RECOVERY PLAN

FAT POCKETBOOK PEARLY MUSSEL

Potamilus (=Proptera) capax

A RECOVERY PLAN FOR THE FAT POCKETBOOK PEARLY MUSSEL

Potamilus (=*Proptera*) *capax* (Green, 1832)

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For

U.S. Fish and Wildlife Service
Region 4
Atlanta, Georgia

Approved: [signature]
Associate Director, U.S. Fish and Wildlife Service

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Disclaimer

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PART I

INTRODUCTION

Potamilus (=*Proptera*) *capax*, hereafter referred to as *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) where it has remained. 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 1819, suggesting that this previously overlooked name replace *Proptera* Rafinesque (1819). Several workers in the field have adopted this designation. Johnson (1980, p.128) comments on this issue as follows, "As no question of priority of authorship is involved, the resurrection of *Potamilus* appears nugatory". He suggests that the name *Proptera* be maintained in accordance with the "50 year Rule" of the International Commission on Zoological Nomenclature (1974) pending a ruling on the nomenclature of this species by the Commission. Until this issue is resolved, the genus *Potamilus* under which this species was listed as endangered (*Federal Register* 41:24064, June 14, 1976), will be used in this recovery plan.

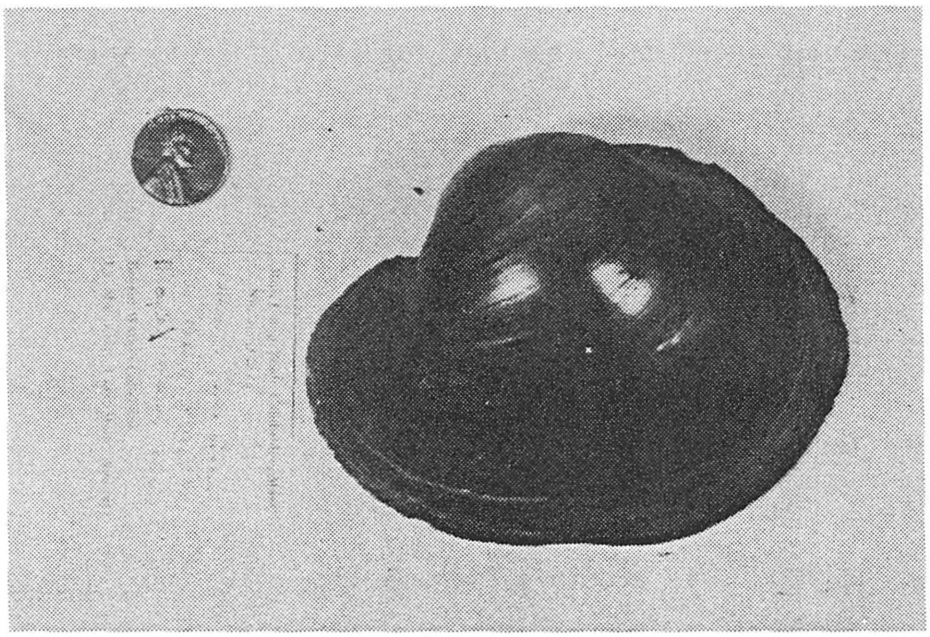
The original description of *P. capax* given by Green (1832) is cited in its entirety below:

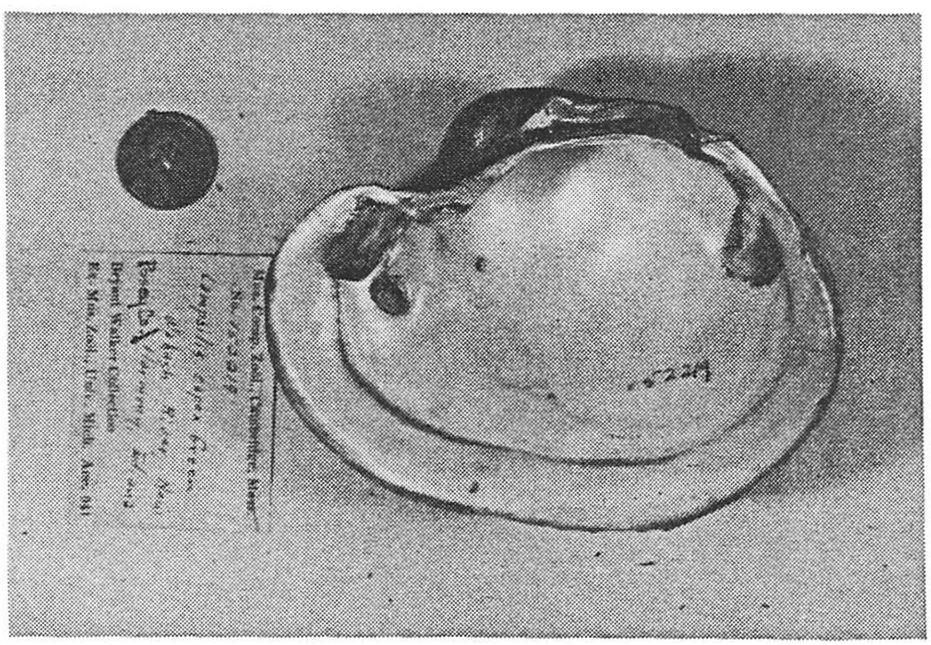
> The valves of this shell are much more convex or globose than any of the uniones which I have seen; and as they are quite thin compared with most of the western species, the cavity in which the animal is lodged is exceedingly *capacious* -- hence its name. The anterior end is broad, rounded, and slightly 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.

PLATE I

POTAMILUS CAPAX





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 Ohio River, 150 miles below Louisville, Kentucky.

DISTRIBUTION

Historic (prior to 1970)

There are few published distribution records for *P. capax*. Most of our knowledge of this species' past distribution is based on museum collections. Appendix A is a compilation of museum records, adapted from Bates and Dennis (1983), which indicates the historic range of *P. capax*. Except where indicated, the species identifications have been verified. In many historic collections date and locality data are often incomplete; however, most *P. capax* records appear to be from three areas, the upper Mississippi River (above St. Louis, MO), the Wabash River, Indiana, and the St. Francis River, Arkansas.

Figure 1 presents the historic distribution records for *P. capax* within the St. Francis and White River drainages in Arkansas and Missouri.

