

RECOVERY PLAN

*Purple Cat's Paw
Pearlymussel*

U.S. Fish and Wildlife Service



RECOVERY PLAN

for

Purple Cat's Paw Pearlymussel
(Epioblasma (=Dysnomia) obliquata obliquata (=E. sulcata sulcata))

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Recovery plans delineate reasonable actions which are believed to be required to recover and/or protect the 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 citations should read as follows:

U.S. Fish and Wildlife Service. 1990. Purple Cat's Paw Pearlymussel Recovery Plan. Atlanta, GA. 26 pp.

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Fish and Wildlife Reference Service
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EXECUTIVE SUMMARY FOR THE PURPLE CAT'S PAW PEARLYMUSSEL RECOVERY PLAN

Current Status: This subspecies is listed as endangered. Presently, the purple cat's paw pearlymussel is known from two relic, apparently nonreproducing, populations--one in Tennessee and one in Kentucky. Historically, the subspecies occurred in the Ohio River and its larger tributaries in Ohio, Indiana, Illinois, Kentucky, Tennessee, and Alabama.

Habitat Requirements and Limiting Factors: The purple cat's paw inhabits boulder to sandy substrates in large rivers of the Ohio River basin. The subspecies' distribution and reproductive capacity have been seriously impacted by the construction and operation of reservoirs on these large rivers. Unless reproducing populations are found or created and existing populations are maintained, this subspecies will likely become extinct in the foreseeable future.

Recovery Objective: Downlisting. Because of the lack of available habitat for the establishment of all needed populations, recovery is unlikely.

Recovery Criteria: To establish six distinct viable populations.

Actions Needed:

1. Create captive population to prevent the subspecies' imminent extinction.
2. Utilize existing legislation/regulations to protect subspecies.
3. Search for new populations and monitor existing populations.
4. Develop and utilize an information/education program.
5. Determine threats and alleviate those that threaten the subspecies' existence.
6. Through reintroduction and protection, establish six viable populations.
7. Develop and implement cryopreservation techniques for the subspecies.

Cost (1,000's):

<u>Year</u>	<u>Need 1</u>	<u>Need 2</u>	<u>Need 3</u>	<u>Need 4</u>	<u>Need 5</u>	<u>Need 6</u>	<u>Need 7</u>	<u>Total</u>
1992	25.0	3.0	30.0	25.0	0.0	25.0	5.0	113.0
1993	25.0	3.0	30.0	20.0	25.0	25.0	5.0	133.0
1994	25.0	3.0	2.0	1.0	25.0	25.0	5.0	86.0
1995	2.0	3.0	0.0	1.0	25.0	10.0	2.0	43.0
1996	2.0	3.0	2.0	1.0	?	10.0	2.0	20.0*
1997	2.0	3.0	0.0	1.0	?	10.0	2.0	18.0*
1998	2.0	3.0	2.0	1.0	?	0.0	2.0	10.0*
1999	2.0	3.0	0.0	1.0	?	0.0	2.0	8.0*
2000	2.0	3.0	2.0	1.0	?	0.0	2.0	10.0*
2001	2.0	3.0	0.0	1.0	?	0.0	2.0	8.0*
2002	2.0	3.0	2.0	1.0	?	0.0	2.0	10.0*
<u>Total:</u>	91.0	33.0	70.0	54.0	75.0*	105.0	31.0	459.0*

*See next page.

*Habitat improvement costs needed for the subspecies' recovery will not be known until the magnitude of specific threats is determined through research.

Date of Recovery: Total recovery is unlikely for this subspecies. The downlisting date cannot be estimated at this time. As mussels do not reproduce until about age 5, more than 10 years is needed to document reproduction and assess viability.

