clearcutting, and other activities which cause erosion, bank slumping, and canopy removal. Other methods of habitat improvement should also be investigated.

6. Develop and implement a program to monitor population levels and habitat conditions of presently established populations as well

as introduced and expanding populations. Once recovery actions are implemented, the response of the species and its habitat must be monitored to assess any progress toward recovery.

7. Assess overall success of recovery program and recommend action (delist, continued protection, implement new measures, other studies, etc.). The recovery plan must be evaluated periodically to determine the progress of the recovery plan and to recommend future actions.

BIBLIOGRAPHY

Adams, C. C. 1915. The variations and ecological distribution of the snails of the genus Io. Mem. Nat. Acad. Sci. 12(2):1-184.

Ahlstedt, S. A. 1980. Recent mollusk transplants into the North Fork Holston River in southwestern Virginia. IN: Bull. Amer. Malacol. Union 1979:21-23.

Ahlstedt, S. A. and S. R. Brown. 1980. The naiad fauna of the Powell River in Virginia and Tennessee (Bivalvia: Unionacea). IN: Bull. Amer. Malacol. Union 1979:40-43.

Ahlstedt, S. A. 1981a. The molluscan fauna of Copper Creek (Clinch River system) in southwestern Virginia. IN: Bull. Amer. Malacol. Union 1980:4-6.

Ahlstedt, S. A. 1981b. The molluscan fauna of the Duck River between Normandy and Columbia Dams in central Tennessee. IN: Bull. Amer. Malacol. Union 1980.

Ahlstedt, S. A. 1983. The molluscan fauna of the Elk River in Tennessee and Alabama. American Malacological Bulletin, Vol. 1 (1983): 43-50.

Bates, J. M. 1962. The impact of impoundment on the mussel fauna of Kentucky Reservoir, Tennessee River. Am. Midl. Nat. 68(1):232-236.

Bates, J. M. 1975. Overbank and tailwater studies. TVA contract TV-38606A, Final report.

Bates, J. M. and S. D. Dennis. 1978. The mussel fauna of the Clinch River, Tennessee and Virginia. Sterkiana 69-70:3-23.

Blankenship, S. and D. R. Crockett. 1972. Changes in the freshwater mussel fauna of the Rockcastle River at Livingston, Kentucky. Trans. Ky. Acad. Sci. 33:37-39.

Boepple, J. F. and R. E. Coker. 1912. Mussel resources of the Holston and Clinch Rivers of eastern Tennessee. Bur. Fish. Doc. No. 765. pp. 3-13.

Bogan, A. and P. Parmalee. 1983. Tennessee's Rare Mollusks. IN: Tennessee's Rare Wildlife, Final Report: TWRA, Tennessee Department of Conservation and Tennessee Heritage Prg. June 1979. Univ. of Tenn., Knoxville. 360 pp.

Branson, B. A. 1974. Stripping the Appalachians. Natural History. 83(9):53-60, Nov. 1974.

Branson, B. A. and D. L. Batch. 1972. Effects of strip mining on small stream fishes in east-central Kentucky. Proc. of Biol. Soc. Wash. 84(59):507-518.

Cahn, A. R. 1936. The molluscan fauna of the Clinch River below Norris Dam upon completion of that structure. Unpublished TVA report, Norris, TN.

Cairns, J., Jr., J. S. Crossman, K. L. Dickson, and E. E. Herricks. 1971. The recovery of damaged streams. ASB (Assoc. Southeast. Biol.) Bull., 18:79-106.

Coker, R. E. 1915. The common and scientific names of freshwater mussels. Dept. of Comm., Bur. Fish. Econ. Cir., No. 15. 4 pp.

Coker, R. E. and T. Surber. 1911. A note on the metamorphosis of the mussel (Lampsilis laevissimus). Bio. Bull. 20:179-182.

Conrad, T. A. 1836-1843. Monography of the family Unionidae or Naiades of Lamarck (Freshwater bivalves shells) of North America. No. 1:1-12, No. 2:17-24, No. 3:25-32, No. 4:33-40, No. 5:41-48, No. 6:49-56, No. 7:57-64, No. 8:65-72, No. 9:78-80, No. 10:81-94, No. 11:95-102, No. 12:103-110, No. 13:111-117.

Dennis, S. D. 1981. Mussel fauna of the Powell River, Tennessee and Virginia. Sterkiana 71:1-7.

Ellis, M. M. 1931. Some factors affecting the replacement of the commercial freshwater mussels. U.S. Bur. Fish, Circ. 7:1-10.

Ellis, M. M. 1936. Erosion silt as a factor in aquatic environments. Ecology 17:29-42.

Franklin, R. I. 1980. Evolutionary change in small populations. IN: Conservation biology an evolutionary-ecological perspective. Michael E. Soule' and Bruce A. Wilcox (eds.). Published by Sinauer Assoc., Inc., Sunderland, MA. pp. 135-149.

Fuller, S. 1974. Clams and mussels (Mollusca: Bivalvia). pp. 215-273. IN: C. W. Hart and S.L.H. Fuller (eds.). Pollution ecology of freshwater invertebrates. Academic Press. NY. 389 pp.

Fuller, S. 1977. Freshwater and terrestrial mollusks. IN: J. E. Cooper, S. S. Robinson, and J. B. Funderburg (eds.). Endangered and threatened plants and animals of North Carolina. North Carolina State Museum of Natural History, Raleigh. pp. 143-194.

Grace, T. B. and A. C. Buchanan. 1981. Naiades of the lower Osage River, Tavern Creek, and Maries River, MO. U.S. Army Corps of Eng., Kansas City Dist., MO. 147 pp.

Hickman, M. E. 1937. A contribution to Mollusca of east Tennessee. Unpublished master's thesis, Dept. of Zool., Univ. of Tenn., Knoxville. 165 pp. 104 pl.

Hill, D. M., E. A. Taylor, and C. F. Saylor. 1974. Status of faunal recovery in the North Fork Holston River, Tennessee and Virginia. Proc. of the Twentyeighth Annual Conference, Southeastern Assoc. of Game and Fish Comm., Nov. 17-20, 1974. White Sulfur Springs, WV. pp. 398-414.

Hinkley, A. A. 1906. Some shells of Mississippi and Alabama. Nautilus. 20(3):34-36, 20(4):40-44, 20(5):52-55.

Hynes, H.B.N. 1970. The ecology of running waters. Toronto: University of Toronto Press.

Hynes, H.B.N. 1974. The biology of polluted waters. Toronto: University of Toronto Press.

Ingram, W. M. 1956. The use and value of biological indicators of pollution: Fresh water clams and snails. IN: "Biological Problems in Water Pollution," (C. M. Tarzwell, Ed.), pp. 94-135. Robert A. Taft, Sanitary Eng. Center. Cincinnati, OH.

