CANDIDATE AND LISTING PRIORITY ASSIGNMENT FORM

SCIENTIFIC NAME: Lexingtonia dolabelloides

COMMON NAME: slabside pearlymussel

LEAD REGION: 4

INFORMATION CURRENT AS OF: January 17, 2001

STATUS/ACTION (Check all that apply):
___ New candidate
_X_ Continuing candidate
    _X_ Non-petitioned
    ___ Petitioned - Date petition received: ___
        ___ No finding yet
        ___ 90-day positive - FR date: ___
        ___ 12-month warranted but precluded - FR date: ___
        __ Is the petition requesting a reclassification of a listed species?
    ___ Listing priority change
        Former LP: ___
        New LP: ___
___ Candidate removal: Former LP: ___ (Check only one reason)
    ___ A - Taxon more abundant or widespread than previously believed or not subject to a degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status.
    ___ F - Range is no longer a U.S. territory.
    ___ M - Taxon mistakenly included in past notice of review.
    ___ N - Taxon may not meet the Act's definition of "species."
    ___ X - Taxon believed to be extinct.

ANIMAL/PLANT GROUP AND FAMILY: Clams and Mussels - Unionidae

HISTORICAL STATES/TERRITORIES/COUNTRIES OF OCCURRENCE: Alabama, Kentucky, Tennessee, Virginia

CURRENT STATES/TERRITORIES/COUNTRIES OF OCCURRENCE: Alabama, Tennessee, Virginia

LEAD REGION CONTACT (Name, phone number): Lee Andrews, 404/679-7217

LEAD FIELD OFFICE CONTACT (Office, name, phone number): Robert S. Butler, Asheville, North Carolina Field Office, 828/258-3939, ext. 235

SUPPORT FIELD OFFICE(S): Abingdon, Virginia Field Office; Cookeville, Tennessee Field Office; Daphne, Alabama Field Office

BIOLOGICAL INFORMATION (Describe habitat, historic vs. current range, historic vs. current population estimates (# populations, #individuals/population), etc.):

The following description, biology, and life history of the slabside pearlymussel is taken from Parmalee and Bogan (1998) and others cited in their book "The Freshwater Mussels of Tennessee." The slabside pearlymussel is a moderately-sized mussel that reaches about 9 centimeters (3.5 inches) in length. The shape of the shell is subtriangular, and the very solid, heavy valves are moderately inflated. Shell texture is smooth and somewhat shiny in young specimens, becoming more dull with age. Shell color is greenish yellow, becoming brownish with age, with a few broken green rays or blotches, particularly in young individuals. Internally, the pseudocardinal teeth are triangular or blade-like in shape. There is a single lateral tooth. The color of the nacre (mother-of-pearl) is white, or rarely straw-colored.

Adult freshwater mussels are filter-feeders, siphoning phytoplankton, diatoms, and other microorganisms from the water column. For their first several months juvenile mussels employ foot (pedal) feeding, and are thus suspension feeders that feed on algae and detritus. Mussels tend to grow relatively rapidly for the first few years, then slow appreciably at sexual maturity (when energy is being diverted from growth to reproductive activities). As a group, mussels are extremely long-lived, living from a few decades to a maximum of approximately 200 years. Large, heavy-shelled riverine species tend to have longer life spans. No age specific information is available for the slabside pearlymussel. However, considering that it is a moderately-sized, heavy-shelled riverine species, it seems probable that it is relatively long-lived.

Most mussels, including the slabside pearlymussel, have separate sexes. Males expel clouds of sperm into the water column, which are drawn in by females through their incurrent siphons. Fertilization takes place internally, and the resulting zygotes develop into specialized larvae termed glochidia inside the water tubes of her gills. The slabside pearlymussel utilizes all four gills as a marsupium for its glochidia. It is thought to have a spring or early summer fertilization period with the glochidia being released during the summer in the form of conglutinates, which are analogous to cold capsules (i.e., gelatinous containers) with scores of glochidia contained within. Glochidia must come into contact with a specific host fish(es) in order for their survival to be ensured. Without the proper host fish, the glochidia will perish.

