Scaleshell Mussel Recovery Plan

(*Leptodea leptodon*)

February 2010

Department of the Interior
United States Fish and Wildlife Service
Great Lakes – Big Rivers Region (Region 3)
Fort Snelling, MN

Cover photo:

Female scaleshell mussel (*Leptodea leptodon*),
taken by Dr. M.C. Barnhart, Missouri State University

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Prepared by

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for

Region 3
U.S. Fish and Wildlife Service
Fort Snelling, Minnesota

Approved: ______________________
ACTING Regional Director, Region 3
U. S. Fish and Wildlife Service

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Disclaimer

This is the final scaleshell mussel (*Leptodea leptodon*) recovery plan. Recovery plans delineate reasonable actions believed required to recover and/or protect listed species. Plans are published by the U.S. Fish and Wildlife Service and sometimes prepared with the assistance of recovery teams, contractors, state agencies, and others. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not necessarily represent the views or the official positions or approval of any individuals or agencies involved in plan formulation, other than the U.S. Fish and Wildlife Service. They represent the official position of the U.S. Fish and Wildlife Service only after being signed by the Regional Director. Approved recovery plans are subject to modifications as dictated by new findings, changes in species status, and the completion of recovery actions.

The plan will be revised as necessary, when more information on the species, its life history ecology, and management requirements are obtained.

Literature citation:

U.S. Fish and Wildlife Service. 2010. Scaleshell Mussel Recovery Plan (*Leptodea leptodon*). U.S. Fish and Wildlife Service, Fort Snelling, Minnesota. 118 pp.

Recovery plans can be downloaded from the FWS website: http://endangered.fws.gov

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EXECUTIVE SUMMARY

Current Species Status: The scaleshell mussel (*Leptodea leptod*on) is a federally listed, endangered species that once occurred in 56 rivers in the Mississippi River Drainage. The species has undergone a dramatic reduction in range and is believed to be extirpated from 9 of the 13 states it historically occurred in. While the species has been documented from 18 streams in the last 25 years, it can only be found consistently in three streams in Missouri where it is still very rare.

Habitat Requirements and Limiting Factors: The scaleshell occurs in medium to large rivers with low to medium gradients. It primarily inhabits stable riffles and runs with gravel or mud substrate and moderate current velocity. The scaleshell requires good water quality, and is usually found where a diversity of other mussel species are concentrated. More specific habitat requirements of the scaleshell are unknown, particularly of the juvenile stage. Water quality degradation, sedimentation, channel destabilization, and habitat destruction are contributing to the decline of the scaleshell throughout its range. The spread of the non-native zebra mussel (*Dreissena polymorpha*) may threaten scaleshell populations in the near future.

The scaleshell must complete a parasitic phase on freshwater drum (*Aplodinotus grunniens*) to complete its life cycle. The scaleshell's complex life cycle and extreme rarity hinders its ability to reproduce. The sedentary nature of the species and the low density of remaining populations exacerbate threats to its survival posed by the natural and manmade factors. Further, the relatively short life span of the scaleshell may render it less able to tolerate periods of poor recruitment. The remaining populations are very susceptible to local extirpation, with little chance of recolonization because of their scattered and isolated distribution.

Recovery Strategy:

<u>Scope of threats and recovery:</u> Streams occupied by the scaleshell have numerous and widespread threats affecting the species. In some cases, these threats are related to the surrounding land use and can originate far upstream of extant populations. Therefore, threats not only need to be addressed immediately adjacent to occupied sites, but also in the watershed upstream. Some recovery actions may need to be implemented on a large scale in order to restore aquatic habitat downstream. Recovery efforts on this scale will not be possible without soliciting outside help to restore aquatic habitat and improve surface lands. The assistance of federal and state agencies, conservation groups, local governments, private landowners, industries, businesses, and farming communities will be essential in implementing the necessary recovery actions for the scaleshell to meet recovery goals. The role of private landowners, non-profit organizations, and corporations cannot be over emphasized as most land in watersheds occupied by the scaleshell is under private ownership.

<u>Addressing threats:</u> To solicit outside help and foster the many partnerships needed to address threats, a recovery implementation team will be formed. This team may be made up of species experts and representatives from federal and state wildlife agencies, other federal and state agencies, non-government organizations, academia, and other concerned groups with a diversity

of expertise on conservation science and public relations within the scaleshell's range. This team will take a strategic approach to address threats and work with willing partners to carry out the appropriate recovery actions to protect existing habitat, alleviate threats, and restore habitat. First, threats will be identified, assessed, and mapped for each watershed occupied by the scaleshell. Then a strategic recovery implementation database will be developed to guide recovery efforts for each population. The database will be used to prioritize populations, threats, and needed recovery actions as well as track recovery efforts and document when threats to each population have been alleviated. The threat mapping and strategic database are an integral part of the recovery strategy for the scaleshell.

Watershed improvements will be aimed at addressing the various causes of habitat degradation including sedimentation; point and non-point pollution sources; substrate destabilization; land, bank, and channel erosion; and eutrophication. Examples of watershed improvements to alleviate these threats include, but are not limited to the following: improving wastewater treatment plants, reestablishing protective riparian corridors to reduce sedimentation; stabilizing stream banks; reducing sheet run-off; using no-till agricultural methods; controlling nutrient enrichment by carefully planning heavy livestock use areas; excluding cattle from streams by erecting fences and providing alternative water supplies; development of gravel mining guidelines; and implementing voluntary best management practices to control run-off for a variety of agricultural, silvicultural, and construction activities.

Other factors that potentially will affect the scaleshell in the future include the introduction of non-native species, predation by small mammals, and mussel die-offs due to drought, contaminant spills, and disease. The scaleshell recovery implementation team will call on the nation's leading experts to devise methods to reduce the likelihood of zebra mussel or black carp invasions into streams occupied by the scaleshell. Emergency response strategies will be developed that will outline response protocols to effectively deal with mussel kills and invasions of non-native species that do occur. Measures will also be taken to control predators at select sites where it is identified as a significant factor contributing to the scaleshell's decline.

Because only a small number of scaleshell populations exist, it is essential that they all be protected. Utilizing existing legislation, regulations, and programs (i.e., ESA, CWA, FWCA, wetland and water quality regulations, stream alteration regulations, FERC relicensing, etc.) to protect the scaleshell and its habitat is a reasonable means to protect remaining scaleshell populations.

<u>Sound science</u>: Achieving the recovery goals and criteria outlined in this plan will also be dependent upon the application of sound science to make informed management decisions. Because the recovery implementation team will include species experts and experts in conservation science, it will serve in this capacity as well. The recovery implementation team will coordinate and oversee the implementation of the recovery objectives outlined in this plan. Other roles of the team include, but are not limited to the following: 1) determine the effectiveness of recovery actions and adapt management measures accordingly, 2) determine ongoing research needs, 3) interpret and apply scientific information and consult with appropriate experts to make sound and scientifically-based management decisions, 4) assist FWS

in determining when reclassification/delisting is appropriate, and 5) assist FWS in conducting five-year reviews.

Artificial propagation: The remaining populations of the scaleshell are also in imminent danger of extirpation because of their extremely small size and isolated distribution. The small number and low density of remaining populations exacerbate threats to its survival posed by natural and manmade factors. Recruitment failures could lead to their extirpation, with little chance of recolonization, in a relatively short period of time because of the short life-span of the species. Therefore, augmenting existing populations through artificial propagation is considered necessary for the continued existence of the scaleshell. This is the most urgent recovery action at this time. The goal of a propagation program for the scaleshell is to augment and stabilize populations. Augmenting existing populations will help ensure populations persist long enough to allow habitat improvements to take effect and to permit further scientific study. Preventing further loss of populations may also preserve genetic diversity of the species.

Research: The successful recovery of the scaleshell mussel will depend on the extent of our knowledge of the species and the causes of its decline. Critical aspects of the biology, ecology, and genetics of the species will be investigated, the results of which will direct recovery actions and inform management decisions. Data will be collected on the tolerance of the scaleshell to specific pollutants and the occurrence of these chemicals in watersheds in order to focus efforts to minimize or eliminate them. Lastly, how various water quality and environmental impacts associated with the operation of dams will be investigated to inform conservation efforts to recover populations located downstream of these operations.

Recovery in historical range: Initial recovery efforts will focus on watersheds where extant populations exist in order protect and stabilize those populations. Once the recovery requirements are met to downlist the species to threatened, more restoration efforts will be shifted to additional areas of the scaleshell's historical range to meet the recovery objectives to delist the species. Because improvements need to take place throughout entire watersheds, a long period of time will be required for habitat improvements to begin to have beneficial effects on populations and the habitat they depend on.

Public outreach: An outreach and education program will be carried out to heighten awareness of the scaleshell as an endangered species and to solicit outside help with recovery actions. Outreach material will be developed and produced to target the general public, schools, government agencies, congressionals, businesses, landowners, and other key partners needed to carry out the recovery actions. The goal of this outreach program is to increase appreciation for the scaleshell and provide information on how to become involved in recovery efforts. To increase the willingness of potential partners to participate in the recovery of the scaleshell, materials will highlight the many benefits of the scaleshell recovery actions such as cleaner water and improved health of the stream ecosystem overall.

Recovery Goals and Objectives: The ultimate goal of the recovery actions outlined in this plan is to reclassify and eventually delist the scaleshell. The objectives are to ensure the long-term viability of the scaleshell by stabilizing and protecting existing populations and restoring its habitat and watersheds it depends on. Recovery of the scaleshell in the near future is not likely because of the extreme rarity of the species, the extent of the decline that has occurred, and the large-scale of habitat restoration required to have a positive effect on populations.

Recovery Criteria: The scaleshell will be considered for downlisting to threatened status when the following criteria have been achieved:

1. Through protection of existing populations, successful establishment of reintroduced populations, or the discovery of additional populations, four stream populations exist, each in a separate watershed and each made up of at least four local populations located in distinct portions of the stream. Each stream population must exist in a separate watershed so that a single stochastic event, such as a toxic spill or disease outbreak, will not affect more than one of the four stream populations. This criterion is based on the available information and the best professional judgment of species experts (see Appendix v), and may be revised based on additional biological, demographic, or genetic information obtained through Recovery Actions 3.1 and 3.4.

2. Each local population in Criteria 1 is viable in terms of population size, age structure, recruitment, and persistence. Currently, what constitutes a viable population of the scaleshell is not known. Population viability will be defined when Action 3.4.2 (Research Population Dynamics of the Scaleshell) is completed. In the future, this criterion will be revised to incorporate the definition of population viability resulting from this recovery action (3.4.2).

3. Threats to local populations in Criterion 1 have been identified and addressed per the measurable criteria developed in Action 2.3. Currently it is not feasible to identify in this criterion the specific threats to populations and thresholds at which those threats are reduced to the level where criteria 1 and 2 are achieved. However, the thresholds for this criterion will be defined through the implementation of key actions in the plan as follows. Step 1: Identify and map present and foreseeable threats to local populations in a GIS database (Action 2.2). Step 2: Define measurable criteria for alleviating/reducing each of those threats and prioritize threats according to effects to local populations (Action 2.3). Step 3: Apply the appropriate recovery actions outlined in this plan to alleviate/reduce threats. Step 4: Track the progress of recovery implementation (Action 7.2).