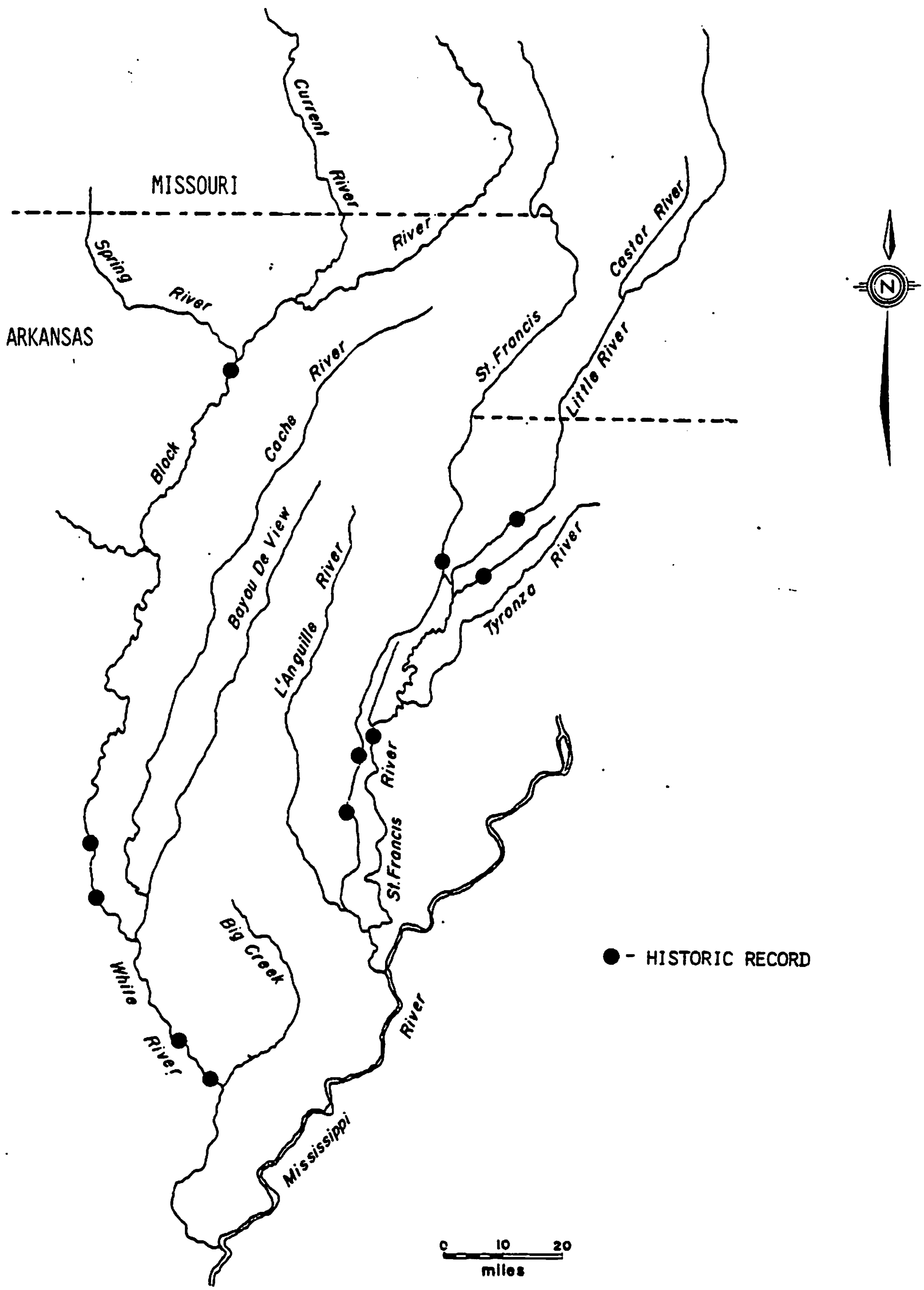


FIGURE 1. HISTORICAL DISTRIBUTION OF *POTAMILIS CAPAX* IN THE ST. FRANCIS AND WHITE RIVER DRAINAGES, ARKANSAS AND MISSOURI.

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 Wabasha, Minnesota and Grafton, Missouri (a reach of more than 500 miles), [by H. and A. van der Schalie (1950)] 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. Distribution records for P. capax in the Wabash River, Indiana are illustrated in Figure 2.

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

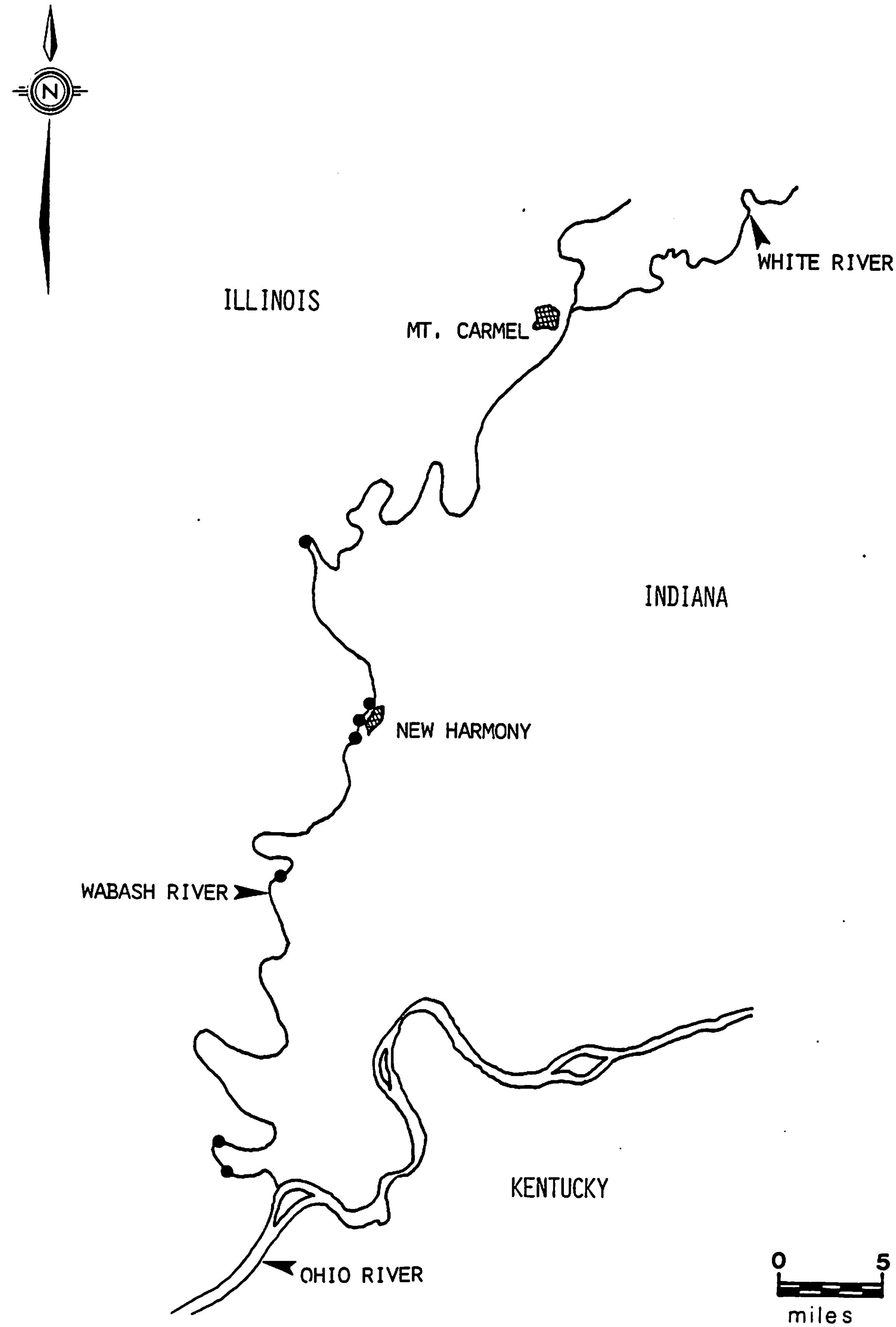


FIGURE 2. DISTRIBUTION RECORDS FOR POTAMILIS CAPAX IN THE LOWER WABASH RIVER, INDIANA AND ILLINOIS.

