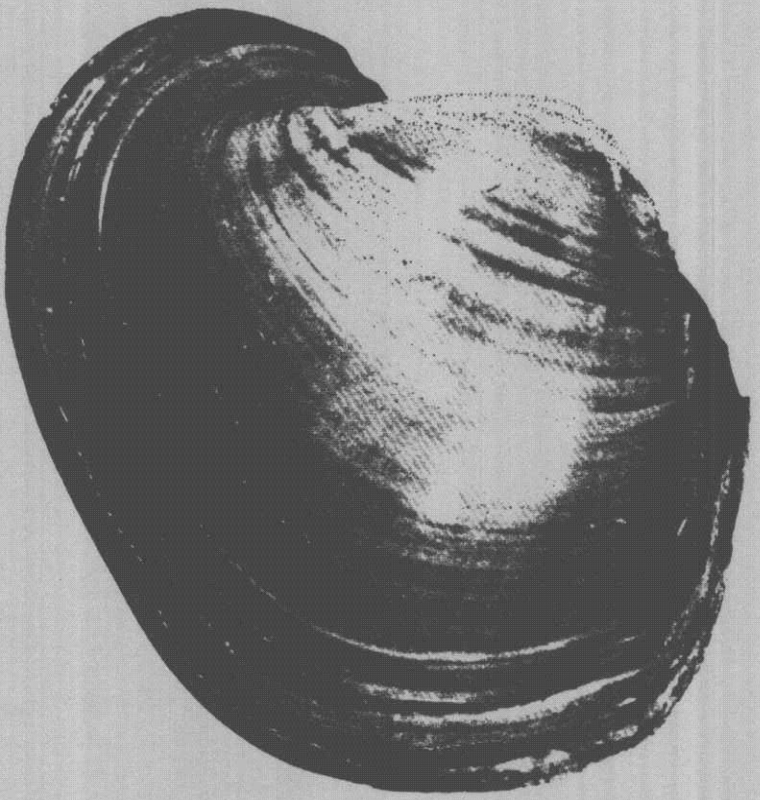
Fat Pocketbook Pearly Mussel



RECOVERY PLAN

A RECOVERY PLAN FOR THE FAT POCKETBOOK PEARLY MUSSEL
Potamilus capax (Green 1832)

Prepared By
Sally D. Dennis
Ecological Consultants, Inc.
Shawsville, Virginia 24162
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Revised By
James H. Stewart
U.S. Fish and Wildlife Service

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

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

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

Literature citation should read as follows:

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EXECUTIVE SUMMARY

Current Status: The fat pocketbook is known to exist in approximately 200 miles of the St. Francis River system, including the Floodway and associated drainage ditches; the lower Wabash River, Indiana; the mouth of the Cumberland River, Kentucky; and the Mississippi River, Missouri. Over 2,000 individuals were transplanted from the St. Francis Floodway to the Mississippi River by the Missouri Department of Conservation in 1989 to augment that population in an effort to restore viability. Fresh dead shells have been collected from the Ohio River in Kentucky. The historic records of this species from the Green River, Kentucky, remain as questionable. The only known viable population of the fat pocketbook is in the St. Francis Floodway, Arkansas.

Goal: Protection of the St. Francis populations and location or reestablishment of two viable populations in two river systems outside the St. Francis River system will qualify this species for downlisting. The goal for delisting has not been identified.

Recovery Criteria: Recovery of this species to a level for downlisting to threatened status is dependent upon protection of the populations in the St. Francis River system and the location or reestablishment of two viable populations in two rivers outside the St. Francis.

Actions Needed:

(1) Preserve existing populations in St. Francis River system.

(2) Determine if viable populations exist outside the St. Francis River.

(3) Conduct life history studies of this species.

(4) Establish two populations outside the St. Francis River, if necessary.

(5) Develop an educational program.

TABLE OF CONTENTS

Part I: Introduction

Background

Potamilus capax was described by Green in 1832 as Unio capax. The same year, it was described by Lea as Symphynota globosa. Since Green's description preceded that of Lea by several months, the name capax is accepted for this species. It was subsequently placed in the genus Lampsilis by Smith (1899) and moved to the genus Proptera by Ortmann (1914). The genus Proptera was described by Rafinesque in 1819, with P. alata given as the type. Morrison (1969) pointed out an earlier Rafinesque description for this genus, Potamilus Rafinesque (1818), suggesting that this previously overlooked name replace Proptera Rafinesque (1819). Clarke (1986) provided further documentation for the use of Potamilus rather than Proptera. Turgeon et al. (1988) use Potamilus as the generic name in their effort to bring some consistency to mollusk nomenclature. This species was listed as endangered in 1976 (41 FR 24064).

Description

The original description of P. capax given by Green (1832) is cited in its entirety below:

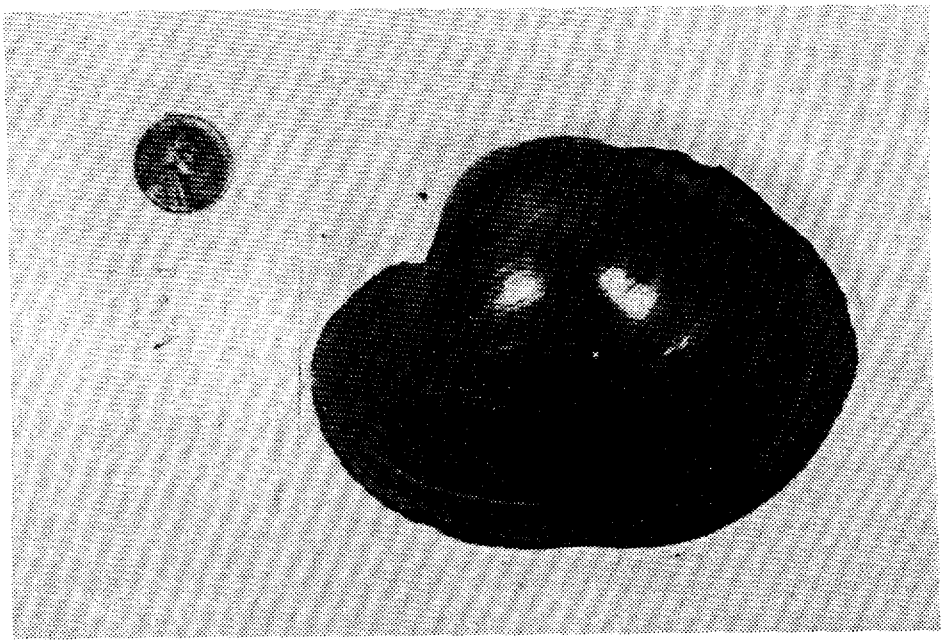
The valves of this shell are much more convex or globose than any of the uniones which I have seen; and as they are quite thin compared with most of the western species, the cavity in which the animal is lodged is exceedingly capacious -- hence its name. The anterior end is broad, rounded, and slightly angular near the hinge; the posterior margin is very narrow, and also rounded; these valves do not close perfectly on each other, but gape at the opposite margins; this is more remarkable in old than in young individuals. The epidermis is smooth, yellowish, and frequently clouded with brown. The nacre is bluish white, and often very beautifully iridescent. The beaks are recurved over the tegument. The teeth resemble very much those of the U. ovatus of Mr. Say, but they are much thinner. These characters, I think, will be sufficient to distinguish the Unio capax from every other shell.

