Recovery Plan

Cumberland Bean Pearly Mussel (*Villosa trabalis*)

Recovery Plan for the Cumberland Bean Pearly Mussel

Villosa trabalis (Conrad, 1834)

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for

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THE RECOVERY PLANS 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.

Literature citations should read as follows:

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PART I

INTRODUCTION

The headwater tributary streams of the upper Tennessee and Cumberland River basins contain freshwater mussel species that are endemic to the southern Appalachian Mountains and the Cumberland Plateau region. Ortmann referred to these species as "Cumberlandian" and this region became known as one of the chief centers of freshwater mussel speciation. Ortmann (1924) defined the Cumberland Region to include: the drainages of the Tennessee River system from the headwaters to the vicinity of Muscle Shoals, in Colbert and Lauderdale Counties, Alabama; and the Cumberland River system from the headwaters to the vicinity of Clarksville, Montgomery County, Tennessee (Ortmann, 1925). Thirty-seven of the 90 species of unionids found in the Tennessee River are Cumberlandian, as are 27 of the 78 found in the Cumberland River. These two assemblages are the largest number of unionid species found in any of the world's rivers (Johnson, 1980). Of the 23 American freshwater mussels listed as endangered by the U.S. Department of the Interior, 13 are members of the Cumberlandian faunal group. The Cumberland bean pearly mussel (*Villosa trabalis*) 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).

Villosa trabalis was described by Conrad in 1834 and its type locality is Kentucky, streams of Tennessee, and the Clinch River, Virginia (Bogan and Parmalee, 1983). All records indicate this species is restricted to the tributary streams of the Tennessee and Cumberland Rivers and was reported by Ortmann (1918) as extremely rare.

DISTRIBUTION

Historical

The Tennessee and Cumberland River systems are among the world's most ancient. The Tennessee, containing at least 86 species of Unionacea, has the largest assemblage of unionid species found anywhere, followed by the Cumberland River, which has a unionid fauna of at least 78 species (Johnson, 1978).

Ortmann's 1918 monograph on the naiads in the upper Tennessee River system is the most significant work on that regions's freshwater mussel fauna prior to construction of impoundments and environmental perturbations on many of these streams. Publications by Wilson and Clark (1912, 1914), Shoup et al. (1941), 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.

Villosa trabalis is a Cumberlandian species restricted to the lower and upper tributary streams of the Tennessee River and the upper tributary streams of the Cumberland system. This species is most abundant in the Cumberland system (Wilson and Clark, 1914; Neel and Allen, 1964) and is extremely rare in the Tennessee River drainage (Ortmann 1918, 1925). Historical records for *V. trabalis* prior to 1970 are summarized in table 1.

Present

Villosa trabalis is presently known only from the tributary streams of the upper Cumberland River in Kentucky and Tennessee (Figure 1, Appendix I-Table 1). The greatest concentrations of *V. trabalis* were reported from the Little South Fork Cumberland River in 1982 by Starnes and Bogan (1982), in 1980 by Clarke (1981), and in 1979 by Bogan and Parmalee (1983).

Table 1. Historical records for *Villosa trabalis* prior to 1970.

River	Source
Tennessee River	Hinkley (1906) Ortmann (1918, 1925) Morrison (1942)
South Chicamauga Creek	Ortmann (1918, 1924)
Paint Rock River	Ortmann (1918, 1924)
Flint River	Ortmann (1925)
Hiwassee River	Ortmann (1918, 1924, 1925)
Clinch River	Ortmann (1918) Stansbery (1973)
Cumberland River	Ortmann (1912) Wilson and Clark (1914) Neel and Allen (1964) Stansbery (1969, 1970)
Buck Creek	Blankenship-Specimens collected in 1968-Eastern Kentucky University Record Athearn-specimens collected in 1959-Kentucky Nature Preserves Commission
Obey River	Ortmann (1914) Wilson and Clark (1914) Shoup et al. (1941) Neel and Allen (1964)
Rockcastle River	Williamson (1905) Neel and Allen (1964) Stansbery (1970)
Laurel Fork of Rockcastle River	Neel and Allen (1964) Stansbery (1969)
Beaver Creek	Neel and Allen (1964)

Numerous unpublished field records were obtained through Eastern Kentucky University (EKU) at Richmond, Kentucky Nature Preserves Commission (KNPC), Kentucky Department of Transportation (KDOT), and the Kentucky Department of Fish and Wildlife Resources (KDFWR) at Frankfort. This information reports both live and freshly dead specimens of V. trabalis occurring throughout a 35-mile reach of the Little South Fork and at one location in Kennedy Creek (tributary to the Little South Fork). Based on this information, the freshwater mussel fauna in the Little South Fork including populations of V. trabalis remain in relatively good condition. Starnes and Starnes (1980) reports the Little South Fork as perhaps the most pristine stream remaining in the Cumberland and Tennessee drainages and, Clarke (1981) reports the Little South Fork as "still in remarkably good condition."

Villosa trabalis has also been reported from Buck Creek by Harker et al. (1980) and Clarke (1981). Field records obtained through EKU, KNPC, KDOT, and KDFWR report numerous live and freshly-dead specimens of V. trabalis occurring throughout Buck Creek. Based on this information, populations of V. trabalis in Buck Creek remain in relatively good condition, and Clarke (1981), reports good water quality in Buck Creek.

