Little-wing Pearly Mussel

Recovery Plan

RECOVERY PLAN

for

Little-wing Pearly Mussel (*Pegias fabula*)

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

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Recovery plans delineate reasonable actions which are believed to be required to recover and/or protect the 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:

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PART I

INTRODUCTION

The little-wing pearly mussel (Pegias fabula) was listed as an endangered species without critical habitat on November 14, 1988 (53 FR 45861). This Cumberlandian species probably inhabited many of the moderately high gradient, small to medium tributaries of the Tennessee and Cumberland River systems in Alabama, Kentucky, Tennessee, North Carolina, and Virginia. Historical records exist for 24 stream reaches in these States, but the species is presently known from only six streams (three in Kentucky, one in Tennessee, and two in Virginia). The mussel's range has been reduced, primarily due to coal mining and gas and oil development in the upper Cumberland and Powell River basins. Additional impacts include reservoir construction, poor land use practices, and urbanization which have caused excessive siltation and pollution throughout the species range.

Description, Ecology, and Life History

The little-wing pearly mussel (the only species in the genus Pegias) is small, not exceeding 1.5 inches (3.8 cm) in length and 0.5 inches (1.3 cm) in width. The shell's outer surface (periostracum) is usually eroded, giving the shell a chalky or ashy white appearance. When the periostracum is present, the shell is light green or dark yellowish brown with dark rays of variable width along the shell's anterior surface (Clarke 1981, Bogan and Parmalee 1983, and Ahlstedt 1986).

The little-wing pearly mussel (Pegias fabula) was originally described from a male specimen by Lea (1838) as Margaritana fabula. Simpson (1900) placed the species in a new genus Pegias and listed previous taxonomic synonyms. Ortmann (1913-1914) considered Pegias to be a subgenus of Alasmidonta; however, that opinion has not been followed by most subsequent authorities. The U.S. Fish and Wildlife Service follows Simpson (1900) and Clarke (1981) in considering Margaritana curreyiana Lea, 1840, to be a synonym of Pegias fabula. For a detailed synonymy, see Clarke (1981) and Bogan and Parmalee (1983). Lectotype specimens are located at the U.S. National Museum, Washington, D.C. Pictures are available in Burch (1973, 1975), Clarke (1981), Bogan and Parmalee (1983), and Ahlstedt (1986).

Presently the species is rare, and little is known of its life history. However, ecological observations by biologists collecting the species for taxonomic study, status surveys, studies involving associated fauna, and evaluations of threats to mussel communities have provided some insight into the species' biology (reviewed in Gordon and Layzer 1988). The little-wing pearly mussel inhabits small to medium, low turbidity, cool-water, high to moderate gradient streams in the Cumberland and Tennessee River basins (Bogan and Parmalee 1983, Ahlstedt 1986). Blankenship (1971) reported the mussel in riffles lying on top of the substratum in the Rockcastle River. In the Little South Fork Cumberland River, Starnes and Starnes (1980) reported the mussel partly buried in or on top of the substratum in the transition zone between a long pool and riffle. Di Stefano (1984) reported the species buried in gravel or beneath boulders and slabrock in Horselick Creek. Ahlstedt (1986) suggests that

late spring (May and June) or late fall (October and November) may be the best times to find the species since they tend to be on top of or only partially buried in the substratum during spawning.

Specific food habits of the little-wing pearly mussel 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 species reproductive biology remains 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 gills until the larvae (glochidia) fully develop. Gravid female little-wing pearly mussels have been reported in both September and October, and nongravid or spent females have been observed in March (Ortmann 1913 and 1914, Ahlstedt 1986). Ahlstedt (1986) suggests that the species is a winter or long-term brooder, holding glochidia from midsummer until the following spring. When the glochidia are released into the water, they attach and encyst on the gills or fins of a fish host. When metamorphosis is complete, they drop to the streambed as a juvenile mussel. The species of fish utilized by the little-wing pearly mussel are unknown. Ahlstedt (1986) reports that the banded sculpin (Cottus carolinae) and redline darter (Etheostoma rufilineatum) are found in the same habitat as this mussel in parts of its range and may be prime candidates as host species.