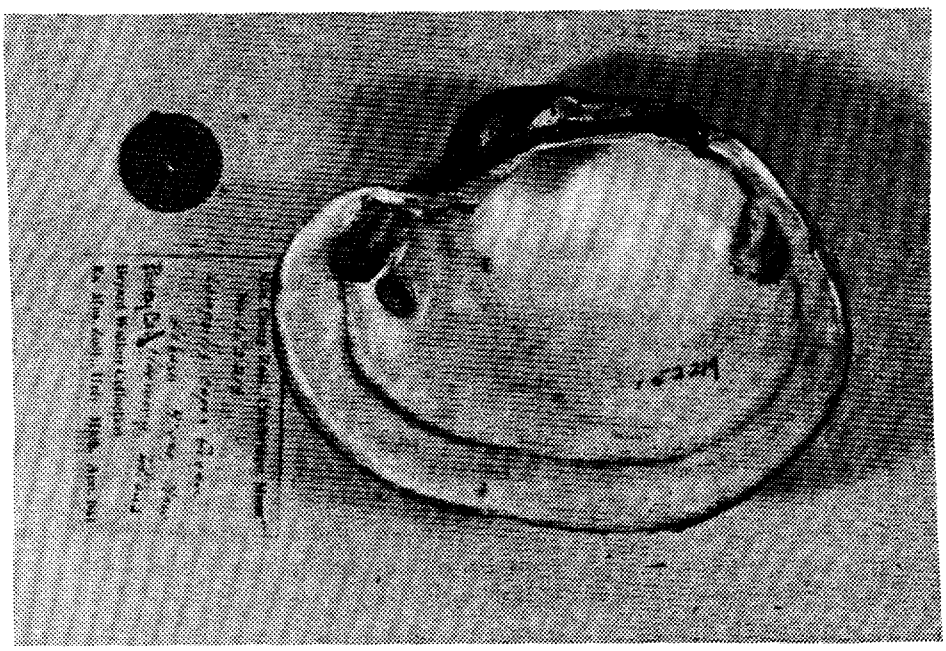
Potamilus capax superficially resembles the more widespread Lampsilis ovata, with which it is occasionally confused. It is distinguished from L. ovata by its shiny yellow to brown epidermis and absence of rays. The strong S-curve of the hinge line and the absence of pronounced sexual dimorphism in shell characters further distinguishes this species. Potamilus capax is illustrated in Plate I.

The type locality given for P. capax (Green 1832) was the Falls of St. Anthony (Mississippi River, Minnesota), and Bayou Teche (Louisiana). The Bayou Teche record is most likely an error; Frierson (1927) suggested that this record was probably Lampsilis satur. Johnson (1980) noted that the Falls of St. Anthony type specimen has been lost and that the Bayou Teche type was in error. The type locality given by Lea for Symphynota globosa was the Ohio River, 150 miles below Louisville, Kentucky.

PLATE I

POTAMILUS CAPAX





Distribution

Historic (prior to 1970)

There are few published distribution records for P. capax. Most of the knowledge of this species' past distribution is based on museum collections. Bates and Dennis (1983) compiled a list of museum records which indicates the historic range of this species. From their findings, most P. capax records appear to be from three areas, the upper Mississippi River (above St. Louis, Missouri); the Wabash River, Indiana; and the St. Francis River, Arkansas. Museums with specimens of P. capax include the University of Michigan Museum of Zoology, Ann Arbor, Michigan; Ohio State University Museum of Zoology, Columbus, Ohio; the United States National Museum, Washington, D.C.; Carnegie Museum, Pittsburgh, Pennsylvania; Harvard University Museum of Comparative Zoology, Cambridge, Massachusetts; and the Academy of Natural Sciences, Philadelphia, Pennsylvania.

In a treatment of the Mollusca of Wisconsin, Baker (1928) reported P. capax only from the Mississippi River in that state, commenting that it was rare above Davenport, Iowa. Van der Schalie and van der Schalie (1950) reported Potamilus capax from the Mississippi River between Wabash, Minnesota and Grafton, Missouri (a reach of more than 500 miles), based on collections made by Ellis in 1931. The authors stated (p. 457) that P. capax was a species "with a wide range but seldom occurring in large numbers." It was most abundant at Hannibal, Missouri. Utterback (1917) in surveying the State of Missouri, reported P. capax only from the Mississippi and Des Moines Rivers.

Published records of P. capax from the Wabash River, Indiana, include Call (1895 and 1900) and Goodrich and van der Schalie (1944). Call (1900) stated that P. capax was "by no means a common shell in Indiana," known only from two large streams, the Ohio and Wabash Rivers. Goodrich and van der Schalie (1944, p. 261) reported P. capax as occurring in a "zone of influx" (the river reach from Grand Chains to the mouth) with species associated with the Ohio River, not typically part of the Wabash drainage.

Two records from the St. Lawrence River system are reported by Johnson (1980) based on specimens on deposit in the Buffalo Museum of Science (originally reported by Robertson and Blakeslee, 1948). Information as to the number and condition of the specimens was vague. Johnson (1980; 180) figures P. capax with a photograph of a broken specimen labeled Niagara River, Buffalo, Erie County, N.Y. with the caption "Collected by Elizabeth Letson, 1906, with the note 'only one I ever found', Buffalo Museum of Science". The occurrence of P. capax in this drainage has not been confirmed by recent collections.