Slabside pearlymussel conglutinates are undescribed, but they are probably shaped like some sort of common fish food item, such as insect larvae, similar to other mussels that expel conglutinates. The slabside pearlymussel's host fishes, which include six species of shiners (popeye shiner, Notropis ariommus; rosyface shiner, Notropis rubellus; saffron shiner, Notropis rubricroceus; silver shiner, Notropis photogenis; telescope shiner, Notropis telescopus; and Tennessee shiner, Notropis leuciodus), are tricked into thinking that they have an easy meal when in fact they have infected themselves with mussel glochidia.

After a few weeks parisitizing the fishes' gill tissues, newly-metamorphosed juveniles drop off to begin a free-living existence on the stream bottom. Unless they drop off in suitable habitat, they will die. Thus, the complex life history of the slabside pearlymussel and other mussels has many weak links that may prevent successful reproduction and/or recruitment of juveniles to existing populations.

The slabside pearlymussel is primarily a large creek to moderately-sized river species, inhabiting sand, fine gravel, and cobble substrates in relatively shallow riffles and shoals with moderate current (Parmalee and Bogan 1998). This species requires flowing, well-oxygenated waters to thrive.

Most studies of the distribution and population status on the slabside pearlymussel were conducted in the first quarter of this century and since the early 1960s. Gordon and Layzer (1989), Winston and Neves (1997), and Parmalee and Bogan (1998) give most of the references for survey work in regional streams. Current, unpublished distribution and status information is taken from State Heritage Programs, agency biologists, and other knowledgeable individuals.

The slabside pearlymussel is a Cumberlandian Region mussel, meaning it is restricted to the Cumberland (in Kentucky and Tennessee) and Tennessee (in Alabama, Tennessee, and Virginia) River systems. Historically, this species occurred in the lower Cumberland River main stem from about Caney Fork downstream to the vicinity of the Kentucky State line, and in the Tennessee River main stem from eastern Tennessee to western Tennessee. Records are known from two Cumberland River tributaries, Caney Fork and Red River. In addition, it is known from nearly 30 Tennessee River system tributaries, including the South Fork Powell River, Powell River, Puckell Creek, Clinch River, North Fork Holston River, Big Moccasin Creek, Middle Fork Holston River, South Fork Holston River, Holston River, French Broad River, West Prong Little Pigeon River, Tellico River, Little Tennessee River, Hiwassee River, Sequatchie River, Paint Rock River, Larkin Fork, Estill Fork, Hurricane Creek, Flint River, Limestone Creek, Elk River, Sugar Creek, Bear Creek, Duck River, North Fork Creek, Big Rock Creek, and Buffalo River. Undocumented, but now lost, populations assuredly occurred in other Cumberlandian Region tributary systems.

Populations of the slabside pearlymussel are generally considered extant (current) if live or fresh dead specimens have been collected since 1980. Currently, it is limited to nine streams in the Tennessee River system, having been extirpated (eliminated) from the Cumberland River system and from the Tennessee River main stem. This species is still known from the Powell River, Clinch River, North Fork Holston River, Big Moccasin Creek, Middle Fork Holston River, Hiwassee River, Paint Rock River, Larkin Fork, Estill Fork, Hurricane Creek, Elk River, Bear Creek, and Duck River. The slabside pearlymussel has been eliminated from about three-fifths of the total number of streams from which it was historically known. The certainty that the slabside pearlymussel occurred in other streams within its historic range increases the percentage of lost habitat and populations, thus making its present status that much more imperiled.