Lesser known populations of Villosa trabalis were reported from the Rockcastle River (Blankenship and Crockett, 1972) and tributary streams which includes the Middle Fork Rockcastle River, Horselick, and Roundstone Creeks (Harker et al. 1980; Clarke, 1981). Field records obtained through EKU, KNPC, KDOT, and KDFWR report both live and freshly-dead specimens of V. trabalis occurring in small numbers in the upper portions of the Rockcastle River. Both live and freshly-dead specimens of V. trabalis were also reported from one location each in the Middle Fork Rockcastle River, Horselick, and Roundstone Creeks.

One live specimen of V. trabalis has recently been collected from the Big South Fork Cumberland River at Station Camp Creek, Scott County, Tennessee in June 1980 (Hatcher and Ahlstedt, 1982). This specimen was collected by two Tennessee Wildlife Resource Agency biologists (Jerry Webb and Bill Upchurch) and verified by the author. This represents the first known record of V. trabalis in the Tennessee portion of the Big South Fork. Harker et al. (1980) reports finding only relict shells of V. trabalis from one location in the Big South Fork at the mouth of Troublesome Creek in Kentucky.

Freshwater mussel surveys by numerous individuals have failed to find live Villosa trabalis in any streams other than the upper Cumberland River system. However, one freshly-dead specimen of V. trabalis was collected in the lower Little Tennessee River by TVA biologists in 1975. This section of the Little Tennessee River was impounded (Tellico Reservoir) in 1979. Freshwater mussel surveys conducted on the Tennessee River by Ellis (1931), van der Schalie (1939), Scruggs (1960), Bates (1962, 1975), Stansbery (1964), Williams (1969), Yokley (1972), Isom (1969, 1971a, 1972), TVA (1979e), and Pardue (1981) report no evidence of Villosa trabalis in the Tennessee River. No recent collections of living Villosa trabalis are known from the Cumberland River. Surveys conducted in the Cumberland by TVA (1976), Parmalee et al. (1980), and Sickel (1982) report no V. trabalis.

Numerous freshwater mussel surveys of the tributary streams to the Tennessee River have failed to find V. trabalis living in the Holston River (TVA, 1981); the North, South, and Middle Forks 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, 1980d; Mullican et al. 1960); French Broad

River (TVA, 1979d); Clinch River (Neves et al. 1980; TVA 1979a; Bates and Dennis, 1978); Powell River (Ahlstedt and Brown, 1980; Dennis 1981; Neves et al. 1980; TVA, 1979c); Duck River (TVA 1972, 1979b; Ahlstedt, 1981b; Isom and Yokley, 1968; van der Schalie, 1973; Ortmann 1924); Buffalo River (TVA, 1980b; van der Schalie, 1973); Elk River (Ahlstedt, 1983; Isom et al. 1973a); Flint River (Isom et al. 1973b); Paint Rock River (TVA, 1980e; Isom et al. 1973b); and numerous additional streams in the lower Tennessee River system as reported by Ortmann (1925).

The only known recent record for Villosa trabalis outside the Cumberland River system since 1970 is one freshly-dead specimen collected by TVA biologists in 1975 from the lower Little Tennessee River. That portion of the Little Tennessee River was lost due to the completion of Tellico Dam in 1979. Thus, it can be assumed that the tributary streams to the upper Cumberland River contain the only known population of V. trabalis. However, many of these tributary streams in the Cumberland system could contain additional populations of V. trabalis. Freshwater mussel surveys are recommended for the Big South Fork Cumberland, Rockcastle, Middle Fork Rockcastle, upper Laurel River above Laurel Reservoir, Obey, Obed, and Clear Fork Rivers, and Horselick, Pittman, Kennedy, Otter, and Roundstone Creeks. Further, intensive freshwater mussel surveys are recommended for tributary streams to the Tennessee River. Those streams include the upper Little Tennessee (above Tellico Reservoir), Hiwassee, French Broad, and Emory Rivers.

ECOLOGY AND LIFE HISTORY

Cumberlandian freshwater mussels are most often observed in clean, fast-flowing water in substrate which contain relatively firm rubble, gravel, and sand swept-free from siltation. These mussels are usually found buried in shallow riffle and shoal areas. Clarke, (1981) reports V. trabalis is typically found in sand or gravel substrates in medium-sized (5-20 m width) streams of moderate gradient where it lives close to riffles and frequently occurs in the transition zone between gravel and sand substrates. Since freshwater mussels are quite long lived--up to 50 years or more for some species--and sedentary, they are especially vulnerable to stream perturbations. Of particular concern are the Cumberlandian species which appear to have suffered severe population declines. Of the Cumberlandian species recorded from the Tennessee River (Ortmann, 1925) in 1924 before the impoundment of Wilson Reservoir, all but six were apparently eliminated. TVA's recent mollusk investigations on the Tennessee River in 1978 produced only three Cumberlandian species (TVA, 1979e; Pardue, 1981).

Villosa trabalis (see photo) is a small to medium-sized Cumberlandian species with solid, elongate, inflated, oval valves. The beaks are relatively high with the surface of the shell unsculptured except for concentric growth rests, and beak sculpturing consisting of course, double-looped ridges. The interior portion of the shell is rounded and the ventral margin is somewhat rounded to almost straight, converging with the posterior-dorsal surface in a rounded point. The posterior ridge is somewhat full and rounded with the surface marked by irregular growth lines. The periostracum is somewhat glossy, olive-green, yellowish-brown, or blackish, covered with many narrow, wavy, dark-green or blackish rays which are numerous towards the posterior margin. Hinge teeth are relatively heavy, the left valve having two, solid, triangular pseudocardinal teeth which are erect, pyramidal, and serrated. Interdentum is of moderate thickness with two, long, straight lateral teeth. Right valve has three pseudocardinal teeth with the large central tooth being sculptured and triangular while the anterior and posterior teeth are reduced. The lateral tooth is long with a slight vestige of a second tooth below. Beak cavity is shallow with anterior muscle scars impressed. Nacre color is white except irridescent, bluish-green posteriorly (Simpson, 1914; Bogan and Parmalee, 1983; Clarke, 1981).