There are a few historic records of Potamilus capax from the Illinois River; however, this species has not been found there in recent years. P. capax was reported from the upper Illinois River by Calkins (1874). Danglade (1914) reported taking it from the lower Illinois River, but did not find it in the upper river. Starrett (1971) did not find P. capax in

the Illinois River during his 1966 survey, and suggested that the species probably disappeared from the upper river before 1900 and from the lower river before 1920.

Recent (since 1970)

Efforts to collect P. capax have accelerated during the 1980's with renewed interest by the U.S. Army Corps of Engineers to conduct maintenance dredging in the St. Francis Floodway and by mussel surveys in the Ohio, Cumberland, and Wabash Rivers (Figure 1). P. capax is now known to exist in the St. Francis Floodway (west of the flood control levee) from the confluence with the St. Francis River (east of the flood control levee) upstream to the confluence of Iron Mines Creek, in Iron Mines Creek and the Right Hand Chute of Little River upstream to Big Lake National Wildlife Refuge, and in numerous drainage ditches associated with these streams in Arkansas. Two live individuals were found in Belle Fountain drainage ditch, a secondary tributary to the Right Hand Chute, in Missouri. It has also been found in the St. Francis River, Arkansas, in an approximately 15 river mile reach below the Marked Tree siphon and in that reach downstream of the confluence with the Floodway (Jenkinson and Ahlstedt 1988).

P. capax has also been collected in the lower Wabash River, Indiana, and in the lower Cumberland River, Kentucky. In the lower Wabash River, nine live specimens were collected. Both juveniles and adults were present, indicating that recruitment has occurred during the past 3 or 4 years (Cummings et. al. 1987). Mussel diversity and abundance was low in this reach and the viability of this population of P. capax is yet to be determined. A search of the upper and middle Wabash River and the Little Wabash River failed to collect P. capax (Cummings et al. 1988, 1989).

Two live individuals of P. capax were found in the Cumberland River near the confluence with the Ohio River in 1987 (Sickel 1987). One was a gravid female as evidenced by the expulsion of a glutinate while being held in a container of river water. Both of these individuals were photographed and returned to the river. The Kentucky State Nature Preserves Commission personnel collected specimens of P. capax from the Ohio River between river mile 848 and 937.8 during 1987-1988 (R. Hannan in litt. 1989). All were dead shells with 1 2/2 listed as fresh dead.

One live-collected specimen taken from the White River, Indiana, is on deposit in the Ohio State Museum of Zoology. Records of one live and three freshly dead specimens of P. capax from the White River, Mile 30.2, Indiana, (collected by C. Burner and R. Glesne, Nov. 4, 1976) were confirmed in a letter from D. Stansbery to Marc Imlay (Nov. 29, 1976).

A number of workers have reported on the mussel fauna of the upper Mississippi River in recent years (Fuller 1978, Thiel 1981). Shells of P. capax estimated to be no more than two years old were collected from the Mississippi River in 1986 (L. Koch, Missouri Department of Conservation, personal communication 1988). There have been no reports of living specimens of this species from the Mississippi River although it is apparent a small population continues to exist.

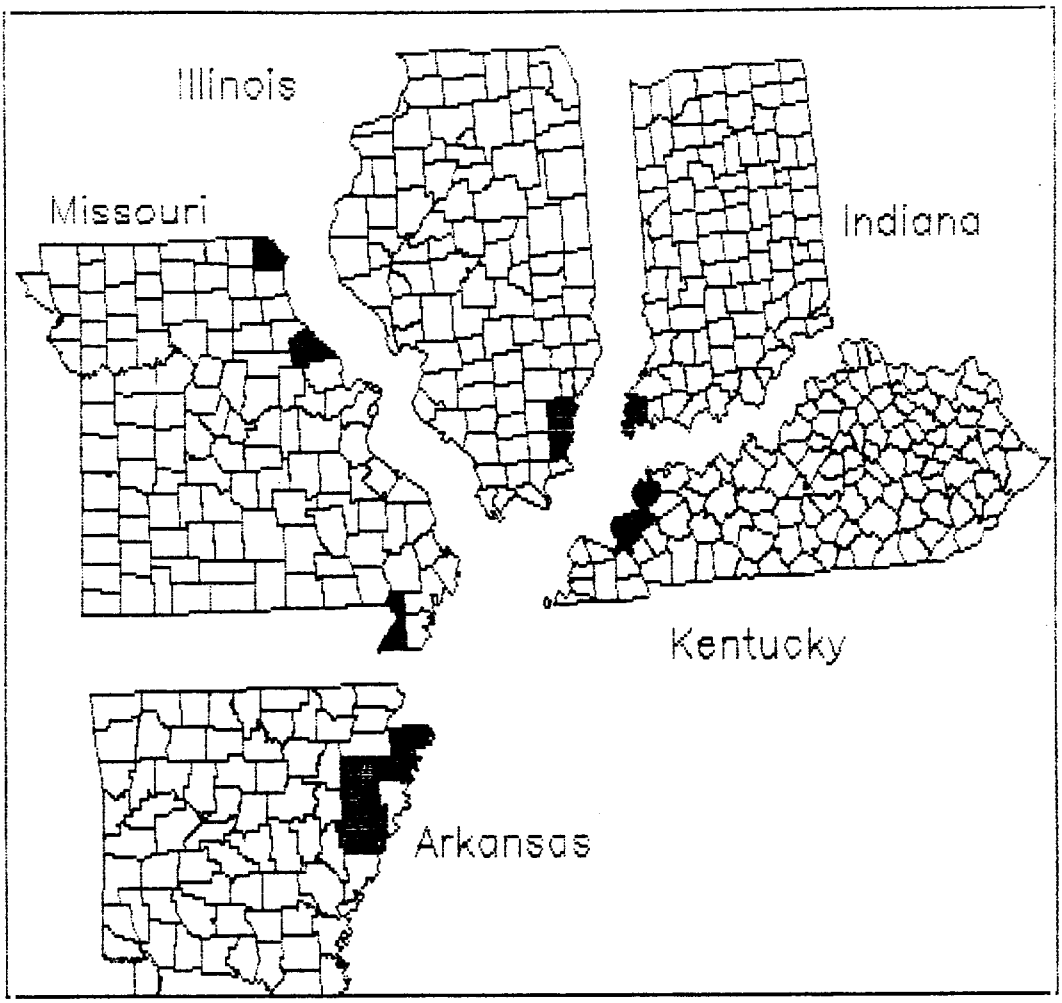


Figure 1. Present range of Potamilus capax

Based on the available data, the only known viable population of P. capax exists in the St. Francis River system, Arkansas. However, there is reason to believe that viable populations may also exist in the Wabash, Ohio, or Cumberland Rivers or some of their tributaries.