During historical times, the slabside pearlymussel was fairly widespread and common in many Cumberlandian Region streams based on collections made in the early 1900s. However, its decline in certain streams may have begun before European colonization. The presence of the slabside pearlymussel in several streams, particularly those in the middle Tennessee River system, is known only by records from aboriginal "kitchen middens" (archeological records of mussels used as food from several hundred to several thousand years before present). The slabside pearlymussel was considered rare by mussel experts as early as 1970 (Stansbery 1971), which represents the first attempt to compile such a list. The extirpation of this species from numerous streams within its historical range indicates that substantial population losses have occurred.

The extant occurrences in the Tennessee River system represent nine isolated populations (two or more streams are considered to represent a single population if there are no absolute barriers, such as large impoundments, separating them). Population size data gathered during the past 10 years indicates that the slabside pearlymussel is rare (experienced collectors may find 4 or fewer specimens per site of occurrence) in about half of its extant populations. Although the species is more common in other populations, it is relatively abundant in only two or three streams. Populations of the slabside pearlymussel are declining rangewide, with the possible exception of the largest populations, which may represent the only viable populations remaining.

THREATS (Describe threats in terms of the five factors in section 4 of the ESA providing specific, substantive information. **If this is a removal of a species from candidate status or a change in listing priority, explain reasons for change**):

A. The present or threatened destruction, modification, or curtailment of its habitat or range. The decline of the slabside pearlymussel in the Cumberlandian Region and other mussel species in the eastern United States is primarily the result of habitat loss and degradation. These losses have been well documented for over 130 years. Chief among the causes of decline are impoundments, stream channel alterations, water pollution, and sedimentation (Williams et al. 1992, Neves 1993, Neves et al. 1997). Specific information presented in this section on threats to the slabside pearlymussel and causes of its decline were gathered primarily from these published sources and other studies generally cited in their works, except where noted.

Impoundments result in the dramatic modification of riffle and shoal habitats and the resulting loss of mussel resources, especially in larger rivers. Impoundment impacts are most profound in riffle and shoal areas, which harbor the largest assemblages of mussel species, including the slabside pearlymussel. Dams interrupt most of a river's ecological processes by modifying flood pulses; controlling impounded water elevations; altering water flow, sediments, nutrients, energy inputs and outputs; increasing depth; decreasing habitat heterogeneity; and decreasing stability due to subsequent sedimentation. The reproductive process of riverine mussels is generally disrupted by impoundments making the slabside pearlymussel unable to successfully reproduce and recruit under reservoir conditions.

In addition, dams can also seriously alter downstream water quality and riverine habitat, and negatively impact tailwater mussel populations. These changes include thermal alterations immediately below dams; changes in channel characteristics, habitat availability, and flow regime; daily discharge fluctuations; increased silt loads; and altered host fish communities. Coldwater releases from large non-navigational dams and scouring of the river bed from highly fluctuating, turbulent tailwater flows have also been implicated in the demise of mussel faunas.

Population losses due to impoundments have probably contributed more to the decline of the slabside pearlymussel and other Cumberlandian Region mussels than any other single factor. The majority of the Tennessee and Cumberland River main stems and many of their largest tributaries are now impounded. For example, over 2,300 river miles (about 20 percent) of the Tennessee River and its tributaries with drainage areas of 25 square miles or greater were impounded by the Tennessee Valley Authority (TVA) by 1971 (Tennessee Valley Authority 1971). The subsequent completion of additional major impoundments on tributary streams (e.g., Duck River in 1976, Little Tennessee River in 1979) significantly increases the total miles impounded behind the 36 major dams in the Tennessee River system. Approximately 90 percent of the 562-mile length of the Cumberland River downstream of Cumberland Falls is either impounded (three locks and dams and Wolf Creek Dam), or otherwise adversely impacted by coldwater discharges from Wolf Creek Dam. Other major U.S. Army Corps of Engineers (Corps) impoundments on Cumberland River tributaries (e.g., Caney Fork) have inundated over 100 miles of potential riverine habitat for the slabside pearlymussel.