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

The little-wing pearly mussel was historically widespread but uncommon (see Table 1 and Figure 1) in the smaller tributaries of the upper Cumberland and Tennessee River basins in Alabama, North Carolina, Kentucky, Tennessee, and Virginia (Stansbery 1976, Clarke 1981, Bogan and Parmalee 1983, Ahlstedt 1986). Based on a 1986 Service-funded survey involving extensive field sampling of potential and historic habitat in Cumberland and Tennessee River tributaries (Ahlstedt 1986) and other data (Steve Bakaletz, U.S. Park Service, Big South Fork National Recreation Area, personal communication, 1986; Richard Neves, Virginia Cooperative Fish and Wildlife Research Unit, personal communication, 1987), the species is now known to inhabit only six stream reaches (three in Kentucky, one in Tennessee, and two in Virginia). Ahlstedt (1986) surveyed 55 potential and/or historic habitats in the Tennessee and Cumberland River basin but was able to find only 17 live specimens. Seven live and three dead specimens were found in Horse Lick Creek in Jackson and Rockcastle Counties, Kentucky. This population, which extends over at least 10 creek miles from the confluence with the Rockcastle River upstream to Clover Bottoms, is one of the healthiest of the surviving populations. Horse Lick Creek, designated as one of Kentucky's Outstanding Resource Waters by the Kentucky Natural Resources and Environmental Protection Cabinet, has good habitat and water quality in most stream reaches and a complex mussel fauna. The Horse Lick Creek watershed is relatively remote, not extensively developed, and partially within the Daniel Boone National

Table 1. Historic (H) and present (P) occurrences of the little-wing pearly mussel. Data taken from Stansbery (1976), Clarke (1981), Bogan and Parmalee (1983), Ahlstedt (1986), and Bakaletz (personal communication, 1987).