Other, unverified records:

Williams (1969) reported P. capax from the Green River, Kentucky, indicating that identification of the specimens was confirmed by Dr. David Stansbery. These records cannot, however, be confirmed by specimens on deposit in the Ohio State Museum of Zoology. As reported by Bates and Dennis (1983), in a synoptic set of shells left at Murray State University (by J. Williams), Proptera purpurata was incorrectly labeled Proptera capax. According to the Kentucky State Nature Preserves Commission (R. Hannan in litt. 1989), there are several small specimens of P. capax that were collected by Bartlett from the "Green River" in an unnumbered collection at the Harvard University Museum of Comparative Zoology. They tentatively lend credence to the specimens of P. capax reported from the Green River by Williams (1969). Some of the mussels collected by Williams were curated at the Ohio State University Museum of Zoology, but P. capax was not among them (D. Stansbery in litt. 1989). The validity of P. capax records from the Green River remains in question. Murray and Leonard (1962) incorrectly figured Proptera purpurata as Proptera capax in their handbook of Unionidae of Kansas. This discounts the only record of P. capax from the Neosho River, Kansas. A record by Branson (1963) from a "strip-pit" in the Verdigris River drainage, Oklahoma, is also most likely in error. As Johnson (1980; p. 129) pointed out: "The single male shell (no longer available) reported ... by Branson (1963: 510) as Capax, was probably also P. purpurata. P. capax does not exhibit sexual dimorphism."

Ecology and Life History

There is conflicting information in the literature regarding the habitat preference of Potamilus capax. Branson's probably erroneous (1963) record of P. capax from the strip-pit in Oklahoma has been cited by others, such as Fuller (1978), as indication that P. capax prefers lentic water. This conclusion is not supported by other collection records. Parmalee (1967) reported P. capax from sand and mud bottoms, in flowing water a few inches to more than eight feet in depth. Bates and Dennis (1983) found P. capax in sand, mud, and fine gravel substrates in the St. Francis River, Arkansas. Clarke (1985) reported this species primarily from sand substrates in the St. Francis River, Arkansas. Jenkinson and Ahlstedt (1988) reported P. capax from the full range of habitat types, including shifting sand and flocculent mud, to hard clay and gravel. According to their findings, the most likely habitat is a mixture of sand, silt and clay. Examination of museum records indicates that P. capax is a large river species which requires flowing water and stable substrate.

The life cycle of Potamilus capax is unknown; however, it most likely is similar to that of other members of the Unionidae. Specifically, reproductive anatomy is similar to other members of the sub-family Lampsilinae, discussed by Ortmann (1912). The "axe-head" glochidium,

figured by Coker and Surber (1911) provided the basis for moving this species to the genus Proptera, from Lampsilis (Ortmann 1914). Potamilus capax is probably a long-term breeder (bradytictic), and is reported gravid in June, July, August and October (Surber 1912, Ortmann 1914).

While the fish host of P. capax is unknown, it is probably a large river species. Fish hosts given for other members of this genus include: Aplodinotes grunniens (freshwater drum) for P. alata, P. purpurata and P. ohiensis and Pomoxis annularis (white crappie) and Fundulus notatus (blackstripe topminnow) for P. ohiensis, based on the work of Coker and Surber (1911), Surber (1913), Howard (1913, 1914), Wilson (1916) and Neves (1989 pers. comm.).

Reasons for Decline

Channelization and Impoundment

The greatest impact on the habitat of Potamilus capax throughout its historic range has been from activities related to navigation and flood control. Channel maintenance dredging has been particularly destructive. As a large river species requiring lotic conditions, P. capax is especially vulnerable to such perturbations.

The upper Mississippi River has been impounded for navigation and is dredged routinely to maintain a 9-foot navigation channel. Potamilus capax, once widespread in this river, has disappeared in recent years even from areas where other species (including the endangered species Lampsilis higginsi) continue to exist.

Impoundment for navigation purposes is not always detrimental to mussel populations. While some habitat is made unsuitable for riverine species, river reaches immediately below dams are often enhanced for mussel habitation. In many rivers, productive mussel beds have been found immediately below navigation dams (Isom 1969, Bates 1970, Dennis 1984). Danglade (1914) reported finding P. capax in the Illinois River "more frequently below locks and dams where the water was swifter."

The absence of P. capax in the upper Mississippi River may indicate that it is particularly sensitive to the impacts of dredging. Dredging is deleterious to freshwater mussels in a number of ways. The most apparent is the actual removal of mussels and their habitat by the cutter head of the dredge. Long-term dredging for channel maintenance generally results in shifting sand substrate over large reaches of river bottom. Once the substrate is disturbed by dredging, there is continuous erosion and deposition of fine materials resulting in accumulations of loose, unstable material downstream. Few freshwater mussels are adapted to live in this habitat. In addition to these direct effects, alterations in flow patterns resulting from the dredging may affect distribution or behavior patterns of fish species which act as hosts. Such a change could drastically reduce reproductive success of the mussel species dependent upon these fish.

The presence of P. capax in dredged portions of the St. Francis Floodway indicates a recolonization of the channelized river reaches. These findings, however, do not confirm that P. capax can continue to reproduce in channelized portions of the St. Francis River. It is possible that fish infected with glochidia in the shoal reaches are carrying the young mussels upstream. Until the life history of P. capax is known, the importance of the shoal areas to recruitment cannot be determined.

