

Recovery Plan

Pink Mucket Pearly Mussel
Lampsilis orbiculata

DISCLAIMER

THIS IS THE COMPLETED PINK MUCKET 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 ROLE IN PREPARING THIS PLAN. THIS PLAN IS SUBJECT TO MODIFICATION AS DICTATED BY NEW FINDINGS, CHANGES IN SPECIES STATUS, AND COMPLETION OF TASKS DESCRIBED IN THE PLAN. GOALS AND OBJECTIVES WILL BE ATTAINED AND FUNDS EXPENDED CONTINGENT UPON APPROPRIATIONS, PRIORITIES, AND OTHER CONSTRAINTS.

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.

This plan was prepared under contract by Steven Ahlstedt, Tennessee Valley Authority, Norris, Tennessee.

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RECOVERY PLAN FOR THE
PINK MUCKET PEARLY MUSSEL

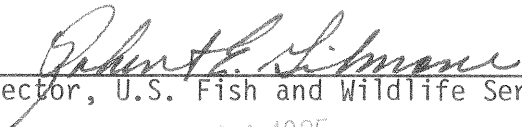
Lampsilis orbiculata (Hildreth, 1828)

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PART I
INTRODUCTION

Freshwater mussels (naiades) are known to occur in every temperate and tropical climate with approximately one-half of the extant species living in North America. Eastern North America still contains the most diverse freshwater molluscan fauna known in the world. Stansbery (1970) reported that fauna numbers over a thousand species of bivalves and gastropods combined. The richest assemblages of freshwater mussels were reported from the Tennessee, Cumberland, and Ohio River systems.

Twenty-three freshwater mussels in the United States are listed as endangered by the U.S. Department of Interior. Almost all of these species were known from the Tennessee, Cumberland, and Ohio River systems. The pink mucket pearly mussel (Lampsilis orbiculata) 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).

Hildreth (1828) described Unio orbiculatus from the Muskingum River in Marietta and Washington Counties, Ohio. However, the description for U. orbiculatus by Hildreth (1828) does not fit that (the description) of L. orbiculata. The earliest name which fits the description of L. orbiculata is by Say (1831) in his description of Unio abruptus. Unio abruptus is undoubtedly the proper description

for L. orbiculata as reported by Binney (1858), Clarke (1982), and Bogan and Parmalee (1983). Another closely related endangered species, (Lampsilis higginsii (Lea, 1857)), is often confused with L. orbiculata; however, both are considered valid species (Havlik, 1980; USFWS, 1983; Clarke, 1982; Stansbery, Ohio State University-personal communication).

DISTRIBUTION

Historical

Historical records for L. orbiculata indicate this is strictly an Ohioan or Interior Basin species, found mainly in the Tennessee, Cumberland, and Ohio River drainage with occasional records from the Mississippi River drainage. Historically, L. orbiculata occurred in 25 river systems and was an extremely widespread in distribution (Table 1). This species has never been collected in large numbers from any one site or drainage and, therefore, it has usually been considered rare. Wilson and Clark (1914) reported L. orbiculata as being "fairly common" in their collections from the middle portion of the Cumberland River taking one to three specimens from each mussel bed. Ortmann (1919) reported this species as rare in the Monongahela River (only one specimen found) and in the Allegheny River (only a few specimens found). Further down the Ohio River Ortmann (1919) reported only two dozen L. orbiculata in the shell heaps of clam diggers. Ortmann (1925) also reported L. orbiculata as rarely occurring in the Tennessee River up to the lower Clinch River near Knoxville, Tennessee.

Table 1. Historical records for Lampsilis orbiculata prior to 1970 and subfossil specimens recorded to 1982.

River	Source
Tennessee River	Hinkley (1904, 1906) Ortmann (1918, 1919, 1925) van der Schalie (1939) Morrison (1942) archaeological specimens Stansbery (1964, 1970, 1976) Isom (1969, 1972) Johnson (1980)
Flint River, Alabama	Johnson (1980)
Limestone Creek, Alabama	Ortmann (1925) Johnson (1980)
Duck River	Johnson (1980)
Holston River	Lewis (1871) Hickman (1937) Johnson (1980)
French Broad River	Johnson (1980)
Clinch River	Ortmann (1918, 1919, 1925) Cahn (1936) Hickman (1937) Stansbery (1973) specimens collected mid-1960's Johnson (1980)
Cumberland River	Call (1885) Marsh (1885) Wilson and Clark (1914) Neel and Allen (1964) Johnson (1980) Sickel (1982) subfossil shells
Obey River	Shoup et al. (1941) Johnson (1980)
Ohio River	Call (1885, 1896, 1900) Sterki (1907) Ortmann (1911, 1912, 1919, 1925) Goodrich and van der Schalie (1944) Parmalee (1960, 1967) Stansbery (1962)

Table 1. Continued.

River	Source
Ohio River (continued)	Johnson (1980) Taylor (1980) subfossil specimens
Allegheny River	Ortmann (1919) Johnson (1980)
Monongahela River	Ortmann (1919) Johnson (1980)
Elk River, West Virginia	Taylor and Hughart (1981)
Kanawha River, West Virginia	Stansbery (1972) archaeological specimens
Scioto River	Stansbery (1965) archaeological specimens Johnson (1980)
Muskingum River	Hildreth (1828) Ortmann (1918, 1919) Bates (1970) Stansbery (1970, 1974) Johnson (1980)
White River, Indiana	Say (1817) Call (1896, 1900) Utterback (1917) Ortmann (1919) Goodrich and van der Schalie (1944) Johnson (1980)
Wabash River, Indiana and Illinois	Say (1817) Binney (1858) Call (1896, 1900) Baker (1906) Ortmann (1919) Goodrich and van der Schalie (1944) Parmalee (1967) Johnson and Baker (1973) Johnson (1980)
Mississippi River, Illinois and Iowa	Pratt (1876) Baker (1906) Ortmann (1919, 1925) Grier and Mueller (1922-23)

Table 1. Continued.

River	Source
Illinois River	Calkins (1874) Baker (1906) Danglade (1914) Ortmann (1919) Starrett (1971) Johnson (1980)
Quachita River, Arkansas	Wheeler (1918) Ortmann (1919)
Old River (Quachita River system)	Wheeler (1918)
Black River	Ortmann (1919) questionable specimens
Sac River, Missouri	Ron Oesch (personal communication) 1 relict specimen July 1969
St. Francis River, Missouri	Ron Oesch (personal communication) 4 relict specimens May 1972

Additional records of L. orbiculata from the Ohio River include Call (1885, 1896, 1900), Simpson (1900, 1914), Sterki (1907), Goodrich and van der Schalie (1944), LaRoque (1967), and Taylor (1980, subfossil specimens). Archaeological specimens have been reported from the Kanawha and Scioto Rivers by Stansbery (1965, 1972). Hildreth (1828), Ortmann (1919), Stansbery (1974), and Bates (1970) reported L. orbiculata from the Muskingum River. In Indiana and Illinois, L. orbiculata was reported from the Wabash and White Rivers (Say, 1817; Call, 1896 and 1900; Baker, 1906). This species was also reported from the Mississippi River in Illinois and Iowa by Pratt (1876), Baker (1906), Simpson (1900), Grier and Mueller (1923); and the Illinois River by Calkins (1874), Baker (1906), Danglade (1914). West of the Mississippi River, this species has been reported from the Quachita, Old, and Black Rivers (Wheeler, 1918; Ortmann, 1919).

From the southern tributaries of the Ohio River system, L. orbiculata is reported from the Cumberland River by Call (1885), Marsh (1885), Simpson (1900, 1914), Wilson and Clark (1914), Neel and Allen (1964), and the Obey River (tributary to Cumberland) by Shoup et al. (1941). Numerous records of L. orbiculata were also reported from the Tennessee River (Hinkley 1904, 1906; Ortmann 1918, 1919, 1925; van der Schalie 1939; Stansbery 1964; Isom 1969, 1972). Lampsilis orbiculata has also been reported from numerous tributary streams to the Tennessee River including Limestone Creek, Alabama (Ortmann, 1925); Flint River, Alabama (Johnson, 1980); Duck River (Johnson, 1980); Holston River (Lewis, 1971; Hickman, 1937), French Broad River (Johnson, 1980); and the Clinch River (Ortmann, 1918, 1919, 1925; Cahn, 1936; Hickman, 1937; Stansbery, 1973 specimens collected mid-1960's; Johnson, 1980).

Based on this information, L. orbiculata had a widespread historical distribution where it was apparently rare throughout its range. Historical records for L. orbiculata prior to 1970 are summarized in Table 1.