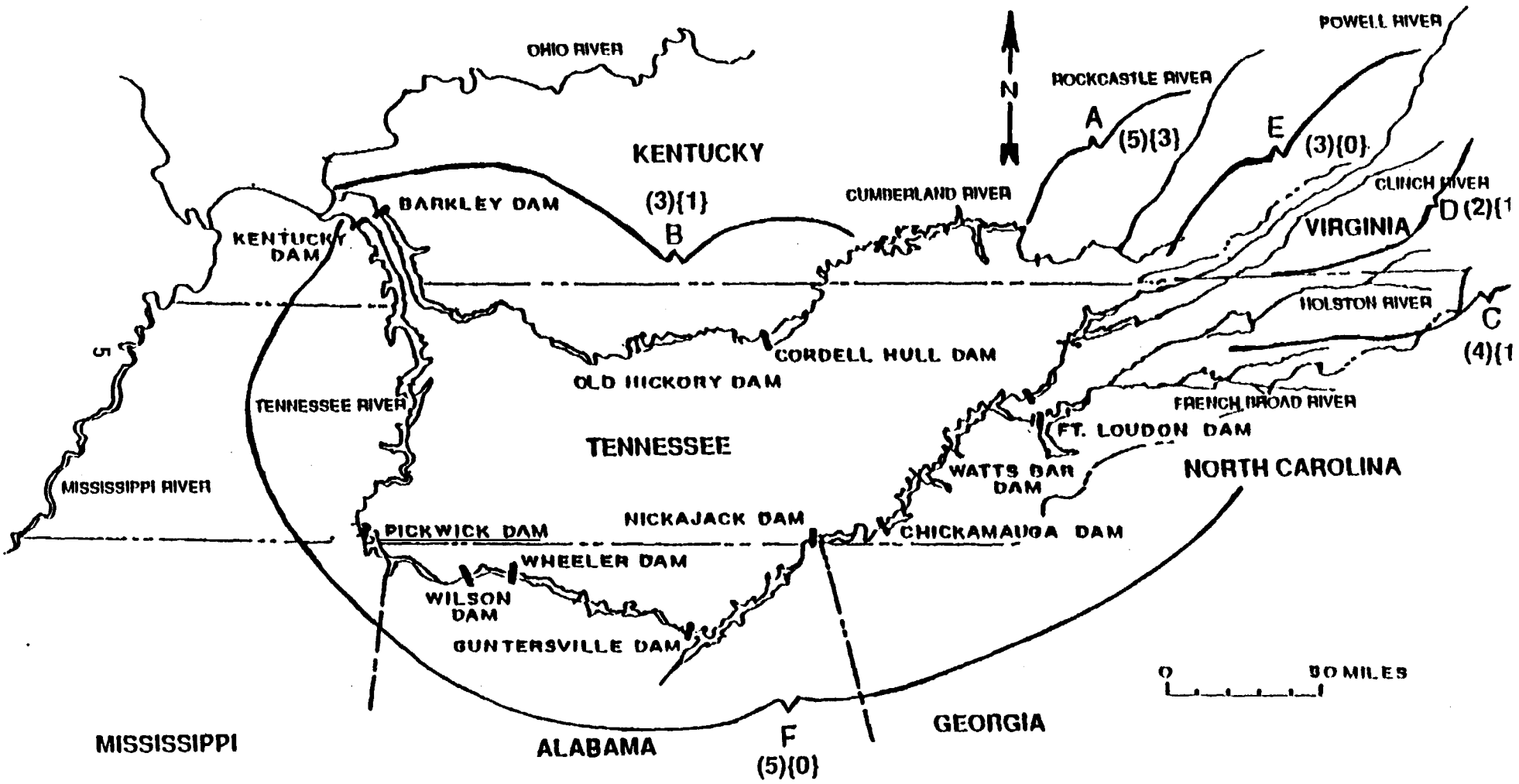
Cumberland River System

(H)	Rockcastle River	Laurel and Rockcastle Counties, KY
(P)	Horse Lick Creek	Jackson and Rockcastle Counties, KY
(H)	Buck Creek	Pulaski County, KY
(H)	Pitman Creek	Pulaski County, KY
(P)	Big South Fork Cumberland River	McCreary and Wayne Counties, KY
(P)	Little South Fork Cumberland River	McCreary and Wayne Counties, KY
(P)	Cane Creek	Van Buren County, TN
(H)	Collins River	Warren County, TN
(H)	Stones River	Rutherford County, TN
(H)	West Fork Red River	Todd County, KY

Tennessee River System

(H)	South Fork Holston River	Washington County, VA, and Sullivan County, TN
(H)	Middle Fork Holston River	Smyth County, VA
(P)	North Fork Holston River	Smyth and Washington Counties, VA
(H)	Big Moccasin Creek	Scott County, VA
(P)	Clinch River	Tazewell County, VA
(H)	Copper Creek	Scott County, VA
(H)	Flag Pond	Lee County, VA
(H)	Wallen's Creek	Lee County, VA
(H)	Powell River	Lee County, VA
(H)	French Broad River	State and County Unknown
(H)	Valley Creek	Cherokee County, NC
(H)	Elk River at Estell Spring	Franklin County, TN
(H)	Blue Water Creek	Lauderdale County, AL
(H)	Duck River	County Unknown, TN

Figure 1. Number of historic (number in parenthesis) and number of present (1988) populations [number in brackets] by drainage area. Drainage Area A = Cumberland River drainage above Lake Cumberland, B = Cumberland River drainage below Lake Cumberland, C = Holston River drainage, D = Clinch River drainage above confluence with the Powell River, E = Powell River drainage, and F = Tennessee River drainage from and including the French Broad River to the Ohio River. Distributional data from Ahlstedt (1986), Clarke (1981), and Stansbery (1976) and from personal communications with Bakaletz (1986) and Neves (1987). (See Table 2 for number of viable populations needed per drainage area to meet recovery objectives.)


OHIO RIVER
KENTUCKY
(3){1}
B
BARKLEY DAM
KENTUCKY DAM
CUMBERLAND RIVER
ROCKCASTLE RIVER
A
(5){3}
POWELL RIVER
E
(3){0}
CLINCH RIVER
VIRGINIA
D (2){1
HOLSTON RIVER
C
(4){1
CORDELL HULL DAM
OLD HICKORY DAM
TENNESSEE RIVER
FRENCH BROAD RIVER
FT. LOUDON DAM
TENNESSEE
WATTS BAR DAM
NORTH CAROLINA
MISSISSIPPI RIVER
PICKWICK DAM
NICKAJACK DAM
CHICKAMAUGA DAM
WHEELER DAM
WILSON DAM
GUNTERSVILLE DAM
0
50 MILES
MISSISSIPPI
ALABAMA
F
(5){0}
GEORGIA

Forest. However, the watershed has oil, gas, and coal deposits, and the exploration and development of these resources has already begun. This population will survive only if protection of the species is considered during the development of these resources.