Isom, B. G. 1969. The mussel resources of the Tennessee River. Malacologia 7(2-3):397-425.

Isom, B. G. 1971a. Mussel fauna found in Fort Loudoun Reservoir, Tennessee River, Knox County, TN, in Dec. 1970. Malacol. Review 4:127-130.

Isom, B. G. 1971b. Effects of storage and mainstream reservoirs on benthic macroinvertebrates in the Tennessee Valley. Res. Fish and Limn. Sp. Publ. No. 8. Am. Fish. Soc. pp. 179-191.

Isom, B. G. 1972. Mussels in the unique Nickajack Dam construction site, Tennessee, 1965. Malacol. Rev. 5-4-6.

Isom, B. G. and R. G. Hudson. 1982. In vitro culture of parasitic fresh-water mussel glochidia. Nautilus 96(4):147-151.

Isom, B. G. and P. Yokley, Jr. 1968. The mussel fauna of Duck River in Tennessee, 1965. Am. Midl. Nat. 80(1):34-42.

Isom, B. G., Paul Yokley, Jr., and C. H. Gooch. 1973a. Mussels of the Elk River Basin in Alabama and Tennessee. 1965-1967. Am. Midl. Nat. 89(2):437-442.

Isom, B. G., P. Yokley, Jr., and C. H. Gooch. 1973b. The mussels of the Flint and Paint Rock River systems of the southeast slope of the Cumberland Plateau in North America, 1965-1967. Am. Midl. Nat. 89(2):442-446.

Jenkinson, J. J. 1981. The Tennessee Valley Authority Cumberlandian Mollusk Conservation Program. Bull. Amer. Malacol. Union 1980:62-63.

Lea, I. 1834. Observations on the naiades; and descriptions of new species of that and other families. Trans. Am. Philos. Soc. 5:23119.

Lea, I. 1845. Descriptions of new freshwater and land shells. Proc. Am. Philos. Soc. 4:162-168.

Lefevre, G. and W. C. Curtis. 1910. Experiments in the artificial propagation of freshwater mussels. Bull. U.S. Bur. Fish. 20:615-626.

Lewis, J. 1871. On the shells of the Holston River. Am. J. Conch., 6(3):216-228.

Loar, J. M., L. L. Dye, R. R. Turner, and S. G. Hildebrand. 1980. Analysis of environmental issues related to small-scale hydroelectric development 1. Dredging. ORNL, Env. Science Div. Publ. No. 1565, Oak Ridge, TN. 134 pp.

Loosanoff, V. L. 1961. Effects of turbidity on some larval and adult bivalves. Gulf Caribb. Fish. Inst. Univ. Miami Proc. 14:80-95.

Minear, R. A. and B. A. Tschantz. 1976. The effect of coal surface mining on the water quality of mountain drainage basin systems. Jour. Wat. Poll. Control Fed. 48(11):2549-2569.

Morrison, J.P.E. 1942. Preliminary report on molluscan fauna found in the shell mounds of the Pickwick landing basin in the Tennessee River valley.
IN: William S. Webb and David L. DeJarnette, an archaeological survey of Pickwick Basin in the adjacent portions of States of Alabama, Mississippi, and Tennessee. Bur. Am. Ethnol. Bull. 129:337-392.

Neel, J. K. and W. R. Allen. 1964. The mussel fauna of the upper Cumberland Basin before its impoundment. Malacologia 1(3):427-459.

Neves, R. J., G. B. Pardue, E. F. Benfield, and S. D. Dennis. 1980. An evaluation of endangered mollusks in Virginia. Final Report for Vir. Comm. of Game and Inland Fisheries, Project No. E-F-1. Richmond, VA. 140 pp.

Neves, R. J. and A. Zale. 1982. Freshwater mussels (Unionidae) of Big Moccasin Creek, southwestern Virginia. Nautilus 96(2):52-54.

Ortmann, A. E. 1911. Monograph of the naiades of Pennsylvania. Mem. Carnegie Mus. 4:279-347.

Ortmann, A. E. 1912. Notes upon the families and genera of the nayades. Annals Carnegie Mus. 8:222-365.

Ortmann, A. E. 1918. The nayades (freshwater mussels) of the upper Tennessee drainage with notes on synonymy and distribution. Proc. Am. Philos. Soc. Phila. 57:521-626.

Ortmann, A. E. 1920. Correlation of shape and station in freshwater mussels. Proc. Am. Philos. Soc. 19:269-312.

Ortmann, A. E. 1921. The anatomy of certain mussels from upper Tennessee. Nautilus 34(3):81-91.

Ortmann, A. E. 1924. The naiad fauna of Duck River in Tennessee. Am. Midl. Nat. 9(1):18-62.

Ortmann, A. E. 1925. The naiad fauna of the Tennessee River system below Walden Gorge. Am. Midl. Nat. 9(7)321-372.

Pardue, J. W. 1981. A survey of the mussels (Unionidae) of the upper Tennessee River. 1978. Sterkiana 71:41-51.

Parmalee, P. W., W. E. Klippel, and A. E. Bogan. 1980. Notes on the prehistoric and present status of the naiad fauna of the middle Cumberland River, Smith County, TN. Nautilus 94(3):93-105.

Pilsbry, H. and S. N. Rhoads. 1897. Contributions to the zoology of Tennessee. No. 4, Mollusks. Proc. Acad. Nat. Sci., Phila. pp. 487-506.

Raleigh, R. F., D. H. Bernett, and L. O. Mohn. 1978. Changes in fish stocks after major fish kills in the Clinch River near St. Paul, VA. Amer. Midl. Nat. 99:1-9.

Schmidt, J. 1982. The freshwater mussels of the Stones River above J. Percy Priest Reservoir, TN. Master's thesis, Tenn. Tech. Univ. at Cookeville. 65 pp.

Scruggs, G. D., Jr. 1960. Status of freshwater mussel stocks in the Tennessee River. U.S. Fish and Wildlife Service. Special Report, Fisheries No. 37:1-41.

Shoup, C. S., J. H. Peyton, and G. Gentry. 1941. A limited survey of the Obey River and adjacent streams in Tennessee. Tenn. Dept. of Conserv., Div. Game and Fish, Misc. Pub. No. 3. 76 pp.

Sickle, J. B. 1982. A survey of the freshwater mussels of the lower Cumberland River from Barkley Dam tailwater downstream to the Ohio River. Nashville Dist. U.S. Army Corps of Engineers. 24 pp.

Simpson, C. T. 1899. The pearly freshwater mussels of the United States; their habits, enemies, and diseases; with suggestions for their protection. Bull. U.S. Fish Comm. 18:279-288.