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PART I
INTRODUCTION

The purple cat's paw pearl mussel (*Epioblasma (=Dysnomia) obliquata obliquata (=E. sulcata sulcata)*) was listed as an endangered species (without critical habitat) on July 10, 1990 (55 FR 28210). This freshwater mussel historically occurred in the Ohio River and its larger tributaries in Ohio, Indiana, Illinois, Kentucky, Tennessee, and Alabama. Presently, the purple cat's paw pearl mussel is known from only two relic, apparently nonreproducing, populations--one in a reach of the Cumberland River in Tennessee and one in a reach of the Green River in Kentucky. The distribution and reproductive capacity of this subspecies was seriously impacted by the construction of impoundments on the large rivers it once inhabited. Unless reproducing populations are found or methods are developed to enhance the reproductive capabilities of the existing populations, this subspecies will likely become extinct in the foreseeable future.

Description, Ecology, and Life History

The purple cat's paw pearl mussel was described by Rafinesque (1820). The white cat's paw (*Epioblasma (=Dysnomia) obliquata perobliquata (=E. sulcata delicata)*), also a federally listed species, is the northern subspecies of the cat's paw pearl mussel. The purple cat's paw has a medium-sized shell that is subquadrate in outline (Bogan and Parmalee 1983). The shell's outside surface has numerous distinct growth lines. It is yellowish-green, yellow, or brownish in color and has fine, faint, wavy green rays with a smooth and shiny surface. The shells of the young often have a satin-like surface. The inside of the shell is purplish to deep purple (the inside of the white cat's paw shell is white). For a more detailed description, see Bogan and Parmalee (1983).

Little is known of this rare subspecies' life history. The purple cat's paw, which is characterized as a large-river species (Bates and Dennis 1985), has been found inhabiting water of shallow to moderate depth and with moderate to swift currents (Bogan and Parmalee 1983, Gordon and Layzer 1989). The subspecies has been reported from boulder and sand substrates. The specific food habits of the purple cat's paw are unknown, but it likely feeds on food items similar to those consumed by other freshwater mussels. Freshwater mussels are known to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924).

The subspecies' reproductive biology remains virtually unknown, but it likely reproduces like other freshwater mussels. Males release sperm into the water column, which are taken in by the females through their siphons during feeding and respiration. The fertilized eggs are retained in the females' gills until the larvae (glochidia) fully develop. The glochidia are released into the water where they attach and encyst on the gills or fins of a fish host. When metamorphosis is complete, they drop to the streambed as juvenile

mussels. The fish hosts utilized by the purple cat's paw and the habitat of the juvenile mussel are unknown.

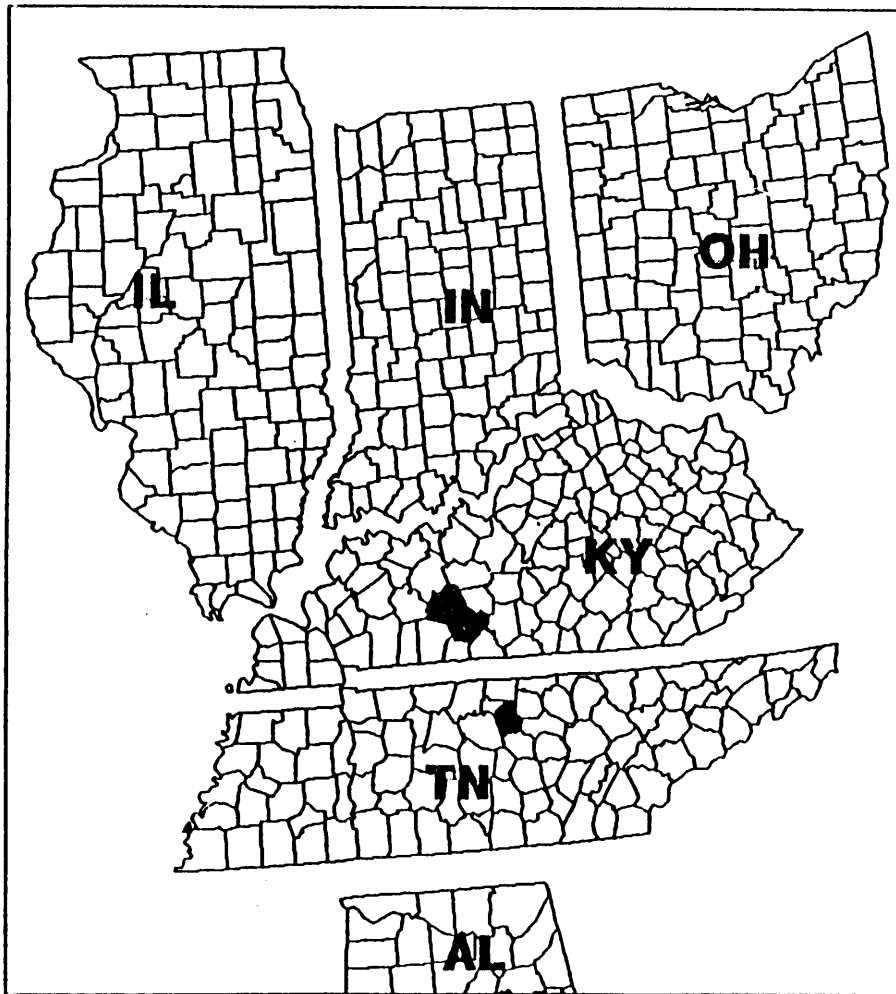
Distribution, Reasons for Decline, and Threats to Its Continued Existence