The life history for Villosa trabalis is probably similar to that of most unionids and is briefly illustrated in figure 2. Males produce sperm which are discharged into the surrounding water and dispersed by water currents. Females downstream from the males obtain 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 for V. trabalis is formed by the posterior half of the outer gill, with an unsually long nonmarsuptial section at the posterior end. The edge of the marsupium is broad and intensely black with ovisacs being eight to twenty-four in number.

The family Unionidae are 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. Villosa trabalis is reported to be a bradytictic species (Bogan and Parmalee, 1983).

The glochidia of V. trabalis are rather large, subovate (Ortmann, 1912) and hookless. Hookless glochidia typically have a more spoon-shaped, delicate shell and are most frequently parasitic on gill filaments of fish (Coker and Surber, 1911; Lefevre and Curtis, 1910). The fish host(s) for V. trabalis are unknown but fish host studies for two closely related members of the genus Villosa (Villosa vanuxemi and Villosa nebulosa) by Zale and Neves (1982) indicate some degree of host specificity. The banded sculpin (Cottus carolinae was found to be the fish host for V. vanuxemi, and the smallmouth bass and rock bass (Micropterus dolomieui and Ambloplites rupestris) were hosts for V. nebulosa.

REASONS FOR DECLINE AND CONTINUED THREATS

Historically, Villosa trabalis was never widespread in the Tennessee River system. Ortmann (1918, 1925) reported this species to be extremely rare in the Tennessee River drainage. Wilson and Clark (1914) reported this species to have its center of distribution in the Cumberland system where later, Neel and Allen (1964) reported it as common.

Villosa trabalis has become increasingly rare throughout its range. The reasons for this decline are not totally understood, but impoundments, siltation, and pollution are speculated by various authors to be the major causes. Clarke (1981) reports the decline of V. trabalis as clearly attributable to the effects caused by stream impoundment and pollution in the form of acid mine wastes. Sam Call (personal communication) reports that *V. trabalis* populations in the Rockcastle River system are in jeopardy of being lost due to water pollution, and *V. trabalis* population(s) in the Big South Fork Cumberland River are heavily affected by silt and coal mine wastes which enter into the Big South Fork from the New River (an upper Cumberland River tributary stream in Tennessee) where extensive coal mining is in progress throughout the watershed.

Impoundment

Possibly the single greatest factor which 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 Army Corps of Engineers have constructed numerous dams on the Tennessee and Cumberland River systems. A total of 51 dams are integrated into the TVA water control system. TVA has 36 dams in the Tennessee River basin of which nine 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, altered temperatures, and anoxic conditions. Tributary dams typically have hypolimnial discharges that cause the stream below the dam (reservoir tailwater) to differ significantly from both preimpoundment conditions and from upstream river reaches.

Hypolimnial discharges 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 environmental changes typically include reductions in the 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 45 mussel species and 9 river snail species in the dewatered riverbed following closure of Norris Dam. In a return visit to the area four months later, he could not find a single live mussel. Isom et al. (1973a) collected 34 species of freshwater mussels in the Elk River directly below the construction site at Tim's Ford Dam prior to the completion of the dam. Ahlstedt (1983) while sampling in 1980 reported no living mussels for almost 8 miles below Tim's Ford Dam after its completion in 1970.

Siltation

Siltation is another factor which has severly affected freshwater mussels, especially Cumberlandian species. In rivers and streams, the greatest diversity and abundance of mussels is usually associated with gravel and/or sand substrates. These substrates 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 which 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 long-lived and sedentary by nature, many species have been unable to survive in a layer of silt greater than 0.6 centimeters (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. Mussel life-cycles can be affected indirectly from siltation by impacting host-fish populations by smothering fish eggs or larvae, reducing food availability, or filling of interstitial spaces in gravel and rubble substrate, thus eliminating spawning beds and habitat critical to the survival of young fishes (Loar et al. 1980).

Coal production in the Appalachian region, which includes the 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 future of 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 run off 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. Lynn Starnes (personal communication) states that impacts caused from coal surface mining have had disastrous effects on both fish and molluscan populations in the upper Cumberland and Tennessee Rivers. She reports seeing bedrock completely covered with coal fines. Vaughan (1978) reported that so much land has been disturbed by mining in the New River watershed (a Cumberland River tributary 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 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 point 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 the upper Cumberland River and southwest Virginia can be expected to grow in the future as coal production increases.

Pollution

A third factor which must be considered is the impact caused by various forms of pollutants. An increasing number of streams throughout the United States receive municipal, agricultural, and industrial waste discharges. The damage suffered varies according to a complex of interrelated factors, which include the characteristics of the receiving stream and the nature, magnitude, and frequency of the stresses being applied. The degradation can be so severe and of such duration that the streams are no longer considered valuable in terms of their biological resources (Hill et al. 1974). These areas will not recover if there are residual effects from the pollutants or if there is an inadequate pool of organisms for recruitment or recolonization (Cairns et al. 1971).