Present

Lampsilis orbiculata is presently known from 16 different rivers representing three major geographic regions (Figures 1 and 2, Appendix A, Table 1). Based on the number of locations where specimens have been found or observed, the greatest concentrations of L. orbiculata are reported from the Tennessee River (Yokley, 1972; TVA, 1978; Pardue, 1981; Leroy Koch (TVA) and James Sickel (Murray State University, personal communication); Cumberland River (TVA, 1976; Parmalee et al. 1980; Koch, personal communication); Osage River (Grace and Buchanan, 1981; Oesch, personal communication); and the Meramec River (Buchanan, 1980; Oesch, personal communication).

Hundreds of fresh dead specimens of L. orbiculata have been observed by the author, Leroy Koch (personal communication), and Parmalee et al. (1980) from commercial sheller's cull and stockpiles located on the Tennessee and Cumberland Rivers. Juvenile L. orbiculata, less than five years of age, have been observed in the Tennessee River (Koch, personal communication), Paint Rock River (author), and the Meramec River (Buchanan, 1980) indicating that successful reproduction is occurring in these rivers.

Taylor (1983) reports that "a good-sized healthy population" of L. orbiculata exists in a small stretch of the Kanawha River below Kanawha Falls. Clarke (1982) also reported three live specimens found

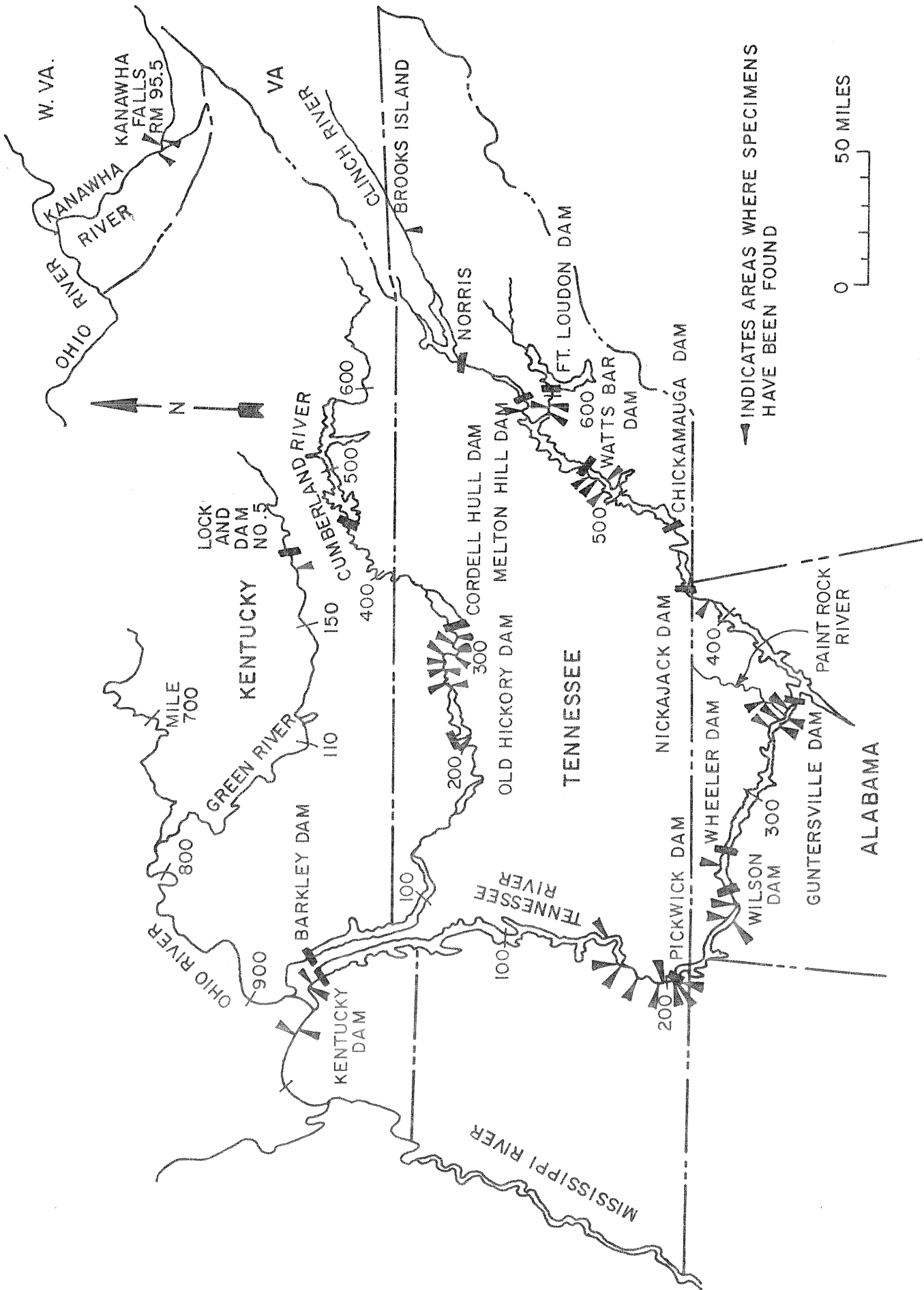


Figure 1: Tennessee, Cumberland and Ohio River Systems - Recent Locations for LAMPISILIS ORBICULATA (HILDRETH, 1828)

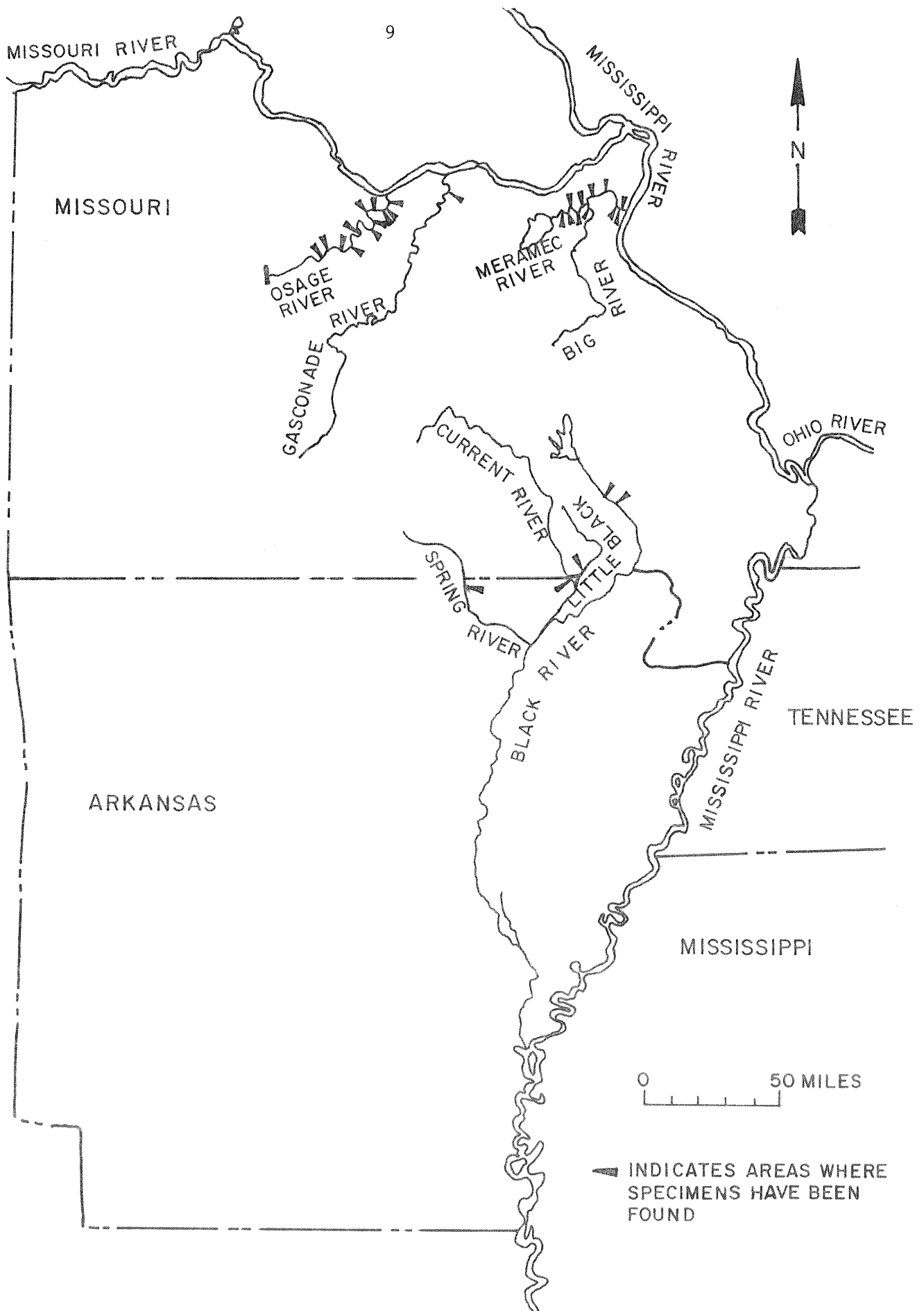


Figure 2 : Osage, Gasconade, Meramec, Big, Black, Little Black, Current, and Spring Rivers — Recent Locations for LAMPASILIS ORBICULATA (Hildreth, 1828)

during his survey of the Kanawha. In all probability, the Cumberland River has a reproducing population of L. orbiculata based on the number of specimens observed and aged by Parmalee et al. (1980), Koch (personal communication) and the author.

