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RECOVERY PLAN

ALABAMA LAMP PEARLY MUSSEL

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A RECOVERY PLAN FOR THE

ALABAMA LAMP PEARLY MUSSEL

Lampsilis virescens (Lea, 1858)

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This plan was prepared under contract by Leroy M. Koch, Tennessee Valley Authority, Muscle Shoals, Alabama.

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TABLE OF CONTENTS

PART I

INTRODUCTION

The most diverse freshwater mussel fauna in North America occurs in the southern Appalachian Mountains and Cumberland Plateau region of the southeastern United States. Mussel species endemic to this region in the Tennessee and Cumberland River systems are referred to as "the Cumberlandian fauna" (Ortmann, 1924). Of the 23 species of freshwater mussels listed as endangered by the U.S. Department of the Interior, 13 are members of the Cumberlandian fauna. The Alabama lamp pearly mussel (Lampsilis virescens, Lea, 1858), one of these Cumberlandian species, was listed as endangered on June 14, 1976 (Federal Register 41[115]:24062-24067).

Lampsilis virescens was described by Lea in 1858 from the Tennessee River at Tuscumbia, Alabama. The valves of this species are roughly two and one-half inches long, relatively thin, and yellowish-brown in color (Figure 1). Bogan and Parmalee (1983) describe L. virescens in more detail as follows:

> "The shell is elliptical or obovate in outline. The valves are subinflated with a low posterior ridge. The moderately full beaks are sculptured with numerous delicate ridges, looped up in the middle and open behind. The epidermis is rather smooth and shiny, greenish to straw-colored and sometimes faintly rayed, especially on the posterior slope. The anterior end of the shell is round; the dorsal margin is slightly curved and the ventral margin is straight, curving up posteriorly. The posterior end of the shell in males is bluntly pointed; in the females, it is slightly more inflated and rounded."

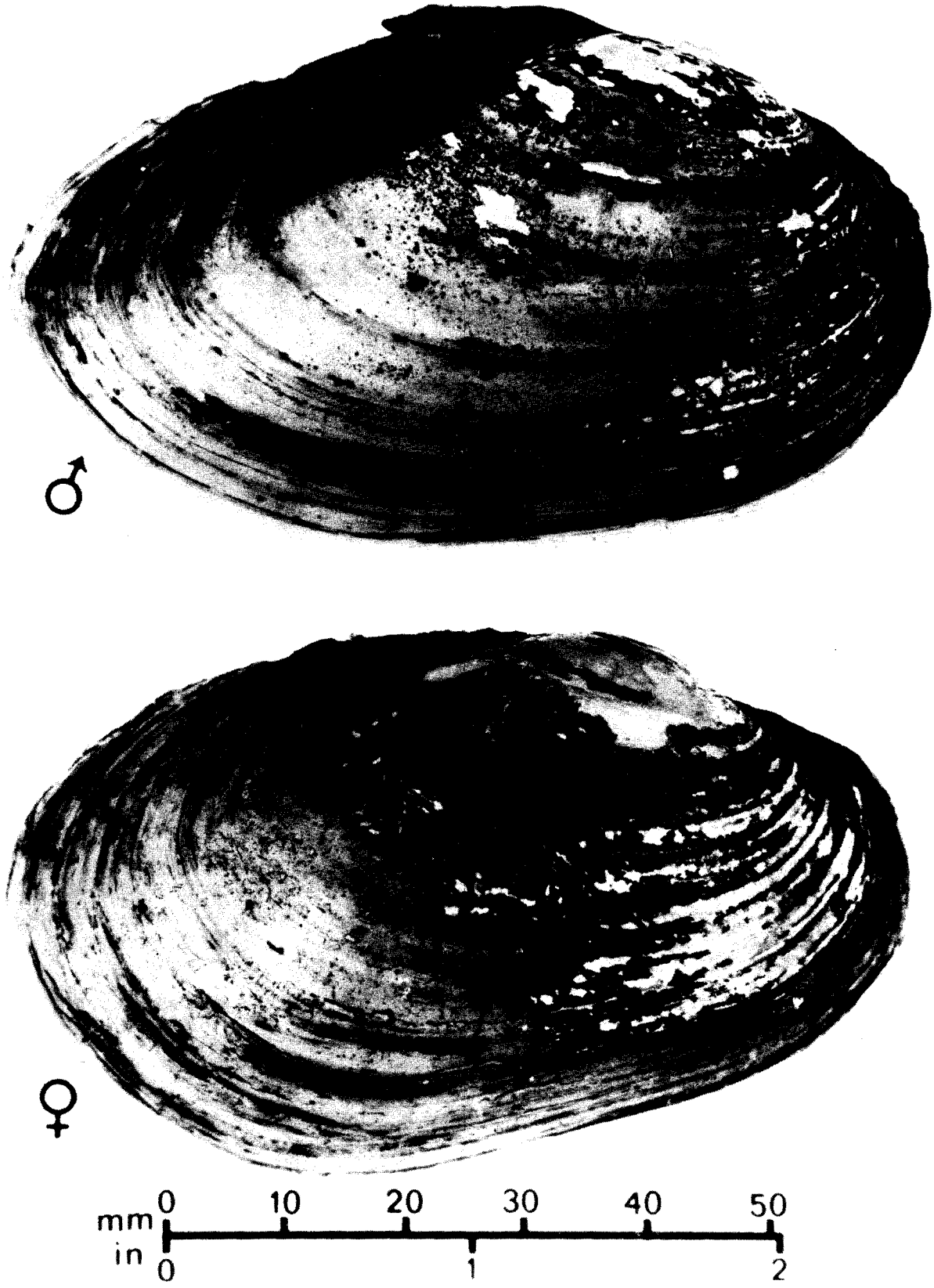

Figure 1. *Lampsilis virescens* **(Lea, 1858). OSUM #18741. Photo by A. E. Spreitzer.**

DISTRIBUTION

Historical

Lampsilis virescens is apparently restricted to the Tennessee River drainage in northern Alabama and Tennessee. Ortmann (1925) considered this species restricted to the Tennessee River drainage and noted it did not occur in the Cumberland River system. Stansbery (1976) restricted the range of L. virescens to the Tennessee River system from the lowermost tributaries of the Clinch River to Tuscumbia, Alabama.