Soulé, M. E. 1980. Thresholds for survival: Maintaining fitness and evolutionary potential. IN: Conservation biology an evolutionary-ecological perspective. (ed.) Michael E. Soulé and Bruce A. Wilcox. Published by Sinauer Assoc., Inc., Sunderland, MA. Ch. 8, pp. 151-169.

Stansbery, D. H. 1964. The Mussel (Muscle) Shoals of the Tennessee River revisited. Am. Malacol. Union Ann. Rept. 1964:25-28.

Stansbery, D. H. 1969. Changes in naiad fauna of the Cumberland River at Cumberland Falls in eastern Kentucky. Am. Malacol. Union Ann. Rep. 1969:16-17.

Stansbery, D. H. 1970. Eastern freshwater mollusks. (I) The Mississippi and St. Lawrence River systems. IN: A. H. Clarke (eds.). 1970. Rare and endangered mollusks of North America. Malacologia 13:9-12.

Stansbery, D. H. 1972. The mollusk fauna of the North Fork Holston River at Saltville, Virginia. Am. Malacol. Union Bull. 1972:45-46.

Stansbery, D. H. 1973. A preliminary report on the naiad fauna of the Clinch River in the southern Appalachian mountains of Virginia and Tennessee (Mollusca: Bivalvia: Unionidae). Am. Malacol. Union Bull. 1972:20-22.

Stansbery, D. H. and W. J. Clench. 1974. The Pleuroceridae and Unionidae of the North Fork Holston River above Saltville, Virginia. Am. Malac. Union Bull. 1973:33-36. 1 map, 1 table.

Stansbery, D. H. and W. J. Clench. 1975. The Pleuroceridae and Unionidae of the Middle Fork Holston River in Virginia. Am. Malacol. Union Bull. 1974:51-54. 1 map, 1 table.

Stansbery, D. H. and W. J. Clench. 1978. The Pleuroceridae and Unionidae of the Upper South Fork Holston River in Virginia. Am. Malacol. Union. Bull. 1977:75-78.

Stansbery, D. H., R. M. Sinclair, and B. G. Isom. 1983. The distribution of the Unionid mollusks in the Stones River in central Tennessee. American Malacological Bulletin, Vol. 1 (1983):pp. 93.

Starns, L. and A. Bogan. 1982. Unionid Mollusca (Bivalvia) from Little South Fork Cumberland River, with ecological and nomenclatorial notes. Brimleyana. No. 8:101-119.

Stein, C. B. 1971. Naiad life cycles: Their significance in the conservation of the fauna. IN: Rare and endangered mollusks (Naiads) of the U.S., USDOI (Fish and Wildlife Service), Region 3, Federal Building, Fort Snelling, Twin Cities, MN. pp. 19-25.

Tennessee Valley Authority. Unpublished field records collected by Steven Ahlstedt (Big South Fork Cumberland River (1978), North Fork Holston River (1976), Clinch River (1978), Powell River (1981)), Office of Natural Res., East. Area Fld. Operations Group, Norris, TN.

Tennessee Valley Authority. 1967. Fish kill in Clinch River below steam-electric power plant of App. Power Co., Carbo, Virginia, June 10-14, 1967. pp. 1-29.

Tennessee Valley Authority. 1968. Stream pollution resulting from mineral wastes originating at Saltville, Virginia, and appraisal by control possibilities. Tennessee Valley Authority, Knoxville.

Tennessee Valley Authority. 1976. Mussel fauna of the Cumberland River in Tennessee. September 1976. TVA unpublished data. Div. of Env. Planning, Water Qual. and Ecol. Branch, Muscle Shoals, AL; and the Div. of For., Fish and Wildlife Dev., Norris, TN.

Tennessee Valley Authority. 1978. Recent mollusk investigations on the Tennessee River. TVA unpublished data. Div. of Env. Planning, Water Qual. and Ecol. Branch, Muscle Shoals, AL. 126 pp.

Tennessee Valley Authority. 1979a. An evaluation of mussel populations in the Clinch River, Tennessee and Virginia. August 1979. TVA unpublished data. Div. of Wat. Res., Fish and Aquatic Ecol. Branch, Norris, TN. 14 pp.

Tennessee Valley Authority. 1979b. An evaluation of mussel populations in the Duck River, Tennessee. MayJune 1979. TVA unpublished data. Div. of Wat. Res., Fish and Aquatic Ecol. Branch, Norris, TN. 11 pp.

Tennessee Valley Authority. 1979c. An evaluation of mussel populations in the Powell River, Tennessee and Virginia. June 1979. TVA unpublished data. Div. of Wat. Res., Fish and Aquatic Ecol. Branch, Norris, TN. 15 pp.

Tennessee Valley Authority. 1979d. A qualitative survey of fish and macroinvertebrates of the French Broad River and selected tributaries. June-August 1977. TVA unpublished data. Office of Natural Resources, East. Area Fld. Oper. Group, Norris, TN.

Tennessee Valley Authority. 1980a. The fisheries resource of the Tennessee Valley Tailwaters - Tim's Ford. TVA unpublished data. Division of Wat. Res., Norris, TN. 17 pp.

Tennessee Valley Authority. 1980b. Freshwater mussels of the Buffalo River. TVA unpublished data. Off. Nat. Res., East. Area Fld. Oper. Group, Norris, TN.

Tennessee Valley Authority. 1980c. Freshwater mussels of the Nolichucky River. TVA unpublished data. Off. Nat. Res., East. Area Fld. Oper. Group, Norris, TN.

Tennessee Valley Authority. 1980d. Freshwater mussels of the Paint Rock River. TVA unpublished data. Off. Nat. Res., East. Area Fld. Oper. Group, Norris, TN.

Tennessee Valley Authority. 1981. Freshwater mussels of the Holston River. TVA unpublished data. Off. Nat. Res., East. Area Fld. Oper. Group, Norris, TN.

Tucker, J. M. 1972. A composition and distribution study of the Pelecypod fauna of the Stone's River in Tennessee. J. Tenn. Acad. of Sci. 47:69.

U.S. Department of the Interior. 1975. Endangered and threatened wildlife and plants. U.S. Fish and Wildlife Service. Fed. Reg. 40(188):44329-44333.

U.S. Department of the Interior. 1976. Endangered and threatened wildlife and plants. U.S. Fish and Wildlife Service. Fed. Reg. 41(115):24062-24067.

U.S. Department of the Interior. 1976. Proposed South Fork New River national wild and scenic river (North Carolina). U.S. Department of the Interior, Bur. of Outdoor Rec. March 1976. 541 pp.

University of Michigan, Museum of Zoology, Mollusk Division (Mussels records for Dromus dromas). Ann Arbor.

van der Schalie, H. 1939. Additional notes on the naiades (freshwater mussels) of the lower Tennessee River. Am. Midl. Nat., 22(2):452-457.

van der Schalie, H. 1973. The mollusks of the Duck River drainage in central Tennessee. Sterkiana, 52:45-55.