Lesser known populations of L. orbiculata are reported from the Clinch River, Tennessee upstream from Norris Dam and downstream from Melton Hill Dam (TVA; 1979, 1982); lower Ohio River (Koch and Jeff Pardue (TVA), personal communication); Green River, Kentucky (U.S. EPA, 1981; Sam Call, Kentucky Dept. of Natural Resources, personal communication); Big River, Missouri (Buchanan, 1980; Ron Oesch, personal communication); Black River, Missouri (Buchanan, 1980; Ron Oesch, personal communication); Little Black River, Missouri (Buchanan, 1979); Current River, Arkansas (Alan Buchanan, Missouri Dept. of Conservation, personal communication); and the Gasconade River (Stansbery and Oesch, personal communication). One fresh-dead specimen of L. orbiculata was found by the author in 1979 from the lower Little Tennessee River (Coytee Springs). This area is now impounded by Tellico Reservoir.

In view of the above information, L. orbiculata appears to have adapted to existence in the impounded Tennessee and Cumberland Rivers. The river-lake conditions in the upper reaches of these impoundments caused by discharges or releases through dams are apparently suitable for survival and propagation of L. orbiculata. The rare occurrence of L. orbiculata in smaller streams such as the Clinch River above Norris Dam and the Paint Rock River may result from sub-optimum habitat for this otherwise larger river species; however, conditions are apparently being met for the continued survival of this species.

ECOLOGY AND LIFE HISTORY

Freshwater mussels (naiades), are benthic animals that usually remain buried in the substrate with only the most posterior margin of the shell and siphons exposed to the water column. Freshwater mussels are found in a variety of habitats ranging from mud and sand, between bedrock ledges, to rubble and gravel substrates. The majority of freshwater mussel species are normally found in riverine conditions in relatively firm rubble, gravel, and sand substrates swept-free of silt. Typically, most mussel species are found buried in the substrate in riffle and shoal areas.

Lampsilis orbiculata (see photo) is an Ohioan or Interior Basin species found in medium to large rivers (20 m wide or greater) in habitats ranging from silt to boulders, rubble, gravel, and sand substrates (Hickman, 1937; Yokley, 1972; Buchanan, 1980; Clarke, 1982). Lampsilis orbiculata is most often associated with larger rivers (Ohio, Tennessee, and Cumberland Rivers) in moderate to fast-flowing water, at depths ranging from 0.5 to 8.0 m. Ortmann (1919) collected this species from riffles with strong currents as did Bogan and Parmalee (1983). Buchanan (1980) reported L. orbiculata occurring at water depths ranging from 2.5 cm to 1.5 m in both standing and flowing water. The author has collected this species in the Tennessee and Cumberland Rivers at depths of 2.7 to 8.0 m in moderate to fast-flowing water.

The outward appearance of L. orbiculata is characterized by an elliptical, subovate, subquadrate shell attaining a size of approximately 105 mm long, 82 mm high, and 61 mm wide. Valves are inflated, thick, heavy, unsculptured, and gaping at the anterior-ventral base.



♀



♂

Lampsilis orbiculata

0 1
cm

Lampsilis orbiculata is sexually dimorphic. In males, the anterior margin of the shell is curved or rounded and the posterior end is somewhat pointed. In females, the anterior margin is rounded with the posterior-ventral area expanded, broad, and somewhat truncated to accommodate the marsupium (Hildreth, 1828; Simpson, 1914; Johnson, 1980). The posterior ridge is well defined in males and younger specimens being distinct along the dorsal margin. The surface of the shell is smooth except for wide, relatively dark, concentric growth rests. Beaks are located in the anterior portion of the shell, with young individuals marked with faint beak sculpture consisting of looped ridges. The outer covering of the shell (periostracum) can be glossy in younger specimens or dull in old individuals. Color is yellow to yellowish or greenish brown with wide, greenish rays present in younger specimens. Umbos are broad, moderately inflated, inclined forward, and project above the hinge line. The hinge line is long, full, and heavy.

The left valve consists of two large, triangular, pseudocardinal teeth of almost equal height separated by two curved lateral teeth with a short, medium width, flat interdentum. The right valve has one large triangular pseudocardinal tooth and one large, medium length, elevated, slightly curved lateral tooth. Anterior and posterior adductor muscle scars and pallial line are deep and well impressed. Nacre coloration is generally pink or salmon, to solid, iridescent, silvery white.

The life history of L. orbiculata is unknown; however, it is probably similar to that of most naiades (Figure 3). Males produce sperm which are discharged into the surrounding water and dispersed by water currents. Females downstream from the males obtain these

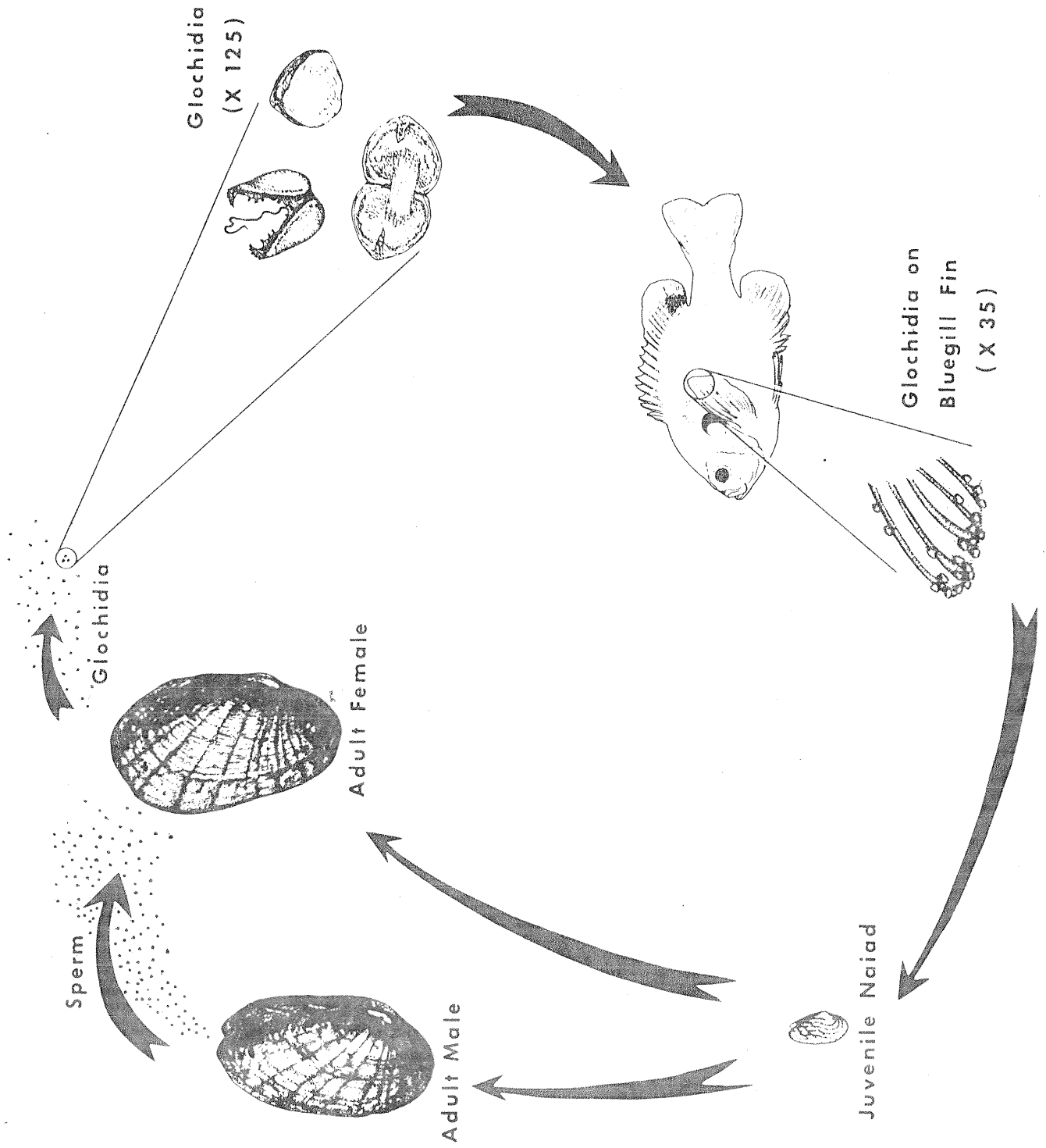


Figure 3. Typical naiad life cycle depicting the various stages. The life cycle for most species of naiades is very similar to that depicted here (Grace and Buchanan 1981).

sperm during feeding and respiration (Stein, 1971). Fertilization of the eggs 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 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 early spring and release glochidia by mid- to late-summer of the same year. L. orbiculata is a bradytictic species becoming gravid in August with females having glochidia in September which are released (discharged) the following year in June (Ortmann; 1912, 1919).