The absence of freshwater mussels can 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, some data are available concerning the adverse impacts of some pollutants on freshwater mussels along with other components of the ecosystem. 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. Clarke (1981) reports that the decline of *V. trabalis* in the upper Cumberland system is clearly attributable to pollution from acid mine wastes, and Starnes and Starnes (1980) reports that increases in coal surface mining in the upper Cumberland and Tennessee drainages has increased siltation and decreased water quality to the point that the mollusk population is declining and could soon disappear. 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 in 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 Saltsville, 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 it mouth (wood pulp and paper mill); and the Tellico River below Tellico Plains, Tennessee (wood pulp and extracting mill).

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 which 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 completly eliminated for a distance of approximately 3 or 4 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 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. Following the fish kills, fish populations sampled by Raleigh et al. (1978) on the Clinch River near St. Paul, Virginia, 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) all report an almost total elimination of the freshwater mussel fauna from Carbo, Virginia (CRM 264.2) to just above St. Paul (CRM 255). 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 dischages 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 USFWS and TVA biologists. *Villosa trabalis* was historically known to occur in the upper Clinch River as reported by Ortmann (1918) and Stansbery (1973). However, this species has not been seen in the Clinch River since the mid-1960s Stansbery (1973).

PART II

RECOVERY

A. Recovery Objectives

The ultimate objective of this recovery plan is to maintain and restore viable populations* of Villosa trabalis 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 V. trabalis populations and (2) by establishing populations in rivers and river corridors which historically contained V. trabalis. 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 Villosa trabalis exists in Buck Creek, Rockcastle, and the Little South Fork Cumberland Rivers. These three populations are dispersed throughout each river so that it is unlikely that one event would cause the total loss of either population.
2. Through reestablishment and/or discoveries of new populations, viable populations exist in two additional rivers (to include at least one in the Tennessee River system). Each of these rivers will contain a viable population that is distributed such

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*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.

that a single event would be unlikely to eliminate Villosa trabalis 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 occurrred in the upper Cumberland and Tennessee drainages and no foreseeable increase in coal-related siltation exists in streams containing V. trabalis.

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 V. trabalis with emphasis on Buck Creek, Rockcastle, and the Little South Fork 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 which identifies essential habitat and specific areas in need of protection.

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

1.3.1 Determine impacts of coal industry related pollution on the 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 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 educational program using such items as slide/tape shows, brochures, etc. 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 introducing 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 transplants.

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

2.4 Introduce the species within its 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 1.2.2 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 V. trabalis with emphasis on Buck Creek, Rockcastle, and the Little South Fork Cumberland Rivers. The greatest known concentrations of V. trabalis occur in Buck Creek and the Little South Fork Cumberland Rivers with lesser known populations in the Rockcastle River system and the Big South Fork Cumberland River. The protection of these populations and their habitats including transplanted individuals are essential for the continued survival of the species and will be required to meet the recovery objectives.

   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 encouraging States to enforce existing laws and regulations.

1.2 Conduct population and habitat surveys. Most needed surveys in the Tennessee River system have already been completed by TVA as part of the Cumberlandian Mollusk Conservation Program (Jenkinson, 1981) and other TVA projects since 1970. No *V. trabalis* were found during these surveys. However, additional freshwater mussel surveys are recommended in the Tennessee system for the upper Little Tennessee, Sequatchie, Hiwassee, French Broad, and Emory Rivers in Tennessee. Further, the tributary streams to the upper Cumberland River which includes the Big South Fork Cumberland, Rockcastle, Middle Fork Rock-castle, upper Laurel River, Obed, and Obey Rivers, and Wolf, Clear Fork, Horse Lick, Pittman, Kennedy, Otter, and Roundstone Creeks are highly recommended for additional 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, ecological associations, and essential elements (biotic and abiotic factors) for all life history stages. Some of the work necessary for the characterization of habitat has been accomplished for another endangered species as part of TVA's Cumberlandian Mollusk Conservation Program. The final report on this is expected in 1984. However, intensive studies are necessary to have intimate knowledge of V. trabalis 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 which identifies essential habitat and specific areas in need of protection.

1.3 Determine present and foreseeable threats to the species and its host fish and strive to minimize and/or eliminate them. Many factors presently adversely affect the species, host fish, and its habitat. Additional 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, deep mining, and orphan mines) is 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 if they are found to be populated by or are restocked with the species. 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 are suggested.

1.3.2 Investigate and inventory factors negatively impacting the species and its environment. Other factors such as road construction, dredging, herbicide and pesticide spraying, and chlorinated effluents may also 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 further adding to the decline of *V. trabalis*.

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 survival and recovery of the species. Before delisting could be accomplished, anticipated negative impacts on the species must be addressed.

1.3.4 Determine measures that are needed to minimize and/or eliminate adverse impacts and implement where necessary. 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 Solicit help in protecting the species and its essential habitat. 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 which might prove harmful to the species and its habitat. These impacts typically include strip mining, oil and gas drilling, industrial development, road and bridge construction, installation of sewage treatment plants and their operation, and the use of herbicides along roads and power line corridors as well as pesticides and fertilizers for farm crops. Studies of this nature have already been completed for the Clinch and Powell watersheds (tributaries to the upper Tennessee River) by the USFWS.

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. The support of local government officials and planners will be essential if the river habitat is going to receive sufficient protection to reach recovery.