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)

Recent records of P. capax are few. Figure 3 shows the area of the St. Francis River, Arkansas, which currently supports populations of P. capax. Since collecting within this reach has been very comprehensive, no attempt is made here to identify individual sites. Specimens of P. capax have been reported throughout the areas designated on the map as regions A and B.

The St. Francis River has been divided into two separate drainages by construction of a series of ditches and levees. As indicated in Figure 3, the area presently supporting P. capax populations is part of the

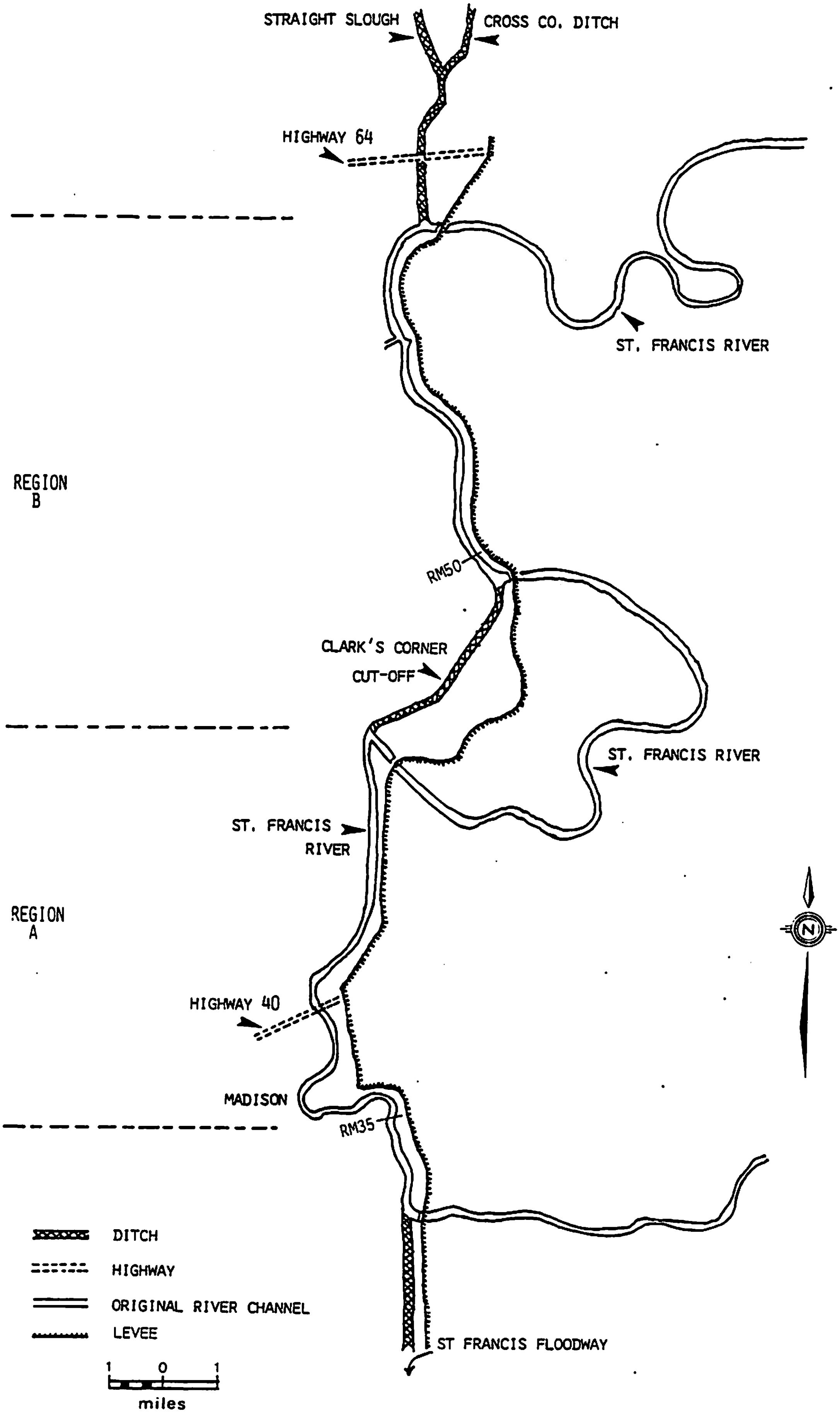


FIGURE 3. LOCATION OF <u>POTAMILIS</u> <u>CAPAX</u> HABITAT IN THE ST. FRANCIS RIVER, ARKANSAS

western drainage. The portions of the St. Francis River lying to the east of the levee no longer support P. capax (Bates and Dennis, 1983).

Region A is the last remaining reach of the St. Francis River which has not been dredged. The substrate here is generally stable and consists of a series of shoal areas and islands. Potamilus capax were reported by Bates and Dennis (1983) as relatively abundant within this reach when it was sampled in 1979-1980. Clarke (1984) confirmed the occurrance of P. capax within this river reach in his 1984 survey.

Region B includes a portion of the original St. Francis River channel which has been subjected to channelization and a ditch (Clark's Corner cut-off) which cuts off a portion of the river channel. At the time of initiation of the Bates, Dennis survey, active dredging was going on in the area of Clark's Corner Cut-off. Clark (1984) reported finding P. capax distributed throughout region B, but noted that their abundance here was half that found in region A. Age class data reported by Clark (1984) indicate that the majority of mussels found in this region were 5 years old or less.

The St. Francis River population is presently the only verified population of this species remaining. Clark (1976) reported taking 2 specimens of P. capax from the Wabash River, Indiana in 1975. David Stansbery (personal communication) reported finding a few freshly dead shells of P. capax in the Wabash River above New Harmony, Indiana, during a survey for a proposed pipeline crossing (approx. 1976). These shells could have washed into the area from the Wabash or White Rivers. 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).

While a number of workers have reported on the mussel fauna of the upper Mississippi River in recent years (Fuller, 1978; Thiel, 1981) there have been no reports of living specimens of Potamilus capax from this river. Relic shells are occasionally reported (Freitag, 1978; Pogge and Schneider, 1980), but these are primarily from dredge spoils and cannot be considered as recent records.

It appears, based on the most current data that the last remaining confirmed population of Potamilus capax exists in the St. Francis River, near Madison, Arkansas.

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. Since P. capax has not been reported before, or since, from the Green River, the 1969 records are considered to be in error. A similar error was made by Murray and Leonard (1962) who 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; 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 habitat preference of Potamilus capax. Branson's probably erroneous (1963) record of P. capax from a strip pit in Oklahoma has been cited by others, e.g. 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 (1984) reported this species primarily from sand substrates in the St. Francis River, Arkansas. 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 (see Figure 4). 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), 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 *Proptera* (=*Leptodea*) *laevissima* and *Pomoxis annularis* (white crappie) for *P.* (=*Leptodea*) *laevissima*, based on the work of Coker and Surber (1911), Surber (1913), Howard (1913, 1914) and Wilson (1916).