The scaleshell will be considered for removal from the protection of the Endangered Species Act when the following criteria are achieved:

1. Through protection of existing populations, successful establishment of reintroduced populations, or the discovery of additional populations, a total of eight stream populations exist, each in a separate watershed and each made up of at least four local and geographically distinct populations. At a minimum, one stream population must be located in the Upper Mississippi River Basin, four in the Middle Mississippi River Basin (two of these must exist east of the Mississippi River), and three in the Lower Mississippi

River Basin. Completion of action 3.4.2 or 3.4.3 may indicate more local populations, streams, or geographical regions are required. This criterion is based on the available information and the best professional judgment of species experts (see Appendix v), and may be revised based on additional biological, demographic, or genetic information obtained through Recovery Actions 3.1 and 3.4.

2. Each local population in Criteria 1 is viable in terms of population size, age structure, recruitment, and persistence. Currently, what constitutes a viable population of the scaleshell is not known. Population viability will be defined when Action 3.4.2 is completed. In the future, this criterion will be revised to incorporate the definition of population viability resulting from this recovery action (3.4.2).

3. Threats to local populations in Criterion 1 have been identified and addressed per measurable criteria developed in Action 2.3. Currently it is not feasible to identify in this criterion the specific threats to populations and thresholds at which those threats are reduced to the level where criteria 1 and 2 are achieved. However, the thresholds for this criterion will be defined through the implementation of key actions in the plan as follows. Step 1: Identify and map present and foreseeable threats to local populations in a GIS database (Action 2.2). Step 2: Define measurable criteria for alleviating/reducing each of those threats and prioritize threats according to effects to local populations (Action 2.3). Step 3: Apply the appropriate recovery actions outlined in this plan to alleviate/reduce threats. Step 4: Track the progress of recovery implementation (Action 7.2).

Actions Needed: Recovery actions needed for the scaleshell include: 1) stabilize existing populations through artificial propagation to prevent extirpation; 2) formation of partnerships and utilization of existing programs to protect remaining populations, restore habitat, and improve surface lands; 3) improve understanding of the biology and ecology of the scaleshell; 4) further delineate the current status and distribution of the scaleshell; 5) restore degraded habitat in areas of historical range; 6) reintroduce the scaleshell into portions of its former range; 7) initiate various educational and public outreach actions to heighten awareness of the scaleshell as an endangered species and solicit help with recovery actions; and 8) track recovery and conduct periodic evaluations with respect to recovery criteria.

Total Estimated Costs of Recovery (priority 1, 2, and 3 actions defined on page 47):

COST ESTIMATE (000's)				
Fiscal Year (FY)	**Priority 1 Actions**	**Priority 2 Actions**	**Priority 3 Actions**	**Total**
FY 1	2715	76	2	2793
FY 2	2666	71	3	2740
FY 3	2637	0	2	2639
FY 4	2596	0	2	2598
FY 5 - 50	13230	535	1846	15611
Total	23844	682	1855	**26381**

Date of Recovery: If all funding requirements are met, the anticipated date of recovery is 2055. The threats affecting scaleshell populations not only occur in the vicinity of occupied habitats, but are often distributed widely within the surrounding watersheds. Because improvements need to take place throughout entire watersheds, a long period of time will be required for habitat improvements to begin having beneficial effects on populations and associated habitat.

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PART 1. INTRODUCTION

Status of the Species

The scaleshell mussel (*Leptodea leptodon*) was listed as endangered on October 9, 2001 (66 FR 51322). The species has a recovery priority number of two, meaning that it is a species with a high degree of threat and is likely to have a low recovery potential [see U.S. Fish and Wildlife Service (USFWS) 1990: 4 and Appendix IV].

Taxonomy

Phylum:	Mollusca; (Linne 1758, Cuvier 1797)
Class:	Bivalvia; (Linne 1758 after Bonnani 1681)
Order:	Unionoida; (Stoliczka 1871)
Family:	Unionidae; (Fleming 1828, Ortmann 1911)
Genus:	*Leptodea*; (Rafinesque, 1820)
Species:	*Leptodea leptodon*; (Rafinesque, 1820)

The scaleshell is reported to have been first described by Rafinesque in 1820. However, there is some question whether his original description applies to the scaleshell. Clarke (1996) argues that the original description of the shell and abundance of the species better fits the pink papershell (*Potamilus ohiensis*) or possibly the cracking pearlymussel (*Hemistena lata*). The following synonymy of the scaleshell mussel is from Parmalee and Bogan (1998).

Unio (*Leptodea*) *leptodon* Rafinesque, 1820; Rafinesque, 1820:295, pl. 80, figs. 5-7
Unio leptodon Rafinesque, 1820; Say, 1834: no pagination
Symphynota leptodon (Rafinesque, 1820); Férussac, 1835:25
Alasmodonta leptodon (Rafinesque, 1820); Lapham, 1852:370
Leptodea leptodon (Rafinesque, 1820); Conrad, 1853:262
Lampsilis (Proptera) leptodon (Rafinesque, 1820); Simpson, 1900:575
Proptera leptodon (Rafinesque, 1820); Sterki, 1907:393
Lampsilis leptodon (Rafinesque, 1820); Vanatta 1915:551
Lasmonos leptodon (Rafinesque, 1820); Utterback, 1916a:388
Paraptera leptodon (Rafinesque, 1820); Ortmann, 1918:571
Lampsilis (*Leptodea*) *leptodon* (Rafinesque, 1820); Frierson, 1927:82
Anodon purpurascens Swainson, 1823; Swainson, 1823a:pl. 160
Symphynota tenuissima Lea, 1829; Lea, 1829:453, pl. 11, fig. 21
Margarita (*Unio*) *tenuissimus* (Lea, 1829); Lea, 1836:38
Unio tenuissimus (Lea, 1829); Hanley, 1843:206, pl. 20, fig. 42
Margaron (*Unio*) *tenuissimus* (Lea, 1829); Lea, 1852c:38
Unio velum Say, 1829; Say, 1829:293
Leptodea velum (Say, 1829); Haas, 1969a:419
Lampsilis blatchleyi Daniels, 1902; Daniels, 1902:13, pl. 2
Lampsilis (*Proptera*) *blatchleyi* Daniels, 1902; Simpson, 1914:190
Leptodea blatchleyi (Daniels, 1902); Goodrich and van der Schalie 1944:316

Description

The following description of the scaleshell is summarized from Buchanan (1980), Cummings and Mayer (1992), Oesch (1995), Watters (1995), Parmalee and Bogan (1998), and Barnhart (2001). The shell reaches a length of approximately 10 centimeters (4 inches), although old individuals may reach 12 centimeters (4 ¾ inches). The periostracum is smooth, yellowish green or brown, with numerous faint green rays (Figure 1). The shells are elongate, very thin, compressed, and rhomboidal. The anterior end is rounded. The dorsal margin is straight, and the ventral margin is gently rounded. Beaks are small and low, and nearly even with the hinge line. The beak sculpture, which may not be visible in older individuals, is inconspicuously compressed and consists of four or five double-looped ridges. The pseudocardinal teeth are reduced to a small, thickened ridge. The lateral teeth are moderately long with two indistinct teeth occurring in the left valve and one fine tooth in the right valve. The beak cavity is very shallow. The nacre is pinkish white or light purple and highly iridescent.

The scaleshell exhibits marked sexual dimorphism (Figure 2). The most notable difference is the morphology of the posterior end. In males, the posterior end is bluntly pointed. In females, the periostracum forms a broad, ruffled extension of the posterior end of the shell (Buchanan 1980). Males and females also differ in overall size and shape. Females are usually smaller and less tall than males of similar age. Lastly, the beak of the female is located further anterior than that of the male (Barnhart 2001).

The anatomy of the soft tissues of the scaleshell have not been described. Baker (1928) reported it to be similar to the fragile papershell (*Leptodea fragilis*). Utterback (1915) described the anatomy of the fragile papershell as follows: "Branchial opening round, with spreading, yellowish tentacles [papillae]; anal slightly crenulated, with thickened edges and normal diaphragm; supra-anal long, extending to dorsal ala, usually closed; mantles parallel at edges, dark colored and thickened on edges of siphonal openings, white patch at base of branchial papillae, crenulated along border in front of branchial opening, post-ventral region of mantle darker than that of female; palpi united only at base, very long in old specimens; foot large, powerful, very extensile; gills dark tan, pointed posteriorly, inner gills longer and broader than outer, inner laminae of inner gills entirely connected to visceral mass." The extent of which this description of the fragile papershell applies to the scaleshell needs further investigation using living specimens. Based on recent photos of the scaleshell from the Meramec Basin, Missouri (Figures 3 and 4), the above description does fit the species to some degree.

Historical Distribution and Abundance

The scaleshell historically occurred in 56 rivers in 13 states within the Mississippi River Drainage (Table 1, Figure 5). Williams *et al.* (1993) reported the historical range as Alabama, Arkansas, Illinois, Indiana, Iowa, Kentucky, Missouri, Ohio, Oklahoma, South Dakota, Tennessee, and Wisconsin. Historical records also exist in Minnesota (Clarke 1996). While the scaleshell had a broad distribution historically, it apparently was not a common species locally (Call 1900, Baker 1928, Stansbery 1970, Gordon 1991, Oesch 1995, Clarke 1996). No quantitative data exist on the historic abundance of the scaleshell, but early descriptions of its distribution indicate that it was rare. Call (1900) considered the species "fairly common but not an abundant species" in the Ohio and Wabash rivers. Baker (1928) stated, "This is apparently a rare species in most places." In describing the status of the scaleshell in the Mississippi River system, Stansbery (1970) wrote, "the expression 'widespread and everywhere rare' fits this species perfectly." Additionally, the small number of specimens in museum collections indicates that the scaleshell was a rare species (Clarke 1996).

Several historical reports of the scaleshell are questionable or appear to be erroneous. Williams *et al.* (1993) listed Michigan and Mississippi as part of the scaleshell's range, but no valid records exist in these states. Therefore, its presence cannot be confirmed in those states (Szymanski 1998). The scaleshell has been reported from a portion of the St. Lawrence drainage in New York. However, the source specimens for the St. Lawrence River record were later identified as wingless examples of *Leptodea fragilis* (fragile papershell), a common species in New York (Strayer and Jirka 1997). Given this and that no other confirmed specimens have been found in the Great Lakes Basin, the historical occurrence of the species in the St. Lawrence Basin is doubtful. Scammon (1906) reported the scaleshell in Kansas, but this record is considered invalid by Murray and Leonard (1962). Aughey (1877) reported a collection of scaleshell in the Nemeha River, Nebraska. However, his collections have been lost or discarded, and much of his work has been questioned by several authors (Hoke 2000*a*). Therefore, the occurance of scaleshell in Nebraska cannot be confirmed. Lastly, Utterback (1915) mentioned the occurrence of the scaleshell in the Neosho River, Missouri. However, no river exists in Missouri by that name. This is most likely a typo because Utterback was specifically discussing mussel collections from Missouri. However, the river name could have changed, or Utterback possibly was referring to the Neosho River in Kansas or Oklahoma.

See Appendix I for a detailed discussion of the scaleshell's historical distribution and abundance.

Present Distribution and Abundance

The scaleshell is believed to be extirpated from Minnesota, Iowa, Wisconsin, and all states east of the Mississippi River (Table 1a and 1b, Figure 5). Most of this decline occurred before 1950 (USFWS 2001). Since 1950 the species has become increasingly rare and its range further restricted. Currently, the scaleshell can only be consistently found, although very rare, in three Missouri streams including the Meramec, Bourbeuse, and Gasconade rivers. It has been reported from 15 additional streams in the last 25 years, but only has been represented by a small number or a single specimen (live or dead) collected during one or more extensive mussel surveys of these rivers. These streams include the Big, Big Piney, Osage, and Missouri rivers in Missouri; Missouri River in South Dakota; Myatt Creek, St. Francis, White, Spring, South Fork Spring, Strawberry, South Fourche LaFave, Cossatot, Saline (a tributary of the Little River), and the Little Missouri rivers in Arkansas; and Kiamichi River in Oklahoma. In all, in the last 25 years, the scaleshell has been reported from 18 of the 56 rivers where it historically occurred (Table 1).