During a 1985-86 mussel survey of the Big South Fork Cumberland River, funded by the Corps of Engineers, Nashville, Tennessee (Bakaletz, personal communication, 1986), a good population of the little-wing pearly mussel was discovered in a roughly 2.1-mile river section from Oil Well Branch downstream to Bear Creek in McCreary County, Kentucky. This population exists within the Big South Fork National River and Recreation Area, which is administered by the National Park Service. A large portion of the Big South Fork is impacted by siltation and acid mine drainage from coal mining activities. The short reach inhabited by this species is in a river section that has apparently recovered from upstream impacts, and is upstream of the coal mining and impoundment impacts that degrade the lower river today. Twenty other mussel species also occur in this river reach, including the federally listed Cumberland bean pearly mussel (Villosa trabalis). The little-wing pearly mussel does not inhabit the entire river reach (more than 10 miles) populated by the Cumberland bean pearly mussel, possibly due to its greater sensitivity to environmental degradation.

When Ahlstedt (1986) surveyed the Little South Fork Cumberland River, McCreary and Wayne Counties, Kentucky, in 1985, he found 3 live and 126 dead specimens from just above Kentucky State Highway Route 92 bridge downstream to Freedom Church Ford. More recent studies (1987-1988) by Robert Anderson (Tennessee Cooperative Fishery Research Unit, personal communication, 1988) indicate the little-wing probably no longer survives in that river reach. The lower portion of the river section once inhabited by the species is being impacted by drainage from abandoned mined lands (Sherry Evans and Skip Call, Kentucky Department of Environmental Protection, personal communication, 1986; Anderson, personal communication, 1988). Lick Creek, a tributary in this river reach, had substantially elevated concentrations of dissolved solids, sulfates, aluminum, iron, and manganese in November 1985 (Evans and Call, personal communication, 1986). Studies are presently underway to determine the cause of mussel losses from this river section (Anderson, personal communication, 1988). Although the species has been eliminated from the lower river, Anderson (personal communication, 1988) reports that it still survives in limited numbers upstream from the Route 92 bridge.

Four live and three dead specimens were reported from Cane Creek, Van Buren County, Tennessee (Ahlstedt 1986). This river has very limited mussel habitat, and the species is apparently limited to a few shoals immediately upstream of the swinging bridge at Sweetgum, Tennessee. Downstream from this population, Cane Creek is impounded by the backwaters of Great Falls Lake on the Caney Fork River. Upstream from this population, the cobble and boulder substrate is apparently unsuitable habitat for this species, and at some places upstream the creek goes underground.

The population in the North Fork Holston River (three live and three dead specimens collected), Smyth County, Virginia, is relatively small (Ahlstedt

1986). The North Fork Holston River has been extensively sampled at many sites, and, except for one individual taken near Saltville, Virginia (Neves, personal communication, 1987), all specimens, past and present, have been taken at one shoal near County Road 622 bridge, Nebo, Virginia.

Six relic shells and one live animal were found in the Clinch River in Tazewell County, Virginia, below the County Road 639 bridge (Neves, personal communication, 1987). This population is similar in size to the North Fork Holston and Cane Creek populations. All of these populations are small and range over short river reaches.

The little-wing pearly mussel was known from many tributaries of the Tennessee and Cumberland River systems (Table 1 and Figure 1), and it likely inhabited other streams but was extirpated before it was discovered. Habitat loss and water quality deterioration, attributed to impoundments, industrial and municipal pollution, acid mine drainage, and siltation resulting from mining, agriculture, and construction activities, are the primary reasons for the losses. However, some losses are apparently due to less drastic changes in water and habitat quality since some populations have been extirpated from stream reaches that still contain mussel communities (Stansbery 1976).

Potential threats to the species and its habitat could arise from development of coal, oil, and/or gas reserves in the watersheds of Horse Lick Creek, Big South Fork Cumberland River, Little South Fork Cumberland River, Clinch River, and Cane Creek. Past unregulated activities from development of these reserves have contributed and continue to contribute to the species' decline. Current activities not in compliance with appropriate regulations are also a threat to the species.