The purple cat's paw pearl mussel was historically distributed in the Ohio, Cumberland, and Tennessee River systems in Ohio, Illinois, Indiana, Kentucky, Tennessee, and Alabama (Bogan and Parmalee 1983, Isom, *et al.*, 1979, Kentucky State Nature Preserves Commission 1980, Parmalee, *et al.*, 1980, Watters 1986, Stansbery 1970). Based on personal communications with knowledgeable experts (Steven Ahlstedt and John Jenkinson, Tennessee Valley Authority, 1987; Mark Gordon and Robert Anderson, Tennessee Technological University, 1988; Arthur Bogan, Philadelphia Academy of Sciences, 1988; Ronald Cicerello, Kentucky State Nature Preserves Commission, 1988; and David Stansbery, Ohio State University, 1987) and a review of literature, the subspecies survives (see map) in only two river reaches--the Cumberland River in Tennessee and the Green River in Kentucky. Many of the historic populations were apparently lost when the river sections they inhabited were impounded. These impoundments seriously reduced the availability of riverine habitat and likely affected the distribution and availability of the mussel's fish host.

The State of Indiana has no current records of the subspecies in the State (Indiana Department of Natural Resources, *in litt.*, 1988). The subspecies has not been collected in Illinois in over 100 years (Illinois Natural History Survey Division, *in litt.*, 1988). The subspecies is apparently extirpated from the State of Ohio (Michael Hoggarth, Ohio Department of Transportation, *in litt.*, 1991). The historic collection site in Alabama (on the Tennessee River at Muscle Shoals) is now impounded (Bogan and Parmalee 1983).

In Kentucky the subspecies is now known only from the Green River, Warren and Butler Counties (Kentucky Department of Fish and Wildlife Resources and Kentucky State Nature Preserves Commission, *in litt.*, 1988). This Green River population is represented by only one old but freshly dead individual taken on the Green River in Warren and Butler Counties, Kentucky, in 1988 (Robert Anderson, Tennessee Technological University, *in litt.*, 1988). Prior to 1988, the mussel had not been collected in the Green River since 1971 (Kentucky State Nature Preserves Commission, *in litt.*, 1988). The middle Cumberland River (Smith County, Tennessee) contains the only known living representative of the purple cat's paw in Tennessee (U.S. Army Corps of Engineers, *in litt.*, 1988).

The continued existence of these two surviving populations is questionable. Unless reproducing populations can be found or methods can be developed to maintain these or create new populations, the subspecies will become extinct in the foreseeable future. Any individuals that do still survive in these two river reaches are also threatened from other factors. The Green River in Kentucky has



Distribution of the purple cat's paw pearly mussel (*Epioblasma* (= *Dysnomia*) *obliquata obliquata* (= *E. sulcata sulcata*)): All States with historic population records, counties with extant populations, and counties with possible extant populations.