Instream gravel mining has been implicated in the destruction of mussel populations. Negative impacts associated with gravel mining include stream channel modifications (e.g., altered habitat, disrupted flow patterns, sediment transport), water quality modifications (e.g., increased turbidity, reduced light penetration, increased temperature), macroinvertebrate population changes (e.g., elimination, habitat disruption, increased sedimentation), and changes in fish populations (e.g., impacts to spawning and nursery habitat, food web disruptions) (Kanehl and Lyons 1992). Gravel mining activities threaten the slabside pearlymussel populations in the Powell and Elk Rivers in the Tennessee River system.

Heavy metal-rich drainage from coal mining and associated sedimentation has adversely impacted portions of the upper Tennessee River system in Virginia. The low pH commonly associated with mine runoff can reduce glochidial encystment rates. Acid mine runoff, thus, may be having local impacts on recruitment of the slabside pearlymussel. Mine discharge from the 1996 blowout of a large tailings pond on the upper Powell River resulted in a major fish kill (L.M. Koch, Service, pers. comm. 1996). Powell River mussel populations were inversely correlated with coal fines in the substrate; when coal fines were present, decreased filtration times and increased movements were noted in laboratory-held mussels (Kitchel et al. 1981). In a quantitative study in the Powell River, a decline of

federally listed mussels and the long-term decrease in overall species composition since about 1980 was attributed to general stream degradation due primarily to coal mining activities in the headwaters (Ahlstedt and Tuberville 1997).

Contaminants contained in point and non-point discharges can degrade water and substrate quality and adversely impact mussel populations. The effects are especially profound on juvenile mussels, which can readily ingest contaminants, and glochidia, which appear to be very sensitive to certain toxicants. Mussels are very intolerant of heavy metals, and even at low levels, certain heavy metals may inhibit glochidial attachment to fish hosts.

Sediment from the upper Clinch River has been found to be toxic to juvenile mussels (Ahlstedt and Tuberville 1997). It was speculated that the presence of toxins in the Clinch River may explain the decline and lack of mussel recruitment at some sites in the Virginia portion of that stream. Numerous streams have experienced mussel and fish kills from toxic chemical spills and other causes, particularly in the upper Tennessee River system in Virginia (Neves 1986).

Siltation and general sedimentation runoff has been implicated in the decline of stream mussel populations. Sources of silt and sediment include poorly designed and executed timber harvesting operations and associated activities; complete clearing of riparian vegetation for agricultural, silvicultural, or other purposes; and those construction, mining, and other practices that allow exposed earth to enter streams. Specific impacts on mussels from silt and sediments include clogged gills thus reducing their feeding and respiratory efficiency, impaired reproductive activity, disrupted metabolic processes, reduced growth rates, substrate instability, and the physical smothering of mussels under a blanket of silt.

B. Overutilization for commercial, recreational, scientific, or educational purposes. The slabside pearlymussel is not a commercially valuable species, but may be increasingly sought by collectors with its increasing rarity. Most stream reaches inhabited by this species are restricted, and its populations are small. Although scientific collecting is not thought to represent a significant threat, localized populations could become impacted and possibly extirpated by overcollecting, particularly if this activity is unregulated.

C. Disease or predation. The occurrence of disease in mussels is virtually unknown. Several mussel dieoffs have been documented during the past 20 years (Neves 1986). Although the ultimate cause is unknown, some researchers believe that disease may be a factor.

Predation on the slabside pearlymussel by muskrats represents a localized threat, as determined by Neves and Odum (1989) in the upper North Fork Holston River in Virginia. They concluded that muskrat predation could limit the recovery potential of endangered mussel species or contribute to the local extirpation of already depleted mussel

populations. Although other mammals (e.g., raccoon, mink) occasionally feed on mussels, the threat is not significant.