1.4.2 Work with local, State, and Federal agencies to encourage them to utilize their authoriites to protect the species and its river habitat. Local, State, and Federal agencies (Soil Conservation Service, 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, brochures, etc. Present this material to business groups, civic groups, youth groups, church organizations, etc.</u> The Cumberland River system contained (at least historically) an extremely rich freshwater mussel fauna. Buck Creek and the Little South Fork Cumberland River both still maintain good populations of freshwater mussels. However, a brief informative program or pamphlet is needed to point out the basic problems, uniqueness of these 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 Buck Creek and the Little South Fork Cumberland River appear eligible for Scenic River status under the National Wild and Scenic Rivers Act (USDOI, 1976). Such a designation would provide some 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 Big South Fork Cumberland is presently under consideration for Wild and Scenic River status, which would offer some protection to the Big South Fork watershed, and The Nature Conservacy is pursuing land acquisition at one location in the upper Clinch River. Both of these methods are designed to protect sensitive areas.

2. Determine the feasibility of introducing the species back into rivers within its historic range and introduce where feasible. The protection and preservation of Buck Creek, Little South Fork Cumberland, and Rockcastle River populations would be a significant step towards recovery. The establishment of populations in other rivers (both Tennessee and Cumberland River systems) and the expansion of populations in streams where it is currently found would be a significant step toward recovering the species and possibly delisting. Further, the factors that caused extinction or population reductions at potential transplant sites must be 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 fifteen potential transplant sites for another endangered freshwater mussel *Conradilla* caelata. As part of that program, fifteen sites were evaluated as potential transplant sites based on a correlation of stream characteristics with known populations of the species. Upon completion of all data analysis, those sites chosen as transplant sites received caelata during the fall of 1982. Although these transplated specimens have not been evaluated for success (e.g. survivability and reproduction) it represents some means or method(s) used for trying to save an endangered species until "other" techniques are developed or refined. Similar studies for V. trabalis are recommended. Further studies are required in the tributaries of Tennessee and Cumberland Rivers for possible transplant sites. Those tributary streams suggested for study include the (1) upper Little Tennessee River, (2) Hiwassee, (3) French Broad, (4) Sequatchie, (5) upper Clinch and, (6) Emory Rivers of the Tennessee River system and the (1) Big South Fork Cumberland, (2) Clear Fork, (3) Obed, (4) Obey, (5) Wolf and (6) Laurel Rivers, (7) Roundstone, (8) Horselick, (9) Rock, (10) Pittman and (11) Kennedy Creeks 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, and/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 Conradilla 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 V. trabalis 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 V. trabalis.

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 1.2.2 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.

4. Determine the number of individuals required to maintain a viable population. Theoretical considerations by Franklin (1980) and Soule'(1980) indicate that 500 individuals represent a minimum theoretical population level (effective population size) which 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 corresponding to this theoretical population size can be expected to be larger, possibly by as much as 10 times. The factors which will influence the required 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.

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 River. 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 watershed, 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 stream or riverbank. This would prevent farming up to the riverbank, construction activities, clear cutting, 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 towards 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.

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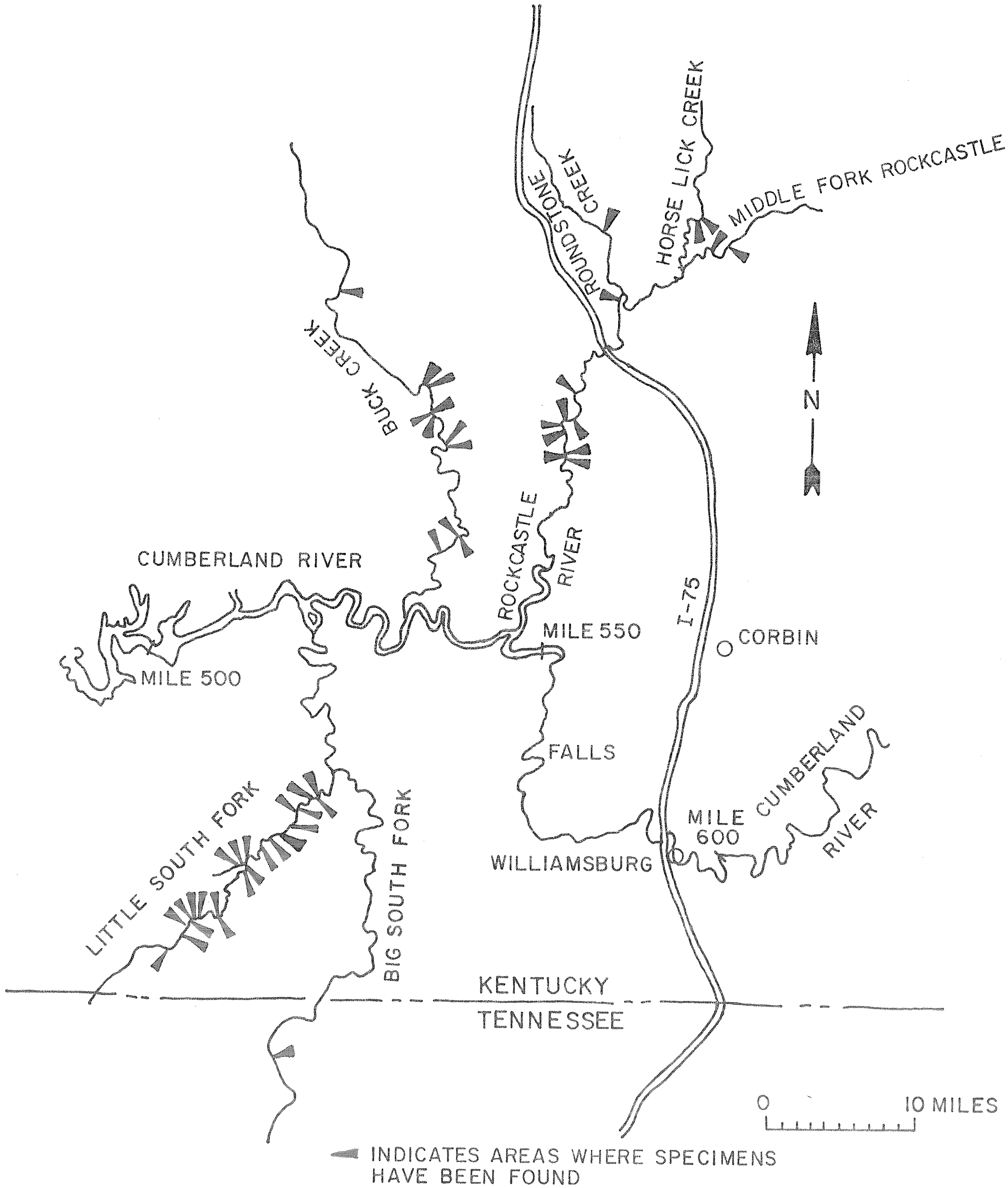