PRESENT POPULATIONS

■ KNOWN EXTANT

experienced water quality problems related to the impacts from oil and gas production in the watershed, and commercial mussel fishing has occurred in the Green River in recent years. The individuals still surviving in the Cumberland River are potentially threatened by gravel dredging, channel maintenance, and commercial mussel fishing. Although the subspecies is not commercially valuable, incidental take of the species has occurred in the Cumberland River during commercial mussel fishing for other species.

Additionally, neither of the two extant populations is known to be reproducing. Therefore, unless reproducing populations can be found or methods can be developed to maintain these or create new populations, the subspecies will be lost in the foreseeable future. In fact, the two populations (Cumberland and Tennessee River populations) may contain only old individuals that have passed their reproductive age.

PART II
RECOVERY

A. Recovery Objectives

The ultimate goal of this recovery plan is to restore viable populations of the purple cat's paw (Epioblasma (=Dysnomia) obliquata obliquata (=E. sulcata sulcata)) to a significant portion of its historic range in the Ohio River basin and to remove the subspecies from the Federal List of Endangered and Threatened Wildlife and Plants. However, total recovery for the purple cat's paw may not be possible. The subspecies is presently known from only two, apparently nonreproducing, populations, and suitable habitat for reintroduction is limited. NOTE: A viable population is defined as a reproducing population that is large enough to maintain sufficient genetic variation to enable it to evolve and respond to natural habitat changes. The number of individuals needed to obtain a viable population will be determined as one of the recovery tasks.

The subspecies will be considered for reclassification to threatened status when the likelihood of the subspecies becoming extinct in the foreseeable future has been eliminated by achievement of the following criteria:

1. Through protection of existing populations and successful establishment of reintroduced populations or the discovery of additional populations, a total of at least four Ohio River system tributaries contain viable populations. These populations will be distributed within the Ohio River system as follows: two populations in the upper Ohio River basin in Ohio, Indiana, or Illinois; one population in Kentucky; and one population in Tennessee.
2. Two naturally reproduced year classes exist within each of the four populations. Both year classes must have been produced within 10 years, and one year class within 5 years, of the downlisting date. Within 1 year of the downlisting date, gravid females of the subspecies and its fish host must be present in each river.
3. Biological and ecological studies have been completed, and the recovery measures developed and implemented from these studies are beginning to be successful, as evidenced by an increase in population density and/or an increase in the population size and the length of the river reach inhabited within each of the populations.

The subspecies will be considered for removal from Endangered Species Act protection when the likelihood of the subspecies

becoming threatened in the foreseeable future has been eliminated by the achievement of the following criteria:

1. Through protection of existing populations and successful establishment of reintroduced populations or the discovery of additional populations, a total of at least six Ohio River system tributaries contain viable populations. These populations will be distributed within the Ohio River system as follows: one population in Ohio, one population in Indiana, one population in Illinois, two populations in Kentucky, and one population in Tennessee.
2. Two distinct naturally reproduced year classes exist within each of the six populations. Both year classes must have been produced within 10 years, and one year class within 5 years, of the downlisting date. Within 1 year of the recovery date, gravid females of the subspecies and its fish host must be present in each river.
3. Studies of the mussel's biological and ecological requirements have been completed, and recovery measures developed and implemented from these studies have been successful as evidenced by an increase in population density and/or an increase in the population size and the length of the river reach inhabited within each of the six populations.
4. No foreseeable threats exist that would likely threaten survival of any of these six populations.
5. Where habitat had been degraded, noticeable improvements in water and substratum quality have occurred.