In addition to the record from the type locality at Tuscumbia, Alabama (Lea, 1858), this species has been reported from Spring Creek at Tuscumbia, Alabama, and Beech Creek (Lewis, 1876). The reference to Beech Creek is probably a tributary to Browns Creek which enters the Tennessee River at Tennessee River Mile 356.5, Marshall County, Alabama. Ortmann (1925) reported this species from the Emory River system in Roane and Morgan Counties and from Coal Creek in Anderson County, all in Tennessee. Smith collected L. virescens in Bear Creek and Little Bear Creek (then known as Cedar Creek--see Isom and Yokely, 1968) in Franklin County, Alabama, and from the Paint Rock River in Jackson County, Alabama (Ortmann, 1925). A mollusk collection donated to the Academy of Natural Sciences in Philadelphia by C. M. Wheatly in 1918 contained a record from the Tennessee River in Jackson County, Alabama (Arthur Bogan, Academy of Natural Sciences, Philadelphia, personal communication). The above-mentioned historical distribution records are shown in Figure 2. In

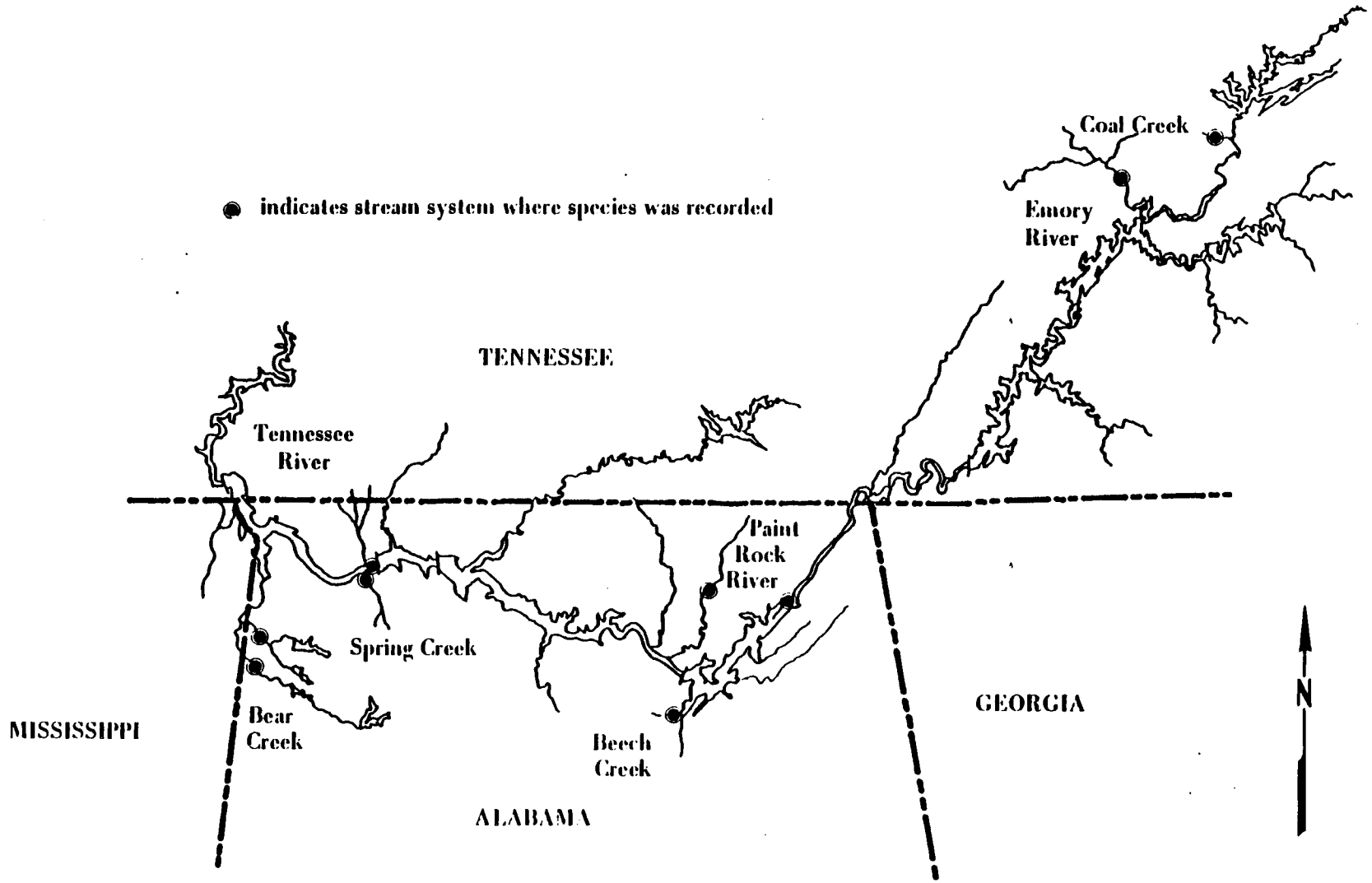

Figure 2. Stream Systems with Historical Records of Lampsilis virescens (Lea, 1858).

addition, Morrison (1942) recorded L. virescens from shell mounds in Lauderdale County, Alabama.