Vaughn, G. L. 1978. Effects of strip mining on fish and diatoms in streams of the New River drainage basin. IN: Environmental aspects of coal production in the Appalachian Region. Appalachian Res. Proj., Univ. of Tenn., Env. Center, Knoxville. 654 pp.

Warren, R. E. 1975. Prehistoric Unionacean (freshwater mussel) utilization at the Widow's Creek site (1Ja305), northeast Alabama. Unpublished master's thesis, Anthropology, Univ. of Neb., Lincoln.

Williams, J. C. 1969. Mussel fishery investigation Tennessee, Ohio, and Green Rivers final report. Kentucky Dept. of Fish and Wildlife Res. Proj. Number 4-19R. 107 pp.

Wilson, C. B. and H. W. Clark. 1912. The mussel fauna of the Kankahee Basin. Dept. of Comm. and Labor, Bur. Fish. Doc. No. 758. 52 pp.

Wilson, C. B. and H. W. Clark. 1914. The mussels of the Cumberland River and its tributaries. U.S. Bur. of Fish Doc. No. 781. 63 pp.

Wilson, C. B. and E. Danglade. 1914. The mussel fauna of central and northern Minnesota. Rep. U.S. Comm. Fish for 1913, Appendix V, pp. 1-29. Separately issued as Bur. Fish. Doc. No. 803.

Yokley, P., Jr. 1972. Freshwater mussel ecology, Kentucky Lake, Tennessee. Tennessee Game and Fish Comm. Proj. 4-46-R. 133 pp.

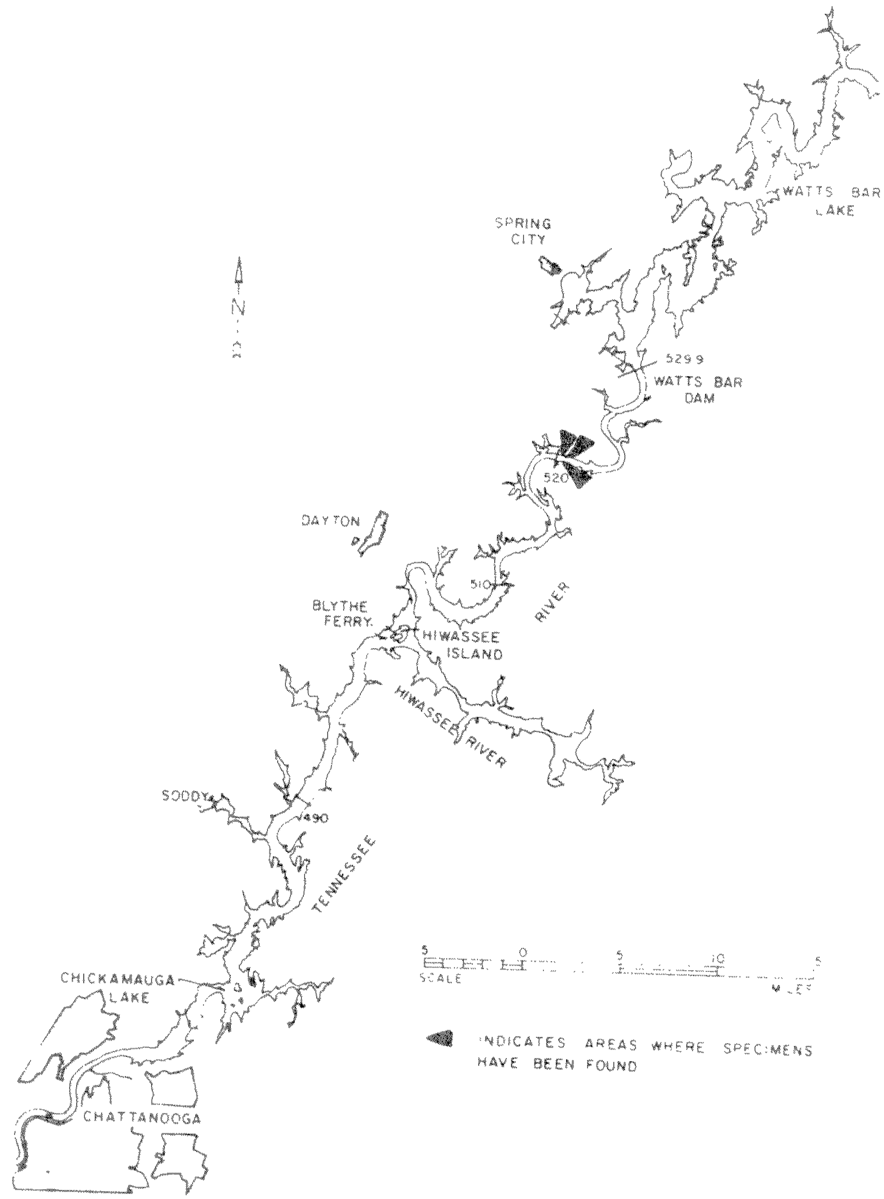

Figure 1 : Tennessee River — Recent Locations for DROMUS DROMAS, (Lea 1834)