REASONS FOR DECLINE

1. 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.

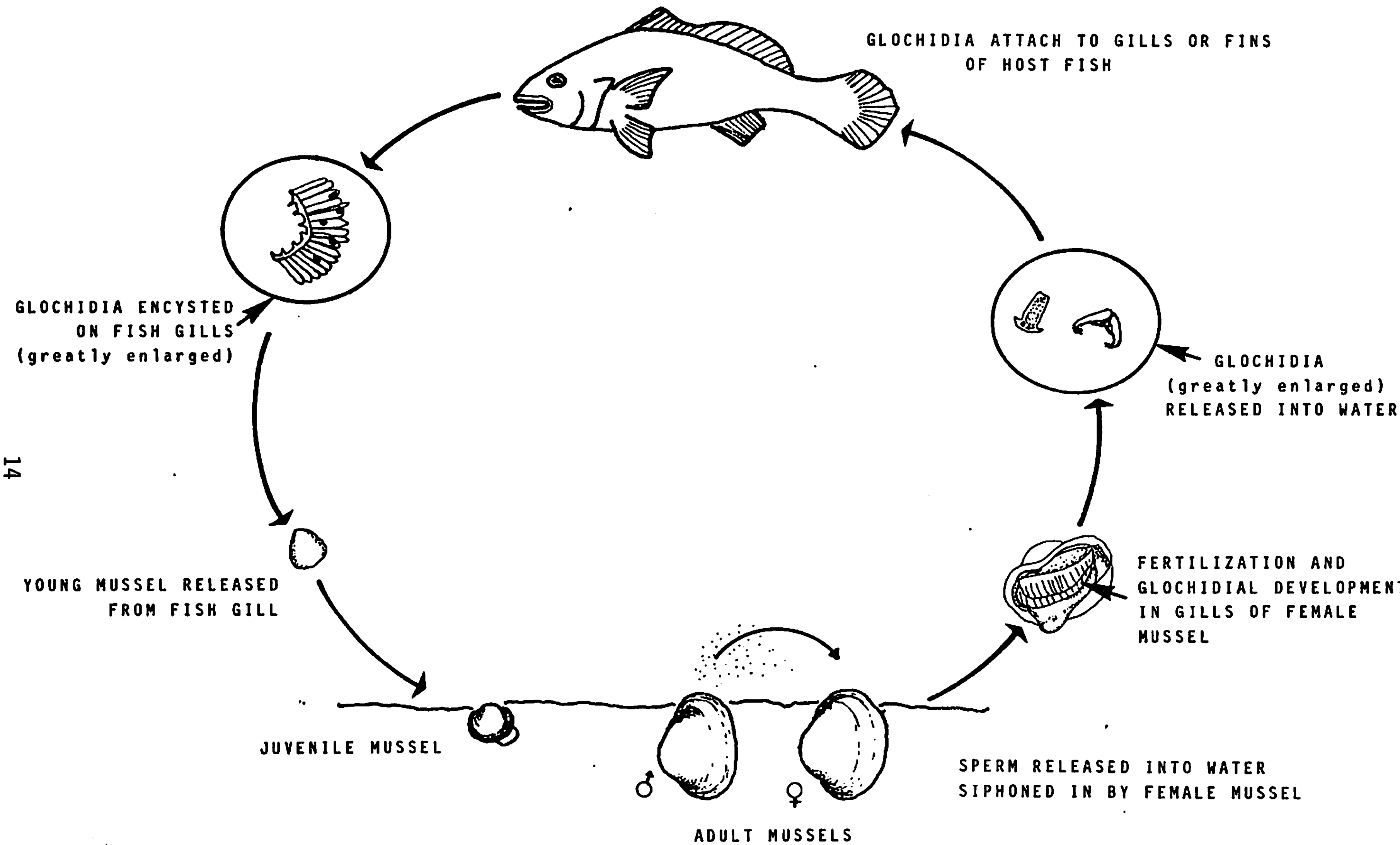


FIGURE 4. LIFE CYCLE OF A TYPICAL FRESHWATER MUSSEL

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 region B of the St. Francis River (Figure 3), a dredged portion of the river discussed above, seems to indicate a recolonization of the channelized river reaches by P. capax. 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 of region A to recruitment in region B cannot be determined.

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 is found along the bank where some undredged mud ledges remain. Potamilus capax was not 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.

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. With the exception of the river reach above Madison, Arkansas, most of the historic range of _P. capax_ in this basin no longer supports mussel communities.

2. 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 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. Dennis (1984) reported results of field and laboratory studies on the effects of suspended silt on freshwater mussels. She 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.

3. Pollution

Although 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 (e.g. Foster and Bates, 1978) with little data on other 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 re-establishing viable* populations within its known geographic range.

The present status of P. capax is particularly precarious because the only documented living population of this species may be in immediate danger. The habitat supporting this species is proposed for channel maintenance dredging by the Army Corps of Engineers, and dredging was in progress when discovery of specimens of P. capax in the dredge spoil area resulted in cessation of this activity pending consultation with the Fish and Wildlife Service (Bates and Dennis, 1983). Since the river channel has been dredged immediately above and below the mussel bed at Madison, Arkansas, this reach now constitutes a constriction in the river. Extensive channelization of the drainage basin above this reach increases flow of water (and subsequent flooding) during periods of high water.

* viable population = 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.

Unless a recovery program is initiated, this habitat may be eliminated due to activities already accomplished, even if no further dredging is undertaken. Additionally, public pressure from local landowners to dredge this river reach is very high due to the impact of flooding on agricultural industries.

Recovery objectives for downlisting the species from endangered to threatened status will be met when:

1. The existing population inhabiting the St. Francis River between Madison, Arkansas and the Highway 64 bridge is protected;

2. At least two other viable populations are established and protected in the St. Francis River basin at sufficient distance apart that the same impact is unlikely to affect all populations; and

3. 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 (above St. Louis), the White or Wabash Rivers, Indiana or others.

B. Stepdown Outline:

1. Preserve existing P. capax population and habitat in the St. Francis River in the vicinity of Madison, Arkansas.

1.1 Use existing legislation and cooperation of Federal, State, and local authorities to protect this river reach from further disturbance.

1.2 Identify habitat characteristics essential to the continued existence of P. capax within this river reach.

1.3 Identify present and foreseeable threats to the species and its habitat within this river reach and work to eliminate them.

1.3.1 Solicit (from appropriate government agency) hydrologic and water quality data necessary to predict long-term negative effects on habitat stability resulting from previous channelization of the river drainage above the existing mussel bed.

1.3.2 Work with Federal, State, and local agencies to alleviate problems identified in 1.3.1.

1.3.3 Develop public education program to educate farmers on effects of agriculture practices and alternatives to limit degradation of habitat.

1.4 Explore the possibility of enhancing existing habitat for the support of P. capax.

1.5 Institute a program of annual monitoring of the St. Francis River population to ensure continued viability.

2. Determine if viable populations of P. capax exist outside of the St. Francis River.

2.1 Conduct surveys of the Wabash and White Rivers in Indiana to determine if P. capax remains extant in either of these rivers.