Figure 1: Upper Cumberland River tributaries – Recent Locations for Villosa trabalis (Conrad 1834)

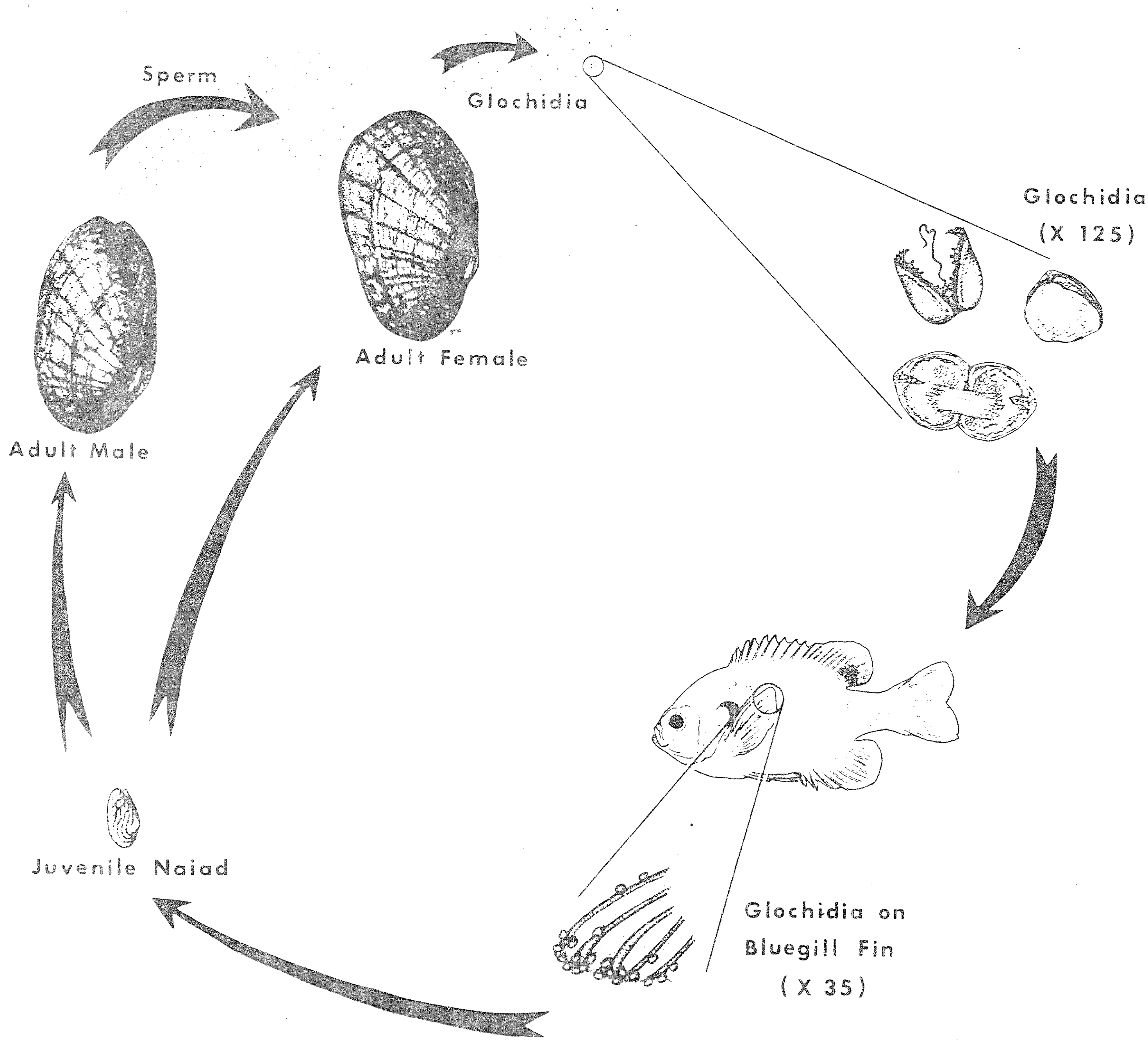

Figure **2.** Typical naiad life cycle depicting the various stages. The life cycle for most species of naiades is very similar to that depicted here (Grace and Buchanan 1981).