B. Narrative Outline

1. Prevent the imminent extinction of the purple cat's paw. Presently, the purple cat's paw exists only in two rivers, and it is likely that neither population is reproducing. It is thus critical to the subspecies' survival that it be brought into captivity and artificially propagated.
 - 1.1 Develop the technology to maintain and reproduce mussels in captivity. Research is underway to artificially propagate freshwater mussels. However, the technology to maintain adult mussels in captivity has not been developed. Techniques are needed for the long-term captive maintenance of adult mussels as well as the procedure to bring captive adults to a reproductive state.
 - 1.2 Determine the best methods of collecting purple cat's paws for maintenance of an artificially reproducing captive population and implement.
 - 1.3 Maintain a captive population of the purple cat's paw pearlymusse^l. A captive population is needed to prevent the imminent extinction of the subspecies because of the lack of reproduction in the wild. However, a captive population may also be needed to prevent the subspecies' extinction from the impacts of the zebra mussel (Dreissena polymorpha) (see Task 3.4). Large numbers of zebra mussels have been found attached to native mussels in the Great Lakes. This exotic mussel, which has recently invaded the Ohio River, is known to kill the native mussels it attaches to.
 - 1.4 Determine the feasibility of augmenting extant populations and reestablishing the purple cat's paw in historic habitat. Augment and reintroduce where feasible. The total historic distribution of the purple cat's paw is unknown, but available records indicate that the subspecies once was widespread in the large rivers of the Ohio River basin. To recover the subspecies, extirpated populations will need to be reestablished, unless substantial additional populations are found. Rivers for possible reintroduction will be selected based on present and expected future habitat and water quality.
 - 1.4.1 Determine the need, appropriateness, and feasibility of augmenting and expanding existing populations. The existing populations are likely below the number needed to maintain long-term viability. Thus, they will likely need to be supplemented to reach a viable size.

- 1.4.2 Develop a successful technique for reestablishing and augmenting populations. Sufficient specimens of the mussel are not available to allow for translocation of enough adults to establish or augment populations. Propagation and reintroduction techniques should be developed and evaluated for the subspecies.
 - 1.4.3 Coordinate with appropriate Federal and State agency personnel, local governments, and interested parties to identify streams suitable for augmentation and reintroduction and those most easily protected from further threats.
 - 1.4.4 Reintroduce the subspecies into its historic range and evaluate success. Using techniques developed in Task 1.3.2, reintroduce and monitor success.
 - 1.4.5 Implement the same protective measures for any introduced populations that were outlined for established populations.
2. Preserve present populations and occupied habitat. Because only two populations exist, it is essential that these populations be protected.
 - 2.1 Continue to utilize existing legislation and regulations (Federal Endangered Species Act, Federal and State surface mining laws, water quality regulations, stream alteration regulations, etc.) to protect the subspecies and its habitat. Prior to and during implementation of this recovery plan, the two extant populations should be protected by the full enforcement of existing laws and regulations.
 - 2.2 Solicit help in protecting the subspecies and its essential habitat. Section 7 consultation under the Endangered Species Act, Fish and Wildlife Coordination Act requirements, and other habitat protection programs can assist in protection of the subspecies, but these programs alone cannot recover the purple cat's paw. The assistance of Federal and State agencies, conservation groups, and local governments will be essential. Also, support of the local industrial, business, and farming communities, as well as other local individuals and groups, will be needed to meet the goal of recovering the subspecies. Without a commitment from the local people who have the greatest influence on habitat quality in the streams inhabited by the subspecies, recovery efforts will be doomed.

- 2.2.1 Meet with appropriate Federal, State, and local government officials and regional and local planners to inform them of our plans to attempt recovery and request their support and assistance.
 - 2.2.2 Meet with local business, mining, logging, farming, and/or industry interests and elicit their support in implementing protective actions.
 - 2.2.3 Develop an educational program using such items as slide/tape shows, brochures, etc. Present this material to Federal and State agencies, local governments, business groups, civic groups, youth groups, schools, church organizations, etc. Educational material which outlines the recovery goals and emphasizes the other benefits of maintaining and upgrading habitat quality will be extremely useful in informing the public of the recovery objectives.
- 2.3 Evaluate the use of land acquisition and other land management options as a means of protecting present and reintroduced populations, and use these methods where feasible. Watershed and riparian habitat protection can be an important tool in the protection and improvement of aquatic habitat.
3. Determine threats to the subspecies, conduct research necessary for the subspecies' management and recovery, and implement management where needed.
 - 3.1 Conduct life history research on the subspecies to include such factors as reproduction, food habits, age and growth, and mortality rates. Unless the subspecies' life history and environmental requirements are defined, recovery efforts may be inconsequential or misdirected.
 - 3.2 Characterize the subspecies' habitat requirements (relevant physical, biological, and chemical components) for all life history stages. The purple cat's paw appears to be sensitive to habitat degradation. Where the subspecies coexists with other mussel species, it occurs in fewer numbers than most other subspecies; and it has been extirpated from some river reaches where other mussels still exist in large numbers. Knowledge of the subspecies' habitat needs and ecological associations (especially host fish requirements) is needed to focus management and recovery efforts on the specific problems within the subspecies' habitat that limit the recovery of the purple cat's paw.