The collection site of one specimen of this species in the Bryant Walker Collection at the University of Michigan Museum of Zoology (UMMZ) is listed as "Alabama River, Alabama." This is the only record of L. virescens outside of the Tennessee River system and may be an error. Van der Schalie noted L. virescens belonged to the Tennessee drainage and discussed its affinities to Lampsilis claibornensis in the Cahaba River (van der Schalie, 1938). He did not list L. virescens as present in the Alabama River system (van der Schalie, 1981). Two older collections of L. virescens in the UMMZ are accompanied by locality data that could not be related to present streams or individual sites.

Table 1 presents a synopsis of literature records for Lampsilis virescens. Collections providing records of L. virescens included: The Ohio State University Museum of Zoology (OSUM); Carnegie Museum of Natural History; the Academy of Natural Sciences, Philadelphia; the Delaware Museum of Natural History; UMMZ; and Herbert Athearn, Cleveland, Tennessee.

Present

Records of collections made after 1964 indicate that the Paint Rock River and its tributaries, Hurricane Creek, Estill Fork and Larkin Fork, contain the only known remaining population of L. virescens. The Tennessee Valley Authority surveyed the Paint Rock River (PRR) in 1980 from PRRM 24.5 to 60.0 and the lowermost portions of Estill Fork and

Table 1. Literature records of *Lampsilis virescens*

River	Reference
Tennessee River	Lea (1858) Lea (1860) Lea (1870) Ortmann (1918) Stansbery (1964) Ortmann (1925)
Spring Creek	Lewis (1876) Call (1885) Ortmann (1918) Ortmann (1925)
Bear Creek System	Ortmann (1918) Ortmann (1925) Isom and Yokley (1968)
Paint Rock System	Isom, Yokley, and Gooch (1973) Ortmann (1918) Ortmann (1925) Stansbery (1970a) Stansbery (1971)
Beech Creek	Lewis (1876)
Emory River System	Ortmann (1918) Ortmann (1925)
Coal Creek	Ortmann (1918) Ortmann (1925)

Hurricane Creek. Lampsilis virescens comprised approximately 3.6 percent of the total number of live and fresh dead mussels collected during this survey. Isom and Yokley (1973) visited six sites on the Paint Rock River in 1965 and 1967 and recorded live L. virescens from two locations in the Paint Rock River and one station from Larkin Fork. Athearn collected this species alive from Larkin Fork in 1969 (OSUM records). Several other lots at OSUM taken during the 1960's and 1970's indicate a population in the upper Paint Rock River and its tributary Estill Fork. Herbert Athearn (Cleveland, Tennessee, personal communication) observed a live L. virescens during 1966 in the upstream portion of Estill Fork in Tennessee. Based on records from 1965 to the present, L. virescens occurs in the headwaters of the Paint Rock River and its major tributaries. Recent records of live L. virescens in the Paint Rock River system are presented in Figure 3.

Recent surveys and isolated collections in other streams which once contained L. virescens have failed to locate living specimens. In 1974 Carol Stein found two complete specimens and one valve of L. virescens while collecting in the Little Emory River just above its impounded mouth (OSUM records, personal communication). The two complete specimens probably had been dead less than two years. No other recent collections from the Emory River system have been found. Lampsilis virescens may still exist in the Emory River system; however, no confirmation apparently exists.