All six populations could potentially be impacted by such actions as road construction, stream channel modifications, logging activities, agricultural activities, impoundments, land use changes, pesticide use, and other projects or activities in the watershed if such activities are not planned and implemented with the survival of the species and the protection of its habitat in mind. Because all populations inhabit only short stream reaches that are within 1 to 5 miles of bridges and fords, they are also vulnerable to toxic spills.

All six of the known populations are small and isolated. Population isolation restricts the natural interchange of genetic material among populations, and small population size reduces the intra-population reservoir of genetic variability. The loss of genetic diversity could adversely affect, over time, the species' ability to evolve and respond to natural habitat changes. According to Soulé (1980), a minimum of roughly 500 individuals is recommended to maintain genetic variability and evolutionary potential within a population. The absolute sizes of the little-wing pearly mussel populations are unknown, but considering the limited extent of available habitat and the densities of individuals (no little-wing pearly mussels were taken in 30 quantitative samples

[Ahlstedt 1986]), it is likely each of these populations, with the possible exception of Horse Lick Creek and Big South Fork Cumberland River, contains less than 500 individuals (Steve Ahlstedt, Tennessee Valley Authority, personal communication, 1986).

PART II

RECOVERY

A. Recovery Objectives

The ultimate goal of this recovery plan is to restore viable populations* of the little-wing pearly mussel (Pegias fabula) to a significant portion of its historic range in the Cumberland and Tennessee River systems (Figure 1) and remove the species from the Federal List of Endangered and Threatened Wildlife and Plants.

The species will be considered for reclassification to threatened status when the likelihood of the species' 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 discovery of additional populations, a total of eight distinct viable populations* exist in the Cumberland and Tennessee River systems (see Table 2 for location of populations).

2. 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 recruitment and an increase in population density and/or an increase in the population size and length of river reach inhabited within each of the eight populations.

The species will be considered for removal from Endangered Species Act protection when the likelihood of the species 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 discovery of additional populations, a total of 13 distinct viable populations* exist in the Cumberland and Tennessee River systems (see Table 2 for location of populations).

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* 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.

Table 2. Historic and present (1988) little-wing pearly mussel distribution by drainage area and the number of viable populations that must be present before the mussel can be considered for reclassification to threatened status or removed from the Federal list of endangered and threatened species. Distributional data from Ahlstedt (1986), Clarke (1981), and Stansbery (1976) and from personal communications with Bakaletz (1986) and Neves (1987).

River Systems	Number of Present and Known Historic Populations	Number of Present Populations	Number of Viable* Populations Needed to Reclassify to Threatened	Number of Viable* Populations Needed to Remove from ESA Protection
Cumberland River System				
Drainage Area A** Cumberland River drainage upstream of Lake Cumberland	6	3	3	3
Drainage Area B Cumberland River drainage downstream of Lake Cumberland	4	1	1	2
Tennessee River System				
Drainage Area C Holston River drainage	4	1	1	2
Drainage Area D Clinch River drainage above confluence with the Powell River	2	1	1	2
Drainage Area E Powell River Drainage	3	0	1	2
Drainage Area F Tennessee River drainage from and including the French Broad River drainage to the Ohio River	5	0	1	2
Total	24	6	8	13

*See definition of viable population in text.
**Location of Drainage Areas A thru F can be seen Figure 1.

2. 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 recruitment and an increase in population density and/or an increase in the population size and length of river reach inhabited within each of the 13 populations.

3. No foreseeable threats exist that would likely threaten survival of any of these 13 populations.

4. Where habitat had been degraded, noticeable improvements in water and substratum quality have occurred.

B. Narrative Outline

1. Preserve present populations and occupied habitat. Because so few populations exist, it is essential that all populations are protected.

1.1. 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 species and its habitats. Prior to and during implementation of this recovery plan, the present populations (see Table 1) can be protected only by the full enforcement of existing laws and regulations.

1.2. Solicit help in protecting the species and its essential habitats. Section 7 consultation under the Endangered Species Act and Fish and Wildlife Coordination Act activities can assist in protection of the species, but these programs alone cannot recover the little-wing pearly mussel. The assistance of Federal and State agencies and conservation groups as well as local governments will be essential. Also, support of the local industrial, business and farming communities, as well as local people, will be needed to meet the goal of recovering the species. Without a commitment from the local people who have an influence on habitat quality in the streams inhabited by the species, recovery efforts will be doomed.

1.2.1. 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.