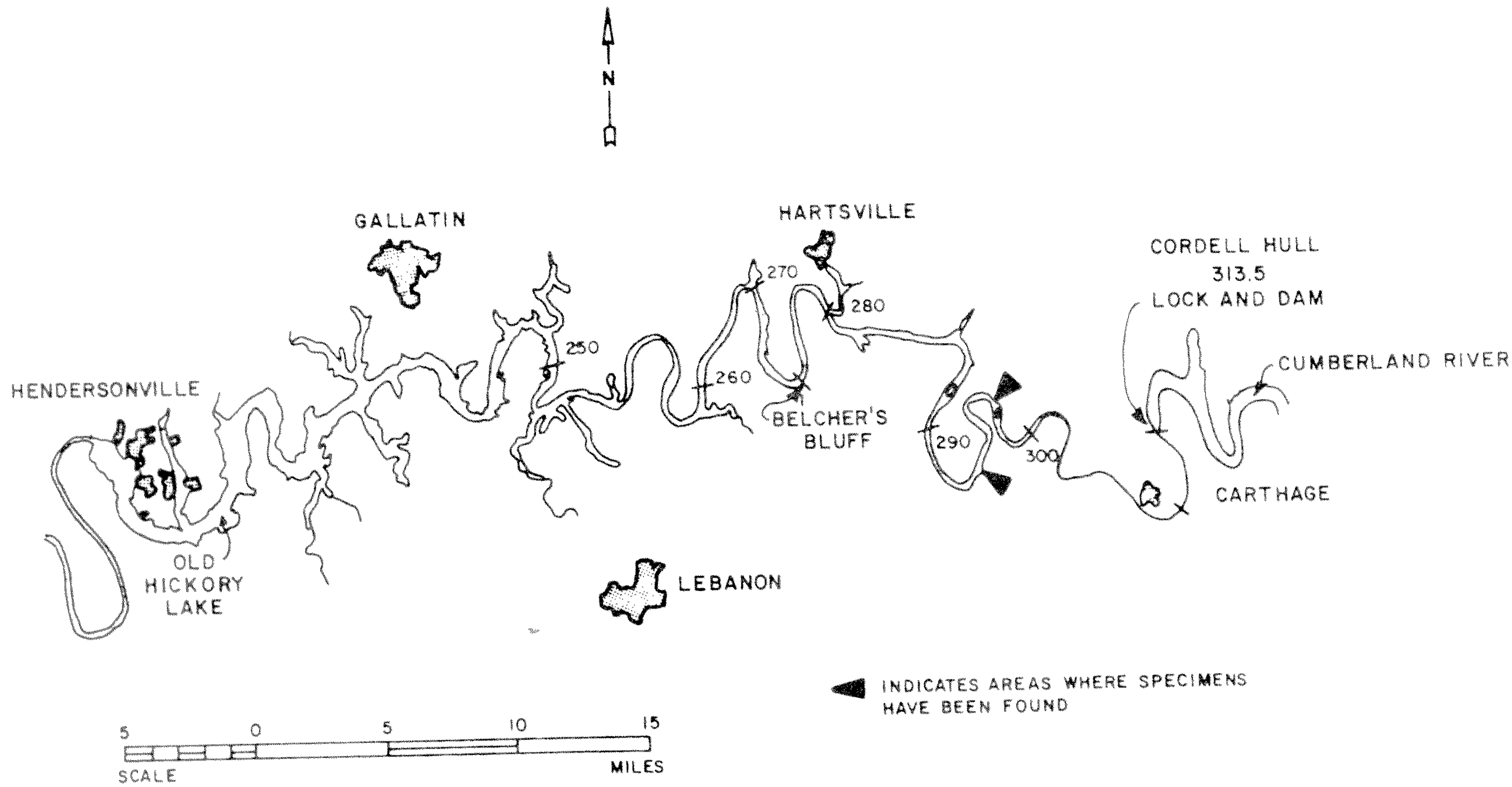

Figure 2 : Cumberland River – Recent Locations for <u>DROMUS DROMAS</u>, (Lea 1834)

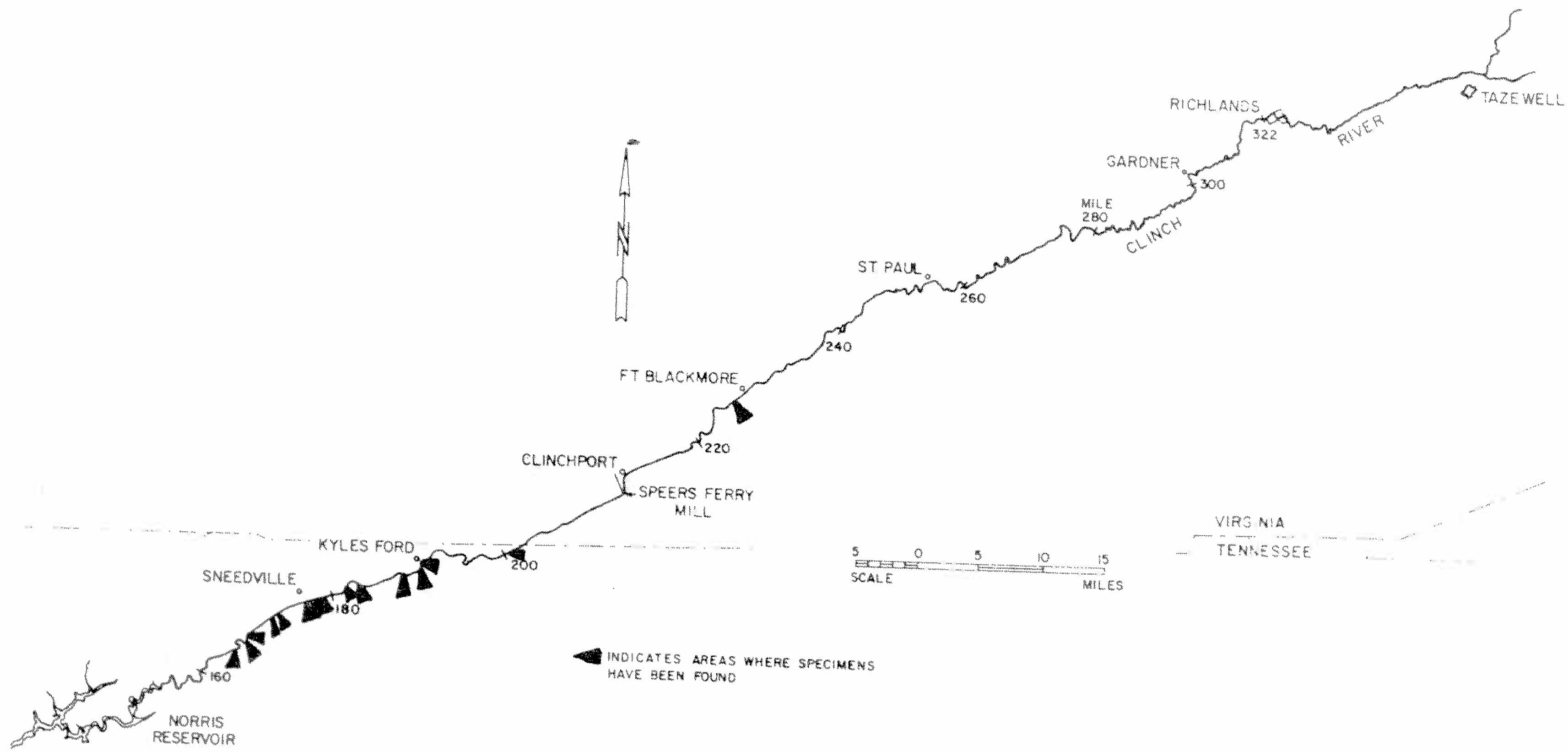

Figure 3 Clinch River – Recent Locations for Dromus Dromas f. Caperatus (Lea 1845)