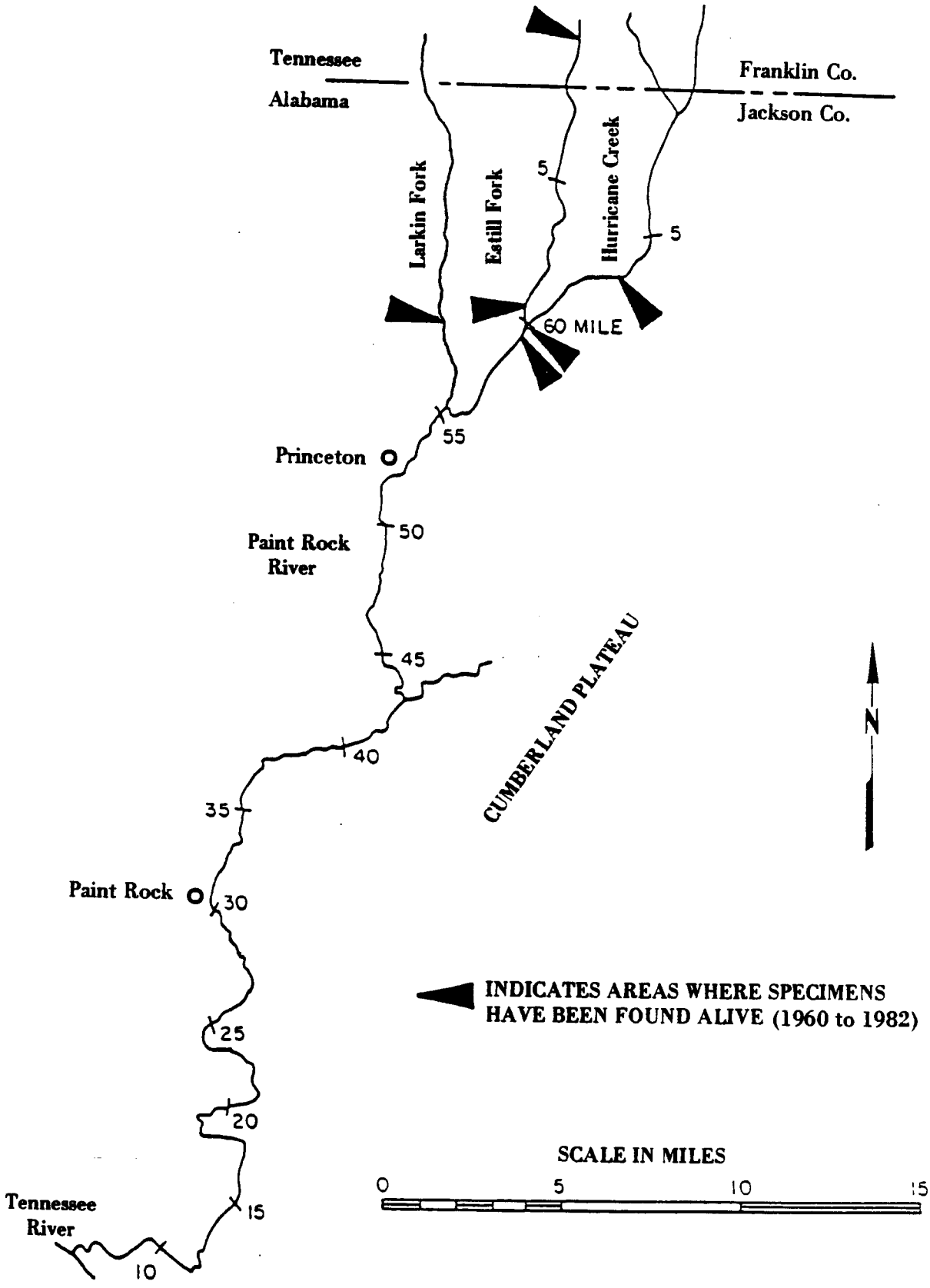

Figure 3. Paint Rock River, Larkin Fork, Estill Fork, and Hurricane Creek—Recent Locations for *Lampsilis virescens* (Lea, 1858).

Isom and Yokley collected mussels at two stations on Bear Creek and one station on Cedar Creek during 1965 but did not report L. virescens from either stream (Isom and Yokley, 1968). They also examined sites on the Flint River in 1965 (Isom and Yokley, 1973) and the Elk River during 1965-1967 without finding L. virescens (Isom, Yokley, and Gooch, 1973). Recent collections in Spring Creek (Paul Yokley, personal communication) have not included L. virescens. No recent records of L. virescens are known from Coal Creek, the mainstream Tennessee River or Beech Creek. Lampsilis virescens is probably extirpated in the Tennessee River. Other freshwater mussel surveys and collections within the historic range of L. virescens that have failed to record this species include portions of the Tennessee River by Scruggs, 1960; Isom, 1969, 1972; TVA, 1979; and Pardue, 1981. In addition, collections from Indian Creek in Madison County, Alabama (Isom, 1968), and from the Sequatchie River (Hatcher and Ahlstedt, 1982) and Elk River (Ahlstedt, 1983) did not include L. virescens.

ECOLOGY AND LIFE HISTORY

The life history of Lampsilis virescens has not been studied but is presumed to be similar to that of other freshwater mussels, particularly other members of the genus Lampsilis. Figure 4 illustrates the typical reproductive cycle of a freshwater mussel. During the spawning period, males discharge sperm into the water column and females obtain these sperm during siphoning. The fertilized eggs are held

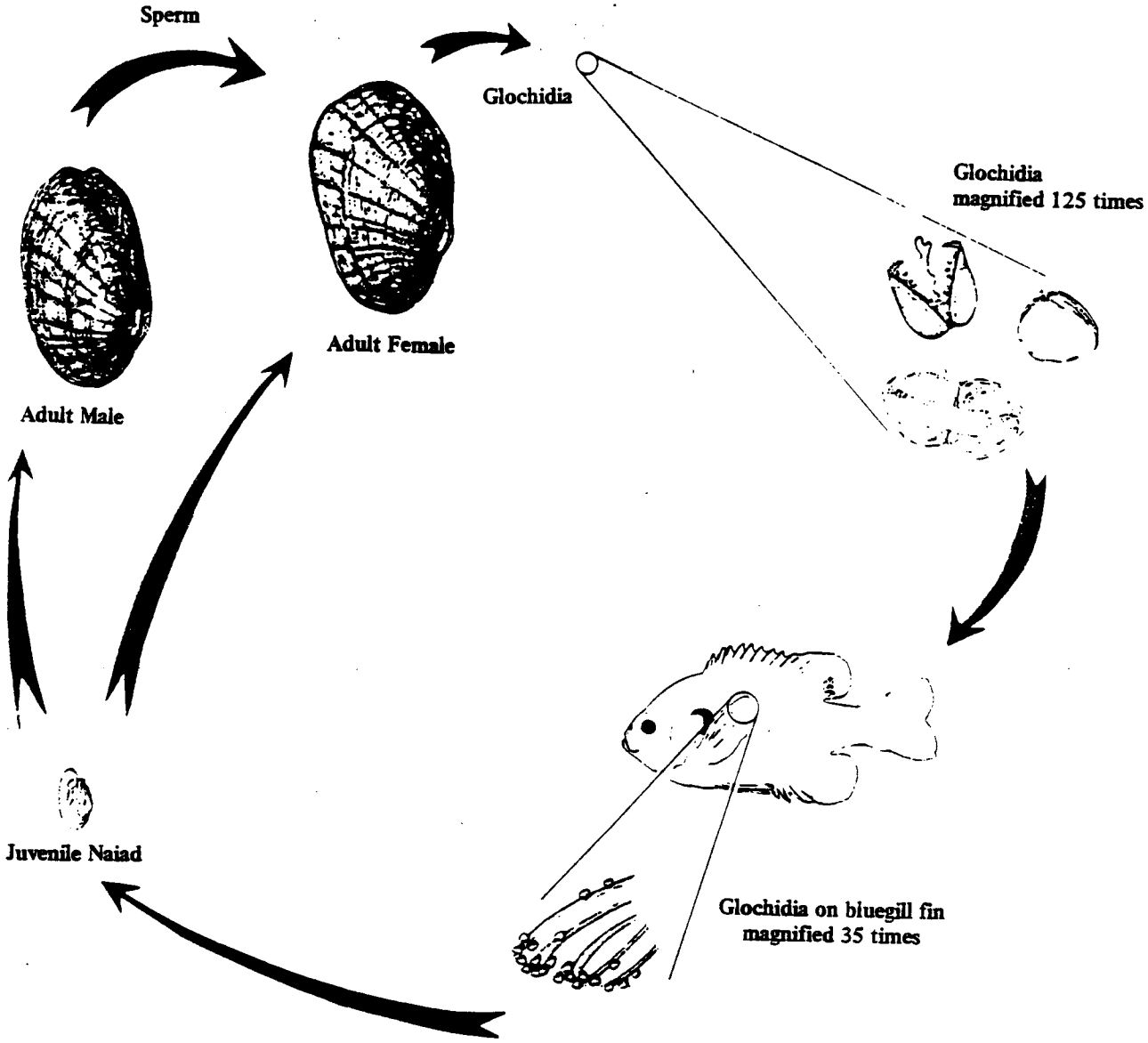

Figure 4. Typical Life Cycle of a Freshwater Mussel (Grace & Buchanan, 1981).