The anatomy of L. orbiculata has been described by Ortmann (1911, 1912). Females of genus Lampsilis typically have a flap (mantle flap) which sets this group apart from other genera. The flap has numerous teeth along its edge and projects at the anterior end in a free lobe. An eye spot, typically found in most Lampsilis species, has been observed on the mantle flaps of L. orbiculata (Dave Stansbery, personal communication). The glochidia of L. orbiculata might be called bean-shaped and hookless. Hookless glochidia typically have a more spoon-shaped delicate shell, and are more frequently parasitic on the gill filaments of fish (Lefevre and Curtis, 1910; Coker and Surber, 1911). Ortmann (1911) reported that L. orbiculata glochidia are peculiar in that two sizes were observed, with the smaller glochidia more common.

Fish hosts for L. orbiculata are unknown. However, Surber (1913) reported the sauger as a host fish for another closely related endangered species, Lampsilis higginsii.

REASONS FOR DECLINE AND CONTINUED THREATS

Many species of freshwater mussels, including L. orbiculata, have been totally eliminated from some river systems in the United States. Historically, L. orbiculata had a widespread distribution occurring in at least 25 rivers (Table 1). This species was never collected in large numbers from any one site or drainage and therefore has always been considered as uncommon or rare. Reasons for the decline of freshwater mussels in general are not totally understood, but due to the longevity of most mussel species--up to 50 years--and their rather sedentary nature, they are especially vulnerable to stream perturbations such as impoundments, siltation, and pollution.

Impoundment

Possibly the single greatest factor contributing to the decline of freshwater mussels, not only in the Tennessee Valley, but other regions as well, is the alteration and destruction of stream habitat due to impoundments for flood control, navigation, hydroelectric power production, and recreation.

Since the early 1930's and 1940's, the Tennessee Valley Authority, Aluminum Company of America (Alcoa), and the U.S. Army Corps of Engineers have constructed 51 impoundments throughout the Tennessee and Cumberland River systems alone. Stream impoundments affect species

composition by eliminating those species not capable of adapting to reduced flows, altered temperature regimes, and anoxic conditions. Tributary dams typically have hypolimnial discharges that cause the stream below the dam (reservoir tailwater) to differ significantly from preimpoundment conditions and from upstream river reaches. Possible effects of hypolimnial discharges include: altered temperature regimes, extreme water level fluctuations, reduced turbidity, seasonal oxygen deficits, and high concentrations of certain heavy metals (TVA, 1980). Biological responses attributable to these environmental changes can include reductions in the fish and benthic macroinvertebrate communities (Isom, 1971). 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 including L. orbiculata and nine 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. Clarke (1981) warned that Pleurobema plenum, another federally listed endangered species, will survive in the Green River, Kentucky, only if its natural habitat is restored. L. orbiculata is also found in the Green River (Call, personal communication). The completion of the Green River Dam in 1969 may eventually eliminate both species from that river system.

Siltation

Siltation is another factor that has severely affected freshwater mussels. In rivers and streams, the greatest diversity and abundance of mussels are 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 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 long-lived and sedentary by nature; many species are unable to survive in a layer of silt greater than 0.6 cm (Ellis, 1936). Since most freshwater mussels are riverine species that require clean, flowing water over stable, silt-free rubble, gravel, and sand shoals, the smothering action of silt 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).

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 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, some data are available concerning the adverse impacts of some pollutants on freshwater mussels along with other components of the ecosystem. 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 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). Williams (1969) in his study of the mussel fauna of the Green River reports an almost total elimination of the freshwater mussel fauna below Greensburg, Kentucky, due to oil brine pollution.

DISCUSSION

All the aforementioned reasons for decline and continued threats have obviously impacted freshwater mussel communities in many streams. However, observations and sampling by various individuals using a variety of sampling techniques indicate that L. orbiculata still is geographically widespread and frequently is encountered in the Tennessee, Cumberland, and Meramec Rivers, and a small portion of the Kanawha River. The age distribution observed suggests that this species is reproducing in sections of each of these streams. Occasional specimens are also found in smaller streams (see Appendix, Table A-1) which suggest that L. orbiculata may persist at low population levels in these streams as well. Mainstream dams constructed on the Tennessee and Cumberland Rivers may have created habitat suitable for the survival and propagation of L. orbiculata. Clark (1976) reported that impoundments do not have the same effects on different species of mussels. Clark further reported that some species have benefitted from impoundment and are reproducing in large numbers. This has been observed by the author in the overbank areas of the Tennessee and Cumberland Rivers. Large numbers of Quadrula metanevra, Quadrula quadrula, and Fusconaia ebena as well as large concentrations of

Anodonta grandis have been observed in the impounded portions of the Tennessee and Cumberland Rivers. Other rivers may also be maintaining populations of L. orbiculata since some dams (especially mainstream dams) allow for riverine conditions.

PART II
RECOVERY

A. Recovery Objectives

The ultimate objective of this recovery plan is to maintain and restore viable populations* of L. orbiculata to a significant portion of its historic range and remove the species from the federal list of endangered and threatened species. Based on the current widespread distribution of this species and the number of populations known, this species could now be considered for downlisting to threatened status. 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. When two additional viable populations of L. orbiculata are found in any two rivers except the Tennessee, Cumberland, and Meramec Rivers. Both of these rivers will contain viable populations that are distributed such that a single event would be unlikely to eliminate L. orbiculata from the river system. Survey data must show at least five viable populations with each population having a minimum of two year-classes between 4 and 10 years of age as evidence of reproduction.
2. Additional mussel sanctuaries are established or expanded in river systems which contain known concentrations of L. orbiculata.
3. An education program is established for the public with major emphasis towards commercial mussel fishermen.
4. 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.

*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.

B. Step-Down Outline

Prime Objective: Delist

1. Conduct population and habitat surveys for L. orbiculata.
 - 1.1 Determine species' present distribution and status.
 - 1.2 Identify essential habitat and specific areas in need of protection.
2. Preserve populations and presently used habitat of L. orbiculata.
 - 2.1 Determine specific threats faced by the species.
 - 2.2 Continue to utilize existing legislation and regulations to protect the species and its habitat.
 - 2.3 Determine and implement protection strategies for areas identified in Task 1.2.
3. Develop education programs.

C. Narrative Outline

1. Conduct population and habitat surveys. Numerous freshwater mussel surveys since 1970 have documented the occurrence of L. orbiculata in at least 16 different rivers (Figures 1 and 2). Reproducing populations are known to occur in three of these rivers (Tennessee, Cumberland, and Meramec) and one young specimen (five years old) has been found in the Paint Rock River. Before L. orbiculata can be delisted, two additional reproducing populations in two separate rivers are required. Each river must contain two population centers of L. orbiculata with at least two year classes of four to ten years of age as evidence of a reproducing population.

Intensive dive/float freshwater mussel surveys and/or the use of a commercial mussel fishermen are recommended to locate specimens of L. orbiculata in the rivers known to support this species. Those streams which may contain reproducing populations of L. orbiculata in order of priority include the lower Ohio River below Owensboro, Kentucky; the Green River from Mumfordsville, Kentucky, downstream to Lock and Dam No. 4; Osage River (Missouri); Black River (Arkansas); Kanawha River (West Virginia) below Kanawha Falls; and the Muskingum River, near Marietta, Ohio. When and if viable reproducing populations are found in two additional rivers (other than the Tennessee, Cumberland, or Meramec) the prime objective of this recovery plan will be satisfied.

- 1.1 Determine species' present distribution and status. Determine if lesser known populations described earlier are successfully reproducing.
- 1.2 Identify essential habitat and specific areas in need of protection. State protected mussel sanctuaries have been established for portions of the Tennessee, Cumberland, and Clinch Rivers. All three of these rivers have populations of L. orbiculata. Populations of this species in the State of Missouri are also protected to some extent since commercial mussel fishing is not allowed in the State. However, it is recommended that States be encouraged to establish or extend sanctuaries in areas with known concentrations of L. orbiculata. One such area highly recommended is the Kanawha River below Kanawha Falls, West Virginia.