D. The inadequacy of existing regulatory mechanisms. The States of Alabama, Kentucky, Tennessee, and Virginia prohibit the taking of mussels for scientific purposes without a State collecting permit. However, enforcement of this permit requirement is difficult. Furthermore, State regulations do not generally protect mussels from other threats.

Existing authorities available to protect riverine ecosystems, such as the Clean Water Act (CWA), administered by the Environmental Protection Agency (EPA) and the Corps, may not have been fully utilized. This may have contributed to the general habitat degradation apparent in riverine ecosystems and loss of populations of aquatic species in the Southeast. Although the slabside pearlymussel coexists with other federally listed mussels and fishes throughout most of its range, listing under the Endangered Species Act (Act) would provide additional protection. Federal permits would be required to take the species, and Federal agencies would be required to consult with the Service when activities they fund, authorize, or carry out may adversely affect the species.

E. Other natural or manmade factors affecting its continued existence. The remaining populations of the slabside pearlymussel are generally small and geographically isolated. The patchy distribution pattern of populations in short river reaches makes them much more susceptible to extirpation from single catastrophic events, such as toxic chemical spills. Such a spill that occurred in the upper Clinch River in 1998 killed thousands of mussel specimens of several species, including three federally listed species. Furthermore, this level of isolation makes natural repopulation of any extirpated population impossible without human intervention.

Population isolation prohibits the natural interchange of genetic material between populations, and small population size reduces the reservoir of genetic diversity within populations, which can lead to inbreeding depression (Avise and Hambrick 1996). It is likely that some populations of the slabside pearlymussel are below the effective population size (Soulé 1980) required to maintain long-term genetic and population viability.

The present distribution and status of the slabside pearlymussel in the Tennessee River system may be indicative of the detrimental bottleneck effect resulting when the effective population size is not attained. A once large population of this species occurred throughout much of the lower two-thirds of the Tennessee River main stem and in several larger tributary systems. In this region, there were no absolute barriers to genetic interchange among its tributary sub-populations and those of its host fishes (see "Description, Biology, and Life History" section above) that occurred in various streams. With the completion of numerous main stem Tennessee River dams during primarily the first half of this century, the main stem population was soon extirpated, and the remaining

populations isolated. Whereas small isolated tributary populations of imperiled short-lived species (e.g., most fishes) would have theoretically died out within a decade or so after impoundment, the long-lived slabside pearlymussel (see "Description, Biology, and Life History" section above), would potentially take decades to expire post-impoundment. Without the level of genetic interchange the species experienced historically (i.e., without the reservoir barrier), many small isolated populations that are now comprised predominantly of adult specimens may be slowly dying out. Even given the improbable absence of the impacts addressed in factors A through D above, we may lose smaller isolated populations of this species to the devastating consequences of below-threshold effective population size. In reality, degradation of these isolated stream reaches resulting in ever decreasing patches of suitable habitat is contributing to the decline of the slabside pearlymussel.

SUMMARY OF REASONS FOR REMOVAL OR LISTING PRIORITY CHANGE:

FOR RECYCLED PETITIONS:

a. Is listing still warranted? ___
b. To date, has publication of a proposal to list been precluded by other higher priority listing actions? ___
c. Is a proposal to list the species as threatened or endangered in preparation? ___
d. If the answer to c. above is no, provide an explanation of why the action is still precluded.

LAND OWNERSHIP (Percentage Federal/state/private, identify non-private owners): The slabside pearlymussel occurs in streams that run exclusively through private lands.

PRELISTING (Describe status of conservation agreements or other conservation activities): The Service has implemented ecosystem management in conserving, restoring, and recovering Federal trust species and their habitats nationwide. Shute et al. (1997) summarized the ecosystem approach to the management of imperiled aquatic resources, provided a literature review on the subject, and recommended a series of steps for developing and implementing an ecosystem management program. These include prioritizing riverine systems in need of protection, identifying and partnering with all potential agencies and organizations with watershed interests, prioritizing ecosystem threats, identifying strategies to minimize or eliminate threats, and educating ecosystem inhabitants and other stakeholders.