While the Meramec, Bourbeuse, and Gasconade rivers support the largest known scaleshell populations, these populations are extremely small and restricted to isolated patches of suitable habitat. Based on living and dead specimens collected during a 1997 survey in the Meramec

Basin, the scaleshell occurs at isolated sites between river mile 18.5 and 60.2 of the Meramec and between river mile 1.4 and 76.9 in the Bourbeuse River. The species comprised 0.4 percent of the total number of living mussels found in the basin. This includes 34 living specimens in the Meramec from 9 sites and 10 living specimens from 5 sites in the Bourbeuse River (Roberts and Bruenderman 2000). The scaleshell has been reported in the Gasconade River between river mile 6 and 231. In a 1998/1999 survey, it comprised 0.2 percent of the total number of living mussels found between river miles 92.0 and 256.9. This included 12 living specimens from 9 sites (Bruenderman *et al*. 2001). In a 1994 survey of the lower 85 miles of the Gasconade River, 8 scaleshells were found at 8 sites and comprised 0.1% of the total number of mussels found (Buchanan 1994).

See Appendix I for a more detailed discussion of the scaleshell's present distribution and abundance.

Life History/Ecology

<u>General Biology</u>

Relatively little is known of the life history of the scaleshell. Its general biology is believed to be similar to other bivalved mollusks belonging to the family Unionidae. Adults are suspension feeders, using their gills to remove suspended particles in the water column. While the diet of unionids is a subject of debate, it is believed to include detritus, phytoplankton, zooplankton, diatoms, bacteria, and other microorganisms (Fuller 1974). The extent of selectivity exhibited by mussels feeding on each of these food groups and species within these food groups is poorly understood and is likely to vary by species. Recent evidence suggests that detritus and bacteria may be an important food source (Silverman *et al*. 1997, Nichols and Garling 2000).

Even less is known of the feeding behaviors of juvenile mussels. Juvenile mussels are believed to employ foot (pedal) feeding to some degree for the first several months of their lives, feeding on depositional materials in interstitial water, including bacteria, algae, and detritus (Yeager *et al*. 1994). Pedal feeding in juveniles is accomplished by movements of microscopic cilia lining the foot that carry food particles into the mantle cavity and into the mouth. Juveniles also use the foot in a sweeping motion to draw particles toward the mantle cavity (Reid *et al*. 1992).

Adult unionids spend their entire lives partially or completely buried in the stream bottom (Murray and Leonard 1962). The depth to which they bury themselves may depend on the species, season, and environmental conditions (Parmalee and Bogan 1998). The posterior margin of the shell is usually partially spread, and the siphons extended to facilitate feeding and respiration. During periods of activity, movement is accomplished by extending and contracting a single muscular foot between the valves. Extension of the foot also enables the mussel to wedge itself into the river bottom. In the case of the scaleshell, it has frequently been observed living nearly or completely buried in the substrate to a depth of 13 centimeters (five inches) (Buchanan 1980, Oesch 1995, Roberts and Bruenderman 2000). In other circumstances, it has been found residing on the surface (Roberts and Bruenderman 2000, Bruenderman *et al*. 2001). The behavior of the scaleshell with respect to the extent of its activity level, vertical migration in the substrate, and seasonal movements is not well understood.

Reproductive Biology

To better understand the discussions below related to the scaleshell's life cycle, it is first necessary to provide a general overview of the reproductive biology common to most freshwater mussels. Unionids have an unusual and complex mode of reproduction, which includes a brief, obligatory parasitic stage on fish. Most species typically have separate sexes, and spawning occurs in the spring, summer, or early fall (depending on the species). First, females lay eggs and brood them in specialized chambers in the gills (marsupia). Then males release sperm into the water column that are drawn into the female's incurrent siphon. Fertilization takes place internally within the marsupium. Within the marsupium, fertilized eggs develop into microscopic larvae (glochidia), which only have embryonic stages of a mouth, intestines, heart, and foot. The female may brood glochidia until the following year (long-term brooders) or release glochidia the same year it is fertilized (short-term brooder). Once glochidia are expelled by the female, they must quickly attach to the gills or the fins of an appropriate fish host to complete development. Glochidia that fail to attach to a suitable host will die. Host fish specificity varies among unionids. While some mussel species appear to require a single host species, other species can transform their glochidia into juvenile mussels on several fish species. Following proper host infestation, glochidia transform into juveniles, excyst from the host (drop off), and must settle into suitable habitat to survive. For further information on the life history of freshwater mussels, see Gordon and Layzer (1989), Watters (1995), and Parmalee and Bogan (1998).

Specific information is available pertaining to the scaleshell's reproductive biology. Baker (1928) surmised that the scaleshell is a long-term brooder with spawning occurring in the fall and host infection in spring. Recent observations support Baker's conclusion. Gordon (1991) reported observations of gravid scaleshells in September, October, November, and March (location unknown). In Missouri, gravid specimens have been observed in the Meramec and Gasconade rivers in August, September, October, April, and June (Barnhart 2001, data from Roberts and Bruenderman 2000). Additionally, Barnhart (1998) observed the scaleshell in the Meramec River brooding undeveloped eggs in early August. The only known report of the scaleshell collected in a non-gravid condition is July from the Big River, Missouri (data from Roberts and Bruenderman 2000). Based on these observations, the scaleshell spawns and begins brooding in early August, and glochidia are released the following June in Missouri. Formal studies are needed to better define the breeding season of the scaleshell. These studies should be based on water temperature, in addition to season, as a controlling factor of its reproductive cycle.

The glochidia of the scaleshell are among the smallest in the family Unionidae. A specimen from the Meramec River, Missouri, produced glochidia with an average length and height of 0.0676 and 0.0810 millimeters respectively (Barnhart 1998). The glochidia are semi-elliptical, rounded in the ventral margin, and have a short hinge line, which is typical for the subfamily Lamsilinae (Figure 6). The fact that they are hookless suggests that they are more adapted to attach to the gill of its host. Some unionid species (mainly in the subfamily Anodontinae) have hooked glochidia, which is an adaptation to attach firmly and transform on the fins of hosts (Howard and Anson 1922, Hoggarth and Gaunt 1988). Scaleshell glochidia are brooded by the female in the outer gills (Figure 4). The marsupia occupy the posterior part of the outer pair of gills, and when gravid, extends beyond the original edge of the gills. This observation is similar to Utterback's (1915) description of *L. fragilis*.

Although the scaleshell is small, it has a high fecundity compared to many species. A small female collected from the Gasconade River with a length, width, and height of 44.1, 11.2, and 21.0 millimeters, respectively produced an estimated 419,000 glochidia (Barnhart 2001). For comparison, a Plea's mussel (*Venustachoncha pleasii*) of similar size produced approximately 46,947 glochidia, and a giant floater (*Pyganodon grandis*) with a length, width, and height of 125.5, 81.1, and 56.5 millimeters respectively produced about 235,210 glochidia (Barnhart 2001). The small size of the scaleshell's glochidia may contribute to its ability to produce large numbers of larvae (Barnhart 2001).

Unionids vary in their host specificity. Some mussel species can use a variety of fish species as hosts, but are usually limited to one or two families of fishes. A small number of mussels appear to be limited to a single fish host. The scaleshell appears to utilize the freshwater drum (*Aplodinotus grunniens*) exclusively as a host for its larvae. Barnhart (1998) tested 24 fish species and one amphibian, the mudpuppy (*Necturus maculosus maculosus*), as potential fish hosts in the laboratory. Glochidia only remained attached and transformed into juvenile mussels on the freshwater drum. Other species in the genus *Leptodea* and a closely related genus *Potamilus* are also known to use freshwater drum exclusively as a host (Watters 1994, Barnhart and Roberts 1997*a*, Roe *et al.* 1997, Barnhart 1998). While all available evidence suggests that drum is the host for the scaleshell, it still is considered a potential host until drum with natural infestations of scaleshell glochidia are observed in the wild.

The successful transfer of mature glochidia to a suitable host constitutes one of the critical events in the life cycle of freshwater mussels, and various adaptations to facilitate this process have evolved. The method of host infection greatly varies among species. While some species simply release glochidia into the water where they must haphazardly come into contact with the appropriate host, the process is more intricate and direct in other species. For example, females in the genus *Lampsilis* have an extension of the mantle tissue that strikingly resembles a small fish. This structure is displayed outside the shell from between the valves and is twitched repetitively to attract its predaceous fish host. The host is infested by the female mussel when the fish attempts to eat the lure (Kraemer 1970, Barnhart and Roberts 1997*b*). Other unionid species release conglutinates (small structures made up of gelatinous material that enclose large numbers of glochidia) freely into the water. These structures resemble prey items of the mussel's host fish; the host fish are infested when they attempt to eat them (Chamberlain 1934, Barnhart and Roberts 1997*b*).

How a scaleshell infests its host and the intricacy of this relationship is unknown. One interesting hypothesis is that the scaleshell infests drum via host predation of females (Barnhart 2001). The small size, sexual dimorphism, apparent rarity of females (see sex ratio section below), and the fact that freshwater drum are molluscivores support this hypothesis.

Furthermore, the scaleshell produce glochidia at a small size and young age, which may be another adaptation for consumption by drum (Barnhart 1998). Knowledge of how the scaleshell infests its host and what environmental conditions in the stream might facilitate this interaction might shed light on possible reasons for recruitment failure.

Once attached to its host fish, the scaleshell will disperse with the fish for a period of weeks while they must successfully transform. This phase is another major bottleneck in the life cycle of unionids as not all glochidia that attach to a suitable host successfully transform into juveniles. Barnhart (2003) reported a transformation period for scaleshell glochidia of between two and three weeks on freshwater drum. In these laboratory infestations, most developing glochidia remained encysted on drum for 16 to 20 days in water 25.5° C (77.9 °F). Transformation success of the glochidia varied widely on individual drum, ranging from 0 to 82%. This variation is unexplained and warrants further research. Genetics, age, and acquired immunity from previous parasitic infestations are possible factors affecting the suitability of drum as a host for the scaleshell.

The scaleshell is one of the few unionid species that grow during encystment on the host (Figure 7). Encysted juveniles grow more than four-fold in length before excysting. Bauer (1994) suggested that growth on the host fish and small glochidia size might be correlated with greater host specificity. Other species of *Leptodea* and species in the genus *Potamilus* also grow while encysted on host fish.

Growth and Longevity

Many freshwater mussel species are long-lived. Individuals of many species live more than 10 years, and some have been reported to live over 100 years (Cummings and Mayer 1992). Recent collections of the scaleshell from Missouri indicate that it is relatively short-lived. A sample of 33 dead specimens and 2 living individuals collected in 2000 from a Gasconade River site did not contain any individuals exceeding approximately seven years old, based on counts of external annuli (Barnhart 2001). Likewise, no individuals over approximately six years old were observed out of 44 living individuals collected in 1997 from the Meramec Basin (Roberts and Bruenderman 2000). Based on these collections, it appears that the life expectancy of the scaleshell is less than 10 years. However, these age estimates are speculative because the relationship between age and growth lines has not been validated for this species.