2.2 Survey the Mississippi River in the vicinity of Hannibal, Missouri, to determine if P. capax is extant in this river reach.

3. Re-establish populations of P. capax within its known historical range by transplant or other means.

3.1 Conduct life history studies of P. capax to gather information necessary to establish and maintain naturally reproducing populations.

3.1.1 Collect and examine available data on fish distribution within the known range of P. capax in order to identify fish species most likely to serve as hosts.

3.1.2 Collect and examine life history data for related mussel species.

3.1.3 Examine *P. capax* population on a seasonal basis to determine the period of gravidity.

3.1.4 Conduct experiments to artifically infect suspected fish hosts with *P. capax* glochidia.

3.2 Select appropriate transplant method.

3.2.1 Explore feasibility of establishing populations of *P. capax* by transplanting adult mussels.

3.2.2 Explore feasibility of establishing *P. capax* populations by releasing fish infected with *P. capax* glochidia.

3.2.3 Explore feasibility of establishing *P. capax* populations by transplanting juvenile mussels which have been reared in the laboratory using artificial culture techniques.

3.3 Identify potential transplant sites for *P. capax* in rivers within the species' historical range including the St. Francis River, Arkansas, the Wabash and White Rivers, Indiana, the upper Mississippi River, and others.

3.4 Carry out the transplant program.

3.5 Institute protective measures for newly established populations.

4. Develop and implement a program to monitor success of newly established *P. capax* populations and to evaluate progress of the recovery.

C. Narrative Outline:

1. Preserve existing *P. capax* population and habitat in the St. Francis River in the vicinity of Madison, Arkansas. The river reach from Madison to Highway 64 bridge continues to support a *P. capax* population and must be protected until additional populations are established or discovered.

1.1 Use existing legislation and cooperation of Federal, State, and local authorities to protect this river reach from further disturbance. Cooperation between the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service, the State of Arkansas, and local authorities is necessary to assure protection of this river reach from further dredging, dewatering or other adverse activity.

1.2 Identify habitat characteristics essential to the continued existence of *P. capax* within this river reach. This activity may be concurrent with life history studies. Physical characteristics of *P. capax* habitat within the essential river reach should be described including river flow patterns, water quality characteristics, substrate type and related fauna. Since a portion of this river reach is undredged and contains shoals, and a portion is dredged, the importance of the shoals to the continued survival of *P. capax* and its fish host (when known) must be identified before further channel modification is made.

1.3 Identify present and foreseeable threats to the species and its habitat within this river reach and work to eliminate them. Apply the results of studies conducted under 1.2 to the maintenance or revised management of the essential habitat. The most immediate threat to the survival of *P. capax* in this river reach is from effects of past and future dredging for channel maintenance and flood control.

1.3.1 Solicit (from appropriate government agencies) hydrologic and water quality data necessary to predict long term negative effects on habitat stability resulting from previous channelization of the river drainage above the existing mussel bed. The St. Francis River channel has been enlarged immediately above and below the mussel bed, and the entire drainages above Highway 64 bridge has been channelized extensively.

Because of these alterations in flow patterns, the shoal supporting *P. capax* may be subject to unusual erosion or deposition of substrate during periods of high run-off. Effects of such erosion or depositon should be identified, and potential impact upon the mussel bed estimated. Physical and chemical data to be collected should include: seasonal water flow, sediment load, sedimentation rate, suspended solids, and selected agricultural chemicals (dependant upon local use).

1.3.2 Work with Federal, State, and local government agencies and landowners to alleviate problems identified in 1.3.1. The combined expertise of groups such as the U.S. Fish and Wildlife Service, Army Corps of Engineers, Soil Conservation Service, State water quality control agencies, and local farm cooperatives and agricultural extension services should be pooled to help arrive at solutions to problems arising from flood control measures (e.g. dredging effects) and agricultural practices (soil erosion and chemical application).

1.3.3 Develop public education program to educate farmers on effects of agriculture practices and alternatives to limit degradation of habitat. Past dredging activities by local landowners have accelerated run-off from agricultural land resulting in increased flooding of the lower river. Public pressure to relieve flooding has resulted in widespread dredging and channelization of the river basin by the Army Corps of Engineers. Improved water management in agricultural areas would help alleviate pressure on the lower river.

1.4 Explore the possibility of enhancing existing habitat for the support of *P. capax*. Enhancement might include stabilization of substrate in upstream reaches and/or diversion of excessive flood waters to the eastern drainage.

1.5 Institute a program of annual monitoring of the St. Francis River population to ensure continued viability. This will be necessary to determine if there have been negative impacts to the habitat.

2. Determine if viable populations of *P. capax* exist outside of the St. Francis River. At present, the only documented viable population of *P. capax* exists in the St. Francis River near Madison, Arkansas. The few available records of *P. capax* from the White and Wabash Rivers in Indiana are not adequate to determine the status of *P. capax* in these rivers. While recent surveys indicate that *P. capax* is most likely extirpated from the upper Mississippi River, the river reach near Hannibal, Missouri, has not been surveyed recently. In order to

determine the true status of Potamilus capax, these rivers must be surveyed for the presence of this species.

2.1 Conduct surveys of the Wabash and White Rivers in Indiana to determine if P. capax remains extant in either of these rivers. Two specimens of P. capax were reported from the Wabash River by Clark (1976) and several dead shells of this species reported by Stansbery (pers. communication) from near the confluence of the White and Wabash Rivers in 1978. Since there has been no mussel survey of these rivers within the past 15 years, the present status of P. capax here is unknown.

2.2 Survey the Mississippi River in the vicinity of Hannibal, Missouri, to determine if P. capax is extant in this river reach. Data from Ellis' 1931 survey of the Mississippi River (H. and A. van der Schalie, 1950) indicate that the greatest numbers of P. capax were collected in the river reach adjacent to Hannibal, Missouri. Mussel surveys in upstream reaches of this river (Fuller, 1978; Freitag, 1978; Thiel, 1981) have not reported P. capax; however, data from the Hannibal river reach are lacking. While it is not likely that P. capax remains extant in the Mississippi River, its status in this river reach should be documented.

3. Re-establish populations of P. capax within its known historical range by transplant or other means. The area of the St. Francis River presently supporting P. capax is isolated from other productive reaches (e.g. area below Wappapello Dam) by vast stretches of disturbed habitat (see Bates and Dennis, 1981). Natural colonization of other areas from the Madison population is, therefore, unlikely in the foreseeable future. If additional populations of P. capax are to be established, colonization will have to be aided by transplants or other artificial means. Sites chosen for re-establishment of P. capax populations should resemble sites known to support the species in as many ways as possible including: size, water velocity, substrate type, water quality, fish fauna and mussel assemblages. It will undoubtedly be impossible to find sites which meet all of these criteria, but as many should be met as possible. Dennis (1984) developed a method of tagging, transplanting, and recovering mussels which resulted in a high recovery rate (80%) in undisturbed habitats. Lack of success in transplant experiments has been primarily due to poor site selection and inadequate mechanism for follow up (Dennis, 1984).