Dredging in the St. Francis basin has been primarily for the purpose of irrigation and flood control. Drastic changes in the watershed have resulted in loss of much of the original river channel and its associated mussel fauna. The occurrence of P. capax in the St. Francis River below the Marked Tree siphon is likely dependent upon the population in the St. Francis Floodway and the passage of glochidia-infected fish through the siphons. The stabilization of habitat in drainage ditches and an apparent migratory fish host seems to have enabled P. capax to colonize the habitat created by the Corps of Engineers' flood control efforts.

Bates and Dennis (1983) reported that much of the substrate of the White River, Arkansas, now consists of shifting sand bars. The only stable substrate left in these areas is found along the bank where some undredged mud ledges remain. Potamilus capax has not been reported from this river in recent surveys. A similar situation was reported by Clark (1976) who noted an abundance of shifting sand in the Wabash River, Indiana. Clark (1976) suggested that maintenance dredging was responsible for reductions in the mussel fauna of this river.

Siltation

Siltation has long been associated with reductions in freshwater mussel assemblages. Bartsch (1916) noted effects of heavy siltation on mussels when he described the Missouri River as a faunal barrier due to its heavy load of mud and silt. Coker (1914) predicted the demise of riverine mussel species in favor of a "river-lake" fauna due to the accumulation of silt following impoundment of the Mississippi River. Ellis (1931, 1936) documented deleterious effects of erosion silt on freshwater mussel populations in the Tennessee, Ohio, and Mississippi Rivers where he noted the smothering effect of silt that settled out behind obstructions in the rivers. Ellis (1936) presented field and laboratory data on effects of suspended silt, noting that .25 to 1 inch of deposited silt caused high mortality in mussels. He speculated that in high concentrations, silt interfered with feeding of freshwater mussels.

Most reports of siltation effects are based on observation and inference with little actual supporting data. Scruggs (1960) reported dead mussels in place in the substrate in silted areas of Chickamauga Reservoir (Tennessee River) and noted that recruitment in the commercial species Pleurobema cordatum declined steadily in Wheeler Reservoir following impoundment. He attributed both these observations to effects of siltation. Bates (1962) also reported effects of siltation resulting from impoundment on mussel stocks of Kentucky Lake, Tennessee River.

Negus (1966) observed that young mussels were found only in sand and gravel substrates in the Thames River, never in silt.

More recent reports on this topic are contradictory and confusing. A study by Coon, Eckblad and Trygstad (1977) attributed recent decline in mussels of the Mississippi River to siltation from channel maintenance dredging, while a study by Fuller (1978) stated that such dredging has little adverse affect on mussels in the Mississippi River.

Suspended silt, due primarily to erosion, appears to be increasing as mussel resources decline. This has been observed throughout the Mississippi River drainage (Ellis 1936, Thiel 1981) and particularly the Tennessee River system (Isom 1969, Bates and Dennis 1978, Dennis 1981). While it has been demonstrated that heavy silt deposition, such as occurs behind riverine impoundments, has a smothering effect on mussels (Scruggs 1960, Bates 1962, Isom 1969), the effects of suspended silt are not well documented. Mechanisms most often suggested in the literature involve interference with respiration and/or feeding due to the clogging of gills with silt. Ellis (1936) observed that heavy concentrations of suspended silt caused excessive mucous secretions in freshwater mussels. He proposed that silt interfered with feeding in mussels by causing them to remain closed much of the time and that silt could suffocate mussels by clogging gills. In field and laboratory studies on the effects of suspended silt on freshwater mussels, Dennis (1984) reported that suspended silt in high concentrations interferes with uptake of food and concluded that silt may be an important limiting factor to freshwater mussel distribution.

Pollution

Although the effects of pollution on freshwater mussels have been documented, there are few data available on tolerance limits of freshwater mussels to specific pollutants. A summary of the literature on this topic by Fuller (1978) indicates that most work in this area has dealt with heavy metal concentration by mussels, such as Foster and Bates (1978), with little data on other pollutants. Havlik and Marking (1987) conducted a review of the effects of contaminants on mollusks. Their review included a large number of metals, pesticides and pollutants. The effects of non-point source pollutants have been poorly addressed, primarily due to the complexity and magnitude of this problem.

Effects of pollution on Potamilus capax within its present range cannot be addressed with reliability since the primary source of such influence is from agricultural run-off. The identity and concentration of pollutants from this non-point source varies widely and cannot be predicted.

Part II: Recovery

A. Recovery Objectives:

The objective of this recovery plan is to restore Potamilus capax to non-endangered status by conserving the remaining populations and reestablishing viable* populations within its known geographic range.

The objective of this recovery plan is to reclassify P. capax from endangered status to threatened status when:

(1) The existing population in the St. Francis Floodway and the tributary streams and ditches is protected from habitat modification; and

(2) At least two viable populations are located (or established and protected) in two other river systems within the historic range of P. capax, including the upper Mississippi River, the White or Wabash Rivers in Indiana, or others.

B. Narrative Outline:

1. Preserve existing P. capax population and habitat in the St. Francis Floodway and St. Francis River in Arkansas. This species occurs from near the mouth of the St. Francis River upstream to the Marked Tree siphon, in Iron Mines Creek and the Right Hand Chute of Little River upstream to Big Lake National Wildlife Refuge, in the Straight Slough drainage system of the Floodway, and in other drainage ditches tributary to the Floodway. In addition, it has been found in approximately a 15-mile stretch of the St. Francis River below the Marked Tree siphon and in Belle Fountain Ditch in Missouri.

   1.1 Use existing legislation to protect the St. Francis River system where P. capax occurs. Work with the U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, the State of Arkansas, and local authorities to assure protection of the known populations of P. capax.

   1.2 Institute a monitoring program to ensure viability of existing populations. Develop and initiate a monitoring program at selected sites in the St. Francis Floodway near Madison, in Straight Slough, and in the Right Hand Chute of Little River to gather data on population trends and to ensure the population does not decline from preventable impacts. Monitoring should occur at not more than 3-year intervals.

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* A viable population is a reproducing population large enough to maintain sufficient genetic variation to provide for response to natural habitat changes. The size of this population will be defined as part of the recovery plan.

2. Determine if viable populations exist outside the St. Francis River system. Live specimens of P. capax were collected from the lower Wabash River, Indiana, and from the mouth of the Cumberland River, Kentucky, in 1987. Suitable habitat in these rivers should be surveyed to determine the presence of P. capax and, if present, a determination of whether or not the population is viable should be made.