Sex Ratio

It appears that some scaleshell populations have skewed sex ratios. Barnhart (2001) reported collecting only 10 females out of 57 specimens in the Gasconade River, and no females out of eight specimens in the Bourbeuse River (most of these specimens were fresh dead shells). Likewise, during a 1997 survey of the Meramec River Basin, only 15 females were collected out of 44 living individuals (Roberts and Bruenderman 2000). The sex ratio of the above collections is significantly different from a 50/50 ratio (Chi-Square Test, $P < 0.05$). The reason females appear to be less common than males in the Gasconade River and Meramec Basin is unknown and warrants further research.

Habitat Characteristics/Ecosystem

The scaleshell occurs in medium to large rivers with low to medium gradients. It inhabits a variety of substrate types, but is primarily found in stable riffles and runs with slow to moderate current velocity. Buchanan (1979, 1980, 1994) and Gordon (1991) reported it from riffle areas with substrate consisting of gravel, cobble, boulder, and occasionally mud or sand. Call (1900), Goodrich and Van der Schalie (1944), and Cummings and Mayer (1992) reported collections from muddy bottoms of medium-sized and large rivers. Oesch (1995) considered the scaleshell a typical riffle species, occurring only in clear, unpolluted water with good current. Oesch also noted that it frequently buries itself in gravel to a depth of four to five inches.

The scaleshell is also usually found in stable channels where a diversity of other mussel species are concentrated (i.e. mussel bed). This is typical for many other mussel species as suitable stream habitat for freshwater mussels naturally occurs in relatively small patches separated by longer reaches of unsuitable habitat (Vaughn and Taylor 2000, Vaughn and Pyron 1995, Strayer *et al*. 2004). Roberts and Bruenderman (2000) collected the scaleshell primarily from mussel beds with stable, gravel substrates. The habitat observations discussed above are consistent with the current distribution of the scaleshell; the species is restricted to streams that have maintained relatively good water quality and to stream reaches with stable channels. More specific physical, chemical, and biological habitat requirements of the scaleshell are unknown, particularly of the juvenile stage.

As discussed above, the scaleshell appears to be dependent solely upon freshwater drum to complete its life cycle. Drum are common in larger streams throughout the range of the scaleshell. Drum live most of their lives on or near the bottom, and are usually found in large pools (Pflieger 1997). Their diet consists primarily of fish, crayfish, and immature aquatic insects (Daiber 1953, Moen 1955, Priegel 1967). Additionally, drum are capable of crushing mollusk shells with their heavy pharyngeal teeth and are believed to feed on small freshwater mussels and other mollusks. Spawning of drum is believed to take place in open water and eggs float for one or two days until hatching (Daiber 1953). In Missouri, freshwater drum migrate out of large rivers and reservoirs into tributary streams to spawn in late April and May (Pflieger 1997). Knowledge on the distribution, abundance, habitat use, and behavior of freshwater drum is needed to manage scaleshell populations and determine suitable habitat for reintroduction of the species.

Reasons for Listing/Current Threats

We followed procedures found in section 4 of the ESA (16 U.S.C. 1533) and regulations (50 CFR part 424) promulgated to implement the listing provisions of the ESA. The USFWS may determine a species to be endangered or threatened due to one or more of the five factors described in section 4(a)(1) of the ESA. These factors and their application to the scaleshell are as follows.

The Present or Threatened Destruction, Modification, or Curtailment of its Habitat or Range

The scaleshell has undergone a dramatic range reduction. Its range was once expansive, spanning the Mississippi River Basin in at least 56 rivers in 13 states (Szymanski 1998). Today, the range is greatly reduced with recent occurrences (in the last 25 years) in 18 streams in four states. The scaleshell has been eliminated from all streams east of the Mississippi River and the entire upper Mississippi River drainage. Although much of the decline occurred before 1950, population declines continue in most portions of the species' range, and numerous threats are impacting the few remaining populations. Habitat destruction and degradation as a result of physical, chemical, and biological alterations, has and continues to threaten scaleshell populations throughout its range. The major causes of such alterations are water pollution, sedimentation, channelization, sand and gravel mining, dredging, and impoundments.

A general description of how these factors affect mussels including the scaleshell is given below, followed by specific examples of how these threats are affecting the scaleshell in its extant range. Refer to Szymanski (1998) and Watters (2000) for a more detailed discussion of threats to freshwater mussels.

Mussel biologists generally agree that contaminants are partially responsible for the decline of mussels [Havlik and Marking 1987, Bogan 1993, Williams *et al.* 1993, The National Native Mussel Conservation Committee (NNMCC) 1998]. Mussels are sedentary filter feeders and are vulnerable to contaminants that are dissolved in water, associated with suspended particles, or deposited in bottom sediments (Naimo *et al.* 1992). Mussels appear to be among the most sensitive organisms to heavy metals (e.g. cadmium, chromium, copper, mercury, zinc) some of which are lethal even at low levels (Havlik and Marking 1987, Keller and Zam 1991, Wang *et al*. 2007*a*, Wang *et al*. 2007*b*). Mussels are also sensitive to ammonia (Augspurger *et al*. 2003, Wang *et al*. 2007*a*, Wang *et al*. 2007*b*), which is a common pollutant in streams associated with animal feedlots, nitrogenous fertilizers, and the effluents of municipal wastewater treatment plants (Goudreau *et al*. 1993).

Contaminants enter streams from point and nonpoint sources. Point source pollution is the entry of material from a discrete, identifiable source such as industrial effluents, sewage treatment plants, solid waste disposal sites, and accidental chemical spills. Industrial and municipal effluents often contain heavy metals, ammonia, chlorine, phosphorus, and numerous organic compounds. Direct freshwater mussel mortality from toxic spills and polluted water is well documented (Ortmann 1909, Baker 1928, Cairns *et al.* 1971, Goudreau *et al.* 1988). Decline and elimination of populations may be due to acute and chronic toxic effects that result in direct mortality, reduced reproductive success, or compromised health of the animal or host fish.

Nonpoint source pollution is the entry of material into the environment from a diffuse source such as runoff from urban areas, cultivated fields, pastures, private wastewater effluents, agricultural feed lots and poultry houses, active and abandoned mines, construction, and highway and road drainage. Stream discharge from these sources may accelerate eutrophication (i.e., organic enrichment), decrease oxygen concentration, increase acidity and conductivity, and cause other changes in water chemistry that are detrimental to the survival of unionids and may impact host fishes (Fuller 1974, Dance 1981, Goudreau *et al.* 1988). Eutrophication generally occurs when nutrients are added in concentrations that cannot be assimilated as a result of runoff of organic wastewater contaminants from live stock farms and fertilizers used on row crops. Excessive growths of filamentous algae alter the surface of the stream bottom and may cause shifts in algal communities, disrupting food supplies for mussels. Juvenile mussels, utilizing interstitial habitats, are particularly affected by excessive levels of oxygen-consuming algae during nocturnal respiration (Sparks and Strayer 1998). Pesticides from row crops are a major source of agricultural contaminants, and are known to have direct affect on mussels (Havlik and Marking 1987).

Sediment is material that is suspended in the water, and is being transported, or has been moved, as the result of erosion [U.S. Soil and Conservation Service (USSCS) 1988]. Although sedimentation is a natural process, intensive agricultural practices, channelization, impoundments, timber harvesting within riparian zones, heavy recreational use, urbanization, and other land use activities can accelerate erosion (Chesters and Schierow 1985, Myers *et al.* 1985, Waters 1995, Watters 2000). The water quality impacts caused by sedimentation are numerous. Generally, it affects aquatic biota by altering the substratum and by altering the chemical and physical composition of the water (Ellis 1936, Myers *et al.* 1985, USSCS 1988). Heavy sediment loads can directly affect freshwater mussel survival by interfering with respiration and feeding. Due to their difficulty in escaping smothering conditions (Imlay 1972, Aldridge *et al.* 1987), either sudden or gradual blanketing of the stream bottom with sediment can suffocate freshwater mussels (Ellis 1936). Sediment particles may carry contaminants toxic to mussels (Naimo *et al.* 1992). Increased sediment levels may also reduce feeding efficiency (Ellis 1936), which can lead to decreased growth and survival (Bayne *et al.* 1981).

Channelization, sand and gravel mining, and dredging operations physically remove mussels from the water and may also bury or crush mussels (Watters 2000). More lasting effects of these activities involve the alteration or destruction of important unionid habitat that can extend upstream and downstream of the excavated area. Headcutting, the upstream progression of stream bed destabilization and accelerated bank erosion, can affect an area much larger than the dredging site (Hartfield 1993). In severe cases, this erosional process can extend for several miles upstream. As relatively immobile bottom-dwelling invertebrates, mussels are particularly vulnerable to channel degradation (Hartfield 1993). Accelerated erosion also releases sediment and pollutants, and in some instances, diminishes mussel diversity and habitat as documented in the Yellow and Kankakee Rivers in Indiana, the Big Vermillion River in Illinois, and the Ohio River (Fuller 1974).

Impoundments negatively affect mussels both upstream and downstream by inducing bank and channel scouring, altering water temperature regimes, and altering habitat, food, and fish host availability (Caryn Vaughn, in litt. 1997). Impoundments permanently flood stream channels and eliminate flowing water that is essential habitat for most unionids, including the scaleshell (Fuller 1974, Oesch 1995). Scouring is a major cause of mussel mortality below dams (Layzer *et al.* 1993). Most detrimental, however, is the disruption of reproductive processes. Impoundments interfere with movement of host fishes, alter fish host assemblages, and isolate mussel beds from each other and from host fishes (Stansbery 1973, Fuller 1974, Vaughn 1993, Williams *et al.* 1993). The result is diminished recruitment (Layzer *et al.* 1993).

Dams are effective barriers to fish host movement and migration, which unionids depend on for dispersal. Fish movements are essential for maintaining scaleshell populations in streams where local extirpation occurs as a result of environmental extremes (e.g. drought and predation) or other factors. Further, mussels living upstream from a dam can become reproductively isolated from those living downstream, causing a decrease in genetic diversity locally. On a smaller scale, even small, low head dams and low water crossings constructed across the stream channel can hinder fish movement between suitable habitats and isolate mussel populations from fish hosts and from each other. Watters (1996) determined that the upstream distribution of two mussel species, the fragile papershell (*Leptodea fragilis*) and pink heelsplitter (*Potamilus alatus*), stopped at lowhead dams. These species, like the scaleshell, are believed to use the freshwater drum as a sole host. Further, other structures constructed across the channel of in streams, such as low water road crossings, also hinder or block upstream dispersal of mussels. For example, the upstream distribution of the fat pocketbook (*Potamilus capax*) was found to stop at a fish weir in Southeast Missouri (Roberts *et al.* 1997).

The same threats that caused the extirpation of historical populations of the scaleshell still exist and continue to threaten extant populations. This species appears to be susceptible to pollution and sedimentation. Historically, the species was widespread and occurred in diverse habitats. Today, the scaleshell no longer occurs at disturbed sites that still support other endangered unionids (Szymanski 1998). This suggests that perhaps the scaleshell could be more sensitive to degraded water quality and habitat disturbance than most other unionids. Given the pervasiveness of the sources of pollution and sedimentation, it is apparent that these threats continue to be problematic for the remaining scaleshell populations. The following subsections describe threats to the scaleshell within each watershed.

Upper Mississippi River Basin (upstream from confluence of Missouri and Mississippi rivers)

The scaleshell formerly occurred in eight rivers and tributaries within the Upper Mississippi River Basin. However, this species has not been found in more than 50 years and is believed extirpated from this region (Kevin Cummings, in litt. 1994). It is believed that the same factors that have caused declines and extirpations of other mussel species including impoundments, pollution, sedimentation, and channelization and dredging activities, have caused the disappearance of the scaleshell from the Upper Mississippi River Basin.