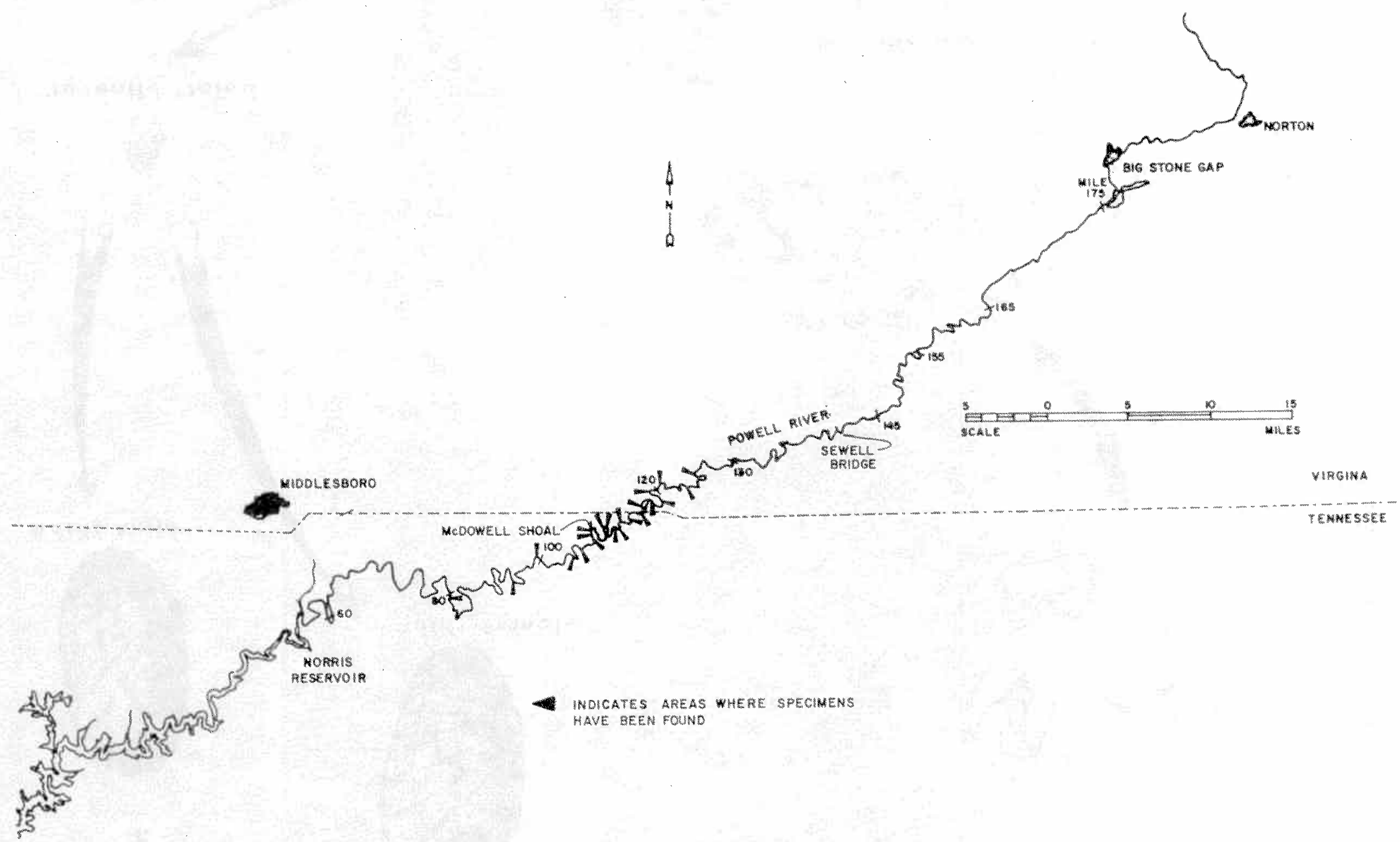

Figure 4 : Powell River — Recent Locations for DROMUS DROMAS f. Caperatus (Lea 1845)

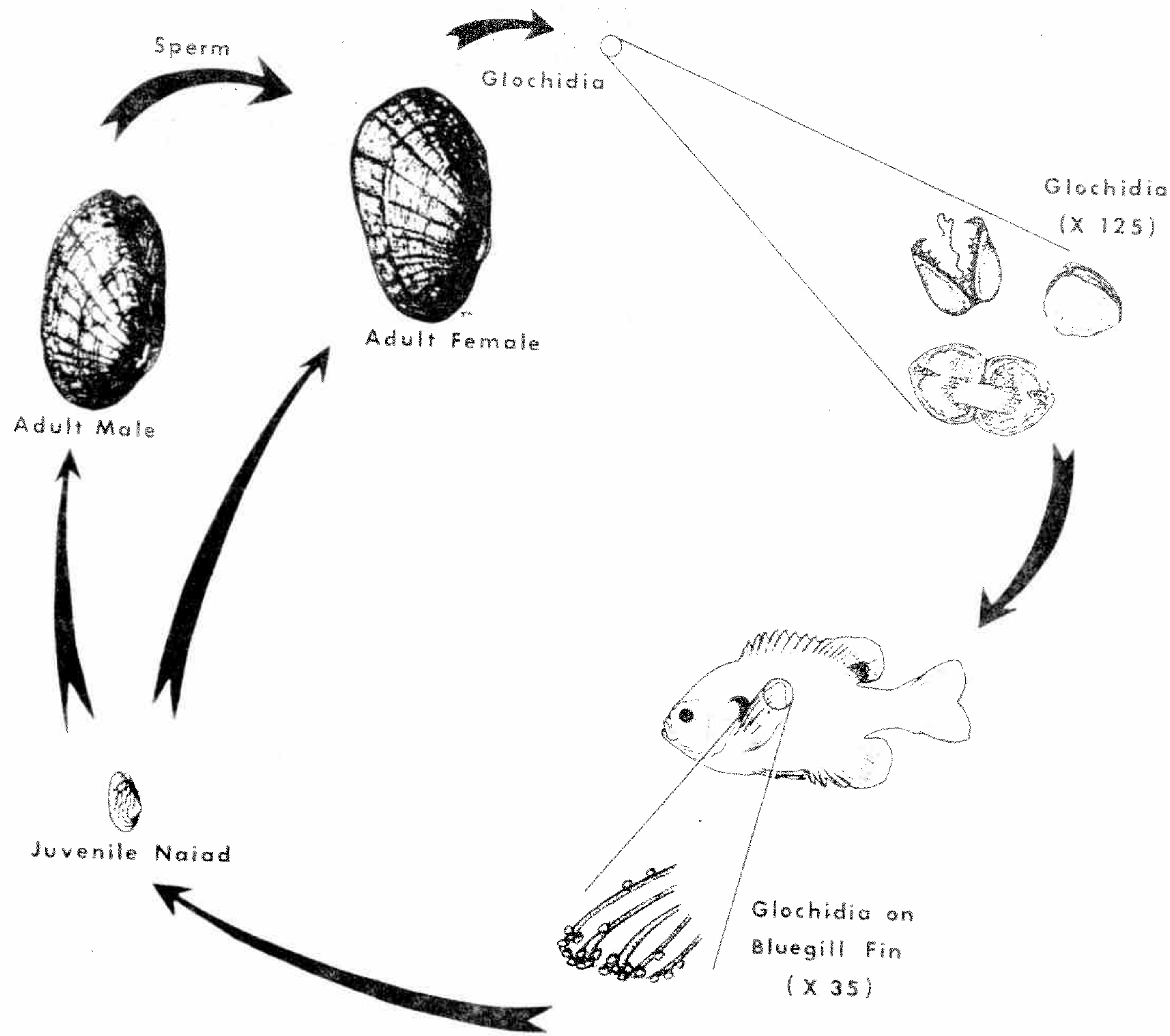

Figure **5.** Typical naiad life cycle depicting the various stages. The life cycle for most species of naiades is very similar to that depicted here (Grace and Buchanan 1981).