1.2.2. Meet with local business, mining, logging, farming, and/or industry interests and try to elicit their support in implementing protective actions.

1.2.3. Develop an educational program using such items as slide/tape shows, brochures, etc. Present this

material to business groups, civic groups, youth groups, schools, church organizations, etc. Educational material outlining the recovery goals and emphasizing the other benefits of maintaining and upgrading habitat quality will be extremely useful in informing the public of our actions.

2. Determine threats to the species, conduct research necessary for the species' management and recovery, and implement management where needed.

2.1 Conduct life history research on the species to include reproduction, food habits, age and growth, mortality factors, etc. The studies of Ahlstedt (1986), Clarke (1981), Anderson (personal communication, 1988), and Neves (personal communication, 1988) provide some data on the species' life history, but much more information is needed to determine the species' requirements. Unless the species' life cycle and environmental requirements are defined, recovery efforts may be inconsequential or misdirected.

2.2 Characterize the species' habitat requirements (relevant physical, biological, and chemical components) for all life history stages. The little-wing pearly mussel appears to be sensitive to habitat degradation. Where the species coexists with other mussel species, its distribution is more restricted. Knowledge of the species' habitat needs and ecological associations is required to focus management and recovery efforts on the specific problems within the species' habitat.

2.3 Determine present and foreseeable threats to the species. Coal mining and oil and gas well development appear to have been major factors in altering the species' habitat and reducing its range in the upper Cumberland River system and in the Powell River. Siltation from poor land use practices and impoundment have also had an impact. However, other impacts are also probable. The mechanism by which the species and its habitat are impacted is not entirely understood, and the extent to which the species can withstand these impacts is unknown. 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 the specific problem areas and determine the specific causative agent(s).

2.4 Based on the biological data and threat analysis, investigate the need for management, including habitat improvement. Implement management, if needed, to secure viable populations. Specific components of the species' habitat may be lacking, and these may limit the species' potential expansion. Habitat improvement programs in the streams and

their watersheds may be needed to alleviate these limiting factors.

2.5 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 which will influence effective population size include sex ratio, length of species' 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.

3. Search for additional populations and/or habitat suitable for reintroduction efforts. Distributional studies of this species have been completed (Ahlstedt 1986; Bakaletz, personal communication, 1986; and Neves, personal communication, 1987). Much of the potential available habitat in the Tennessee and Cumberland River systems has been surveyed; however, it is possible that some relic populations were missed. Further study may yield additional populations, and suitable habitat for transplants could also be identified during these surveys.

4. Determine the feasibility of reestablishing the little-wing pearly mussel in historic habitat and reintroduce where feasible. The historic distribution of the little-wing pearly mussel is unknown, but available records indicate that the species once inhabited 24 streams in the Tennessee and Cumberland River systems. Based on the extent of potential habitat that likely existed in the systems, it is probable that the species was present in many more streams. Streams for possible reintroductions will be selected based on present and expected future habitat and water quality.

4.1. Determine the need, appropriateness, and feasibility of augmenting and expanding existing populations. Most of the populations are likely below the number needed to maintain long-term viability. These populations may be able to expand naturally if environmental conditions are improved. However, some populations may be too small and may need to be supplemented to reach a viable size. Populations for this task will be selected based on present population size, habitat quality, and the likelihood of long-term benefits from the task.

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 populations. Techniques for rearing the species and introduction techniques should be developed to help ensure success.

4.3. Coordinate with appropriate Federal and State agency personnel, local governments, and interested parties to identify streams suitable for augmentation and reintroductions and those most easily protected from further threats.

4.4. Reintroduce the species into its historic range and evaluate success. Using techniques developed in Task 4.2, introduce and monitor success.

4.5. Implement the same protective measures for any introduced populations as outlined for established populations.

5. Develop and implement a program to monitor population levels and habitat conditions of presently established populations as well as newly discovered, introduced, or expanding populations. During and after recovery actions are implemented, the status of the species and its habitat must be monitored to assess any progress toward recovery. This should be conducted on a biennial schedule.

6. Annually assess overall success of the recovery program and recommend action (changes in recovery objectives, delist, continue to protect, implement new measures, 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 species, recovery objectives may need to be modified.

C. Literature Cited

Ahlstedt, S. A. 1986. A status survey of the little-wing pearly mussel (Pegias fabula) (Lea 1838). Report submitted in fulfillment of U.S. Fish and Wildlife Service Contract No. 14-16-0004-84-927. 38 pp.