Middle Mississippi River Basin (between Missouri and Ohio River confluences with Mississippi River)

Similar to the Upper Mississippi River Basin, impoundments, pollution, sedimentation, and channelization and dredging activities are believed to have led to the extirpation of the scaleshell from the entire Ohio River Basin. These same threats continue to adversely affect extant populations in the Middle Mississippi River Basin. Scaleshell habitat in the Meramec River Basin has been reduced in recent years. In 1979, Buchanan found living or dead scaleshell in the lower 180 km (112 mi) of the Meramec River (Buchanan 1979, 1980). In 1997, living or dead specimens were collected only in the lower 96 km (60 mi) of the river (Roberts and Bruenderman 2000). While portions of the lower reach continue to provide suitable habitat, mussel species diversity and abundance above mile 60 have declined noticeably in the last 20 years, and 9 mussel beds are no longer present between river mile 21.5 and 145.7. Roberts and Bruenderman (2000) attributed this decline primarily to the loss of channel stability. Water quality degradation is also a factor as the Meramec flows through the St. Louis Metropolitan area and a number of smaller towns.

Within the Meramec Basin, the Bourbeuse River has undergone the greatest change with respect to mussel populations. In particular, mussel populations have declined in the lower river. Whereas Buchanan (1979, 1980) found this section of the Bourbeuse River to have the greatest mussel diversity, this stretch was nearly devoid of mussels when resurveyed in 1997. Additionally, five mussel beds are no longer present between miles 0.4 and 137. Buchanan (in litt. 1997) and Roberts and Bruenderman (2000) attributed this decline to habitat loss from sedimentation, eutrophication, and substrate destabilization.

The Big River has the lowest species diversity and abundance in the Meramec River Basin. Buchanan (1979, 1980) attributed this to the effects of lead and barite mining. While most mining operations have ceased, 45 dams retaining mine waste and numerous waste piles remain in the Big River Basin. Most of those dams were improperly constructed or maintained. The U.S. Army Corps of Engineers (USACE) found that only one of the 45 dams was safe and 27 received the worst possible rating and could fail during a flood. The poor condition of the dams has led to large influxes of mine waste into the Big River from dam collapse [Missouri Department of Conservation (MDC) 1997]. For example, since 1978, a ruptured tailings dam has discharged 63,000 cubic meters (81,000 cubic yards) of mine tailings into the Big River covering 40 km (25 mi) of stream bottom and negatively impacting the lower 129 km (80 mi) of the river (Alan Buchanan, in litt. 1995), making it less suitable for mussels.

While no major impoundments exist in the Meramec River Basin, several old mill dams (low-head dams) affect the mainstem of the Big and Bourbeuse rivers. Five dams are still in place along the lower 48 km (30 mi) of the Big River, and two dams exist in the lower Bourbeuse River. These structures impound water for several miles upstream eliminating suitable mussel habitat. They are also effective barriers to host fish movement during normal flows (MDC 1997) and thus, continue to depress reproduction and dispersal of the scaleshell and other mussels.

Gravel mining poses an imminent threat to scaleshell populations in the Meramec River Basin due to the high, and increasing, level of interest in gravel mining in the basin (Roberts and Bruenderman 2000). For example, between 1994 and 1998, the USACE issued permits for 230 sites. Additional sites were mined without a permit, but the number of these unauthorized operations is unknown. (Danny McClendon, USACE, St. Louis District, in litt. 1998).

The greatest threat to freshwater mussels reported in the Gasconade River is bank, channel, and substrate instability. This problem is particularly evident in tributaries to the Gasconade River.

Other threats to mussels reported in the Gasconade River Basin include eutrophication, gravel dredging, municipal and industrial wastes, dense populations of the Asian clam, and cattle with unrestricted access to the stream (Bruenderman *et al*. 2001). In 1994, several areas of the lower Gasconade River channel were highly unstable, possibly a result of riparian vegetation removal in conjunction with the 1993 flood. These areas had high cut mud banks with trees fallen into the river, unstable substrate and contained very few mussels. Buchanan (1994) predicted that habitat degradation on this river would continue and postulated that the mussel fauna would be further impacted, with some species possibly disappearing. He noted that below river mile six, only one stable gravel bar contained a diverse mussel fauna. High silt deposition of the Missouri River prohibits the formation of mussel habitat below this area.

The majority of the Osage River system has been impounded and is no longer suitable for freshwater mussels. The majority of remaining mussel habitat occurs below Bagnell Dam in the lower 80 miles of the Osage River proper. This river reach is affected by the operation of Bagnell Dam, which alters flow and temperature regimes, lowers dissolved oxygen levels, and causes channel scouring and accelerated bank erosion. Several instream gravel mining operations, that physically remove mussels from the water and cause headcutting and siltation, currently exist in the Osage River.

Lower Mississippi River Basin (downstream from confluence of Ohio and Mississippi rivers)

Channelization, levee construction, diversion ditches, control structures, and floodways have drastically altered much of the St. Francis River from the mouth above Helena, Arkansas, to Wappapello Dam, Missouri (Bates and Dennis 1983, Ahlstedt and Jenkinson 1987). Bates and Dennis (1983) determined that of the 54 sites sampled, 15 were productive, 10 were marginal, and 29 had either no shells or dead specimens only. They identified 77 km (48 mi) that may still provide suitable mussel habitat, but did not collect the scaleshell. All the remaining river miles are unsuitable for mussels.

The White River between Beaver Reservoir and its headwaters is no longer suitable for mussels due to municipal pollution, gravel dredging, and dam construction (Gordon 1980). Navigational maintenance activities continue to destroy habitat from Newport to the confluence of the Mississippi River (Bates and Dennis 1983). This habitat destruction has relegated mussel species to a few refugial sites.

Species richness in the Spring River, Arkansas below river mile nine has declined markedly from past surveys, with the lower 5.0 km (3.0 mi) of river completely depleted of mussels and no longer providing suitable habitat (Gordon *et al.* 1984, Miller and Hartfield 1986). Sand and gravel dredging, destruction of stream banks, disturbance of mussel beds, deposition of wastes from livestock movement, siltation and surface run-off of pesticide and fertilizer appear to be contributing factors in the degradation of this river reach (Gordon *et al.* 1984).

Within Frog Bayou, potential habitat is restricted to the area between Rudy and the confluence of the Arkansas River. Within this area, streambank modifications and in-stream gravel mining are degrading scaleshell habitat. Two reservoirs, one near Maddux Spring and the other at

Mountainburg, impact the river above Rudy. Below the confluence of the Arkansas River, Gordon (1980) did not find live mussels, likely due to dredging activities (Gordon 1980). During a recent mussel survey of the Poteau River, Oklahoma it was found that species richness decreased below Lake Winster (Vaughn and Spooner 2004). This decrease in species richness was attributed to large-scale disturbance from the upstream impoundment along with other more localized impacts (Vaughn and Spooner 2004).

The proposed Tuskahoma Reservoir (located above Hugo Reservoir) is a potential threat to mussels in the Kiamichi River. Although the USACE has authorized construction, the lack of a local sponsor has rendered the project "inactive" (David Martinez, USFWS, Tulsa, pers. comm. 1997). If constructed, the adverse effects associated with reservoirs (including permanent flooding of the channel and disruption of reproduction) are likely to destroy the mussel fauna both above and below the proposed dam site.

Sewage pollution, gravel dredging, and reservoirs continue to impact the Little River. Pine Creek Reservoir impounds the mainstem of the river. While mussel habitat is present above Pink Creek Reservoir (Vaughn and Taylor 1999), these populations are isolated from downstream populations and species richness is on the low end (i.e. less than 15 species) of typical potential scaleshell sites. Below Pine Creek Reservoir, the mussel fauna is depleted, but recover with increasing distance from the impoundment. Further downstream, mussel species richness and abundance is greatly reduced after the inflow from Mountain Fork River (Vaughn and Taylor 1999). However, the discharge of reservoir water from Pine Creek and periodic discharge of pollution from Rolling Fork Creek seriously impact any remaining scaleshell and prohibit any future recolonization (Clarke 1987).

Hydroelectric dams and artificial lakes have impacted the Ouachita River. The "Old River" (an oxbow system off the mainstem), is now essentially a series of muddy, stagnant pools, with water quality problems resulting from surrounding dumps (Clarke 1987).

In summary, many of the same threats that caused the extirpation of historical populations of the scaleshell still exist and continue to threaten extant populations. Nonpoint and point source pollution is a concern in most streams, but is particularly a problem in the Meramec, Bourbeuse, and Gasconade rivers in Missouri (Bruenderman *et al*. 2001, Roberts and Bruenderman 2000), Spring River in Arkansas (Gordon *et al.* 1984, Miller and Hartfield 1986) and the Little River in Oklahoma (Clarke 1987, Vaughn 1994). Loss of stable substrates and sedimentation is causing deleterious effects in the Meramec and Bourbeuse rivers, Missouri (Bruenderman, pers. comm. 1998); Gasconade River, Missouri (Buchanan 1994); Frog Bayou, Arkansas (Gordon 1980); and Spring River, Arkansas (Gordon *et al.* 1984). Unregulated sand and gravel mining are eliminating important pool habitat (for both the scaleshell and potential fish hosts) in the Meramec, Bourbeuse, Big, and Gasconade rivers in Missouri (Bruenderman, MDC, pers. comm. 1998). Impoundments, channelization, and other dredging activities (e.g., sand and gravel mining) are destroying mussel beds and impairing water quality in Frog Bayou, Arkansas (Gordon 1980); St. Francis River, Arkansas (Ahlstedt and Jenkinson 1987); White River, Arkansas (Bates and Dennis 1983); Spring River, Arkansas (Gordon *et al.* 1984); Little River, Oklohoma (Vaughn and Taylor 1999); and Ouachita River, Arkansas (Clarke 1987). The proposed Kiamichi River Reservoir, if constructed, will have adverse impacts on any remaining populations in Oklahoma. Nearly all scaleshell populations are now restricted to small stretches of rivers with little, if any, potential for expansion or recolonization to other areas. For example, sewage pollution, gravel dredging, and reservoir construction have degraded the Little River in Oklahoma to the extent that only a few small stretches are able to support mussels.

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

It is unlikely that commercial mussel collectors ever purposefully collected the scaleshell because of their small size and thin shell. It is probable, however, that over-harvesting activities impacted scaleshell populations as it has been shown to cause declines in non-commercial species (Anthony and Downing 2001). For example, according to local fishermen, during a period of extended drought, mussel harvesters severely over-harvested mussel beds in the Spring and Black Rivers and completely destroyed most beds (Gordon *et al.* 1984). Commercial harvest is believed to have contributed to mussel declines in the Poteau River, Oklahoma. Vaughn and Spooner (2004) observed piles of discarded mussels left to die from harvesting activities in very shallow water or streamside in the Poteau.

In areas where commercial or other harvest has taken place, scaleshell populations may have been impacted by habitat destruction (i.e., disturbance of stream bottom), trampling, and removal of individuals from the stream. Individuals dislodged from the stream bottom could be washed away into unsuitable habitat, particularly because the scaleshell is a relatively light mussel in the water due to its small size and thin shell. Even for mussels returned to the stream, mortality can still occur (Cochran and Layzer 1993, Williams *et al.* 1993). Further, the removal of large numbers of commercial species such as the washboard (*Megalonaias nervosa*) may adversely affect other mussel species because in large numbers mussels stabilize the streambed, thus increasing the habitat suitability for other species. Also, commercial species perform ecosystem functions that provide habitat for and facilitate other species (Vaughn and Hakenkamp 2001, Spooner 2002). Today, intensive mussel collecting activity can have adverse affects on existing populations, because the scaleshell now occur in very small, isolated areas. The destruction of only a few individuals could be a contributing factor in the extirpation of some populations.