in various portions of the female's gills (marsupium) where they develop into mature larvae (glochidia) prior to being discharged into the water column. Glochidia that attach to gills or fins of an appropriate host fish become encysted and metamorphose to the juvenile stage which falls to the bottom and is capable of surviving on its own. Fuller (1974) listed suspected host fish of Lampsilis ovata, L. radiata and L. teres to include species in the following families: Acipenseridae, Lepisosteridae, Centrarchidae, Ictaluridae, Percicthyidae, and Percidae. The host(s) for L. virescens are unknown.

Ecologically, Lampsilis virescens appears to inhabit sand and gravel substrates in small to medium sized streams (Bogan and Parmelee, 1983). Morrison (1942) considered the few L. virescens found in shell mounds to indicate its preference for tributary streams. Other aspects of the ecology of this species are totally unknown.

REASONS FOR DECLINE

Freshwater mussels, especially members of the Cumberlandian fauna, are considerably less abundant in the Tennessee River system today than they were when the first Europeans explored this river valley. The mussel fauna declined or became extirpated during the time when much of the Tennessee River watershed was cleared of its forest cover to permit agriculture. In addition, the Tennessee River and many of its tributaries were impounded to control floods, facilitate navigation or generate

electric power. Other stream reaches were channelized to accelerate runoff from floodplain fields. More recently, stream reaches also began to receive manmade pesticides, fertilizers and other pollutants. Logical scenarios have been advanced to link these anthropogenic impacts on streams with declines in the aquatic fauna, including the freshwater mussels. Very few studies have been conducted to establish clearly the specific cause and effect relationships or the chain of events by which modification of a stream or watershed may cause the decline of a mussel species.

Stream impacts likely to be deleterious to a typically small stream species like L. virescens include siltation, dredging, channelization, pollution, impoundments, and removal of riparian vegetation associated with agricultural and industrial development. Each of these impacts will be discussed below.

1. Siltation - Poor agricultural practices, strip-mining, logging, and road construction are a few reasons why siltation has increased in rivers and tributaries in the Tennessee Valley. Coal Creek in Tennessee has been severely impacted by coal mining (coal fines) and it is unlikely L. virescens occurs there (Steve Ahlstedt, TVA, personal communication). Isom and Yokely (1968) noted some change in mussel habitat in Bear Creek due to log jams and associated debris; however, they reported no basic chemical or ecological changes in Bear Creek since 1925, other than impoundment of the lowermost 17 miles. Poor farming practices and

clearing of vegetation along stream banks have resulted in heavy suspended sediment and silt deposits in the Paint Rock River.

Silt can directly or indirectly affect the life cycle of mussels in several ways. Host fish populations may be affected because of undesirable habitat and/or the smothering impact upon eggs and larvae. Silt can limit light penetration, dulling the sensitivity of mussel phototactic responses and reducing the production of food (Ellis, 1936). Stansbery (1970b) thought that siltation retarded growth of Amblema plicata. Suspended sediments can cause irritation and clogging of gills and feeding structures (Loar et al., 1980). Ellis' (1936) study showed that many species of mussels died when covered by one-quarter inch of silt.

2. Dredging and channelization - These activities can affect mussels and their habitat directly by removal of substrate and indirectly by increasing siltation. Yokley and Gooch (1976) noted a dredged area may take years to recover its lost mussel populations because bottom conditions are unsuitable for mussels and unattractive to host fish. They also found reduced growth rates in mussels downstream from dredged areas. Gravel dredging in tributary streams is detrimental to mussels including L. virescens and may be a reason for their decline.

Channelization reduces the amount of stream habitat available to mussels and is evident on many Tennessee River tributaries including Spring Creek, Bear Creek and the Paint Rock River. A project initiated in the early 1960's to facilitate drainage in the Paint Rock River watershed included the removal of snags, shoreline timber and straightening of the

channel from PRRM 7.0 to the lowermost reaches of Hurricane Creek, Larkin Fork and Estill Fork (Joe Cathey, Army Corps of Engineers, personal communication). These activities resulted in an unstable shoreline and river substrate.

3. Pollution - Streams affected by waste discharges are subject to various sorts of pollutants which can have deleterious effects upon mussels. Acid mine drainage is an apparent problem in the Emory River system (Steve Ahlstedt, TVA, personal communication). Pesticides applied to agricultural crops may be washed into nearby streams. Toxic chemical spills can reduce stream life in tributary streams drastically. Fish kills have been reported after releases of wood treatment chemicals into Bear Creek (Donald Wade, July 16, 1976 TVA Memorandum to Mahlon Taylor, E&D Building, Muscle Shoals, AL), but it is not certain what effect these discharges have had on mussel populations.

4. Impoundments - Impoundments create conditions inimical to the habitat requirements of Cumberlandian mussels. Silt collected in reservoirs due to reduced flow can smother mussels and create habitat conditions unattractive to host fish. Altered temperatures, anoxic conditions and water level fluctuations can restrict both fish and mussel communities (Isom, 1971). In the Tennessee River proper, impoundments probably caused the decline of many Cumberlandian species. Stansbery (1964) found only two Cumberlandian species downstream from Wilson Dam, an area from which 22 had previously been recorded. The Tennessee River was probably marginal in habitat for L. virescens in historical times and has become even more so due to impoundments.