Blankenship, S. 1971. Notes on Alasmidonta fabula (Lea) in Kentucky (Unionidae). Nautilus, 85(2):60-61.

Bogan, A. E., and P. W. Parmalee. 1983. Tennessee's Rare Wildlife, Volume II: The Mollusks. Tennessee Wildlife Resources Commission and Tennessee Department of Conservation. 123 pp.

Burch, J. B. 1973. Freshwater Unionacean Clams (Mollusca: Pelecypoda) of North America. U.S. Environmental Protection Agency Biota of Freshwater Ecosystems Identification Manual No. 11. 176 pp.

------. 1975. Freshwater Unionacean Clams (Mollusca: Pelecypoda) of North America. Malacological Publications. Hamburg, MI. 204 pp.

Clarke, A. H. 1981. The Tribe Alasmidontini (Unionidae: Anodontinae), Part I: Pegias, Alasmidonta, and Arcidens. Smithsonian Contributions to Zoology, No. 326. 101 pp.

Churchill, E. P., Jr. and S. I. Lewis. 1924. Food and feeding in freshwater mussels. Bull. U.S. Bur. Fish. 39:439-471.

Di Stefano, R. J. 1984. Freshwater mussels (Bivalvia: Unionidae) of Horse Lick Creek, Rockcastle River, Kentucky. Nautilus, 98(3):110-113.

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., and J. Layzer. 1988. Draft report on mussel fauna of Cumberland River system, Tennessee and Virginia. Submitted to U.S. Fish and Wildlife Service, National Ecology Research Center, Ft. Collins, CO. 101 pp.

Lea, I. 1838. Descriptions of new freshwater and land shells. Transactions of the American Philosophical Society, New Series, 6:1-154, plates 1-24. (Reprinted in 1838 in Observations on the Genus Unio, 2:1-154, plates 1-24.)

Ortmann, A. E. 1913-1914. Studies in naiades (in part). The Nautilus 28:41-47, 65-69.

Simpson, C. T. 1900. Synopsis of the naiades, or pearly fresh-water mussels. Proceedings of the U.S. National Museum 22(1205):501-1004.

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., pp. 151-169.

Stansbery, D. H. 1976. Status of endangered fluviatile mollusks in central North America: Pegias fabula (Lea 1838). Report submitted in fulfillment of U.S. Fish and Wildlife Service Contract No. 14-16-0008-755. 6 pp.

Starnes, L. B. and W. C. Starnes. 1980. Discovery of a new population of Pegias fabula (Lea.) (Unionidae). Nautilus, 94(1):5-6.

PART III

IMPLEMENTATION SCHEDULE
KEY TO IMPLEMENTATION SCHEDULE COLUMNS 1 & 4

General Category (Column 1):

Information Gathering - I or R (Research)

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

Acquisition - A

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

Other - O

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

Management - M

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

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

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

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.

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

IMPLEMENTATION SCHEDULE

*1 GENERAL CATEGORY	PLAN TASK	TASK NUMBER	PRIORITY	TASK DURATION	RESPONSIBLE AGENCIES *2			ESTIMATED FISCAL YEAR COSTS *4			COMMENTS/NOTES
					FWS						
					REGION	DIVISION	OTHERS *3	FY 1	FY 2	FY 3	
02-4	Continue to utilize existing legislation and regulations to protect species and its habitat.	1.1	1	Continuous	4, 5	FWE	OSM, TVA, NPS, USFS, KNPC, KDFWR, NCWRC, NCDNRCD, NCNHP, TDOC, TWRA, VCGIF, SSM	1	1	1	
01	Meet with local governmental officials and business interests and elicit their support for recovery.	1.2.1, 1.2.2	2	3 years	4	FWE	NPS, USFS, KNPC, KDFWR, NCWRC, NCDNRCD, NCNHP, TDOC, TWRA, VCGIF	1	1	1	
01	Develop information and education program and present.	1.2.3	1	Continuous	4	FWE	NPS, USFS, KNPC, KDFWR, NCWRC, NCDNRCD, NCNHP, TDOC, TWRA, VCGIF	4	1	1	Task Duration: One year to develop program, then continuous.