2. Preserve populations and present habitat of *L. orbiculata*.
All known populations of *L. orbiculata* and present habitat will continue to be protected by the Endangered Species Act until recovery objectives are met.
 - 2.1 Determine specific threats faced by the species. Many factors presently 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.
 - 2.2 Continue to utilize existing legislation and regulations to protect the species and its habitat. Prior to and during implementation of this recovery plan the species will be protected by the full enforcement of existing laws and regulations.
 - 2.3 Determine and implement protection strategies for areas identified in Task 1.2.
3. Develop education programs. *L. orbiculata* is routinely taken by commercial mussel fisherman because it closely resembles another, more common commercially valuable species *Actinonaias carinata* (mucket). *L. orbiculata* has no value commercially and hundreds of specimens are killed and discarded. Commercial mussel fishermen should be educated to identify the more common endangered species and required to return those specimens unharmed to the river. A brief informative poster, pamphlet, or program is needed to point out basic problems, uniqueness

of river systems, rarity of the resources at risk, potential value of undisturbed systems, and 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.

BIBLIOGRAPHY

- Baker, F. C. 1906. A catalogue of the mollusca of Illinois. Bull. Ill. St. Lab. Nat. Hist. 7(6):53-136.
- Bates, J. M. 1970. Ohio mussel fisheries study Part 1. Mussel studies. Center for Aquatic Biology, Eastern Michigan Univ. at Ypsilanti. Nat. Tech. Info. Serv. Pub. Com-73-10145. pp. 1-108.
- Binney, W. G. (ed.) 1858. The complete writings of Thomas Say on the conchology of the United States. New York, New York: H. Bailliere, 252 pp., 38 pls.
- 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 Prog. June 1979. Univ. of TN., Knoxville. 360 pp.
- Buchanan, A. C. 1979. Mussels (Naiades) of the Little Black River basin in Missouri and Arkansas. U.S. Dept. of Agric., Soil Conserv. Serv., Columbia, Missouri. 69 pp.
- _____. 1980. Mussels (Naiades) of the Meramec River basin. Missouri Dept. of Conservation, Aquatic Series. No. 17, 68 pp.
- Burch, J. B. 1973. Freshwater unionacean clams (Mollusca: Pelecypoda) of North America. Biota of Freshwater Ecosystems, Ident. Man. 11, U.S. Envir. Protection Agency. 176 pp.
- 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. Assoc. Southeast. Biol. Bull. 18:79-106.
- Call, R. E. 1885. Unionidae of the Mississippi Valley. Bull. Des Moines Acad. Sci., 1(1):5-57.
- _____. 1896. On a small collection of mollusks from northern Indiana. Proc. Ind. Acad. Sci., 1895:246-257.
- _____. 1900. A descriptive illustrated catalogue of the mollusca of Indiana. Indiana Dept. of Geol. and Nat. Res., Ann. Rept., 24:335-535, 78 pl.
- Calkins, W. W. 1874. The land and freshwater shells of LaSalle County, Illinois. Proc. Ottawa Acad. Nat. Sci., 48 pp. 1 pl.
- Clark, C. F. 1976. The freshwater naiads of the lower end of the Wabash River, Mt. Carmel, Illinois, to the south. Sterkiana 61:1-14.

- Clarke, A. H. 1981. Determination of the precise geographical areas occupied by four endangered species of freshwater mollusks. Final report. USFWS, Fed. Bldg. Room 668, Fort Snelling, Twin Cities, MN.
- _____. 1982. Survey of the freshwater mussels of the upper Kanawha River (RM 91-95), Fayette County, West Virginia, with special reference to Epioblasma torulosa (Rafinesque) and Lampsilis abrupta (Say) (= Lampsilis orbiculata (Hildreth), of authors). Final Report. USFWS, One Gateway Center, Room 618, Newton Corner, Mass. 02158. Order No. 50181-0546-2. 45 pp.
- Coker, R. W. and T. Surber. 1911. A note on the metamorphosis of the mussel (Lampsilis laevis). Biol. Bull. 20:179-182.
- Danglade, E. 1914. The mussel resources of the Illinois River. U.S. Bur. Fish, Dept. U.S. Comm. Fish. 1913, App. 6, 48 pp.
- Ellis, M. M. 1936. Erosion silt as a factor in aquatic environments. Ecology 17:29-42.
- 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, New York, New York.
- _____. 1977. Freshwater and terrestrial mollusks. pp. 143-194. 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.
- Goodrich, C. and H. van der Schalie. 1944. A revision of the mollusca of Indiana. Amer. Midl. Nat. 32(2):257-326.
- Grace, T. B. and A. C. Buchanan. 1981. Naiades (mussels) of the Lower Osage River, Tavern Creek, and Maries River, Missouri. Missouri Dept. of Conservation, Prepared for U.S. Army Corps of Eng., Kansas City District. 147 pp.
- Grier, N. M. and J. F. Mueller. 1922-1923. Notes on the naiad fauna of the upper Mississippi. II. The naiades of the upper Mississippi drainage. Nautilus 36:46-49; 1923, 96-103.
- Havlik, M. E. 1980. The historic and present distribution of the endangered naiad mollusk Lampsilis higginsii (Lea, 1857). Bull. Am. Malacol. Union 1980: 19-22.
- Hickman, M. E. 1937. A contribution to mollusca of east Tennessee. Unpublished master's thesis, Dept. of Zool., Univ. of TN., Knoxville. 165 pp., 104 pl.

- Hildreth, S. 1828. Observations on, and descriptions of the shells, found in the waters of the Muskingum River, Little Muskingum and Duck Creek, in the vicinity of Marietta, Ohio. *Am. J. Sci. and Arts*, 14:276-291.
- 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 Twenty-eighth Annu. Conf. Southeast Assoc. of Game and Fish Comm.*, Nov. 17-20, 1974. White Sulphur Springs, WV. pp. 398-414.
- Hinkley, A. A. 1904. List of Alabama shells collected in Oct. and Nov., 1903. *Nautilus* 18(4):37-45, (5):54-57.
- _____. 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*. University of Toronto Press, Toronto, Ontario.
- _____. 1974. *The biology of polluted waters*. University of Toronto Press, Toronto, Ontario.
- Ingram, W. M. 1956. The use and value of biological indicators of pollution: Fresh water clams and snails. pp. 94-135. IN: C. M. Tarzwell (ed.) *Biological problems in water pollution*. Taft Sanitary Eng. Center, Cincinnati, OH.
- Isom, B. G. 1969. The mussel resources of the Tennessee River. *Malacologia* 7(2-3):397-425.
- _____. 1971. Effects of storage and mainstream reservoirs on benthic macroinvertebrates in the Tennessee Valley. *Res. Fish, and Limnol, Spec. Publ. No. 8*. *Am. Fish. Soc.* pp. 179-191.
- _____. 1972. Mussels in the unique Nickajack Dam construction site Tennessee 1965. *Malacol. Rev.* 5:4-6.
- Johnson, R. I. 1980. Zoogeography of North American Unionacea (Mollusca: Bivalvia) north of the maximum Pleistocene glaciation. *Bull. Mus. Comp. Zool.* 149(2):189 pp.
- _____. and H. B. Baker. 1973. The types of Unionacea (Mollusca: Bivalvia) in the Acad. of Nat. Sci. of Phila. *Proc. Acad. Nat. Sci. Phila.* 125(9):145-186, pls. 1-10.
- Lamarck, J. B. P. A. 1815-1822. *Histoire naturelle des animaux sans vertebres*. Tome V-VII, 8 Vol.
- La Rocque, A. 1966-1970. Pleistocene mollusca of Ohio. *Ohio Div. Geol. Surv. Bull.*, Vol. 62, 4 pts.
- Lea, I. 1857. Description of eight new naiades. *Proc. Acad. Nat. Sci. Phila.*, 1857.