It is difficult to determine whether impoundment of the lower portions of tributary streams has affected the Cumberlandian mussel fauna further upstream. Isom and Yokley (1968) felt the lower impounded portion of Bear Creek had an effect on the unimpounded creek due to changes in the fish fauna and consequent fish-mussel relationships resulting in an invasion of large-river mussels. They found no similar effect of impoundment in the Paint Rock River (Isom and Yokley, 1973).

The historically restricted distribution of L. virescens and lack of information about changes in various stream populations prevents a more precise determination of the reasons for the species' decline. A combination of all these factors is probably the most likely reason for the overall decline of Cumberlandian species including L. virescens.

PART II

RECOVERY

A. Recovery Objectives

The ultimate objective of this recovery plan is to restore viable populations* of Lampsilis virescens to the point that this species can be removed from the Federal list of endangered and threatened species. This can be accomplished by (1) protecting and enhancing habitats containing L. virescens populations and (2) ensuring the establishment or expansion of populations in streams within the historical range of this species. The Alabama lamp pearly mussel shall be considered recovered, i.e., no longer in need of Federal Endangered Species Act protection, when the following criteria are met:

1. A viable population of Lampsilis virescens exists in the Paint Rock River above the impounded portion in Wheeler Reservoir, upstream to and including Larkin Fork, Estill Fork, and Hurricane Creek tributaries. This population should be distributed within this stream such that it is unlikely a single adverse event would result in the total loss of that population.

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*viable population - a reproducing population that is large enough to maintain sufficient genetic variation to enable it to evolve and respond to natural habitat changes.

2. Through introductions and/or discoveries of new populations, a viable population is established in each of two additional streams within the historical range of this species. The population in each stream must be distributed such that a single adverse event would be unlikely to eliminate Lampsilis virescens from the river system. For these populations, surveys must show that three year classes exist including an adult year class naturally produced within each of the population centers and two younger year classes naturally produced within each of the population centers.

3. The species and its habitat in each stream are protected from foreseeable anthropogenic and natural threats.

B. Step-down Outline

Prime Objective: Recover the species to the point that it no longer requires Federal Endangered Species Act protection.

1. Preserve the present population and habitat of Lampsilis virescens in the Paint Rock River and its major tributaries including Larkin Fork, Estill Fork, and Hurricane Fork.

1.1 Conduct population surveys and essential habitat analyses.

1.1.1 Determine species' present distribution and status.

1.1.2 Describe the species' habitat (relevant physical, chemical, biological elements) for all life history stages.

1.1.3 Disseminate above information in a form for general use by appropriate public and private agencies.

1.2 Identify current and foreseeable threats to the species and take action to mitigate or eliminate them.

1.2.1 Solicit the cooperation of municipal, State, and Federal agencies to identify and inventory proposed and future projects that may affect the species and its habitat.

1.2.2 Determine measures needed to minimize and/or eliminate adverse impacts and implement these measures where necessary.

1.3 Solicit support in protecting the species and its essential habitat and provide copies of the recovery plan to interested parties.

1.3.1 Meet with local government officials and regional and local planners to inform them of recovery plans and request their support.

1.3.2 Encourage State and Federal agencies to use their authorities to protect the species and its habitat.

1.3.3 Meet with local industry representatives and solicit support in identifying and mitigating any adverse impacts of their activities on the species and its habitat.

1.3.4 Meet with landowners adjacent to prime habitat for the species, inform them of the recovery objectives and solicit their support for the species and habitat protection.

1.3.5 Develop and implement an educational program for civic, church, school, and other groups, explain the uniqueness of the species and its habitat and define the groups' role in the species' protection and recovery.

2. Conduct life history research on the species, including fish host identification, host fish dispersal, age and growth,

reproductive biology, longevity, mortality factors and population dynamics.

3. Determine the feasibility of introducing the species into rivers within its historic range and implement such activities where feasible.

   3.1 Locate suitable sites for transplants within rivers which meet the environmental and life cycle requirements for survival and reproduction of the species.

   3.2 Determine a successful method of establishing new populations, such as introducing adults, juveniles, infected host fish, artificially cultured individuals or combinations of these or alternative means.

   3.3 Implement introductions based upon results of 3.1 and 3.2.

4. Investigate the necessity of habitat improvement or establishment and, if feasible and desirable, identify techniques and sites for such actions and implement.

5. Develop and implement a program to monitor population trends and habitat conditions of current and introduced populations.

6. Evaluate individual recovery actions and overall success of the recovery plan.

C. Narrative Outline

1. Preserve the present population and habitat of Lampsilis virescens in the Paint Rock River and its major tributaries, including Larkin Fork, Estill Fork, and Hurricane Creek.

Based on recent survey and collection data, Lampsilis virescens occurs in limited numbers in the Paint Rock River system. Preservation of this population and its habitat is essential for the continued survival of the species and to allow for natural population expansion.

1.1 Conduct population surveys and essential habitat analyses. As a first step, it will be necessary to determine the species' current status, distribution, and habitat requirements. This task will provide the necessary background information for accomplishment of other recovery tasks.

1.1.1 Determine species' present distribution and status. Mussel population surveys were recently completed on portions of the Paint Rock River

system by TVA as part of their Cumberlandian Mollusk Conservation Program (CMCP). The lower Paint Rock River should be surveyed from the Highway 72 bridge crossing to Wheeler Reservoir. The Emory River system should be surveyed upstream from the impounded portion in Watts Bar Reservoir. Thorough mussel surveys are recommended for Bear Creek from Bear Creek Dam downstream to the impounded portion in Pickwick Reservoir, Cedar Creek from Cedar Creek Dam downstream to its confluence with Bear Creek, and Little Bear Creek from Jordans Mill downstream to its confluence with Cedar Creek. Additional surveys are recommended for Beech Creek, Flint River, Spring Creek, Sequatchie River, Lookout Creek, and other major, unsurveyed streams within the historic range of L. virescens.