A number of conservation measures are available to federally listed and other species pursuant to Federal regulations and other Federal and State activities. Conservation actions by Federal, State, and private organizations, groups, and individuals are facilitated under several sections of the Act once species have been listed. The CWA has greatly reduced point discharge pollutants into streams and provides ways and means of addressing non-point source pollution as well. Partnering with State and Federal agencies and the coal industry, The Nature Conservancy (TNC)

is addressing the complex issue of abandoned mine lands, which may continue to impact slabside pearlymussel populations (see “factor A” above), by working on the Coal Re-mining Initiative.

Numerous stakeholders have realized that restoring and protecting riparian habitat improves water quality and is crucial for mussels. The Asheville Field Office has partnered with other field offices, TNC, and a legion of stakeholders to initiate several watershed-based riparian habitat restoration projects on streams having diverse aquatic faunas within the Cumberlandian Region. Streams that harbor extant populations of the slabside pearlymussel and are the focus of these riparian restoration efforts include the upper Clinch River, Tennessee and Virginia, and the Paint Rock River, Alabama and Tennessee. TNC also has selected the upper Clinch River, which has more species at risk mussels and fishes than any other small watershed in North America, as one of eight critical watersheds nationwide for protecting aquatic biodiversity (Master et al. 1998).

TNC has designated the community-based project on the Clinch River a bioreserve. Local citizens with water quality concerns for that watershed, which has a fairly large, but declining, population of the slabside pearlymussel have established the Paint Rock River Initiative (PRRI). By working closely with key partners (e.g., Resource Conservation and Development Councils, Natural Resources Conservation Service (NRCS), numerous other agencies and organizations), riparian habitat restoration activities conducted by the Service and TNC are proceeding in high-biodiversity watersheds in the Cumberlandian Region. The Clinch River Bioreserve and PRRI field representatives work closely with landowners and other stakeholders to effect riparian and aquatic habitat restoration. On-the-ground efforts that have helped improve riverine habitat in Bioreserves and other watershed-based riparian restoration projects include reducing erosion by stabilizing streambanks and using no-till agricultural methods, controlling nutrient enrichment by carefully planning heavy livestock use areas, establishing buffer zones by erecting fencing and revegetating riparian areas, developing alternative water supplies for livestock, and implementing voluntary Best Management Practices to control run-off for a variety of agricultural and construction activities. Programs administered by NRCS are becoming an increasingly important tool used in addressing habitat concerns associated with impaired Cumberlandian Region streams.

New watershed-based habitat restoration projects with slabside pearlymussel populations are just getting underway. One of these is located on the Duck River (a Tennessee River tributary in Tennessee), which harbors a sizable, but localized population of the slabside pearlymussel. A stress analysis is being planned for the Duck River. The stress analysis determines the location, type, severity, and extent of non-point source impacts facing that stream. Designed to function as a foundation for a holistic riparian habitat restoration program, priority reaches of high-quality habitat can be focused upon for restoration activities once a stress analysis has been completed and accompanying mussel survey information has been compiled.

Water and stream habitat quality improvements have made it possible for mussel populations to expand in some river reaches and may lead to augmenting depleted or reintroducing extirpated mussel populations in other streams. Such improvements in habitat conditions have come to fruition in parts of the Cumberlandian Region through the concerted efforts of the TVA, EPA,

and other Federal agencies, State water resources and natural resources agencies, industry, municipalities, conservation organizations, and concerned citizens. For instance, TVA has modified water releases from several of its dams to improve water quality conditions in the tailwaters. Reintroduction of the slabside pearlymussel into some of these stream segments is becoming more of a reality due to these efforts.