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PART III

IMPLEMENTATION SCHEDULE

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

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

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

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

Cumberland Bean Pearly Mussel
(Villosa trabalis)

Part III Implementation Schedule

*1 General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency: FWS Region	Responsible Agency: FWS Program	Responsible Agency: *2 Other	Estimated Fiscal Year Costs: FY 1	FY 2	FY 3	*3 Comments/Notes
01-04	Continue to utilize existing legislation and regulations to protect species and habitat.	1.1	1	Continuous	4	SE,ES,LE	Tennessee Valley Authority (TVA), Tennessee Wildlife Resources Agency (TWRA), Kentucky Department of Fish and Wildlife Resources (KDFWR), Kentucky Nature Preserves Commission (KNPC), and Tennessee 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. *3. Note: Task costs have not been estimated for this plan. This species' present/historic distribution coincides with that of other listed species. 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.
I1,I2	Determine species' present distribution and status.	1.2.1	3	2 yr.	4	SE	TWRA, THP, TVA, KNPC, and KDFWR	---	---	---	
R3,R8, R9,R10, R11	Characterize habitat and determine essential elements.	1.2.2	2	2 yr.	4	SE	TWRA, THP, KDFWR, KNPC, and TVA	---	---	---	
R3,O2, M3	Determine the extent of preferred habitat and present information in a manner which identifies areas in need of special attention.	1.2.3	2	1 yr.	4	SE	TWRA, THP, TVA, KNPC, and KDFWR	---	---	---	
I12,I14	Determine present and foreseeable threats to species.	1.3.1, 1.3.2, and 1.3.3	1	3 yr.	4	SE&ES	TWRA, THP, TVA, KNPC, and KDFWR	---	---	---	
M3,M7	Determine measures needed to minimize threats and implement where needed to meet recovery.	1.3.4	2	Unknown	4	SE&ES	TWRA, THP, TVA, KDFWR, KNPC, and Tennessee and Kentucky Nature Conservancy (TNC)	---	---	---	

Cumberland Bean Pearly Mussel
(*Villosa trabalis*)

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	FY 2	FY3	Comments/Notes
O1,O4	Solicit help in protecting species and essential habitat.	1.4.1, 1.4.2, 1.4.3, and 1.4.4	2	Continuous	4	SE&ES	TWRA, TNC, TVA, THP, KDFWR, and KNPC	---	---	---	
O1	Develop and utilize information and education program (slide/tape shows, brochures, etc.) for local distribution.	1.4.5	2	1 yr. for developing continuous implementation	4	SE&ES	TWRA, TNC, TVA, THP, KDFWR, and KNPC	---	---	---	
M7,A1-A7,O3,O4	Investigate the use of Scenic River status, mussel sanctuaries, land acquisitions, and/or other means to protect the species.	1.5	2	Unknown	4	SE&ES	TWRA, THP, KDFWR, KNPC, and TVA	---	---	---	
I13	Survey rivers within species' historic range to determine availability of suitable transplant sites.	2.1 and	3	1 yr.	4	SE	TWRA, THP, KDFWR, KNPC, and TVA	---	---	---	Task 2.1-2.3 may not be required if other populations are found in Task 1.2.1.
R13,R7	Determine best method of establishing new populations.	2.3	3	2 yr.	4	SE	TWRA, THP, KDFWR, KNPC, and TVA	---	---	---	
M2	Reestablish populations within historic range as needed to meet recovery.	2.4	3	Unknown	4	SE	TWRA, THP, KDFWR, KNPC, and TVA	---	---	---	
I12,I14, M3,M7	Implement same protective measures for these reestablished populations as for known populations.	2.5	3	Continuous	4	SE,ES	TWRA, KNPC, TVA, KDFWR, THP, and TNC	---	---	---	

Cumberland Bean Pearly Mussel
(*Villosa trabalis*)

Part III Implementation Schedule

General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency: FWS Region	FWS Program	Other	Estimated Fiscal Year Costs: FY 1	FY 2	FY 3	Comments/Notes
R3,6,8, 9,10,11, 14	Conduct life history studies on a need-to-know basis.	3	2	Unknown	4	SE	TWRA, KNPC, TVA, KDFWR, and THP	---	---	---	
R8-R11	Determine the number of individuals required to maintain a viable population.	4	3	Unknown	4	SE	TWRA, THP, KDFWR, TVA, and KNPC	---	---	---	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	2	Unknown	4	SE	TWRA, THP, KDFWR, TVA, and KNPC	---	---	---	
I1,I2	Develop and implement a monitoring program.	6	2	Unknown	4	SE	TWRA, THP, KDFWR, TVA, and KNPC	---	---	---	
O4	Annual assessment of recovery program and modify where needed.	7	2	Continuous	4	SE	TWRA, KNPC, TVA, THP, KDFWR, and TNC	---	---	---	

GENERAL CATEGORIES FOR IMPLEMENTATION SCHEDULES *

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

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

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

* (Column 1) - Primarily for use by the U.S. Fish and Wildlife Service.