As the scaleshell become more uncommon, the interest of scientific and shell collectors may increase. Scaleshell occurrences are generally localized, easily accessible, and exposed during low flow periods, and, therefore, are also vulnerable to take for fish bait, curiosity, or vandalism. Prior to the listing of the scaleshell as an endangered species, up to five freshwater mussels per day could be legally collected in Missouri and used for fishing bait (MDC 2003). While this provision does not include federally listed species or state species of conservation concern, the scaleshell can easily be confused with other species, particularly by untrained collectors. However, the low density of scaleshell populations minimizes the likelihood of a scaleshell being collected.

Disease or Predation

Although natural predation is usually not a factor for stable, healthy mussel populations, small mammal predation could pose a problem for scaleshell populations (Gordon 1991). Small mammals, such as river otters, muskrats, and raccoons, are common predators of the scaleshell throughout their range, particularly during periods of low water providing easy access to mussel beds. These mammals are so effective at finding and eating freshwater mussels that malacologists consider collecting dead shells from middens a good way to determine the presence of rare species. For example, freshly killed scaleshell specimens were found among other species at several sites with active raccoon middens during a freshwater mussel survey of the Meramec and Bourbeuse Rivers (Roberts and Bruenderman 2000). Muskrat predation has been shown to be potentially detrimental to the recovery of rare mussels (Neves and Odom 1989). While the large size or thick shells of some species afford protection from small mammal predators, the small size and fragile shell of the scaleshell makes it an easy and desirable prey species. Extant scaleshell populations in Arkansas and Oklahoma are small, isolated, and have very limited recolonization potential. Thus, the removal of even a small number of individuals could significantly affect these populations. Small populations are less resilient to these natural predators, and therefore, are much more threatened by them. Consequently, predation could exacerbate ongoing population declines of the scaleshell.

Bacteria and protozoans persist at unnaturally high concentrations in streams with high sediment load or in water bodies affected by point source pollution, such as sewage treatment plants (Goudreau *et al.* 1988). At such concentrations, mussel ova and glochidia are more subject to infection (Ellis 1929). Disease and parasites may have caused major die-offs of freshwater mussels in the late 1970s throughout the eastern United States (Neves 1986). For example, significant die-offs of freshwater mussels occurred in 1977 and 1978 in the Meramec and Bourbeuse Rivers. Large numbers of mussels of all species, including the scaleshell, were lost. Buchanan (1986) presumed an epizootic or other disease caused the die-off since no environmental impact was reported or could be found.

Little is known about predators of juvenile mussels. As microscopic inhabitants in the bottom of the stream, juvenile freshwater mussels probably fall prey to a variety of macroinvertebrate predators such as hydra, various aquatic insect larvae, and crayfish. Flatworms have been shown to be voracious predators of newly metamorphosed juvenile mussels (Barnhart 2002, Delp 2002, Zimmerman and Neves 2003). However, juvenile mussels grow rapidly and can exceed the size of these tiny predators (Barnhart 2002, Delp 2002).

The Inadequacy of Existing Regulatory Mechanisms

The passage of the Clean Water Act (CWA) resulted in many positive consequences for freshwater ecosystems (including a decrease in lead and fecal coliform bacteria), and set the stage for the regulations and the water standards that exist today. Goals of the CWA include the protection and enhancement of fish, shellfish, and wildlife providing conditions suitable for recreation in surface waters and eliminating the discharge of pollutants into U.S. waters. However, despite the implementation of the CWA, degraded water quality still presents problems for sensitive aquatic organisms such as freshwater mussels. Specifically, nationwide stream and lake sampling has indicated continuing increases in nitrate, chloride, arsenic, and cadmium concentrations (Neves 1993). In recent studies, mussels have been found to be very sensitive to ammonia, which is one of the most common pollutants in streams (Augspurger *et al*. 2003, Wang *et al*. 2007*a*, Wang *et al*. 2007*b*). These studies have called into question if the Environmental Protection Agency's (EPA) current national water quality criteria are protective of freshwater mussels because those criteria were derived from a toxicity database predating the recent data available for freshwater mussels.

Nonpoint pollution sources appear to be the cause of increases in nitrogen. Many of the impacts discussed above occurred in the past as unintended consequences of human development. Improved understanding of these consequences has led to regulatory (e.g., CWA) and voluntary measures (e.g., best management practices for agriculture and silviculture) and improved land use practices that are generally compatible with the continued existence of the scaleshell. Nonetheless, the scaleshell is highly restricted in numbers and distribution and shows little evidence of recovering from historical habitat degradation and losses.

In 1997, gravel mining became a more serious threat for the scaleshell range-wide when a court ruling (American Mining Congress versus USACE) changed the interpretation of the CWA as it applies to the regulation of gravel mining (Roell 1999). Previously, gravel mining was more strictly regulated because "incidental fallback" (the incidental soil movement from excavation, such as the soil that is disturbed when dirt is shoveled, or back-spill that comes off a bucket and falls into the same place from which it was removed) was considered fill in surface waters, thus triggering the permitting process of the USACE under Section 404 of the CWA. Prior to the 1997 ruling, gravel mining operators were required to obtain a USACE Section 404 permit and follow several conditions outlined on the permit. Except in very small tributaries, the USACE required all operators to establish a streamside and riparian buffer and prohibited removing gravel from flowing water (i.e., no in-stream mining) or from below the water table (Danny McClendon, USACE, St. Louis District, pers. comm. 1998). These requirements avoided most adverse effects to mussels including headcutting, channel modification, and the physical crushing or removal of mussels. Furthermore, the USACE's permit process included consultation with the USFWS concerning the presence of federally listed species at each proposed mining site. However, the 1997 ruling eliminated the USACE' authority to regulate most instream gravel mining activities, thereby eliminating the section 404 permit and the conditions that protected mussel beds. Therefore, the scaleshell has lost much of its protection from gravel mining. The USACE will still retain oversight authority and require a permit for gravel mining activities that deposit fill into streams greater than incidental fallback under Section 404 of the CWA (i.e. instream gravel stockpiling, stream crossings, and select removal methods). A USACE permit would also be required under Section 10 of the Rivers and Harbors Act for navigable waterways. However, many gravel mining operations do not fall under these two categories.

The Missouri Department of Natural Resources (MDNR) is currently responsible for regulating gravel mining in Missouri, but has limited regulatory authority. City, county, and state operators using their own equipment and private operations are not required to obtain a MDNR permit for instream gravel mining. In Arkansas, instream gravel mining will still be controlled by the Arkansas Open-Cut Mining and Land Reclamation Code, which contains required conditions to reduce impacts (Roell 1999). Additionally, since MDNR is not a federal agency, Section 7 of the ESA, which required the USACE to consult with the USFWS regarding the presence of federally listed species at proposed gravel mining sites, is no longer applicable. Without the section 7 consultation process, mussel beds containing federally listed species could be adversely affected by gravel mining operations.

Although recognized by species experts as threatened in the state of Arkansas, the scaleshell has not been afforded state protection prior to becoming federally listed as an endangered species. Missouri and Oklahoma previously listed it a species of conservation concern (Sue Bruenderman, in litt. 1998; Caryn Vaughn, pers. comm. 1995). However, these designations were primarily used for planning and communication purposes and did not afford any significant state protection from direct take and habitat destruction (David Martinez, pers. comm. 1997; Paul McKenzie, USFWS, Columbia, MO, pers. comm. 1997).

Other Natural or Manmade Factors Affecting Its Continued Existence

Biological traits: The inherent biological traits of freshwater mussels increase their vulnerability to extinction (Neves 1993). Their complex life cycle offers many opportunities for reproduction to fail including incomplete fertilization due to low density upstream populations, failure to attach to the appropriate fish host, and unsuccessful transformation on the fish host. If a larva successfully transforms on a host, it is further challenged with dropping off into suitable habitat. Estimated chances of successful glochidial transformation and excystment (detachment) range between 0.0001 percent (Jansen and Hanson 1991) and 0.000001 percent (Young and Williams 1984). As a result of fish host-specificity and the difficulty of locating suitable habitat, even under optimal conditions, freshwater mussel population growth occurs very slowly. Furthermore, the sedentary nature of mussels limits their dispersal capability. This trait, coupled with low recruitment success, translates into the need for decades of immigration and recruitment for re-establishment of self-sustaining populations.

Population size and habitat fragmentation: The small number and low density of the remaining scaleshell populations exacerbate threats to its survival posed by the natural and manmade factors discussed above. Although the scaleshell was always locally rare though broadly distributed, the widespread loss of populations and the limited number of collections in recent years indicates that the current population densities are much lower (due to the previously identified threats) than historical levels. Despite any evolutionary adaptations for rarity, habitat loss and degradation increase a species' vulnerability to extinction (Noss and Cooperrider 1994). Similarly, as the number of occupied sites decreases, and the likelihood of extinction increases (Vaughn 1993). This increased vulnerability is the result of chance events. Environmental variation, random or predictable, naturally causes fluctuations in populations. However, small and low density populations are more likely to fluctuate below the minimum viable population (i.e., the minimum number of individuals needed in a population to persist) (Szymanski 1998). If population levels stay below this minimum size, an inevitable and often irreversible slide toward extinction will occur. Further, the shorter life span of the scaleshell may render it less able to tolerate periods of poor recruitment or increased mortality than longer-lived mussel species (Barnhart 2001).

Small populations are also more susceptible to inbreeding depression and genetic drift. Populations subjected to either of these problems usually have low genetic diversity, which reduces fertility, survivorship, and the ability to adapt to environmental changes. Also, chance variation in age and sex ratios can affect birth and death rates. Skewing of these ratios may lead to death rates exceeding the birth rates, and when this occurs in small populations there is a higher risk of extinction (Szymanski 1998).

Similarly, the fertilization success of females may be related to population density, with a threshold density required for any reproductive success to occur (Downing *et al.* 1993). Many of the remaining scaleshell populations may be at or below this threshold density. Because females must siphon sperm released by males into the water column, successful spawning events depend on upstream males. Therefore, a low density or lack of upstream males can result in incomplete fertilization of females. In 2002, a gravid female scaleshell collected from the Meramec River Basin, Missouri was observed to be only partially fertilized (Dr. M.C. Barnhart, pers. comm. 2003). This individual is one of only a few females in which the gill contents were examined under a microscope to determine the developmental condition of the eggs. The incomplete fertilization of this female may be an indication that spawning failures may be occurring because small populations may have individuals too scattered to reproduce effectively. These populations will be, if the aforementioned threats go unabated, forced below or forced to remain below the minimum threshold. As a result, reproduction is diminished or ceases, and the current decline to extinction will be accelerated.

Species that occur in low numbers must rely on dispersal and immigration for long-term persistence. In order to retain genetic viability and guard against chance extinction, movement between populations must occur. Although the scaleshell naturally occurs in patches within a river and necessarily possesses mechanisms to adapt to such a discontinuous distribution, anthropogenic (man-made) influences have fragmented and further lengthened the distance between occupied patches of suitable habitat. Empirical studies have shown that with increasing isolation, immigration and colonization rates decrease. Also, as previously explained, natural recolonization of mussels occurs at a very low rate (Vaughn 1993). Therefore, preservation of a population (including all partially isolated patches in a river) structure is imperative for long-term freshwater mussel survival. Unfortunately, many of the extant scaleshell populations now occur as single, isolated sites. These highly isolated populations are very susceptible to natural stochastic events and human-induced environmental change.