3.1 Conduct life history studies of P. capax to gather information necessary to establish and maintain naturally reproducing populations. Knowledge of the fish host is necessary to evaluate potential areas as suitable habitat for P. capax. Without this information, one of the most important aspects of the species' niche is unknown. Information gathered through this activity will contribute to the recovery plan in the following ways:

A. It will aid in determining the suitability of a potential transplant site for support of naturally reproducing populations of P. capax, regardless of the means of transplant.

B. It will allow for transplant of P. capax by releasing infected host fish.

Life history studies will involve: a. determining which fish species is/are most likely to serve as natural host(s) (Tasks 3.1.1, 3.1.2); b. determining when infection of host fish takes place (Task 3.1.3); and c. conducting experiments to artifically infect suspected fish host species with glochidia (Task 3.1.4).

3.1.1 Collect and examine available data on fish distribution within the known range of P. capax in order to identify fish species most likely to serve as hosts. The number of fish which occur in the interior basin is very large, however, not all are equally likely to serve as hosts for P.

capax. Identifying fish species which share the same natural distribution and habitat preference will help to narrow the choice of fishes for study and increase the likelihood of success.

3.1.2 Collect and examine life history data for related mussel species. While the life history of P. capax is unknown, some data are available for closely related species (i.e. other species of Potamilis and members of the genus Leptodea). Information as to seasonal reproductive cycles and suspected fish hosts for these species alone will facilitate the search for a host fish.

3.1.3 Examine P. capax population on a seasonal basis to determine the period of gravidity. This activity is crucial to life history and/or propagation studies which involve working with mature glochida. Knowledge gained in this activity will determine time frame for artificial infection of suspected host fish.

3.1.4 Conduct experiments to artificially infect suspected fish hosts with P. capax glochidia. Data gathered in Tasks 3.1.1 - 3.1.3 will be used to identify potential fish hosts and determine the time when mature glochidia are available. In this activity, selected fish species will be infected with P. capax glochidia and observed to determine if encystment and metamorphosis of glochidia takes place. These studies should be conducted on site (at the river) if possible under conditions closely approximating natural habitat to avoid possible adverse reaction of fish to the stresses of laboratory confinement.

3.2 Select appropriate transplant method. Mussel transplants have met with varying degrees of success, depending on the methods used and the choice of transplant site. There are presently three alternative approaches to establishing mussel populations in a new habitat. Each of these methods should be explored as to its applicability of P. capax recovery. Most likely, a transplant program will involve more than one of these methods. All of the methods outlined below share two problems associated with transplants. First is the problem of deciding where to place the transplanted mussels. Habitat which seems optimal from the standpoint of the researcher may not be the best location from the standpoint of the mussel and its fish host. Knowledge of the fish host and its habitat requirements is necessary to insure a reproducing population. The second obstacle is the difficulty involved in evaluating success of the transplant. The effort can only be considered successful when it has been demonstrated that the transplanted population is reproducing naturally in its new habitat. This may take several to many years depending on the transplant method chosen.

3.2.1 Explore feasibility of establishing populations of *P. capax* by transplanting adult mussels. The major advantage of transplanting adult mussels is that they are easy to collect and mark, and that they can be placed in a designated area and observed periodically to monitor survival (Dennis, 1984). This will provide some basis for evaluating success. The disadvantages are that it requires a large number of live mussels for the initial transplant, and that the ultimate success can only be determined by finding offspring of the transplanted adults. Since the transplanted mussels are of reproductive age at the time of transplant, however, the evaluation time will be shorter than if juvenile mussels are transplanted. If the existing *P. capax* population is large enough to sustain a loss of several hundred living specimens (the exact number to be determined as part of this activity) without damage to that population, this may be the fastest and most easily monitored method.

3.2.2 Explore feasibility of establishing *P. capax* populations by releasing fish infected with *P. capax* glochidia. Releasing infected fish at a transplant site may be the best means of re-establishing natural mussel populations since the fish are likely to deposit juvenile mussels in areas where subsequent re-infection can occur. This method was used widely by the Bureau of Commercial Fisheries during the early 1900's to enhance recruitment of commercially valuable mussel species (Coker et al., 1921; LeFevre and Curtis, 1912). The disadvantage of this method as with others is the difficulty involved in finding newly established populations and monitoring reproductive success.

3.2.3 Explore feasibility of establishing *P. capax* populations by transplanting juvenile mussels which have been reared in the laboratory using artificial culture techniques. The potential advantage of this method is that many juvenile mussels can be obtained from one adult gravid female mussel, and that it does not require knowledge of the host fish species to obtain the juveniles. The disadvantages are: 1. the method has not been proven effective in field trials; 2. the problems associated with evaluating of transplant success are still paramount, and 3. presence of the fish host is still necessary for maintenance of a naturally reproducing populations.

Rearing freshwater mussels without the fish hosts (Isom and Hudson, 1982) is still in the experimental stages, and considerable work will need to be done before it can be demonstrated effective for *P. capax*. Field trials alone, using non-endangered species, may take many years, and the laboratory rearing portion of the studies are not yet complete. In the case of *P. capax*, the research time involved may be very long since no member of the genus *Proptera* (=*Potamilis*) has been successfully reared to date. The TVA has so far been unsuccessful in rearing *Proptera alata*, the interior basin species most closely related to *P. capax* (Hudson, pers. communication).

The actual transplanting of juvenile mussels also imposes problems due to their small size. Unlike adult mussels, many may be washed away or eaten by fish and other predators. Evaluating success will take many years since it will involve waiting for the transplanted juveniles to reach sexual maturity and begin reproducing themselves. If the fish host is not present, or does not frequent the area in which the juvenile mussels are planted, natural reproduction may not take place.

3.3 Identify potential transplant sites for *P. capax* in rivers within the species' historical range (if possible), including the St. Francis River, Arkansas, and the Wabash and White Rivers, Indiana, the upper Mississippi River, and others. The most important factor in the success of mussel transplants is the choice of sites recommended. While the recovery effort is aimed at populations of *P. capax*, the populations should be considered as part of a larger mussel community. *Potamilus capax* has always been a minor component of the mussel fauna (Call, 1900) and does not characteristically exist in isolated populations. Although the relationship of a mussel species to other members of the mussel community is presently unknown, it may be of significance and should be considered part of the species' "niche". The presence of a mussel community in an area is an indication that the site may be appropriate for the support of many species, and it is frequented by potential host fish. Based on mussel surveys by Bates and Dennis (1981), the most promising area of the St. Francis River for transplant of *P. capax* is a reach from below Wappapello Dam to Rombauer Bridge. This area presently supports mussel assemblages similar in composition to those in the Madison reach, with the exception of *P. capax*.

Since there are few historic collection records from this reach of river, it is not known whether *P. capax* ever occurred here. A comparison of fish distribution records would aid in the evaluation of this site as a potential transplant site. Additional transplant sites in the St. Francis and other rivers need to be identified.