2.1 Conduct a survey of the Wabash, Little Wabash, and White Rivers in Indiana for existing populations. A survey of the lower Wabash River in 1987 found five specimens of P. capax, all downstream of the confluence of the White River, a tributary (Cummings et al. 1987). A survey of the upper and middle Wabash River and the Little Wabash River in 1988 did not find any shells or live P. capax (Cummings et al. 1988, 1989). The species may exist in the White River. These streams should be intensively surveyed for the occurrence of P. capax using SCUBA when mussels are found and the water depth is more than 5 feet deep.

2.2 Conduct a survey of the Ohio River for existing populations. This species is likely to still exist in the Ohio River. This is evidenced by the occurrence of P. capax in the mouth of the Cumberland River (Sickel 1987). It has not been found or reported from more upstream reaches of the Cumberland River. An intensive search of the Ohio River, especially between the Wabash and Cumberland Rivers is warranted. The use of SCUBA to search mussel beds where water depth is over 5 feet is recommended.

2.3 Conduct a survey of the Mississippi River in the vicinity of Hannibal, Missouri, for existing populations. Seven valves of P. capax were collected from the Mississippi River in 1986 (L. Koch, Missouri Department of Conservation, pers. comm. 1988). While it is difficult to document how long these individuals have been dead, it is estimated to be no longer than 2 years. To augment this apparent population of P. capax, the Missouri Department of Conservation, with the cooperation of the Memphis District Corps of Engineers and Tennessee Valley Authority, transplanted over 2,000 P. capax to two sites on the Mississippi River in 1989. All mussels were marked and will be monitored to determine the success of this project. Further survey to determine the extent of the existing population is also needed.

2.4 Determine if any population found in tasks 2.1, 2.2, or 2.3 is viable. When P. capax is encountered in the previously-mentioned surveys, all individuals should be measured and, if possible, their ages estimated to form a basis for recruitment trends. An estimate of mussel density by species to provide for future population trend determinations is desirable. Follow-up monitoring at not more

than 3-year intervals to establish trends over a minimum of a 10-year period will be used to determine viability where possible.

3. Conduct life history studies of P. capax. Recovery of this species can only be accomplished when we know the life history requirements, including the fish host(s), reproductive periods, and habitat requirements for juvenile forms.

   3.1 Determine the fish host(s) and their habitat requirements. ~~Protection of the fish host(s) and their required habitat~~ is necessary for the survival and recovery of this species. Fish species that serve as hosts for closely related species and fish species which share the same natural distribution and habitat preference as P. capax should be selected as likely candidates for this task. Following selection of these likely host species, it will be necessary to artificially infect them with glochidia and determine if they encyst and develop into juvenile mussels. Successful replicate experiments should be achieved to ensure the host identification is accurate. Once the fish host is identified, the habitat requirements of the host must be determined and that habitat must be protected to ensure continued survival of P. capax.

   3.2 Determine the age of P. capax at sexual maturity and the period of gravidity. ~~The age of P. capax at sexual maturity~~ and the period of gravidity are important in assessing the potential impacts to the species and the rate at which this species may recover from impacts. It is obvious that P. capax can tolerate some habitat disturbance and recover. It is important that we know the time period required for recovery. To determine this, we must know the age of sexual maturity, the time and duration of the spawning cycle, and when fertilization occurs.

   3.3 Determine the habitat requirements and life history characteristics of the juvenile mussels. Once other life history characteristics are determined, the habitat of the juvenile mussels should be determined. Adult mussels are frequently capable of withstanding an environmental disturbance that results in the death of juveniles. This task will seek to determine the habitat requirements of juveniles.

4. Establish two populations outside the St. Francis River system by transplant if these populations do not already exist. ~~The relocation of P. capax from the obviously good St. Francis~~ population to other sites within the historic range to meet the recovery objective will occur, if necessary. This transplant will be accomplished unless the existence of viable populations has been documented within the historic range. The occurrence of small populations or of fresh dead shells will be used as an indication that requirements for the survival of this species are present.

Relocation of this species to areas where there is no current evidence of this species or outside the known historic range will require more detailed study of the site as discussed in Part I of this plan.

5. Develop an educational program. For the St. Francis basin and other places where P. capax may exist, a program will be developed and implemented to inform the various interests of the importance of maintaining genetic diversity and of the value of mussels as environmental indicators of habitat quality.

Literature Cited

Baker, F.C. 1928. Freshwater mollusca of Wisconsin. Part II. Pelecypoda. Bull. of Wis. Geol. and Nat. Hist. Survey. 70(2):1-495. pls. 29-105.

Bartsch. P. 1916. The Missouri River as a faunal barrier. The Nautilus, 30:92.

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

Bates, J.M. 1970. Ohio mussel fisheries investigation, final report. Part I, mussels. U.S. Bureau of Commercial Fish. Contract no. 14-17-004-433, pp. 1-107.

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

Bates, J.M. and S.D. Dennis. 1983. Mussel (Naiad) survey--St. Francis, White, and Cache Rivers, Arkansas and Missouri. Final report. Prepared for U.S. Army Corps of Engineers, Memphis Dist. DACW66-78-C0147. 89 pp. Append. A-E, 57 pp., 5 pls.

Branson, D.A. 1963. New mollusk records from Oklahoma and their zoogeographical significance. Trans. Kansas Acad. Sci. 66(3):501-512.

Calkins, W.W. 1874. The land and freshwater shells of LaSalle Co., III. Ottawa Academy of Nat. Sci., Proc. 48 pp.

Call, R.E. 1895. A study of the Unionidae of Arkansas, with incidental references to their distribution in the Mississippi Valley. Trans. Acad. Sci. St. Louis 7(1):1-65, pls. 1-21.

Call, R.E. 1900. A descriptive illustrated catalogue of the mollusca of Indiana. Twenty-Fourth Annual Report of the Indiana Dept. of Geol. and Nat. Res., 1899, pp. 335-1017, pls. 1-78.

Clark, C.F. 1976. The freshwater naiades of the lower end of the Wabash River, Mt. Carmel, Illinois, to the south. Sterkiana. 61:1-14.