- 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. Conchology*, 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 small larval and adult bivalves. *Gulf Caribb. Fish. Inst. Univ. Miami Proc.* 14:80-95.
- Marsh, P. 1885. List of shells collected in central Tennessee by A. A. Hinkley and P. Marsh with notes on species. Published by author. Alledo, IL. 10 pp.
- 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. Ethol. Bull.* 129:337-392.
- Neel, J. K. and W. Allen. 1964. The mussel fauna of the upper Cumberland Basin before its impoundment. *Malacologia* 1(3):427-459.
- Ortmann, A. E. 1911. Monograph of the naiades of Pennsylvania. *Mem. Carnegie Mus.* 4:279-347.
- _____. 1912. Notes upon the families and genera of the nayades. *Ann. Carnegie Mus.* 8:222-365.
- _____. 1918. The nayades (freshwater mussels) of the upper Tennessee drainage with notes on synonymy and distribution. *Proc. Am. Philos. Soc. Phila.* 57:521-626.
- _____. 1919. A monograph of the naiades of Pennsylvania. Pt. 3. Systematic account of the genera and species. *Mem. Carnegie Mus.* 8(1):1-389, pls. 1-21.
- _____. 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. 1960. Mussels from the Angel site, Indiana. *Nautilus* 74(2):70-75.
- _____. 1967. The freshwater mussels of Illinois. *Ill. State Mus. Pop. Series* 8:1-108.

- _____, W. E. Klippel, and A. E. Bogan. 1980. Notes on the pre-historic and present status of the naiad fauna of the middle Cumberland River, Smith County, Tennessee. *Nautilus* 94(3):93-105.
- Pratt, W. H. 1876. List of shells at Davenport, Iowa. *Proc. Davenport Acad. Nat. Sci.* 1:1-165.
- Say, T. 1817. Article Conchology, IN: Am. Ed. of Nicholson's Encyclopedia of Arts and Sci. 1st ed.
- Say, T. 1831. Descriptions of several new species of shells and a new species of *Lumbricus*. *Transylvania Jour. Med.* 4:525-528.
- 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.
- Sickel, 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. 1900. Synopsis of the naiades, or pearly freshwater mussels. *Proc. U.S. Nat. Mus.* 22:501-1044, pl. 18.
- _____. 1914. A descriptive catalogue of the naiades, or pearly freshwater mussels. Bryant Walker, Detroit, MI. 1540 pp.
- Stansbery, D. H. 1962. The naiades recorded from the Ohio River system of North America (Mollusca:Pelecypoda:Unionacea). *Ohio State Mus. Zool. at Columbus.* 6 pp.
- _____. 1964. The Mussel (Muscle) Shoals of the Tennessee River revisited. *Am. Malacol. Union Annu. Rep:*25-28.
- _____. 1965. The molluscan fauna. IN: Prufer, O., et al. *The McGraw Site, a study in Hopewellian Dynamics.* *Cleve. Mus. Nat. Hist. Sci. Publ. (M.S.)*4(1):1-144.
- _____. 1970. Eastern freshwater mollusks. (I) The Mississippi and St. Lawrence River systems. IN: A. H. Clarke (ed.). 1970. *Rare and endangered mollusks of North America.* *Malacologia* 13:9-12.
- _____. 1972. A preliminary list of the naiad shells recovered from the Buffalo site. IN: Bettye J. Broyles, A late 17th century Indian village site (46 Pu 31) in Putnam Co., West Virginia. *Rept. of Arch. Inv. No. 5, West Virginia Geol. and Economic Survey, Morgantown, WV.*
- _____. 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.

- _____. 1974. An annotated list of the naiad mollusks of the Muskingum River in eastern Ohio (Mollusca:Bivalvia:Unionidae). Ohio State Mus. Zool. at Columbus. 4 pp.
- _____. 1976. Naiad mollusks. IN: Endangered and threatened plants and animals of Alabama. Bull. Alabama Mus. Nat. Hist. No. 2:42-52.
- _____. 1980. The naiad mollusks of the Kanawha River below Kanawha Falls with special attention to endangered species (Bivalvia:Unionida:Unionidae). Unpublished technical report. Ohio State Univ. Mus. Zool., Columbus. 16 pp.
- Starrett, W. C. 1971. A survey of the mussels (Unionacea) of the Illinois River, a polluted stream. Ill. Nat. History Survey Bull. 30 (art. 5):1-403.
- 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., USDO I (Fish and Wildlife Service), Region 3, Federal Building, Fort Snelling, Twin Cities, MN. pp. 19-25.
- Sterki, V. 1907. A preliminary catalogue of the land and freshwater mollusca of Ohio. Proc. Ohio State Acad. Sci., SP. Paper No. 12, 4(8):367-402.
- Surber, T. 1913. Notes on the natural hosts of freshwater mussels. Bull. U.S. Bur. Fish. 32, 110-116. Separately issued as Bur. Fish. Doc. No. 778.
- Taylor, R. W. 1980. A survey of the freshwater mussels of the Ohio River from Greenup lock and dam to Pittsburg, PA. A report submitted to U.S. Army Corps of Eng., Huntington, WV. pp. 1-71, 20 pls.
- _____. 1983. A survey of the freshwater mussels of the Kanawha River. Prepared for Huntington District, Corps of Eng., Huntington, WV. Contract No. DACW69-82-C-0081. 62 pp.
- _____ and R. Hughart. 1981. The freshwater naiads of Elk River, West Virginia with a comparison of earlier collections. Nautilus 95(1):21-25.
- Tennessee Valley Authority. 1976. Mussel fauna of the Cumberland River in Tennessee. September 1976. TVA unpublished data. Division of Environmental Planning, Water Quality and Ecology Branch, Muscle Shoals, AL; and the Division of Forestry, Fisheries, and Wildlife Development, Norris, TN.
- _____. 1978. Recent mollusk investigations on the Tennessee River. TVA unpublished data. Division of Environmental Planning, Water Quality and Ecology Branch, Muscle Shoals, AL. 126 pp.

- _____. 1979. An evaluation of mussel populations in the Clinch River, Tennessee and Virginia. August 1979. TVA unpublished data. Division of Water Resources, Fish. and Aquatic Ecology Branch, Norris, TN. 14 pp.
- _____. 1980. The fisheries resource of the Tennessee Valley tailwaters-Tims Ford. TVA unpublished data. Division of Water Resources, Norris, TN. 17 pp.
- _____. 1982. Report on the Clinch River Breeder Reactor (CRBR) mussel survey. TVA unpublished data. Office Nat. Res., Eastern Area Field Operations Group, Norris, TN. 10 pp.
- _____. 1983. Biological assessment of proposed U.S. Army Corps of Engineers navigation dredging and disposal on freshwater mussels at sites downstream from Cordell Hull Dam Cumberland River miles 303.8-309.2. TVA unpublished data. Office of Natural Resources and Economic Development, Knoxville, TN 17 pp.
- Utterback, W. I. 1917. Naiad geography of Missouri. Amer. Midl. Nat. 5(1):26-30.
- U.S. Fish and Wildlife Service. 1983. Recovery plan for the Higgins Eye Mussel (Lampsilis higginsii). Region 3, Twin Cities, MN. 98 pp.
- U.S. Environmental Protection Agency. 1981. Draft environmental impact statement for Mammoth Cave area, Kentucky. USEPA, Region IV, Atlanta, GA.
- van der Schalie, H. 1939. Additional notes on the naiades (freshwater mussels) of the lower Tennessee River. Am. Midl. Nat. 22(2):452-457.
- Wheeler, H. E. 1918. The mollusca of Clark County, Arkansas. Nautilus 31(4):109-125.
- Williams, J. C. 1969. Mussel fishery investigation Tennessee, Ohio, and Green Rivers. Final report. Kentucky Dept. of Fish and Wildlife Res. Proj. N. 4-19R. 107 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.
- Yokley, P., Jr. 1972. Freshwater mussel ecology, Kentucky Lake, Tennessee. Tennessee Game and Fish Comm. Proj. 4-46R. 133 pp.

KEY TO IMPLEMENTATION SCHEDULE COLUMNS 1 AND 4

General Category (Column 1):

Information Gathering - I or R (research)

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

Acquisition - A

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

Other - 0

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

Management - M

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

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.