Another river which should be considered as a potential transplant site for P. capax is the Hatchie River in western Tennessee. This river, which drains westward into the Mississippi River, supports a mussel fauna very close in species compositon to that of the St. Francis River. Although extensive work in this river in recent years (Manning, in press) has not located P. capax, the historical status of this species in the Hatchie is unknown. The potential for this river to serve as a transplant site is worth exploring, since the Hatchie River is presently afforded protection from development under the Wild and Scenic Rivers Act. (Note: Transplantation of an endangered species outside the historical range would be contrary to Service policy and will therefore require special permission of the Director of the Fish and Wildlife Service.)

3.4 Carry out the transplant program. The advantage of transplanting adult mussels is that the mussels are more easily located for follow up studies and success can be determined with greater reliability. This method, however, depends upon having a large initial population from which to remove mussels for transplant and there is the risk that the mussels will not be placed in an area frequented by the proper fish host. Releasing fish previously infected with glochidia allows for a more natural colonization (i.e., young mussels will be dropped in an area frequented by host fish) and requires removal of fewer mussels from the original population, however, it requires knowledge of the host fish and is difficult to evaluate.

3.5 Institute protective measures for newly established populations. Cooperation of Federal, State and local agencies will be essential to protection of newly established populations.

4.0 Develop and implement a program to monitor success of newly established *P. capax* populations and to evaluate progress of the recovery. Since little is known of genetic variability within freshwater mussel populations, viability of transplanted populations will have to be based primarily on observed reproductive success. A sampling program aimed at locating young mussels will have to be designed.

REFERENCES 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. 1981. Preliminary analysis of the mussel stocks of Kentucky Reservoir. Unpub. progress report to Tennessee Wildlife Resources Agency, Nashville, Tenn. 16 pp.

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-C-0147. 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., Ill. Ottawa Academy of Nat. Sci., Proc. 48 p.

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.

Clark, A.H. 1984. Draft report 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). 16 pp.

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., A.F. Shira, H.W. Clark, and A.D. Howard. 1921. Natural History and Propagaton of Fresh Water Mussels. Bull. Bur. of Fisheries, 37, 1919-20. Doc. No. 893.

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.

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 p.

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.

Federal Register, Vol. 41:24064, June 14, 1976.

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.

Freitag, T.M. 1978. A survey of selected dredge sites for the presence of freshwater mussels within the Rock Island District. Rock Island District, Corps of Engineers, Operations Division. Unpublished Report. November, 1978. 12 pp.

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.

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.

International Commission on Zoological Nomenclature. 1974. Amendments to the International Code of Zoological Nomenclature adopted since the Sixteenth International Congress of Zoology, 1963. Bull. Zool. Nomencl. 31(2):83.

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

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

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.

Le fevre, G. and W.C. Curtis. 1912. Studies on the Reproduction and Artificial Propagation of Freshwater Mussels. Bull. U.S. Bur Fish. 30:105-201.

Manning, D. (in Press). Freshwater mussels (Unionidae) of the Hatchie River, A Tributary of the Mississippi River in West Tennessee. Sterkiana No. 72.

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, Pittsburg, 8(2):222-665.

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

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

Pogge, A.F. and G. H. Schneider. 1980. Freshwater mussel survey in Pool 19 river mile 398.3 of the Mississippi River near Burlington, Iowa. Unpublished report submitted to Alter Co., Davenport, Iowa. Dept. of Biol. Sci., Quincy Coll., Quincy, Ill. June 16, 1980.

Rafinesque, C.S. 1819. Proptera. Jl. 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.

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.

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

IMPLEMENTATION

Priorities in column four of the following implementation schedule are assigned as follows:

Priority one (1) - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority two (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.

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

LIST OF ABBREVIATIONS

SE Federal Endangered Species Program
COE Corps of Engineers (Memphis District)
SCS Soil Conservation Service
AES Agricultural Extension Service
AGF Arkansas Game and Fish Commission

Part III Implementation Schedule

General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency			Estimated Fiscal Year Costs			Comments/Notes
					FWS		Other	FY 1	FY 2	FY 3	
					Region	Program					
M-3	Use existing legislation to protect existing populations in St. Francis River from further disturbance.	1.1	1	Continuous	4	SE	COE, AGF	-	-	-	Existing program funding.
R-3	Identify essential habitat characteristics in occupied St. Francis River reaches.	1.2	1	2 years	-	SE	COE Contract	$15,000	$15,000	-	
I-2	Gather existing data on effects of channelization of St. Francis above and below existing St. Francis mussel bed.	1.3.1	1	-	-	-	COE	-	-	-	
M-3	Work with landowners and farmers to develop alternate flood control measures.	1.3.2	2	Continuous	-	-	COE, SCS, AES	-	-	-	Existing program funding.
O-1	Develop public education program on effects of agriculture practices and alternatives to limit degradation of habitat.	1.3.3	3	Continuous	4	SE	SCS, AGF	$5,000	$5,000	$5,000	
I-4	Explore possibility of enhancing existing habitat for the support of <u>P. capax</u>.	1.4	2	1 year			COE	$12,000			Investigate means of stabilizing habitat and reducing sedimentation.
I-1	Institute a program of monitoring of the St. Francis River population to ensure continued viability.	1.5	2	Alternate years	4	SE	AGF Contract	$15,000	-	$15,000	This will be a quantitative estimate.

Part III Implementation Schedule

General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency: FWS Region	Responsible Agency: FWS Program	Responsible Agency: Other	Estimated Fiscal Year Costs: FY 1	FY 2	FY 3	Comments/Notes
I-1	Survey Wabash and White Rivers in Indiana for P. capax.	2.1	2	1 year	-	SE	Contract	$20,000	-	-	If populations are found in these reaches, funding of monitoring will be necessary on alternate years.
I-1	Survey Mississippi River near Hannibal, MO, for P. capax.	2.2	2	1 year	-	SE	Contract	$15,000	-	-	Same as above
I-7	Study available data on fish distribution within known range of P. capax.	3.1.1	1	1 year	-	SE	Contract	$2,500	-	-	
I-7	Study life history data for related mussel species.	3.1.2	2	1 year	-	SE	Contract	$2,500	-	-	
I-7	Examine P. capax population on seasonal basis to determine gravid period.	3.1.3	2	1 year	-	SE	Contract	$12,000	-	-	
I-7	Conduct experiments to artificially infect suspected fish hosts with P. capax glochidia.	3.1.4	2	3 years	-	SE	Contract	$20,000	$20,000	$20,000	
R-13	Explore feasibility of establishing populations of P. capax by transplanting adult mussels.	3.2.1	2	4 years	4	SE	AGF Contract	$40,000	$6,000	$6,000	A five-year study with later years costing $6,000 each.
R-13	Explore feasibility of establishing P. capax populations by releasing fish infected with P. capax glochidia.	3.2.2	2	1 year	4	SE	AGF Contract	$60,000	$10,000	$10,000	A five-year study with later years costing $10,000 each.