Clarke, A.H. 1985. Mussel (Naiad) study; St. Francis and White Rivers; Cross, St. Francis, and Monroe Counties, Arkansas. Department of the Army, Memphis District, Corps of Engineers, Memphis, Tennessee (Order No. 84M 1666R). 28 pp. and appendices.

Clarke, A.H. 1986. Potamilus Rafinesque (1818) versus Proptera Rafinesque (1819) (Unionidae). Malacology Data Net 1(3):58-65.

Coker, R.E. 1914. Water-Power development in relation to fishes and mussels of the Mississippi River. Bureau Fish. Doc. No. 805., Dept. of Commerce, Bur. Fisheries, Washington, D.C.

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

Coon, T.G., J.W. Eckblad, and P.M. Trygstad. 1977. Relative abundance and growth of mussels (Mollusca:Eulamellibrachia) in pools 8, 9, and 10 of the Mississippi River. Freshwater Biology, 7:279-285.

Cummings, K.S., C.A. Mayer, L.M. Page, J.M.K. Berlocher. 1987. Survey of the Freshwater Mussels (Mollusca:Unionidae) of the Wabash River Drainage Phase 1: Lower Wabash & Tippecanoe Rivers. A report to Indiana Department of Natural Resources. 60 pp. + appendices.

Cummings, K.S., C.A. Mayer, and L.M. Page. 1988. Survey of the Freshwater Mussels (Mollusca:Unionidae) of the Wabash River Drainage Phase II: Upper and Middle Wabash River. A report to the Indiana Department of Natural Resources. 47 pp. + appendix.

Cummings, K.S., C.A. Mayer, and L.M. Page. 1989. Survey of the Freshwater Mussels (Bivalvia:Unionidae) in the Little Wabash River Drainage, Illinois. A report to the Illinois Department of Conservation. 37 pp. + appendix.

Danglade, E. 1914. The mussel resources of the Illinois River. U.S. Bur. Fish., Appendix 6 to Report of U.S. Comm. of Fish. for 1913. 48 pp.

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

Dennis, S.D. 1984. Distributional analysis of the freshwater mussels of the Tennessee River system, with special reference to possible limiting effects of siltation. Doctoral Dissertation, VPI & SU, Blacksburg, VA. 171 pp.

Ellis, M.M. 1931. Some factors affecting replacement of the commercial freshwater mussels. U.S. Dept. of Commerce, Bureau of Fisheries. Circ. No. 7.

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

Foster, R.B. and J.M. Bates. 1978. Use of freshwater mussels to monitor point source industrial discharges. Environmental Science & Technology 12(8):958-962.

Frierson, L.S. 1927. A classified and annotated check list of the North American Naiades. Baylor U. Press. 111 pp.

Fuller, S.L.H. 1978. Freshwater mussels (Mollusca:Bivalvia:Unionidae) of the Upper Mississippi River: observations at selected sites within the 9 ft. channel navigation project on behalf of the U.S. Army Corps of Engineers. Academy of Nat. Sci., Phila., PA. 401 pp.

Goodrich, C. and H. van der Schalie. 1944. A revision of the mollusca of Indiana. Am. Midl. Nat. 32(2): 257-326.

Green, J. 1832. Untitled Note. Cabinet of Nat. Hist. and Amer. Rural Sports 2:290.

Havlik, M.E. and L.L. Marking. 1987. Effects of contaminants on naiad mollusks (Unionidae): a review. U.S. Dept. Interior, Washington, D.C. 20 pp.

Howard, A.D. 1913. The catfish as a host for freshwater mussels. Trans. Am. Fish. Soc. 42:65-70.

Howard, A.D. 1914. Experiments in propagation of freshwater mussels of the Quadrula group. Rept. U.S. Comm. Fish. for 1913, Appendix IV, pp. 1-52. Bur. Fish. Doc. No. 801.

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

Jenkinson, J.J. and S.A. Ahlstedt. 1988. A search for additional populations of Potamilus capax in the St. Francis and Cache River watersheds, Arkansas and Missouri. A report to the U.S. Army Corps of Engineers, Memphis TN. 104 pp. and appendices.

Johnson, R.I. 1980. Zoogeography of North American Unioniacea (Mollusca:Bivalvia) north of the maximum pleistocene glaciation. Bull. Mus. Comp. Zool. 149(2):77-189.

Morrison, J.P.E. 1969. The earliest names for North American Naiades. Ann. Rep. Amer. Mal. Union for 1969, pp. 22-24.

Murray, H.D. and A.B. Leonard. 1962. Handbook of Unionid Mussels in Kansas. Univ. of Kansas Mus. Nat. Hist., Misc. Pub. No. 28:1-84, pls. 1-45.

Negus, C.L. 1966. A quantitative study of growth and production of Unionid mussels in the River Thames at Reading. J. Animal Ecol., 35:513-532.

Ortmann, A.E. 1912. Notes upon the families and genera of the Naiades. Annals of the Carnegie Museum, Pittsburgh, 8(2):222-665.

Ortmann, A.E. 1914. Untitled Note. Nautilus, 28:67.

Parmalee, P.W. 1967. The freshwater mussels of Illinois. III. State Mus., Popular Sci. Series 8. 108 pp.

Rafinesque, C.S. 1819. Proptera. JI. Phys. Chim. Hist. Nat., 88:426.

Robertson, I.C.S. and C.L. Blakeslee. 1948. The Mollusca of the Niagara frontier region. Bull. Buffalo Soc. Nat. Sci 19(3):i-ix, 1-191.

Scruggs, G. 1960. Status of freshwater mussel stocks in the Tennessee River. U.S. Fish and Wildl. Serv. Spec. Sci. Rep., Fisheries, 370:1-41.

Sickel, J.B. 1987. Preliminary Survey for Endangered Freshwater Mussels at Cumberland Island Towhead, Confluence of the Cumberland and Ohio Rivers, Livingston County, Kentucky. Report to Donan Engineering, Inc. 9 pp.

Smith H.M. 1899. Lampsilis capax. Bull. U.S. Fish. Comm. pp. 291, pl 84.

Starrett, W.C. 1971. A survey of the mussels (Unionacea) of the Illinois River: a polluted stream. Ill. Nat. Hist. Survey Bull. 30(5):267-403.