State and Federal agencies and the scientific community have cooperatively developed mussel propagation and reintroduction techniques and conducted associated research that has facilitated the reintroduction of mussels into historical habitats. We are planning a major reintroduction project for the Tennessee River at Muscle Shoals, Alabama, a site that was historically the most speciose of all known mussel beds worldwide. A proposed rule to reintroduce 16 federally listed mussel species and one aquatic snail to the remaining habitat of the site below Wilson Dam is currently under review. The slabside pearlymussel also historically occurred at this site. Certain Cumberlandian Region streams with records of the slabside pearlymussel receive a level of State protection from being designated outstanding resource waters.

Public outreach and environmental education play a major role in our recovery and restoration programs, thus benefitting aquatic species such as the slabside pearlymussel. Working with us and various other Federal agencies through a private company, the Tennessee Aquarium in Chattanooga recently installed an imperiled streams exhibit featuring mussels. A large series of brochures, posters, videos, and other materials on subjects such as mussels and fishes, the importance of high water and habitat quality, and stream restoration techniques have been developed for public dissemination.

The slabside pearlymussel historically occurred in Cumberlandian Region streams that drain four states and two Service regions: Region 4 (Alabama, Kentucky, and Tennessee) and Region 5 (Virginia). Endangered species biologists in Region 5 support the Asheville Field Office in our efforts to elevate this species to candidate status. In addition, we have contacted resource managers with the U.S. Geological Survey, EPA, TVA, TNC, Natural Heritage Programs, and State fish and wildlife agencies in these states. These agencies and organizations also support elevation of the slabside pearlymussel to candidate status.

We have not contacted private landowners. However, cooperative landowners in Cumberlandian Region streams with riparian habitat restoration projects have played a major role in the recovery of listed aquatic organisms, including mussels, and are key to the success of these efforts (Neves et al. 1997). Habitat for the slabside pearlymussel is already being benefitted by cooperating landowners in the habitat restoration projects on the Clinch River Bioreserve and the Paint Rock River. If listed, the slabside pearlymussel will become more of a focus organism in project watersheds. We will seek an increasing involvement of private landowners to restore and protect habitats essential for this species' continued survival and recovery.

REFERENCES (Identify primary sources of information (e.g., status reports, petitions, journal publications, unpublished data from species experts) using formal citation format):

Ahlstedt, S.A. and J.M. Tuberville. 1997. Quantitative reassessment of the freshwater mussel fauna in the Clinch and Powell Rivers, Tennessee and Virginia. Pp. 72-97 In: K.S. Cummings, A.C. Buchanan, C.A. Mayer, and T.J. Naimo, eds. Conservation and management of freshwater mussels II: initiatives for the future. Proceedings of a UMRCC symposium, 16-18 October 1995, St. Louis, Missouri. Upper Mississippi River Conservation Committee, Rock Island, Illinois.

Avise, J.C. and J.L. Hambrick, eds. 1996. Conservation genetics: case histories from nature. Chapman and Hall, New York.

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.

Kanehl, P. and J. Lyons. 1992. Impacts of in-stream sand and gravel mining on stream habitat and fish communities, including a survey on the Big Rib River, Marathon County, Wisconsin. Wisconsin Department of Natural Resources Research Report 155. 32 pp.

Kitchel, H.E., J.C. Widlak, and R.J. Neves. 1981. The impact of coal-mining waste on endangered mussel populations in the Powell River, Lee County, Virginia. Unpublished Report to the Virginia State Water Control Board, Richmond. 26 pp.

Master, L.L., S.R. Flack, and B.A. Stein, eds. 1998. Rivers of life: critical watersheds for protecting freshwater biodiversity. The Nature Conservancy, Arlington, Virginia. 71 pp.