<u>Drought</u>: Severe drought is a natural event that can have devastating effects on freshwater mussels because of their inability to escape adverse environmental conditions. Because the scaleshell is primarily a riffle species, many extant scaleshell sites are in relatively shallow water. This makes some local populations susceptible to exposure during drought conditions. For example, unusually low water in 2000 caused the partial exposure of several mussel beds containing the scaleshell in the Gasconade and Meramec River basins (Bruenderman, pers. comm. 2000). Concentrations of mussels, particularly around the peripheral edges of mussel

beds, were exposed for long periods. Based on fresh dead shells collected from these areas, a number of scaleshells and many other species died from desiccation. While some thick-shelled mussel species can survive emersion for extended periods, the thin shell of the scaleshell and its inability to close its valves completely makes it especially vulnerable to emersion (Dr. M.C. Barnhart, pers. comm. 2004). Low water also allows raccoons and other small mammals that prey on mussels to gain easy access to mussel beds.

Non-native species: The introduction of non-native freshwater bivalves into the United States has contributed to the decline of the native mussel fauna. The recent invasion of the exotic zebra and quagga mussels (*Dreissena polymorpha* and *D. bugensis*) pose a substantial threat to native unionids (Herbert *et al.* 1989). The introduction of *Dreissena* into North America probably resulted from an ocean-crossing vessel that discharged freshwater ballast from Europe containing free-swimming larvae (Griffiths *et al.* 1991). Since the introduction of these species, the zebra mussel has proved to be more widespread and abundant. Since the discovery of zebra mussels in North America in Lake St. Clair of the Laurentain Great Lakes in 1988, this prolific species has spread throughout the Mississippi River and many of its tributaries including the Illinois and Ohio basins and the Arkansas (into Oklahoma and Kansas) and Tennessee rivers (Figure 8).

Zebra and quagga mussels have effective dispersal mechanisms, which has facilitated their spread in the United States. Because zebra mussels attach themselves to hard surfaces, they can spread by attaching and living on commercial and recreational vessels. The free swimming, microscopic larva spread naturally downstream of reproducing populations. The larva are also transported from infected waters via bait buckets and live wells of recreational boats and introduced into new areas (Figure 8). Zebra mussels starve and suffocate native mussels by attaching to their shells and the surrounding habitat in large numbers. The spread of this prolific species has caused severe declines of native freshwater mussel species in many areas (Tucker *et al.* 1993; Kent Kroonemeyer, USFWS in litt. 1994; Illinois Natural History Survey, in litt. 1995; USACE, in litt. 2000).

The threat posed by zebra mussels appears to be imminent for the largest remaining populations of the scaleshell. In 1999, a live zebra mussel was collected at river mile 6.9 in the lower Meramec River (Dr. M.C. Barnhart, in litt. 1999). Veligers have been found in Missouri River in Nebraska, indicating the existence of a reproducing population. If zebra mussels successfully colonize the Missouri River, it is likely that they will eventually spread into the Gasconade River (a tributary of the Missouri), which has perhaps the largest population of the scaleshell next to those in the Meramec Basin. Populations in navigable rivers and downstream from reservoirs (e.g., White and Osage Rivers) are particularly vulnerable due to commercial and recreational vessels that utilize these water bodies, which will hasten the invasion. In 2006, an established zebra mussel population was discovered in Lake of the Ozarks and live individuals found subsequently at two locations on the Osage River in Missouri (Steve McMurray, MDC, in litt. 2006). This population was likely introduced by boats.

Zebra mussels have spread throughout much of the Mississippi River Basin, but at this time, no large, established populations are known to occur in streams occupied by the scaleshell. However, they are likely to invade these streams based on the proliferation and spread that has already occurred. Many rivers within the scaleshell's extant range are similar in most ways to other tributaries of the Mississippi River with established zebra mussel populations.

The Asian clam (*Corbicula fluminea*) is another freshwater bivalve that has been introduced into North America. It was first discovered in the United States in the late 1930's (Oesch 1995). Its prolific reproductive capability has allowed it to quickly spread its range across the continent, and the species is now almost ubiquitous throughout the range of the scaleshell. The Asian clam can become the dominant benthic species as densities of several hundred to 10,000/m^2 have been reported in some rivers (Neves 1986, Sickel 1986). The species is believed to compete with native mussels for resources such as food, nutrients, and space (Kraemer 1979, Clark 1986). High densities of Asian clams have been found to negatively affect the survival and growth of juvenile native mussels by disturbance and displacement of young juveniles and possibly through incidental ingestion of newly metamorphosed individuals (Yeager *et al*. 2000). Further, *Corbicula* populations can grow rapidly and are prone to rapid die-offs (McMahon and Williams 1986), which can affect native mussels by depleting the oxygen supply and by producing high levels of ammonia (Strayer 1997).

The black carp (*Mylopharyngodon piceus*) poses a significant threat to the scaleshell in the near future. Native to Eastern Asia, black carp were accidentally brought into the United States in the early 1970s by the aquaculture industry while importing other Chinese carp stocks. Subsequent introductions occurred in the early 1980's as the species was imported as a food fish and as a biological control for yellow grub (*Clinostomum margaritum*) in aquaculture ponds (Nico *et al*. 2005). The number of reports of black carp captured in Arkansas, Illinois, Mississippi, and Missouri suggests that the species may be established and reproducing in the wild (Nico *et al*. 2005).

Because black carp feed on freshwater mollusks extensively, it poses a major threat to the native freshwater mussel fauna if allowed to escape into the wild and establish reproducing populations (Nico and Williams 1996). A four year old black carp was shown to eat an average of 3-4 pounds of mussels per day (USFWS 2002*a*). Smaller mussels (e.g. the scaleshell) and juvenile recruits are probably most vulnerable to being consumed by black carp (Nico *et al*. 2005). If wild populations are established, the black carp is likely to proliferate in North America as other related, non-native carp have such as the grass carp (*Ctenopharyngodon idella*) (Nico and Williams 1996). Currently, there appears to be no existing, economically feasible method to eliminate black carp once they escape into large river systems (Nico *et al.* 2005).

Summary of reasons for listing/current threats

Significant habitat loss and degradation, range reduction, population fragmentation, and small population size has made the scaleshell vulnerable to extinction. The scaleshell has disappeared from the entire upper and most of the middle Mississippi River drainages. Of the 56 known historical stream populations, the species has only been documented in the last 25 years from 18 streams. Although much of the decline occurred before 1950, population declines continue in most of the species' range, and numerous threats, including water quality degradation, loss of stable substrates, sedimentation, channelization, gravel mining, dredging, and impoundments, are negatively affecting the few remaining viable extant populations. The small number and low density of the remaining scaleshell populations exacerbate the threats and adverse effects of chance events to the scaleshell. Additionally, the threat of the non-native zebra mussel and possibly the black carp is impending.

Data Gaps in Available Information

The successful recovery of the scaleshell mussel will depend on the extent of our knowledge of the species and the causes of its decline. More information is needed to successfully recover and conserve this species. Critical aspects of the biology, ecology, and genetics of the species remain unknown and are needed to direct recovery actions and inform management decisions. At the present time, only general aspects of the habitat requirements are known for the scaleshell. The protection of scaleshell populations will require the identification of full set of physical, chemical, and biological habitat features essential for its survival.

While threats affecting the scaleshell have been described, little is known of the distribution and intensity of these threats in specific watersheds. This information will allow threats to be prioritized before taking action to alleviate them and focus efforts to restore habitat in key areas within watersheds. Water quality degradation has been a major factor in the decline of the scaleshell. Data on the tolerance of the scaleshell to specific pollutants and the occurrence of these pollutants in watersheds is needed in order to focus efforts to minimize or eliminate them. Lastly, the recovery of habitat and populations located downstream of dams will be dependent on knowledge of how various water quality and environmental changes associated with the operation of these dams affect the scaleshell.

Conservation Measures

The precipitous decline of freshwater mussels in the U.S. has resulted in a renewed interest in research and conservation of this fauna nation-wide. The Freshwater Mollusk Conservation Society (FMCS) was formed to help conserve this highly imperiled fauna in North America. This organization promotes the conservation of freshwater mussels by exchanging scientific information among researchers and resource agencies and informing the public on mussel biology and conservation issues. In 1998, a broad group of representatives from federal agencies, state agencies, academia, commercial interests, and private entities published a national strategy for the conservation of native freshwater mussels (NNMCC 1998). The goals outlined in this document are to conserve native mussel species, ensure their continued survival, and maintain their ecological, economic, and scientific values to our society. This document outlines critical measures that are necessary to conserve this resource and highlights the subject as a problem worthy of national attention. Other mussel conservation strategies, more focused in scope, also have been published (e.g., USFWS 1994, 1996, 1997*a*, 1997b, 2002b, 2004, Obermeyer 2000). These efforts indicate an increasing body of knowledge, experience, and appreciation of freshwater mussels that can be applied to their conservation, including the scaleshell.

Prior to becoming listed as a federally endangered species, the scaleshell was considered threatened in the state of Arkansas. However, this designation did not afford any legal protection for the species. Missouri and Oklahoma previously listed it as species of conservation concern. However, these designations were primarily used for planning and communication purposes and did not afford any significant state protection from direct take and habitat destruction.

The Endangered Species Act of 1973, as amended, contains protection and recovery provisions for federally listed threatened and endangered species. Conservation measures provided to the scaleshell as an endangered species include recognition, recovery actions, requirements for federal protection, and prohibitions against certain practices. Recognition through listing results in public awareness and conservation actions by Federal, State, and local agencies, private organizations, groups, and individuals. The ESA provides for possible land acquisition and cooperation with the State and requires that recovery actions be carried out for all listed species. The protection required of federal agencies and the prohibitions against certain activities involving listed species are discussed, in part, below.

Section 6 of the ESA allows the USFWS to provide funds to States for the conservation of species. The USFWS also has the latitude to provide funding to private landowners and researchers interested in the conservation of the scaleshell mussel through discretionary monies and other sources as available. The USFWS's Partners for Fish and Wildlife Program can provide funding for habitat restoration or enhancement. Other funding sources are available through other federal agency programs such as the Farm Service Administration's (FSA), Conservation Reserve Program (CRP), and the National Resources Conservation Service's (NRCS) Forestry Incentives Program (FIP),Wetlands Reserve Program (WRP), Environmental Quality Incentives Program (EQIP), and Wildlife Habitat Incentives Program (WHIP) programs.

Private landowners can also benefit from Safe Harbor Agreements which are voluntary arrangements between the USFWS and cooperating non-federal landowners. These agreements benefit endangered or threatened species while giving landowners assurances from additional restrictions. Following development of an agreement, the USFWS will issue an "enhancement of survival" permit, to authorize any necessary future incidental take to provide participating landowners with assurances that no additional restrictions will be imposed as a result of their conservation actions.

Under sections 2(c)(1) and 7(a)(1) of the ESA[2]"Sec. 7. (a) federal Agency Actions and Consultations.- (1) The Secretary shall review other programs administered by him and utilize

2 "(c) Policy- (1)- It is further declared to be the policy of Congress that all Federal departments and agencies shall seek to conserve endangered species and threatened species and shall utilize their authorities in furtherance of the purposes of this Act." "Sec. 7. (a) Federal Agency Actions and Consultations.- (1) The Secretary shall review other programs administered by him and utilize such programs in furtherance of the purposes of this Act. All other Federal agencies shall, in consultation with and with the assistance of the Secretary, utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species and threatened species listed pursuant to section 4 of this Act."

such programs in furtherance of the purposes of this ESA. All other federal agencies shall, in consultation with and with the assistance of the Secretary, utilize their authorities in furtherance of the purposes of this ESA by carrying out programs for the conservation of endangered species and threatened species listed pursuant to section 4 of this ESA.", all federal agencies within the range of the scaleshell, and in consultation with the USFWS, have a responsibility to develop and carry out programs for the conservation of this species.