- 3.3 Determine present and foreseeable threats to the subspecies. Reservoir development on the large rivers within the Ohio River basin appears to have been the major cause of the purple cat's paw's decline. However, other factors have and will likely continue to adversely impact the subspecies. The mechanisms by which the subspecies and its habitat are impacted are also not entirely understood. To minimize and eliminate these threats where necessary to meet recovery, the information gathered under Tasks 2.1 and 2.2 must be utilized to target specific problem areas and determine the specific causative agent(s).
- 3.4 Investigate the relationships with nonnative bivalves. Some malacologists believe the Asiatic clam (Corbicula fluminea) poses a threat to our native mussel fauna. Another exotic clam, the zebra mussel (Dreissena polymorpha), has recently invaded the Great Lakes, and some adverse impacts to native mussels have been noted. The zebra mussel has just been discovered in the Ohio River in small numbers. However, as the species spread so quickly in the Great Lakes, it is expected to invade other river systems in the near future. The relationship between these nonnative mollusks and the native fauna needs to be understood, and, where feasible, measures should be taken to minimize their impact. It has been suggested (Arthur H. Clarke; Ecosearch, Inc; personal communication; 1990) that Corbicula may adversely impact native mussels by consuming a significant portion of their sperm. Clarke suggests that, by concentrating endangered mussels, the loss of sperm would decrease and reproductive success would increase. A study using nonendangered mussels should be used to test this hypothesis.
- 3.5 Determine the degree of threat to the subspecies from commercial mussel fishing; if this constitutes a significant threat to the subspecies, implement measures to minimize or eliminate the threat. Commercial mussel fishermen occasionally take the purple cat's paw. The impact of this take to the subspecies should be determined, and steps should be taken to control take, where necessary. Some river reaches may need to be declared State mussel sanctuaries to fully protect the subspecies from mussel fishing.
- 3.6 Based on the biological data and threat analysis, investigate the need for management, including habitat improvement. Implement management, if needed, to secure viable populations. Individual components of the subspecies' habitat may be lacking, and these may limit the subspecies' potential expansion. Specific

management and habitat improvement programs may be needed to improve the status of some populations.

- 3.7 Determine number of individuals required to maintain a viable population. Theoretical considerations by Franklin (1980) and Soulé (1980) indicate that 500 breeding individuals represent a minimum population level (effective population size), which would contain sufficient genetic variation to enable that population to evolve and respond to natural habitat changes. The actual population size in a natural ecosystem necessary to provide 500 breeding individuals can be expected to be larger, possibly by as much as 10 times. The factors that influence effective population size include sex ratio, length of subspecies' reproductive life, fecundity, and extent of exchange of genetic material within the population, plus other life history aspects. Some of these factors can be addressed under Task 2.1, while others will need to be addressed as part of this task.
4. Search for additional populations and/or habitat suitable for reintroduction efforts. Much of the potential available habitat in the Ohio River system has been surveyed. However, it is possible that some relic populations were missed. Further study may yield additional populations and also help delineate potential habitat for transplants.
5. Develop and implement cryogenic techniques to preserve the subspecies' genetic material until such time as conditions are suitable for reintroduction. The purple cat's paw populations that remain are apparently not reproducing. Artificial propagation techniques may be able to provide juvenile mussels for transplants. However, present habitat conditions may not be suitable in all rivers at this time for reintroduction to succeed. Cryogenic preservation of the purple cat's paw could maintain genetic material (much like seed banks for endangered plants) from both extant populations until such time that the habitat is suitable for reestablishment of the subspecies. Additionally, if a population were lost to a catastrophic event, such as a toxic chemical spill, cryogenic preservation could allow for the eventual reestablishment of the population using the genetic material preserved from that population.
6. Develop and implement a program to monitor population levels and habitat conditions of presently known populations as well as newly discovered, introduced, or expanding populations. During and after recovery actions are implemented, the status of the subspecies and its habitat must be monitored to assess any progress toward recovery. This should be conducted on a biennial schedule.