Neves, R.J. 1986. Recent die-offs of freshwater mussels in the United States: an overview. Pp. 7-18 In: R.J. Neves, ed. Proceedings of the workshop on die-offs of freshwater mussels in the United States, 23-25 June 1986, Davenport, Iowa. Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Neves, R.J. 1993. A state-of-the unionid address. Pp. 1-10 In: K.S. Cummings, A.C. Buchanan, and L.M. Koch, eds. Conservation and management of freshwater mussels. Proceedings of a UMRCC symposium, 12-14 October 1992, St. Louis, Missouri. Upper Mississippi River Conservation Committee, Rock Island, Illinois.

Neves, R.J. and M.C. Odom. 1989. Muskrat predation on endangered freshwater mussels in Virginia. Journal of Wildlife Management 53(4):934-941.

Neves, R.J., A.E. Bogan, J.D. Williams, S.A. Ahlstedt, and P.W. Hartfield. 1997. Status of aquatic mollusks in the southeastern United States: a downward spiral of diversity. Pp. 43-85 In: G.W. Benz and D.E. Collins, eds. Aquatic fauna in peril: the southeastern perspective. Special Publication 1, Southern Aquatic Research Institute, Chattanooga, Tennessee.

Parmalee, P.W. and A.E. Bogan. 1998. The freshwater mussels of Tennessee. The University of Tennessee Press, Knoxville. 328 pp.

Shute, P.W., R.G. Biggins, and R.S. Butler. 1997. Management and conservation of rare aquatic resources: a historical perspective and recommendations for incorporating ecosystem management. Pp. 445-466 In: G.W. Benz and D.E. Collins, eds. Aquatic fauna in peril: the southeastern perspective. Special Publication 1, Southern Aquatic Research Institute, Chattanooga, Tennessee.

Soulé, M.E. 1980. Threshold for survival: maintaining fitness and evolutionary potential. Pp. 151-169 In: M.E. Soulé and B.A. Wilcox, eds. Conservation biology. Sinauer Associates, Inc., Sunderland, Massachusetts.

Stansbery, D.H. 1971. Rare and endangered molluscs in the eastern United States. Pp. 5-18 In: S.E. Jorgensen and R.W. Sharpe, eds. Proceedings of a Symposium on Rare and Endangered Mollusks (Naiads) of the United States. U.S. Fish and Wildlife Service, Twin Cities, Minnesota.

Tennessee Valley Authority. 1971. Stream length in the Tennessee River Basin. Unpublished Report. Tennessee Valley Authority, Knoxville, Tennessee. 25 pp.

Williams, J.D., M.L. Warren, Jr., K.S. Cummings, J.L. Harris, and R.J. Neves. 1992. Conservation status of freshwater mussels of the United States and Canada. Fisheries 18(9):6-22.

Winston, M.R. and R.J. Neves. 1997. Survey of the freshwater mussel fauna of unsurveyed streams of the Tennessee River drainage, Virginia. Banisteria 10:3-8.

LISTING PRIORITY (place * after number)

THREAT			
Magnitude	Immediacy	Taxonomy	Priority
High	Imminent	Monotypic genus	1
		Species	2
		Subspecies/population	3
	Non-imminent	Monotypic genus	4
		Species	5*
		Subspecies/population	6
Moderate to Low	Imminent	Monotypic genus	7
		Species	8
		Subspecies/population	9
	Non-imminent	Monotypic genus	10
		Species	11
		Subspecies/population	12

APPROVAL/CONCURRENCE: Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes to the candidate list, including listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all additions of species to the candidate list, annual retentions of candidates, removal of candidates, and listing priority changes.

Approve: _____ _____
Regional Director, Fish and Wildlife Service Date

Concur: _____ _____
Director, Fish and Wildlife Service Date

Do not concur: _____ _____
Director, Fish and Wildlife Service Date

Director's Remarks: _____

_____

_____

Date of annual review: January 17, 2001

Conducted by: Bob Butler - Asheville, North Carolina FO

Changes from October 25, 1999 CNOR(check one) Yes X No

Approval: _____ _____
Regional Director Dated

Comments: _____

(rev. 6/00)