0 1
cm

Dromedary Pearly Mussel (Dromus dromas) Part III Implementation Schedule

*1 General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency *2 FWS Region	Responsible Agency *2 FWS Program	Responsible Agency *2 Other	Estimated Fiscal Year Costs *3 FY 1	FY 2	FY 3	Comments/Notes
01-04	Continue to utilize existing legislation and regulations to protect species and habitat.	1.1	1	Continuous	4&5	SE,ES,LE	Tennessee Valley Authority (TVA), TN Wildlife Resources Agency (TWRA), VA Comm. of Game and Inland Fisheries (VCGIF), Ky. Dept. of Fish & Wildlife Res. (KDFWR), Ky. Nature Preserves Comm. (KNPC) and TN Heritage Program (THP)	---	---	---	*1. See general categories for Implementation Schedules. *2. Other agencies' responsibility would be of a cooperative nature or projects funded under a contract or grant program. In some cases contracts could be let to universities or private enterprises
I1,I2	Determine species' present distribution and status.	1.2.1	3	2 yr.	4&5	SE	TWRA, THP, VCGIF, TVA KDFWR & KNPC.	---	---	---	
R3,R8, R9,R10 R11	Characterize habitat and determine essential elements.	1.2.2	2	2 yr.	4&5	SE	TWRA, VCGIF KDFWR, KNPC& TVA	---	---	---	*3. Note: Task costs have not been estimated for this plan. This species exists with other listed mussels in the same river systems. Thus, a task aimed at this species will benefit others. Rather than attempting to apportion the costs to each species, recovery tasks will be estimated at a later date when the plans are combined on a watershed basis for implementation.
R3,02, M3	Determine the extent of preferred habitat and present information in a manner which identifies areas in need of special attention.	1.2.3 & 1.2.4	2	1 yr.	4&5	SE	TWRA, THP, VCGIF, TVA, KDFWR & KNPC	---	---	---	
I12,I14	Determine present and foreseeable threats to species.	1.3.1 1.3.2 & 1.3.3	1	3 yr.	4&5	SE&ES	TWRA, VCGIF, TVA, THP, KDFWR & KNPC	---	---	---	
M3,M7	Determine measures needed to minimize threats and implement where needed to meet recovery.	1.3.4	2	Unknown	4&5	SE&ES	TWRA, VCGIF, TVA, THP, KDFWR, KNPC & TN, KY, and VA Nature Conservancy (TNC)	---	---	---	

Dromedary Pearly Mussel (Dromus dromas)

Part III Implementation Schedule

*1 General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency *2 FWS Region	FWS Program	Other	Estimated Fiscal Year Costs *3 FY 1	FY 2	FY 3	Comments/Notes
01,04	Solicit help in protecting species and essential habitat.	1.4.1 1.4.2 1.4.3 & 1.4.4	2	Continuous	4&5	SE&ES	TWRA, VCGIF, TVA, THP, KDFWR, KNPC & TNC	---	---	---	
01	Develop and utilize information and education program (slide/tape shows, brochures, etc.) for local distribution.	1.4.5	2	1 yr. for devel. continued implementation	4&5	SE&ES	TWRA, VCGIF, TVA, THP, KDFWR, KNPC & TNC	---	---	---	
M7, A1-A7, 03, 04	Investigate the use of Scenic River Status, mussel sanctuaries, land acquisitions, and/or other means to protect the habitat.	1.5	2	Unknown	4&5	SE&ES	TWRA, VCGIF, KDFWR, KNPC, TVA, THP & TNC	---	---	---	
I13	Survey rivers within species' historic range to determine availability of suitable transplant sites.	2.1 & 2.2	3	1 yr.	4&5	SE	TWRA, VCGIF, KDFWR, KNPC, TVA & THP	---	---	---	
R13, R7	Determine best method of establishing new populations.	2.3	3	2 yr.	4&5	SE	TWRA, VCGIF, KDFWR, KNPC, TVA & THP	---	---	---	Task 2.1 - 2.3 may not be required if other populations are found in task 1.2.1.

Dromedary Pearly Mussel (Dromus dromas)

Part III Implementation Schedule

General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency: FWS Region	Responsible Agency: FWS Program	Responsible Agency: Other	Estimated Fiscal Year Costs: FY 1	Estimated Fiscal Year Costs: FY 2	Estimated Fiscal Year Costs: FY 3	Comments/Notes
M2	Reestablish populations within historic range as needed to meet recovery.	2.4	3	Unknown	4&5	SE	TWRA, THP VCGIF, KDFWR, KNPC, & TVA	---	---	---	
I12, I14 M3, M7	Implement same protective measures for these reestablished populations as for known populations.	2.5	3	Continuous	4&5	SE, ES	TWRA, VCGIF TVA, KDFWR, KNPC, THP & TNC	---	---	---	
R3,6,8,9, 10,11 & 14	Conduct life history studies on a need-to-know basis.	3	1	Unknown	4&5	SE	TWRA, VCGIF, TVA, THP, KDFWR, KNPC				
R8-R11	Determine the number of individuals required to maintain a viable population.	4	3	Unknown	4&5	SE	TWRA, THP VCGIF, KDFWR, KNPC, & TVA	---	---	---	These studies will be developed and carried out where there is a specific need for data necessary to reach recovery.
M3	Investigate the need for habitat improvement and implementation only where needed to meet recovery objective.	5	3	Unknown	4&5	SE	TWRA, THP VCGIF, KDFWR, KNPC & TVA	---	---	---	
I1, I2	Develop and implement a monitoring program.	6	2	Unknown	4&5	SE	TWRA, THP VCGIF, KDFWR, KNPC & TVA	---	---	---	
O4	Annual assessment of recovery program and modify where needed.	7	2	Continuous	4&5	SE	TWRA, VCGIF TVA, THP, KDFWR, KNPC & TNC	---	---	---	

KEY TO IMPLEMENTATION SCHEDULE COLUMNS 1 & 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. Depredation control
6. Disease control
7. Other management

Priority (Column 4):

1 - Those actions absolutely necessary to prevent extinction of the species.