Surber, T. 1912. Identification of the glochidia of freshwater mussels. U.S. Bur. Fisheries Doc. 771, pp. 1-10, pls. 1-3.

Surber, T. 1913. Notes on the natural hosts of freshwater mussels. Bull. U.S. Bur. Fish. 32:110-116.

Thiel, Pamella A. 1981. A survey of Unionid mussels in the upper Mississippi River (Pools 3 through 11). Technical Bull. No. 124, Dept. of Nat. Resources, Madison, Wisconsin. 24 pp.

Turgeon, D.D., A.E. Bogan, E.V. Coan, W.K. Emerson, W.G. Lyons, W.L. Pratt, C.F.E. Rober, A. Scheltema, F.G. Thompson, and J.D. Williams. 1988. Common and scientific names of aquatic invertebrates from the United States and Canada: Mollusks. American Fisheries Society Publication 16. pp 32.

Utterback, W.I. 1917. Naiad geography of Missouri. Am. Midl. Nat. 5:26-30.

van der Schalie, H. and A. van der Schalie. 1950. The mussels of the Mississippi River. Amer. Midl. Nat., 44:448-466.

Williams, J.C. 1969. Mussel fishery investigation Tennessee, Ohio and Green Rivers final report. Kentucky Dept. of Fish. and Wildlife Resources, Frankfort, Kentucky, 107 pp.

Wilson, C.B. 1916. Copepod parasites of freshwater fishes and their economic relations to mussel glochidia. Bull. U.S. Bur. Fish. 34:331-374.

PART III

KEY TO IMPLEMENTATION SCHEDULE COLUMNS 1 & 4

General Category (Column 1):

Information Gathering - I or R (research)

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

Acquisition - A

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

Other - O

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

Management - M

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

Priority (Column 4):

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

2 - An action that must be taken to prevent a significant decline in species population/habitat quality, or some other significant negative impact short of extinction.

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

IMPLEMENTATION SCHEDULE

General Category	Plan Task	Task Number	Priority	Task Duration	Region	Division	Other	FY 1	FY 2	FY 3	Comments/ Notes
M-3	Use existing legislation to protect the St. Francis system where P. capax occurs.	1.1	1	Continuous	4	FWE	COE AGF EPA				
I-1	Institute a monitoring program to ensure viability of existing population.	1.2	1	3 year intervals	4	FWE	COE AGF	15,000			
I-1	Conduct a survey of the Wabash, Little Wabash, and White Rivers in Indiana for existing populations.	2.1	3	3 years	3, 4	FWE	IDNR	75,000	75,000	75,000	
I-1	Conduct a survey of the Ohio River for existing populations.	2.2	3	3 years	3, 4	FWE	IDNR KNPC	75,000	75,000	75,000	
I-1	Conduct a survey of the Mississippi River in the vicinity of Hannibal, Missouri, for existing populations.	2.3	3	3 years	3	FWE	MDC	75,000	75,000	75,000	
I-1	Determine if new populations are viable.	2.4	3	10 years	3, 4	FWE	AGF, MDC IDNR, KNPC, COE	100,000	100,000	100,000	

IMPLEMENTATION SCHEDULE

General Category	Plan Task	Task Number	Priority	Task Duration	Region	Division	Other	FY 1	FY 2	FY 3	Comments/ Notes
I-14	Determine the fish host(s) and their habitat requirements.	3.1	2	2 years	4	FWE	COE, AGF	150,000	150,000		
I-14	Determine the age of P. capax a sexual maturity and the period of gravidity.	3.2	2	2 years	4	FWE	COE, AGF	50,000	50,000		
I-14	Determine the habitat requirements and life history characteristics of the juvenile mussels.	3.3	2	5 years	4	FWE	COE, AGF	100,000	100,000	100,000	
O-1	Develop an educational program.	5	3	3 years	4	FWE	AGF	25,000	25,000	25,000	

FWE - FWS Fish and Wildlife Enhancement
EPA - U.S. Environmental Protection Agency
COE - U.S. Army Corps of Engineers
AGF - Arkansas Game and Fish Commission
MDC - Missouri Department of Conservation
IDAR - Indiana Department of Natural Resources
KNPC - Kentucky Nature Preserves Commission

PART IV: APPENDIX

List of Reviewers

Mr. Steven A. Ahlstedt
Tennessee Valley Authority
Division of Water Resources
Norris, TN 37828

Arkansas Natural Heritage Commission
The Heritage Center, Suite 200
225 East Markham
Little Rock, AR 72201

Field Supervisor
U.S. Fish and Wildlife Service
100 Otis Street, Room 224
Asheville, NC 28801

Mr. John M. Bates
Ecological Consultants, Inc.
Box 402
Shawsville, VA 24162

Mr. Sam Barkley
AR Game and Fish Commission
2 Natural Resources Drive
Little Rock, AR 72205

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

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

Dr. Arthur H. Clarke
Ecosearch, Inc.
325 E. Bayview
Portland, TX 78374

Dr. John Jenkinson
Tennessee Valley Authority
Division of Water Resources
Norris, TN 37828

Dr. Mark Gordon
392 Shannon Drive, Box D
Cookeville, TN 38501

Indiana Dept. of Natural Resources
608 State Office Building
Indianapolis, IN 46204

Dr. Richard Johnson
Museum of Comparative Zoology
Harvard University
Cambridge, MA 02138

Mr. Leroy Koch
MO Dept. of Conservation
323 S. Main Street
Palmyra, MO 63461

Dr. Cornelius Weber
Environmental Protection Agency
6985 Moorfield Drive
Cincinnati, OH 45230

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

Mr. Kevin Cummings
Illinois Natural History Survey
607 E. Peabody Drive
Champaigne, IL 61820

Mr. Ron Cicerello
KY Nature Preserve Commission
407 Broadway
Frankfort, KY 40601

Dr. Morris Mauney
U.S. Army Corps of Engineers
B-201 Clifford Davis Federal Bldg.
Memphis, TN 38103

Missouri Dept. of Conservation
Post Office Box 180
Jefferson City, MO 65102

Dr. Richard J. Neves
VA Cooperative Fishery Unit
106 Cheatam Hall
VA Polytechnic Institute
and State University
Blacksburg, VA 24061

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

Dr. James B. Sickel
Department of Biology
Murray State University
Murray, KY 42071