Pink Mucket Pearly Mussel
Lampsilis orbiculata

Part III Implementation Schedule

*1 General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency *2		Estimated Fiscal Year Costs *3			Comments/Notes	
					FWS Region	Program	Other	FY 1	FY 2		FY 2
I1,2,3	Determine species' present distribution and status.	1.1	2	1 yr.	3,4,5	SE	ADCNR, ANHC, AGFC, TWRA, THP and INPC	---	---	---	<p>*1. See general categories for Implementation Schedules.</p> <p>*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.</p> <p>*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.</p>
I3	Identify essential habitat and specific areas in need of protection.	1.2	2	1 yr.	3,4,5	SE	Same as above	---	---	---	
I9,10,11,12,14	Determine specific threats faced by species.	2.1	2	1 yr.	3,4,5	SE	Same as above	---	---	---	
O2,3,4	Continue to utilize existing legislation and regulations to protect species.	2.2	1	Continuous	3,4,5	SE,LE,ES	Same as above	---	---	---	
M3,7	Develop and implement protection strategies for areas developed under Task 1.2.	2.3	2	Unknown	3,4,5	SE,ES	Same as above	---	---	---	

Pink Mucket Pearly Mussel
Lampsilis orbiculata

Part III Implementation Schedule

General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency			Estimated Fiscal Year Costs			Comments/Notes
					FWS Region	Program	Other	FY 1	FY 2	FY 3	
01	Develop and implement education programs.	3	3	Unknown	3, 4, 5	SE, ES	Same as above	---	---	---	
Abbreviations: SE - Endangered Species LE - Law Enforcement ES - Ecological Services ADCNR - Alabama Department of Conservation and Natural Resources AGFC - Arkansas Game and Fish Commission ANHC - Arkansas Natural Heritage Commission MDC - Missouri Department of Conservation MDNR - Missouri Department of Natural Resources KDFWR - Kentucky Department of Fish and Wildlife Resources KNPC - Kentucky Nature Preserves Commission TWRA - Tennessee Wildlife Resources Agency THP - Tennessee Heritage Program WVDNR - West Virginia Department of Natural Resources TVA - Tennessee Valley Authority ODNR - Ohio Department of Natural Resources IDC - Illinois Department of Conservation INPC - Illinois Nature Preserves Commission											

APPENDIX A

Table A-1: Recent records for Lampsilis orbiculata

Tennessee River - Leroy Koch (TVA-personal communication)

Date	Location	No. Specimens
1979-1981	Below Pickwick Dam (TRM 206.7)	Est. 150 fresh dead observed
1982	Below Pickwick Dam (TRM 206.7)	19 fresh dead
1982	Below Wilson Dam (TRM 259.4)	13 fresh dead
1982	Below Gunterville Dam (TRM 349.0)	11 fresh dead
July 1983	Below Wilson Dam (TRM 255.8)	3 live

Tennessee River - Steven Ahlstedt (unpublished TVA field records)

Date	Location	No. Specimens
Aug. 1980	Below Southern RR tressel (TRM 591.3)	2 live
Aug. 1981	Long Island (TRM 417-417.2)	2 live
1976	Below Watts Bar Dam (TRM 527.7-528.5)	1 live
Sept. 1983	Below Watts Bar Dam (TRM 528.8)	1 live
Sept. 1983	Below Watts Bar Dam (TRM 528.5)	1 live
Sept. 1983	Rhea Light (TRM 526.3)	1 live

Tennessee River - Pardue (1981)

Date	Location	No. Specimens
1978	TRM 518.0	Present-live
1978	TRM 518.5	Present-live
1978	TRM 520.2	Present-live
1978	TRM 520.3	Present-live
1978	TRM 520.4	Present-live
1978	TRM 520.7	Present-live
1978	TRM 521.0	Present-live
1978	TRM 521.3	Present-live
1978	TRM 525.0	Present-live
1978	TRM 527.4	Present-live
1978	TRM 528.0	Present-live
1978	TRM 528.1	Present-live
1978	TRM 588.4	Present-live
1978	TRM 592.2	Present-live

Tennessee River - James Sickel (Murray State University-personal communication)

Date	Location	No. Specimens
Aug. 1981	Haddox Ferry (TRM 12-17.0)	5 fresh dead

Tennessee River - TVA (1978)

Date	Location	No. Specimens
1978	TRM 22.0	1 live
1978	TRM 164.9	1 live
1978	TRM 170.1	2 live
1978	TRM 183.0	1 live
1978	TRM 197.0	2 live
1978	TRM 203.0	1 live
1978	TRM 203.1	1 live
1978	TRM 251.0	Present-live
1978	TRM 252.8	Present-live
1978	TRM 334.3	Present-live
1978	TRM 336.5	Present-live
1978	TRM 336.6	Present-live
1978	TRM 344.0	Present-live
1978	TRM 345.6	Present-live
1978	TRM 346.5	Present-live
1978	TRM 518.0	Present-live
1978	TRM 518.5	Present-live
1978	TRM 520.2	Present-live
1978	TRM 520.3	Present-live
1978	TRM 520.4	Present-live
1978	TRM 520.7	Present-live
1978	TRM 520.8	Present-live
1978	TRM 521.0	Present-live
1978	TRM 521.3	Present-live
1978	TRM 525.0	Present-live
1978	TRM 527.4	Present-live
1978	TRM 528.0	Present-live
1978	TRM 528.1	Present-live
1978	TRM 588.4	Present-live
1978	TRM 592.5	Present-live

Tennessee River - Yokley (1972)

Date	Location	No. Specimens
1969-1972	Below Pickwick Dam (TRM 200-205.2)	1 live
1969-1972	TRM 152-174.2	2 live

Paint Rock River, Alabama - TVA and USFWS (1983) - Charles Saylor
(unpublished TVA field record)

Date	Location	No. Specimens
July 1983	PRRM 13.0	1 fresh dead (5 years old)

Little Tennessee River, Tennessee - Steven Ahlstedt (TVA unpublished field records)

Date	Location	No. Specimens
Oct. 1979	Coytee Springs (LTRM 6.8)	1 fresh dead

Note: Now Tellico Reservoir

Clinch River - TVA (1979) - Steven Ahlstedt (TVA unpublished field records)

Date	Location	No. Specimens
Aug. 1979	Brooks Island (CRM 184.5)	1 fresh dead

Clinch River, Tennessee - TVA (1982) - Charles Saylor (TVA unpublished field records)

Date	Location	No. Specimens
June 1982	Below Melton Hill Dam (CRM 19.1)	1 live

Cumberland River - Leroy Koch (personal communication)

Date	Location	No. Specimens
July 1982	CRM 275-281	11 live
1983	CRM 272-297.7	110 live

Cumberland River - Parmalee et al. (1980)

Date	Location	No. Specimens
Sept. 1979	Bartletts Bar (CRM 296.8)	2 live

Note: 150-200 fresh dead specimens observed in cull piles.

Cumberland River - TVA (1983)

Date	Location	No. Specimens
Sept. 1983	CRM 307.6-308.1	1 live
Sept. 1983	CRM 307.4	1 live
Sept. 1983	CRM 307.0	3 live
Sept. 1983	CRM 306.2-306.5	1 live
Sept. 1983	CRM 305.3-305.5	3 live
Sept. 1983	CRM 305.3	3 live

Cumberland River - TVA (1976)

Date	Location	No. Specimens
Sept. 1976	Mussel Cook-Out Camp (CRM 270)	Undetermined number of specimens observed
Sept. 1976	Griffin Landing (CRM 275.4)	1 live
Sept. 1976	Cotton Bar (CRM 283.0)	3 live
Sept. 1976	Cotton Bar (CRM 284.3)	3 live
Sept. 1976	Below Rome Island (CRM 291.1)	1 live
Sept. 1976	Below Rome Island (CRM 293.0)	Undetermined number of specimens observed
Sept. 1976	Below Rome Island (CRM 293.1)	2 live
Sept. 1976	Above Bartletts Island (CRM 296.8)	3 live
Sept. 1976	Bartletts Bar (CRM 297.0)	3 live
Sept. 1976	Rowlands Towhead (CRM 302.8)	2 live
Sept. 1976	Carters Island (CRM 305.3)	2 live

Lower Ohio River - Leroy Koch and Jeffrey Pardue (personal communication)

Date	Location	No. Specimens
July 1980	I-24 Bridge (ORM 940.7)	1 fresh dead
July 1980	Mussel Boat (ORM 944.2)	2 fresh dead

Green River, Kentucky - USEPA (1981)

Date	Location	No. Specimens
1981	At Lock 5 (Butler County, Kentucky)	Unknown

Green River, Kentucky - Kentucky Nature Preserves Commission Record (Sam Call record)

Date	Location	No. Specimens
Oct. 1980	Below U.S. Lock Number 5	2 fresh dead

Kanawha River, West Virginia - Clarke (1982)

Date	Location	No. Specimens
Sept. 1982	Below Kanawha Falls (KRM 95.1-94.5)	3 live

Kanawha River, West Virginia - Taylor (1983)

Date	Location	No. Specimens
Sept.-Nov. 1982	Below Kanawha Falls (KRM 94.7)	1 live
Sept.-Nov. 1982	Below Kanawha Falls (KRM 92.8)	1 live
Sept.-Nov. 1982	Below Kanawha Falls (KRM 92.5)	2 live
Sept.-Nov. 1982	Below Kanawha Falls (KRM 91.8)	2 live
Sept.-Nov. 1982	Below Kanawha Falls (KRM 91.0)	4 live

Kanawha River, West Virginia - David Stansbery (Ohio State University-1980 personal communication)

Date	Location	No. Specimens
Aug. 1969	Below Kanawha Falls	1½ dry shells
Sept. 1969	Below Kanawha Falls	1 dry shell
Oct. 1970	Below Kanawha Falls	1 dry shell
Nov. 1976	Below Kanawha Falls	1 live
Oct. 1979	Below Kanawha Falls	1 live