7. Annually assess overall success of the recovery program and recommend action (modify recovery objectives, downlist, delist, continue to protect, implement new measures, or other studies, etc.). The recovery plan must be evaluated periodically to determine if it is on track and to recommend future actions. As more is learned about the subspecies, recovery objectives may need to be modified.

C. Literature Cited

- Bates, J. M., and S. D. Dennis. 1985. Mussel resource survey - State of Tennessee. Tennessee Wildlife Resources Agency Technical Report No. 85-3. 125 pp.
- Bogan, A. E., and P. W. Parmalee. 1983. Tennessee's rare wildlife, Volume II: the mollusks. 123 pp.
- Churchill, E. P., Jr., and S. I. Lewis. 1924. Food and feeding in freshwater mussels. Bull. U.S. Bur. Fish. 39:439-471.
- Franklin, R. I. 1980. Evolutionary change in small populations. IN: Conservation biology, an evolutionary-ecological perspective. Michael E. Soulé and Bruce A. Wilcox (eds.). Published by Sinauer Assoc., Inc., Sunderland, MA. Pp. 135-149.
- Gordon, M. E., and J. B. Layzer. 1989. Mussels (Bivalvia: Unionoidea) of the Cumberland River: review of life histories and ecological relationships. U.S. Fish and Wildlife Service Biological Report. 89(15). 99 pp.
- Isom, B. G., C. Gooch, S. D. Dennis. 1979. Rediscovery of a presumed extinct river mussel Dysnomia sulcata (Unionidae). The Nautilus 93(2-3):84.
- Kentucky State Nature Preserves Commission. 1980. Kentucky natural areas plan - appendix A. The purple cat's paw (Epioblasma (=Dysnomia) obliquata obliquata (=E. sulcata sulcata)) (Rafinesque 1820). Frankfort, KY.
- Parmalee, P. W., W. E. Klippel, and A. E. Bogan. 1980. Notes on the prehistoric and present status of Naiad fauna of the middle Cumberland River, Smith County, Tennessee. The Nautilus 94(3):93-105.
- Rafinesque, Constantine S. 1820. Monographie des coquilles bivalves et fluviatiles de la riviere Ohio. Generales des Sciences-Physiques 5(13):287-322, 3 pl.
- Soulé, M. E. 1980. Thresholds for survival: Maintaining fitness and evolutionary potential. IN: Conservation biology, an evolutionary-ecological perspective. Michael E. Soulé and Bruce A. Wilcox (eds.). Published by Sinauer Assoc., Inc., Sunderland, MA. Chap. 8, pp. 151-169.
- Stansbery, David H. 1970. Eastern freshwater mollusks (I) The Mississippi and St. Lawrence River systems. Malacologia 10(1):9-22.

- Watters, G. T. 1986. The Nature Conservancy Element Stewardship Abstract: Epioblasma obliquata obliquata. The Nature Conservancy, Midwest Regional Office, Minneapolis, MN. Unpublished report. 4 pp.
- U.S. Fish and Wildlife Service. 1990. Endangered and Threatened Wildlife and Plants: Designation of the Purple Cat's Paw Pearlymussel as an Endangered Species. Federal Register 55(132):28209-28213.

PART III

IMPLEMENTATION SCHEDULE

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

1. Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.
2. Priority 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. Priority 3 - All other actions necessary to meet the recovery objective.