APPENDIX I

Recent Records of *Villosa trabalis*

Table 1: Recent records for *Villosa trabalis*

Buck Creek - Kentucky Nature Preserves Commission Records

Date	Location	No. of Specimens
06-13-78	1.2 miles WSW of Dahl	Present
08-30-78	between old and new KY 461 bridge	Present
10-08-80	at Fairview Road Ford, east of Eubank	Present
10-11-80	at Stab, 10.0 miles NE of Somerset	Present
05-05-81	1.5 miles N of Poplarville	1 specimen
05-25-81	between KY route 461 and 80	Present
06-19-82	3.8 miles SE of Bent	Present
06-19-82	1.9 miles ENE of Bent	Present
06-19-82	4.2 miles SE of Shopville	Present

Buck Creek - Kentucky Department of Transportation Records

Date	Location	No. of Specimens
1978 (various dates)	near KY 461 bridge	3 live, 10 fresh dead
0 7-12-78	1.2 miles WSW of Dahl	4 fresh dead
0 7-13-78	1.0 mile SE of Elrod	3 fresh dead
1980	upstream of proposed KY 80 project	2 live
06-09 & 10-80	near KY 1677 bridge	4 live, 42 fresh dead

Buck Creek - Eastern Kentucky University Records

Date	Location	No. of Specimens
07-68	bridge on Hwy. 39 N of Bobtown	1 fresh dead
07-68	bridge on Hwy. 80	1 fresh dead
07-18-82	above KY 461 bridge	2 fresh dead
08-17-82	above KY 1003 bridge	6 fresh dead
09-11-82	below KY 461 bridge	4 fresh dead
10-19-82	below KY 1677 bridge	1 live, 1 fresh dead

Buck Creek - Clarke (1981) Records

Date	Location	No. of Specimens
1980	at KY Hwy. 1677 bridge 2.1 miles N of Stab	Present
1980	at KY Hwy. 192, 0.6 miles SE of Dykes	Present

Little South Fork Cumberland River - Kentucky Nature Preserves Commission Records

Date	Location	No. of Specimens
1977-81	river mile 33.6 (station 2)	Present
1977-81	river mile 31.3 (station 3)	live specimens observed
1977-81	river mile 12.5 (station 11)	Present
1977-81	river mile 9.6 (station 13)	Present
06-07-78	at Ritner Ford	Present
06-14-79	mouth of Kennedy Creek	Present
07-10-79	at Green Church Ford	1 fresh dead
08-14-79	at Freedom Church Ford	Present
10-17-79	at Parmleysville	1 live, 5 fresh dead
01-29-80	1.4 miles SSW of Parmleysville	Present
05-23-81	between Parmleysville and KY route 92 bridge	Present

Little South Fork Cumberland River - Eastern Kentucky University Records

Date	Location	No. of Specimens
11-80	river mile 14.5 near Hwy. 92	3 fresh dead
11-80	river mile 12.5 at confluence of Corder Creek	2 fresh dead
11-80	river mile 10.6 at Jones School Ford	1 fresh dead
11-80	river mile 7.9 at Ritner Ford	5 fresh dead

Little South Fork Cumberland River - Starnes and Bogan 1982

Date	Location	No. of Specimens
1977-81	river mile 33.6 (Station 2)	Present
1977-81	river mile 31.3 (Station 3)	Present
1977-81	river mile 28.5 (Station 4) Parmleysville	Present
1977-81	river mile 14.2 (Station 8) Hwy. 92 crossing	live specimens observed
1977-81	river mile 13.3 (Station 10)	1 live, 3 fresh dead
1977-81	river mile 12.5 (Station 11)	Present
1977-81	river mile 9.6 (Station 13)	4 fresh dead
1977-81	river mile 7.5 (Station 14) Ritner Ford	1 fresh dead
1977-81	river mile 3.8 (Station 16) Freedom Church Ford	Present

Kennedy Creek - Kentucky Nature Preserves Commission Records

Date	Location	No. of Specimens
08-14-79	Kennedy Creek above mouth	Present
01-29-80	Kennedy Creek above mouth	Present
	mouth of Kennedy Creek	Present

Kennedy Creek - Clarke (1981) Records

Date	Location	No. of Specimens
1981	Mouth of Kennedy Creek	Present

No.Rockcastle River - Kentucky Nature Preserves Commission Records

Date	Location	No. of Specimens
10-12-79	at mouth of Eagle Creek	Present
01-25-80	South of Livingston above L&N railroad bridge	Present
05-80	near KY 80 bridge	1 live, fresh dead shells
12-19-80	Rockcastle mile 19.4	5 live, 1 fresh dead
06-27-81	between KY route 80 and I-75 bridges	5 fresh dead

Rockcastle River - Kentucky Department of Transportation Records

Date	Location	No. of Specimens
1980 (various dates)	near Billows	3 live, 22 fresh dead
02-29-81	near mouth of Hawk Creek	2 fresh dead

Rockcastle River - Eastern Kentucky University Records

Date	Location	No. of Specimens
07-75	at KY 490, Rockcastle and Laurel Co. lines	6 fresh dead
11-82	shoal 1 mile below Livingston	1 fresh dead

Rockcastle River - Clarke (1981) Records

Date	Location	No. of Specimens
1980	0.2 miles South of KY Hwy. 80 near Billows	Present

Middle Fork Rockcastle River - Kentucky Nature Preserve Commission Records

Date	Location	No. of Specimens
08-23-79	at Ford, 1.6 miles West of Middle Fork	Present
07-21-82	at mouth of Panther Creek	Present

Horselick Creek - Kentucky Nature Preserves Commission Record

Date	Location	No. of Specimens
07-24-79	below mouth of Raccoon Creek at low water bridge	Present

Horselick Creek - Eastern Kentucky University Record

Date	Location	No. of Specimens
11-21-82	approx. 0.3 miles above mouth	1 fresh dead

Roundtone Creek - Kentucky Department of Fish and Wildlife Resources Record

Date	Location	No. of Specimens
1981	Creek mile 4.8 below Mullins, KY	6 fresh dead

APPENDIX II

List of Reviewers

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