IMPLEMENTATION SCHEDULE

*1 GENERAL CATEGORY	PLAN TASK	TASK NUMBER	PRIORITY	TASK DURATION	RESPONSIBLE AGENCIES *2			ESTIMATED FISCAL YEAR COSTS *4			COMMENTS/NOTES
					FWS						
					REGION	DIVISION	OTHERS *3	FY 1	FY 2	FY 3	
R1-4, R6-8, R9-10, R12, R14	Conduct research necessary for species management and recovery; i.e., habitat requirements, biology, and threat analysis.	2.1, 2.2, 2.3	1	4 years	4	FWE	NPS, USFS, KNPC, KDFWR, NCWRC, NCDNRCD, NCNHP, TDOC, TWRA, VCGIF	25	25	25	
I4, R4, M3-5, M7	Based on biological and threat analysis, investigate need for management and implement where needed.	2.4	*	1 year	4	FWE	NPS, USFS, KNPC, KDFWR, NCWRC, NCDNRCD, NCNHP, TDOC, TWRA, VCGIF	---	---	10	*Priority 1, 2, or 3 (depending on result of 1.3.1, 1.3.2, and 1.3.3).
R14	Determine number of individuals required to maintain viable population.	2.5	3	1 year	4	FWE	NPS, USFS, KNPC, KDFWR, NCWRC, NCDNRCD, NCNHP, TDOC, TWRA, VCGIF	---	---	*	*Unknown.

IMPLEMENTATION SCHEDULE

*1 GENERAL CATEGORY	PLAN TASK	TASK NUMBER	PRIORITY	TASK DURATION	RESPONSIBLE AGENCIES *2			ESTIMATED FISCAL YEAR COSTS *4			COMMENTS/NOTES
					FWS						
					REGION	DIVISION	OTHERS *3	FY 1	FY 2	FY 3	
I1-2	Search for additional populations and suitable habitat.	3	2	1 year	4	FWE	NPS, USFS, KNPC, KDFWR, NCWRC, NCDNRCD, NCNHP, TDOC, TWRA, VCGIF	---	---	10	
R7, R13, M1-2	Develop techniques, select sites, reintroduce the species back into historic habitat, and evaluate and protect any populations established.	4	2	Continuous	4	FWE	NPS, USFS, KNPC, KDFWR, NCWRC, NCDNRCD, NCNHP, TDOC, TWRA, VCGIF	25	20	25	Task Duration: Three years (protection continuous).
I1-2	Develop and implement a monitoring program.	5	2	Continuous	4	FWE	NPS, USFS, KNPC, KDFWR, NCWRC, NCDNRCD, NCNHP, TDOC, TWRA, VCGIF	4	---	4	Biennial.

*1 GENERAL CATEGORY	PLAN TASK	TASK NUMBER	PRIORITY	TASK DURATION	RESPONSIBLE AGENCIES *2 FWS REGION	FWS DIVISION	OTHERS *3	ESTIMATED FISCAL YEAR COSTS *4 FY 1	FY 2	FY 3	COMMENTS/NOTES
04	Annually assess recovery program and modify program and plan where required.	6	3	Continuous	4	FWE	NPS, USFS, KNPC, KDFWR, NCWRC, NCDNRCD, NCNHP, TDOC, TWRA, VCGIF	.5	.5	.5	

*1 - See page 32, entitled "Key to Implementation Schedule - Columns 1 and 4."

*2 - FWS - Fish and Wildlife Service
FWE - Fish and Wildlife Enhancement
NPS - National Park Service
USFS - U.S. Froset Service
OSM - Office of Surface Mining
TVA - Tennessee Valley Authority
KNPC - Kentucky Nature Preserves Commission
KDFWR - Kentucky Department of Fish and Wildlife Resources
NCWRC - North Carolina Wildlife Resources Commission
NCDNRCD - North Carolina Department of Natural Resources and Community Development
NCNHP - North Carolina Natural Heritage Program
TDOC - Tennessee Department of Conservation
TWRA - Tennessee Wildlife Resources Agency
VCGIF - Virginia Commission of Game and Inland Fisheries
SSM - State Office of Surface Mining

*3 - Other agencies' responsibility would be of a cooperative nature on projects funded under a contract or grant program. In some cases contracts could be let to universities or private enterprises.

*4 - All estimates are for FWS funds only (in thousands).

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