2 - Those actions necessary to maintain the species' current population status.

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

APPENDIX

List of Reviewers

Mr. Steven A. Ahlstedt
Field Operations
Division of Water Resources
Forestry Building
Norris, Tennessee 37828

Mr. Herbert D. Athearn
Route 5, Box 376
Cleveland, Tennessee 37311

Mr. John M. Bates
Ecological Consultants, Inc.
1900 Dexter Avenue
Ann Arbor, Michigan 48103

Dr. Arthur E. Bogan
Department of Malacology
Academy of Natural Sciences
Nineteenth and the Parkway
Philadelphia, Pennsylvania 19103

Mr. Alan C. Buchanan
Missouri Department of Conservation
Fish and Wildlife Research Center
1110 College Avenue
Columbia, Missouri 65201

Dr. Arthur H. Clarke
7 Hawthorne Street
Mattapoisett, Massachusetts 02739

Mr. George M. Davis
Academy of Natural Sciences
19th and the Parkway
Philadelphia, Pennsylvania 19103

Ms. Sally D. Dennis
Center of Environmental Studies
Virginia Polytechnic Institute
and State University
Blacksburg, Virginia 24061

Mr. Samuel L.H. Fuller
Department of Limnology
Academy of Natural Sciences
19th. and the Parkway
Philadelphia, Pennsylvania 19103

Mr. Joseph Bruna, Director
Division of Game Management
Department of Fish and Wildlife Resources
592 East Main Street
Frankfort, Kentucky 40601

Mr. Richard Hannan, Coordinator
Kentucky Nature Preserves Commission
407 Broadway
Frankfort, Kentucky 40601

Mr. Charles Gooch
Field Operations
Tennessee Valley Authority
A 251 401 Building
Chattanooga, Tennessee 37401

Dr. William H. Heard
Department of Biology
Florida State University
Tallahassee, Florida 32306

Dr. John C. Hurd
Science Department
La Grange College
La Grange, Georgia 30240

Dr. Marc J. Imlay
Columbia National Fisheries
Research Laboratory
U.S. Fish and Wildlife Service
Route 1,
Columbia, Missouri 65201

Mr. Billy G. Isom
Fisheries and Aquatic Ecology Branch
Division of Water Resources
Tennessee Valley Authority
E & D Building
Muscle Shoals, Alabama 35660

Dr. Eugene P. Keferl
Division of Natural Science
Brunswick Junior College
Brunswick, Georgia 34520

Dr. Paul W. Parmalee
Department of Anthropology
The University of Tennessee
Knoxville, Tennessee 37916

Dr. Hugh J. Porter
Institute of Marine Sciences
University of North Carolina
P.O. Drawer 809
Morehead City, North Carolina 28557

Dr. James B. Sickel
Department of Biology
Murray State University
Murray, Kentucky 40271

Dr. David H. Stansbery
Museum of Zoology
Ohio State University
1813 North High Street
Columbus, Ohio 43210

Dr. Carol B. Stein
Museum of Zoology
Ohio State University
1813 North High Street
Columbus, Ohio 43210

Dr. Edward M. Stern
Department of Biology
University of Wisconsin
at Stevens Point
Stevens Point, Wisconsin 54481

Dr. Fred G. Thompson
Florida State Museum
Museum Road
University of Florida
Gainesville, Florida 32611

Dr. Henry Van der Schalie
15000 Buss Road
Manchester, Michigan 48158

Dr. John D. Williams
Department of Biology
Eastern Kentucky State University
Richmond, Kentucky 23219

Dr. Paul Yokley, Jr.
Department of Biology
University of North Alabama
Florence, Alabama 35630

Virginia Wildlife Federation
Box 1780
Norfolk, Virginia 23501

Dr. R. Don Estes, Leader
Tennessee Cooperative
Fishery Research Unit
Tennessee Technological University
Box 5063
Cookeville, Tennessee 38501

Mr. John Hardcastle
Chapter Chairman
The Nature Conservancy
Capitol Hill Building 114
301 7th Avenue, North
Nashville, Tennessee 37219

Mr. Bob Hatcher, Nongame Biologist
Tennessee Wildlife Resources Agency
Ellington Agricultural Center
P.O. Box 40747
Nashville, Tennessee 37204

Mr. D.W. Yambert
Nongame Biologist
Tennessee Wildlife Resources Agency
Route 3, Box 153-A
Talbott, Tennessee 37877

Mr. Dan Eagars, Zoologist
Tennessee Heritage Program
2611 West End Avenue
Nashville, Tennessee 37203

Dr. Thomas H. Ripley, Manager
Office of Natural Resources
Tennessee Valley Authority
Locust Street Building
Knoxville, Tennessee 37902

Mr. Richard Fitz
Tennessee Valley Authority
Locust Street Building
Knoxville, Tennessee 37902

Mr. John Jenkinson
Tennessee Valley Authority
Evans Building
Knoxville, Tennessee 37902

Mr. Jack M. Hoffman, Chief
Fish Division
Commission of Game and Inland Fisheries
4010 West Broad Street
Box 11104
Richmond, Virginia 23230

Mr. Robert V. Davis, Executive Director
State Water Control Board
P.O. Box 11143
Richmond, Virginia 23230

Dr. Richard Neves
Virginia Cooperative Fishery Unit
106 Cheatham Hall
Virginia Polytechnic Institute
Blacksburg, Virginia 24061

Dr. and Mr. Wayne Starnes
Tennessee Valley Authority
450 Evans Building
Knoxville, Tennessee 37902

Howard Larsen, Regional Director
U.S. Fish and Wildlife Service
One Gateway Center
Newton Corner, Massachusetts 02138

U.S. Fish and Wildlife Service
Ecological Services Field Station
P.O. Box 845
Cookeville, Tennessee 38501

Mr. Anthony J. Campbell
Executive Director
Tennessee Conservation League
1720 West End Avenue
Suite 600
Nashville, Tennessee 37203

Mr. Gary Myers, Executive Director
Tennessee Wildlife Resources Agency
Ellington Agricultural Center
P.O. Box 40747
Nashville, Tennessee 37204

Dr. Mohamed T. El-Ashry, Director
Environmental Quality Staff
Tennessee Valley Authority
Knoxville, Tennessee 37902

Mr. Brian Shult, State Director
The Nature Conservancy
619 East High Street
Charlottesville, Virginia 22901

Mr. Sam Pearsall, Program Coordinator
Tennessee Department of Conservation
Tennessee Heritage Program
701 Broadway
Nashville, Tennessee 37203

Mr. Chuck Cook
The Nature Conservancy
P.O. Box 3017
Nashville, Tennessee 37219

Mr. Ralph Jordan, Jr.
Tennessee Valley Authority
Office of Natural Resources
Forestry Building
Norris, Tennessee 37828