Part III Implementation Schedule

General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency			Estimated Fiscal Year Costs			Comments/Notes
					FWS Region	FWS Program	Other	FY 1	FY 2	FY 3	
R-13	Explore feasibility of establishing P. capax populations by transplanting juvenile mussels which have been reared in the laboratory using artificial culture techniques.	3.2.3	2	1 year	4	SE	AGF Contract	$50,000	$20,000	$6,000	This would be a four year study costing $6,000 the last year.
I-13	Identify potential transplant sites for P. capax.	3.3	3	1 year	-	SE	Contract	$20,000	-	-	Including water quality analysis, substrate analysis and fish species composition.
M-2	Introduce P. capax to selected site(s).	3.4	3	2 years	-	SE	Contract	$10,000	$10,000	-	Additional funding will be necessary if fish artificially infected with glochidia are to be used for re-introduction. This will depend upon results of Task 3.1.4.
M-3	Institute protective measures for newly established populations.	3.5	3	Continuous	-	SE	COE	-	-	-	Existing program funding.
I-1 M-2	Monitor success of newly established P. capax populations.	4.	3	Continuous	-	SE	Contract	$6,000	-	$6,000	Alternate year survey.

GENERAL CATEGORIES FOR IMPLEMENTATION SCHEDULES*

Information Gathering - I or R (research)

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

Management - M

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

Acquisition - A

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

Other - O

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

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

APPENDIX A

A. University of Michigan Museum of Zoology, Ann Arbor, Michigan.

1. Mississippi River

7600 - Mercer Co., Illinois
22850 - Mississippi River
31697 - Hamilton, Illinois
32243 - Hamburg, Illinois
62398 - Martin's Landing, Rock Island Co., Illinois
83905 - Muscatine, Muscatine Co., Iowa
83906 - Mercer Co., Illinois
83908 - Alton, Madison Co., Illinois
129088 - Below La Grange, Lewis Co., Missouri
129282 - Keithsburg, Mercer Co., Illinois
129858 - Below Alma Light, Buffalo Co., Wisconsin
129381 - McGregor, Clayton Co., Iowa
129435 - Above Golden Eagle, Calhoun Co., Illinois
129558 - Clarksville, Pike Co., Missouri
129580 - Hannibal, Marion Co., Missouri
129590 - Hannibal, Marion Co., Missouri
129753 - Peruque, St. Charles Co., Missouri
129905 - Below Grafton, Jersey Co., Illinois
130039 - Mouth Smith's Creek, Muscatine, Iowa

2. Wabash River

83907 - Wabash River, Indiana
83911 - New Harmony, Posey Co., Indiana
83912 - Posey Co., Indiana
83913 - Grand Chain, Posey Co., Indiana
129659 - 4 mi. above mouth, Posey Co., Indiana

3. St. Francis River, Arkansas

62397 - Madison, St. Francis Co., Arkansas
129747 - Parkin, Cross Co., Arkansas

4. Other Records

67825 - White River, Hazelton, Gibson Co., Indiana
83909 - Des Moines River, Keokuk, Lee Co., Indiana
83910 - Spoon River, Fulton Co., Illinois
32234 - Black River, Black Rock, Arkansas

141849 - White River, 1 mi. N.E. Des Valls Bluff, Prairie Co., AR
142662 - Saline (Sabine?) River, Longview, Gregg Co., Texas

B. Ohio State University Museum of Zoology, Columbus, Ohio.

1. Mississippi River

38825 - Muscatine, Muscatine Co., Iowa

2. Wabash River

4473 - Wabash River, Indiana
5238 - Vincennes, Knox Co., Indiana
24408 - Wabash River
39093 - 39097 - Wabash River

3. St. Francis River

13049 - 1 mi. S. Rte 62 bridge, Cross Co., Arkansas, Oct. 1964
42226 - Old Military Road Bridge, Clark Corner Cutoff, St. Francis Floodway, Arkansas, Aug. 1978
34861 - 1 mi. below St. Francis Lake Dam, Poinsett Co., Arkansas
OSUM 1978:235 - Big Eddy Bridge, Clark Corner Cutoff, St. Francis Floodway, Arkansas
OSUM 1978:238 - River Mile 42, St. Francis Co., Arkansas

4. Other Rivers

38794 - White River, 5.5 mi. E. Decker, Knox Co., Indiana
23677 - Iowa River, Iowa City, Johnson Co., Iowa
4474 - Illinois River, Illinois
10267 - Illinois River, New Boston, Mercer Co., Illinois
13987 - White River, 2 mi. S. Clarendon, Monroe Co., Arkansas

C. The United States National Museum, Washington, D.C.

1. Mississippi River

535180 - Muscatine, Iowa
150143 - Burlington, Iowa
150013 - Lee Co., Iowa
84890 - Alton, Illinois
755761 - O'Connell Slough, Des Moines Co., Iowa, Aug. 1907
755356 - 12 mi. S. Muscatine, Louisa Co., Iowa, Aug. 1907
755879 - Montree, Lee Co., Iowa, Aug. 1907
755960 - 1¼ mi. S. Hamburg, Calhoun Co., Illinois
755799 - O'Connell Canal, Des Moines Co., Iowa, Aug. 1907
755795 - Canal Rush, Des Moines Co., Iowa, Aug. 1907
535178 - Muscatine, Iowa
505937 - Muscatine, Iowa
505936 - Iowa City, Iowa
505933 - Iowa City, Iowa
505935 - Muscatine, Iowa
505934 - Muscatine, Iowa
755729 - New Boston, Mercer Co., Illinois
755194 - Princeton, Scott Co., Iowa, July 1907
755342 - South Muscatine, Iowa, Aug. 1907

755372 - Mouth of Muscatine Slough, Louisa Co., Iowa, Aug. 1907
755852 - 2 mi. N. Navoo, Iowa, Aug. 1907
755827 - Dallas, Hancock Co., Missouri, Aug. 1907
755844 - Canton, Lewis Co., Missouri, Aug. 1907

2. Wabash River

84891 - New Harmony, Indiana
40796 - Indiana
26027 - Indiana
477121 - Grayville, White Co., Illinois
512267 - New New Harmony, Indiana, July, 1935

3. Other localities

756585 - Ohio River, Hillerman, Massac Co., Illinois, Aug. 1907
124462 - Ohio River, Jeffersonville, Indiana
308866 - Spencer, Indiana
50011 - White River Wildlife Refuge, Monroe and Desha Co., AR

D. Carnegie Museum, Pittsburgh, Pennsylvania.

Mississippi River, Fairport, Aug. 31, 1920, 2 specimens
St. Francis River, Madison, Arkansas, Aug. 26, 1921, 12 specimens
Wabash River, New Harmony, Indiana, Aug. 8, 1912, 2 specimens
Mississippi River, Martins Landing, Rock Island, Oct. 5, 1912, 6 specimens

Indiana, 2 specimens
Missisippi River, Marcerbo, Illinois, 1 specimen
No locality, 7 specimens

E. Other museum records - unconfirmed identifications:

Putnam Museum: 1133 - Mouth of Iowa River at Toolsboro, Iowa, collected by Harison and Fulton

William Pratt Collection: Davenport, Iowa

University of Arkansas Museum:
76-170-8 White River, DuVall's Bluff, Arkansas, Sept. 1966
76-170-51 White River, Crockett's Bluff, Arkansas, Aug. 1966

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