Key to Acronyms Used in This Implementation Schedule

COE	- U.S. Army Corps of Engineers
FS	- U.S. Forest Service
FWE	- Fish and Wildlife Enhancement
FWS	- U.S. Fish and Wildlife Service
ILDOC	- Illinois Department of Conservation
INDNR	- Indiana Department of Natural Resources
KDFWR	- Kentucky Department of Fish and Wildlife Resources
KSNPC	- Kentucky State Nature Preserves Commission
NPS	- National Park Service
ODNR	- Ohio Department of Natural Resources
TDOC	- Tennessee Department of Conservation
TVA	- Tennessee Valley Authority
TWRA	- Tennessee Wildlife Resources Agency

IMPLEMENTATION SCHEDULE

PRIOR- ITY #	TASK #	TASK DESCRIPTION	TASK DURATION (Years)	RESPONSIBLE PARTY			COST ESTIMATES (\$000'S)			COMMENTS
				FWS		Other	FY 1991	FY 1992	FY 1993	
				Region	Division					
1	1.1, 1.2, 1.3	Develop and maintain captive populations of species.	3 years to develop, then continuous	3, 4, 5	FWE	See *1.	25.0	25.0	25.0	
1	1.4	Develop techniques, select sites, reintroduce the species back into historic habitat, and evaluate and protect any populations established.	Ongoing	3, 4, 5	FWE	See *1.	25.0	25.0	25.0	Task duration: 3 years (protection continues).
1	2.1	Continue to utilize existing legislation and regulations to protect species and its habitat.	Ongoing	3, 4, 5	FWE	See *1.	3.0	3.0	3.0	
2	2.2.1, 2.2.2	Meet with local governmental officials and business interests and elicit their support for recovery.	3 years	3, 4, 5	FWE	See *1.	---	---	1.0	

IMPLEMENTATION SCHEDULE

PRIOR- ITY #	TASK #	TASK DESCRIPTION	TASK DURATION (Years)	RESPONSIBLE PARTY			COST ESTIMATES (\$000'S)			COMMENTS
				FWS		Other	FY 1991	FY 1992	FY 1993	
				Region	Division					
3	3.7	Determine number of individuals required to maintain viable population.	1 year	3, 4, 5	FWE	See *1.	---	---	?	
1	4	Search for additional populations and suitable habitat.	1 year	3, 4, 5	FWE	See *1.	30.0	30.0	---	
1	5	Develop and utilize cryo-preservation techniques.	Ongoing	3, 4, 5	FWE	See *1.	5.0	5.0	5.0	
2	6	Develop and implement a monitoring program.	Ongoing	3, 4, 5	FWE	See *1.	---	---	2.0	Biennial.
3	7	Annually assess recovery program and modify program and plan where required.	Ongoing	3, 4, 5	FWE	See *1.	0.5	0.5	0.5	
*1 - COE, FS, ILDOC, INDNR, KDFWR, KSNPC, NPS, ODNR, TDOC, TVA, and TWRA										

IMPLEMENTATION SCHEDULE

PRIOR- ITY #	TASK #	TASK DESCRIPTION	TASK DURATION (Years)	RESPONSIBLE PARTY			COST ESTIMATES (\$000'S)			COMMENTS
				FWS		Other	FY 1991	FY 1992	FY 1993	
				Region	Division					
1	2.2.3	Develop informa- tion and education program and present.	Ongoing	3, 4, 5	FWE	See *1.	25.0	20.0	---	Task duration: 2 years to develop, then continuous.
2	2.3	Consider use of land acquisition to protect the species.	Ongoing	3, 4, 5	FWE	See *1.	---	---	---	
1	3.1, 3.2, 3.3, 3.4, 3.5	Conduct research necessary for species management and recovery; i.e., habitat requirements, biology, and threat analysis.	4 years	3, 4, 5	FWE	See *1.	25.0	50.0	50.0	
See com- ments.	3.6	Based on biologi- cal and threat analysis, investi- gate need for management and implement where needed.	1 year	3, 4, 5	FWE	See *1.	---	---	---	Priority 1, 2, or 3 (depending on result of 3.1, 3.2, 3.3, 3.4, and 3.5).

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