1.1.2 Describe the species' habitat (relevant physical, chemical, biological elements) for all life history stages. Extensive knowledge of juvenile and adult preferred habitat will be essential to the recovery effort.

1.1.3 Disseminate above information in a form for general use by appropriate public and private agencies. The results of these scientific studies are to be presented in a format that will help planning officials reduce or prevent the destruction of this species and its habitat. These studies will create greater awareness of the species and its habitat among Federal and State regulatory agencies and local government.

1.2 Identify current and foreseeable threats to the species and take actions to mitigate or eliminate them. Identified negative impacts to this species and its habitat will need to be remedied, reduced, or prevented.

1.2.1 Solicit the cooperation of municipal, State, and Federal agencies to identify and inventory proposed and future projects that may affect the species and its habitat. A working relationship must be established with agencies responsible for planning and evaluating proposed activities in stream watersheds where L. virescens exists. Environmental concerns about activities should be addressed as early as possible to protect the species and its habitat.

1.2.2 Determine measures needed to minimize and/or eliminate adverse impacts and implement these measures where necessary. The feasibility of protecting the species and its essential habitat through collection permit restrictions, sanctuaries or other means should be investigated. It will be necessary to meet with representatives of appropriate State agencies to determine if special status can be assigned to essential habitat for the species. Other existing legislative means of habitat protection must be explored. Consultation services should be provided to State and Federal agencies to prevent over collection of mussels or fishes for scientific or other purposes in essential habitat areas.

1.3 Solicit support in protecting the species and its essential habitat and provide copies of the recovery plan to interested parties. Without the support of local residents, the recovery effort is not likely to succeed. Information on recovery should be made to the public through the state and local news media. Special emphasis should be placed on the importance of the species' essential habitat. All local, State, and Federal

development and enforcement agencies should be periodically informed of recovery efforts.

1.3.1 Meet with local government officials, regional and local planners to inform them of recovery plans and request their support. The support and participation of these parties in the recovery effort is necessary to ensure protection of essential habitat. Local officials responsible for enforcing laws and regulations pertaining to the environment should be briefed on activities likely to impact the species such as pollution and poor agricultural practices. These officials should be invited to assist in implementing actions that would reduce or eliminate such adverse activities.

1.3.2 Encourage State and Federal agencies to utilize their authorities to protect the species and its habitat. Present laws and regulations pertaining to the protection of the species and its habitat should be reviewed and strict enforcement of these regulations should be encouraged.

1.3.3 Meet with local industry representatives and solicit their support in identifying and mitigating

any adverse impacts of their activities on the species and its habitat. Cooperation of these industries is an essential part of meeting recovery goals.

1.3.4 Meet with landowners adjacent to prime habitat for the species and inform them of the recovery objectives and solicit their support for the species and habitat protection. Land use adjacent to essential habitat can influence habitat quality. Local landowners should be encouraged to recognize and report new environmental problems as they occur and report on activities which might damage the habitat or destroy the populations. Riparian land adjacent to essential habitat will likely be locally or privately owned, and long-term strategies for the protection of these areas should be developed.

1.3.5 Develop and implement an educational program for civic, church, school, and other groups explaining the uniqueness of the species and its habitat and defining their role in the species' protection and recovery. Public awareness of the Endangered Species Act and of the problems and unique

requirements of the species is necessary for public support of recovery efforts and should be elicited through local television and newspaper articles. The information and education sections of state agencies should also be encouraged to support recovery efforts.

2. Conduct life history research on the species including fish host identification, host fish dispersal, age and growth, reproductive biology, longevity, mortality factors and population dynamics. Information concerning the life history of this species is entirely lacking. Recovery efforts will be greatly aided if the species' life cycle and environmental requirements are defined. Fish host(s) identification and habits need to be determined to ensure likely success of parasitism by glochidia. In addition, habits of the fish host(s) need to be such that newly transformed juveniles, when released from the fish, occupy suitable habitat for development into maturity.

3. Determine the feasibility of introducing the species into rivers within its historic range and implement such activities where feasible. It is unlikely that Lampsilis virescens

will be removed from the Federal endangered species list if other populations are not established.

3.1 Locate suitable sites for transplants within rivers which meet the environmental and life cycle requirements for survival and reproduction of the species. Streams within this species' historic range need to be surveyed to identify suitable transplant sites. Factors to be considered should include substrate, water quality, fish host presence and any other essential factors identified in 2. After suitable streams to receive transplants are determined, selection of the actual transplant sites should be based on a correlation of stream characteristics with known populations of L. virescens and/or other Cumberlandian fauna associated with this species. A prioritized list of transplant sites should result from this activity.

3.2 Determine a successful method of establishing new populations, such as introducing adults, juveniles, infected host fish, artificially cultured individuals or combinations of these or alternative means. TVA is currently evaluating the use of adult transplants to establish populations. It is unlikely that numbers of adult L. virescens sufficient to establish new

populations can be obtained; therefore, other methods should be considered. An artificial medium for the in vitro metamorphosis of glochidia to juveniles has been developed (Isom and Hudson 1982) and offers potential for the production of juveniles to supplement or establish populations. The establishment of mussel populations using glochidia infected fish hosts is being studied at the Virginia Cooperative Fishery Research Unit, Blacksburg, Virginia. These methods are promising alternatives to transplanting adult mussels of species which are extremely limited in numbers.

3.3 Implement introductions based upon results of 3.1 and 3.2. Once suitable transplant sites are located and a successful method of establishing populations is determined the number of individuals available for transplanting and the number needed to maintain genetic variability over an extended period must be determined. Population geneticists and malacologists should be consulted to help resolve these issues before the transplant effort is implemented.