Osage River, Missouri - Grace and Buchanan (1981), Ron Oesch (personal communication)

Date	Location	No. Specimens
June-Sept. 1980	ORM 80.8	1/2 weathered dead
Sept. 1980	ORM 66.6	1 live
June 1980	ORM 65.0	1 live
June 1980	ORM 57.4	2 live
July 1980	ORM 46.1	1 live, 1 subfossil
July-Aug. 1980	ORM 40.5	1 live, 2½ subfossil
Aug. 1980	ORM 37.0	½ subfossil
Aug. 1980	ORM 26.9	1 live, 2 weathered dead, 5 subfossil
Aug. 1980	ORM 23.7	1½ weathered dead, ½ subfossil
Aug. 1980	ORM 22.2	2 subfossil
Aug. 1980	ORM 21.5	4 live, 2 weathered dead, 5 subfossil
Aug. 1980	ORM 17.6	3 live, 4½ weathered dead, 2 subfossil
Aug.-Sept. 1980	ORM 13.6	2 live, 9 weathered dead, 2 subfossil
Sept. 1980	ORM 10.3	2½ weathered dead
Sept. 1980	ORM 5.6	1 dead, 1 weathered dead

Osage River, Missouri - Ron Oesch (personal communication)

Date	Location	No. Specimens
Sept. 1972	Bagnell Dam to Miller County Line	1 live
Feb. 1978	ORM 11	1 live

Meramec River, Missouri - Buchanan (1980), Ron Oesch (personal communication)

Date	Location	No. Specimens
1978	MRM 4.9	1 live
1978	MRM 6.9	1 live
1978	MRM 10.5	1 live
1978	MRM 17.5	1 subfossil
1978	MRM 21.5	1 live
1978	MRM 23.8	1 subfossil
1978	MRM 28.4	1 live
1978	MRM 33.5	1 live
1978	MRM 37.7	1 live
1978	MRM 39.8	1 live
1978	MRM 48.8	1 live
1978	MRM 54.4	1 live

Meramec River, Missouri - Ron Oesch (personal communication)

Date	Location	No. Specimens
Aug. 1967	Above Highway 141 Bridge	1 live
Aug. 1968	Above Bald Creek Road	1 live
Aug. 1969	Highway D to Times Beach	1 relict
Apr. 1970	Below Sappington Bridge	3 fresh valves
June 1971	Above Highway 185 Bridge	1 live
May 1972	At the Aboretum	2 live, 4 valves
Aug. 1972	At the Aboretum	2 relict
May 1976	Highway D to Highway 44	3 relict
Aug. 1977	At Highway 44 Bridge	1 live
July 1978	Daniel Boone Camp	1 live
Sept. 1978	One Mile Above Highway 21 Bridge	1 live

Big River, Missouri - Buchanan (1980), Ron Oesch (personal communication)

Date	Location	No. Specimens
1978	BRM 4.8	1 subfossil

Black River, Missouri - Buchanan (1980), Ron Oesch (personal communication)

Date	Location	No. Specimens
Aug. 1976	At Leeper	1 live
July 1971	Markham Spring Rec. Area	1 live

Little Black River, Missouri - Buchanan (1979)

Date	Location	No. Specimens
Aug. 1979	LBRM 9.1 (Ripley County)	Live specimens observed

Gasconade River, Missouri - Dr. David Stansbery (OSUM)

Date	Location	No. Specimens
Sept. 1964	Gasconade County, Missouri	1 live
Aug. 1971	Gasconade County, Missouri	3 live

Gasconade River, Missouri - Ron Oesch (personal communication)

Date	Location	No. Specimens
Nov. 1970	Near Mt. Sterling	2 live

Current River, Arkansas - Buchanan (personal communication)

Date	Location	No. Specimens
Oct. 1982	At Bridge 2.8 miles west of Success	1 live

Spring River, Arkansas - Alan Buchanan (personal communication)

Date	Location	No. Specimens
Sept. 1983	Highway 58 one-half mile SW of Williford, Sharp County	1 live

Appendix B
List of Reviewers

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

Mr. Martin E. Rivers
Environmental Quality Staff
Tennessee Valley Authority
Room 201, Summer Place Building
Knoxville, Tennessee 37902

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

Mr. Chuck Cook
The Nature Conservancy
Post Office Box 3017
Nashville, Tennessee 37219

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

Director
Kentucky Nature Preserves Commission
407 Broadway
Frankfort, Kentucky 40601

Mr. Bob McCance, Coordinator
Ohio Department of Natural Resources
Division of Natural Areas and
Preserves
Building F, Fountain Square
Columbus, Ohio 43224

Dr. James Henry Wilson
Endangered Species Coordinator
Missouri Department of Conservation
Post Office Box 180
Jefferson City, Missouri 65102

Mr. Steven H. Cole, Chief
Division of Wildlife
Department of Natural Resources
Building C, Fountain Square
Columbus, Ohio 43224

Mr. Keith Guyse
Wildlife Section
Alabama Department of Conservation
and Natural Resources
64 North Union Street
Montgomery, Alabama 36130

Mr. Sam Barkley
Endangered Species Biologist
Arkansas Game and Fish Commission
#2 Natural Resources Drive
Little Rock, Arkansas 72205

Mr. Harold E. Alexander
Endangered Species Coordinator
Arkansas Game and Fish Commission
#2 Natural Resources Drive
Little Rock, Arkansas 72205

Dr. Devere E. Burt, Chairman
Endangered Species and Populations
Committee
Ohio Biological Survey
Director, Cincinnati Museum of
Natural History
1720 Gilbert Avenue
Cincinnati, Ohio 45202

Mr. Peter E. Zurbuch
Assistant Chief
Wildlife Resources
Department of Natural Resources
Post Office Box 67
Elkins, West Virginia 26241

Mr. Michael Sweet
Endangered Species Program
Coordinator
Department of Conservation
Division of Forest Resources and
Natural Heritage
524 South Second
Lincoln Tower Plaza
Springfield, Illinois 62706

Mr. Fred Lafser, Director
Department of Natural Resources
P.O. Box 176
Jefferson City, Missouri 65102

Mr. John McGregor
Kentucky Department of Fish and
Wildlife Resources
#1 Game Farm Road
Frankfort, Kentucky 40601

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

Mr. Steve N. Wilson, Director
Game and Fish Commission
#1 Natural Resources Drive
Little Rock, Arkansas 72205

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. 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 Mrs. Wayne C. Starnes
TVA Forestry Building
Norris, Tennessee 37828

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

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

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 Ave., North
Nashville, Tennessee 37219

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

Mr. D.W. Yambert
Nongame Biologist
Tennessee Wildlife Resources Agency
Route 3, Box 153-A
Talbot, Tennessee 37203

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

Dr. Tom 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. 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

Mr. David Kenney, Director
Department of Conservation
Lincoln Tower Plaza
524 South Second Street
Springfield, Illinois 62706

Mr. Frank H. Beal, Director
Institute of Natural Resources
Division of Environmental Management
309 West Washington Street
Chicago, Illinois 60606

Ms. Mary Lou Marzuki, Chairman
Nature Preserves Commission
320 South Third Street
Rockford, Illinois 61108

Mr. Paul G. Risser, Chief
State Natural History Survey Division
172 Natural Resources Building
607 East Peabody Drive
Champaign, Illinois 61820

Mr. Carl E. Kays, Commissioner
Department of Fish
and Wildlife Resources
#1 Game Farm Road
Frankfort, Kentucky 40601

Ms. Jackie Swigart, Secretary
Department of Natural Resources
and Environmental Protection
5th Floor, Capital Plaza Tower
Frankfort, Kentucky 40601

Mr. Larry R. Gale, Director
Department of Conservation
P.O. Box 180
Jefferson City, Missouri 65102

Mr. David C. Callaghan, Director
Department of Natural Resources
1800 Washington Street, East
Charleston, West Virginia 25305

Regional Director
U.S. Fish and Wildlife Services
Twin Cities Regional Office
Federal Building, Fort Snelling
Twin Cities, Minnesota 55111

Mr. John Saxon, Chairman
Department of Pollution Control
and Ecology
8001 National Drive
P.O. Box 9583
Little Rock, Arkansas 72219

Ms. Susan Brenholts, Director
Department of Arkansas Natural
and Cultural Heritage
Continental Building, Suite 500
Main and Markham
Little Rock, Arkansas 72201

Mr. Harold K. Grimmett
Executive Director
Natural Heritage Commission
Continental Building, Suite 500
Main and Markham
Little Rock, Arkansas 72201