4. Investigate the necessity of habitat improvement or establishment and, if feasible and desirable, identify techniques and sites for some actions and implement. Suitable

habitat for L. virescens may need to be artificially created. The U. S. Army Engineer Waterways Experiment Station (WES) in Vicksburg, Mississippi, is designing a gravel bar habitat for mussels in the Tombigbee River. Methods of establishing habitat or improving habitat need to be carefully studied and evaluated using common Cumberlandian mussel species before implementation with L. virescens.

5. Develop and implement a program to monitor population trends and habitat conditions of existing and introduced populations. During and after the implementation of recovery actions, a monitoring program should be conducted to evaluate the species' recovery and status. Delisting of the species will be dependent upon the results of this monitoring program. Interagency cooperation in identifying new or proposed threats to the species or its habitat will be necessary to implement appropriate changes in recovery actions.

6. Evaluate individual recovery actions and overall success of the recovery plan. As a working document, the recovery plan will need to be evaluated periodically to incorporate new alternatives, delisting or downlisting options or other actions necessary for successful recovery.

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PART III

IMPLEMENTATION

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

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

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
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
ADCNR	Alabama Department of Conservation and Natural Resources
ANHP	Alabama Natural Heritage Program

Part III Implementation Schedule

*1 General Category	Plan Task	Task Number	Priority	*2 Task Duration	Responsible Agency			Estimated Fiscal Year Costs			*4 Comments/Notes
					FWS		*3				
					Region	Program	Other	FY 1	FY 2	FY 3	
R1	Determine L. virescens' present distribution and status.	1.1.1	2	2 yr.	4	SE	TVA TWRA ADCNR	-	-	-	*1. See General Categories for Implementation Schedules.
R3	Describe the species' habitat for all life history stages.	1.1.2	2	2 yr.	4	SE	TVA	-	-	-	*2. Time allotted under task duration may vary depending upon funding levels and success of the research.
O-1,4	Disseminate above information to appropriate public and private agencies.	1.1.3	3	Unknown	4	SE	TVA TWRA ADCNR	-	-	-	*3. Other agencies' responsibility would be of a cooperative nature or projects funded under a contract or grant program. In some cases contracts could be let to universities or private enterprises.
M3	Solicit cooperation of municipal, state and federal agencies to identify and inventory proposed and future projects that may affect the species and its habitat.	1.2.1	1	Continuous	4	SE	TVA TWRA ADCNR	-	-	-	*4. Note: Task costs have not been estimated for this plan. This species' present distribution coincides with that of four other endangered mussels (Toxolasma cylindrella, Fusconaia edgariana, Fusconaia cuneolus, and Lampsilis orbiculata). Thus, a task aimed at this species will benefit others. Rather than attempting to apportion the cost to each species, recovery tasks will be estimated at a later date when the plans are combined on a watershed basis for implementation.

Part III Implementation Schedule

General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency			Estimated Fiscal Year Costs			Comments/Notes
					FWS						
					Region	Program	Other	FY 1	FY 2	FY 3	
M3	Determine measures needed to minimize and/or eliminate adverse impacts and implement these measures where necessary.	1.2.2	1	Unknown	4	SE	TVA TWRA ADCNR	-	-	-	
O-1,4	Meet with local government officials and regional and local planners to inform them of recovery plans and request their support.	1.3.1	3	Unknown	4	SE	TVA TWRA ADCNR	-	-	-	
M3	Encourage State and Federal agencies to utilize their authorities to protect the species and its habitat.	1.3.2	1	Continu-ous	4	SE LE	TVA TWRA ADCNR	-	-	-	
O1	Meet with local industry representatives and solicit their support in identifying and mitigating any adverse impacts of their activities on the species and its habitat.	1.3.3	1	Continu-ous	4	SE	TVA TWRA ADCNR	-	-	-	
O1	Meet with landowners adjacent to prime habitat for the species and inform them of the recovery objectives and solicit their support for the species and habitat protection.	1.3.4	1	Continu-ous	4	SE	TVA TWRA ADCNR ANHP	-	-	-	

Part III Implementation Schedule

General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency			Estimated Fiscal Year Costs			Comments/Notes
					FWS						
					Region	Program	Other	FY 1	FY 2	FY 3	
01	Develop and implement an educational program for civic church, school and other groups explaining the uniqueness of the species and its habitat and defining their role in the species' protection and recovery.	1.3.5	3	Continuous	4	SE	TVA TWRA ADCNR	-	-	-	
R-3,14	Conduct life history research on the species concerning fish host identification, host fish dispersal, age and growth, reproductive biology longevity, mortality factors and population dynamics.	2	2	3 years	4	SE	TVA	-	-	-	
M2	Locate suitable sites for transplants within rivers which meet the environmental and life cycle requirements for survival and reproduction of the species.	3.1	3	1 year	4	SE	TVA TWRA ADCNR	-	-	-	
R13	Determine a successful method of establishing new populations.	3.2	3	Unknown	4	SE	TVA	-	-	-	
M2	Implement introductions based upon results of 3.1 and 3.2	3.3	3	Unknown	4	SE	TVA TWRA ADCNR				

Part III Implementation Schedule

General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency			Estimated Fiscal Year Costs			Comments/Notes
					FWS						
					Region	Program	Other	FY 1	FY 2	FY 3	
R2 M3	Investigate the necessity of habitat improvement or establishment and, if feasible and desirable, identify techniques and sites and implement.	4	3	Unknown	4	SE	TVA TWRA ADCNR	-	-	-	
R1	Develop and implement a program to monitor population trends and habitat conditions of current and introduced populations.	5	2	Continuous	4	SE	TVA TWRA ADCNR	-	-	-	
114	Evaluate individual recovery actions and overall success of the recovery plan.	6	3	Annually	4	SE		-	-	-	

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.

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