Section 7(a)(2) of the ESA, as amended, requires federal agencies to evaluate their activities with respect to any species that is proposed or listed as endangered or threatened. Regulations implementing the section 7 interagency cooperation provisions of the ESA are codified at 50 CFR Part 402. Section 7(a)(2) requires federal agencies to ensure activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of the scaleshell mussel. If a federal agency's action is likely to adversely affect the scaleshell mussel, the responsible federal agency must initiate formal consultation with the USFWS. Federal agencies that may have jurisdictional responsibilities within the range of the scaleshell include, but is not limited to, the U.S. Forest Service, USACE, Federal Energy Regulatory Commission (FERC), Natural Resources Conservation Service (NRCS), U.S. Environmental Protection Agency (USEPA), Farm Services Administration, and Federal Highway Administration.

Sections 9 and 10 of the ESA and their implementing regulations found at 50 CFR 17.21 set forth a series of general prohibitions and exceptions that apply to all endangered wildlife. These prohibitions, in part, make it illegal for any person subject to the jurisdiction of the United States to take (including harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect; or attempt any such conduct), import or export, ship in interstate or foreign commerce in the course of commercial activity, or sell or offer for sale in interstate or foreign commerce any listed species. It also is illegal to possess, sell, deliver, carry, transport, or ship any such wildlife that has been taken illegally. Certain exceptions apply to USFWS agents and those of State conservation agencies.

Section 10 of the ESA and its implementing regulations codified at 50 CFR 17.22 and 17.23 provide for the issuance of permits to carry out otherwise prohibited activities involving endangered wildlife under certain circumstances. For endangered species, such permits are available for scientific purposes, to enhance the propagation or survival of the species, and for incidental take in connection with otherwise lawful activities.

The CWA was passed in 1972, and has greatly reduced the point-source discharge of pollutants into streams (Neves *et al*. 1997). Municipalities and industries have improved wastewater treatment facilities with grants and aid from the USEPA and State environmental protection departments. Nonpoint-source pollution is dealt with in a number of ways under the CWA, including providing funds through Section 319 nonpoint-source pollution program to improve water quality and reduce nutrient loading, sedimentation, and the likelihood of other pollutants entering streams. In addition, the States, USEPA, and U.S. Geological Survey (USGS) have assessed and monitored water quality in streams throughout much of the range of the scaleshell.

Federal government involvement also includes the Fish and Wildlife Coordination Act (FWCA), which is intended to protect fish and wildlife resources and their habitats by coordinating with natural resource agencies on their projects. Programs under the U.S. Department of Agriculture (USDA), particularly those administered by the NRCS [e.g., Conservation Reserve Enhancement Program (CREP), EQIP, WRP, Fish and Wildlife Habitat Improvement Program], are increasingly addressing restoration of impaired streams with imperiled species. The NRCS is routinely adopting animal waste management plans to reduce nutrient and sediment input into streams throughout the country.

The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA) authorizes the USFWS and the National Oceanic and Atmospheric Administration to issue regulations preventing the unintentional introductions of aquatic nuisance species. On February 2, 1999, the President issued Executive Order (EO) 13112 on invasive species. The EO places increased emphasis on efforts to prevent the introduction of invasive species; to provide for their control; and to minimize the economic, ecological, and human health impacts that invasive species cause. Regulations under the NANPCA and the EO will help prevent the incidental importation of other mollusks that are harmful to native species. The USFWS has developed four priorities under the title "Director's Priorities FY 1999-2000." One of the priorities is to develop and implement an aggressive program to enhance the USFWS's capability and leadership role to respond effectively to present and future invasive species problems and issues. All USFWS offices will focus efforts via three goal statements—enhance leadership, take direct action, and raise public awareness.

As part of a memorandum of understanding with the USFWS, the Oklahoma Department of Environmental Quality (ODEQ) agreed to recognize a USFWS list of Aquatic Resources of Concern in Oklahoma. The list includes the Kiamichi River and Little River drainages in southeast Oklahoma, based on their inhabitation by federally listed species. The memorandum provides for the USFWS to receive special notification of proposed discharge permit actions pending before the ODEQ, where those actions involve waters listed as Aquatic Resources of Concern.

The Oklahoma Department of Wildlife and Conservation amended its regulations to designate the Kiamichi River as a mussel sanctuary (9 Oklahoma Regulations 1909, effective January 1, 1993). Likewise, in 1997 and 2000, the Arkansas Game and Fish Commission designated the Ouachita River upstream of Camden as a mussel sanctuary. With this designation, these rivers are closed to all commercial harvest. It also provides additional protection to the scaleshell and other federally listed species by prohibiting activities that might disrupt the species' habitats.

Since the scaleshell was listed as an endangered species, several efforts have been made specifically to help conserve the species and improve its habitat. USFWS funds (i.e., discretionary and Section 6) and state funds have also been used to fund survey work in various portions of its range, ongoing monitoring of the species' population numbers, and conducting searches for additional populations. Since 1998 there have been several multi-year scaleshell projects funded through section 6 of the ESA that focused on producing and releasing artificially propagated juveniles into the wild in Missouri. The goal of these projects is to develop propagation methods and stabilize the most significant remaining populations of the scaleshell and other species through augmentation of existing populations. Unfortunately, propagation efforts have been limited by the availability of gravid females. Release sites include extant sites in the Meramec, Bourbeuse, and Gasconade rivers. Other release sites will depend on the collection location and availability of gravid females. This effort is intended to help stabilize populations while habitat improvements are implemented in these watersheds.

Several habitat improvement projects have been completed within the Bourbeuse River Basin through the USFWS's Partners for Fish and Wildlife and the MDC's Private Lands Program in cooperation with volunteer private landowners. These actions involve the following land management actions that have made habitat and watershed improvements benefiting the scaleshell: 1) establishment of planned grazing systems to address overgrazing, 2) providing alternative watering sources away from streams and drainages to address cattle watering in streams, 3) reestablishing a protective riparian corridor to reduce erosion and sedimentation of streams and drainages, and 4) bank stabilization to reduce bank erosion, and 5) improving and reinforcing low water stream crossings to reduce stream bed erosion and improve fish passage. These efforts are just now getting underway at specific sites in the Bourbeuse River Basin.

The USGS's Columbia Environmental Research Center is conducting a large-scale research project funded by the USFWS and USEPA to develop and apply methods to conduct toxicity tests for freshwater mussels (including the scaleshell). This study will 1) develop methods for conducting acute and chronic toxicity tests with glochidia and juvenile life stages of mussels, 2) evaluate the acute or chronic effects of ammonia, chlorine, and copper on glochidia and juvenile mussels (surrogates and listed species), and 3) develop American Society for Testing and Materials standards for conducting toxicity tests with freshwater mussels. The main focus of this study is to determine if USEPA's national water quality standards are protective of freshwater mussels to apply to the monitoring of point-source discharges of pollutants into streams.

Biological Constraints and Needs

Several biologically inherent factors of the scaleshell mussel must be considered for planning and management of the species. While the scaleshell once had a broad distribution, it appears to have been naturally uncommon where it was found. What may limit its natural abundance is unknown. Its current distribution is also limited within a river by available habitat. Many of the extant populations now occur as single, isolated sites. These highly isolated populations are very susceptible to stochastic events and local extirpation with little chance of recolonization.
The scaleshell requires stable riffles and runs with moderate current velocity and is usually found in mussel beds. This habitat is naturally patchy in distribution. The survival and eventual recovery of the scaleshell is dependent on stable stream channels and maintenance of good water quality. The sessile nature of the species makes it especially vulnerable to environmental disturbances because it cannot move to avoid threats. Any activities within watersheds that contribute to a deterioration of the water quality or destroy occupied habitat would adversely affect the scaleshell and hinder recovery efforts

The complex life cycle, skewed sex ratio, and extreme rarity of the scaleshell offers several opportunities for reproduction to fail. As with most freshwater mussels, there are two major annual events during its life cycle, and most of the time will be found in some stage of its reproduction. The scaleshell is a long-term brooder that spawns in August and infects its host the following June. It appears to rely solely on the freshwater drum (*Aplodinotus grunniens*) to reproduce. Therefore, the maintenance of drum populations and habitat is also necessary for the continued existence of the scaleshell. The fertilization of females depends on the density of upstream males, and therefore, a low density or lack of males can lead to incomplete fertilization of eggs brooded by the females. Likewise, a lack of females due to a skewed sex ratio further hinders reproduction. After females are fertilized they must come into contact with and successfully infect the appropriate fish host. The glochidia must then successfully attach to the host, transform, and drop off into suitable habitat, which is naturally patchy in distribution in rivers. Transformed juveniles that reach suitable habitat must then survive, as a very thin-shelled microscopic organism, a plethora of invertebrate predators in the benthic ecosystem until it grows to a larger size. Undoubtedly, natural mortality is high during all of these critical life stages.

Even as adults, the scaleshell is more susceptible to natural and manmade threats to its survival than most other mussel species. Its small size and fragile shell makes it vulnerable to predation and physical disturbance such as trampling. Its thin shell and inability to close completely makes it vulnerable to emersion from drought. Further, the relatively short life span of the scaleshell may render it less able to tolerate periods of poor recruitment or increased mortality than longer-lived mussel species. (see additional discussion above in *The Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range*).

PART II: RECOVERY

Recovery Strategy

Scope of threats and recovery: Streams occupied by the scaleshell have numerous and widespread threats affecting the species. In some cases, these threats are related to the surrounding land use and originate upstream of extant populations. Therefore, threats not only need to be addressed immediately adjacent to occupied sites, but also in the watershed upstream. Some recovery actions may need to be implemented on a large scale in order to restore aquatic habitat downstream. Recovery efforts on this scale will not be possible without soliciting outside help to restore aquatic habitat and improve surface lands. The assistance of federal and state agencies, conservation groups, local governments, private landowners, industries, businesses, and farming communities will be essential in implementing the necessary recovery actions for the scaleshell to meet recovery goals. The role of private landowners, non-profit organizations, and corporations cannot be over emphasized as most land in watersheds occupied by the scaleshell is under private ownership.

Addressing threats: To solicit outside help and foster the many partnerships needed to address threats, a recovery implementation team will be formed. This team may be made up of species experts and representatives from federal and state wildlife agencies, other federal and state agencies, non-government organizations, academia, and other concerned groups with a diversity of expertise on conservation science and public relations within the scaleshell's range. The team will work with willing partners to carry out the appropriate recovery actions to protect existing habitat, alleviate threats, and restore habitat. Because each scaleshell stream poses unique challenges to recovery, a strategic approach to recovery implementation is needed. First, threats will be identified, assessed, and mapped for each watershed occupied by the scaleshell. Then a strategic recovery implementation database will be developed to guide recovery efforts for each population. The database will be used to prioritize populations, threats, and needed recovery actions as well as track recovery efforts and document when threats to each population have been alleviated. The threat mapping and strategic database are an integral part of the recovery strategy for the scaleshell.

Watershed improvements will be aimed at addressing the various causes of habitat degradation including sedimentation; point and non-point pollution sources; substrate destabilization; land, bank, and channel erosion; and eutrophication. Examples of watershed improvements to alleviate these threats include, but are not limited to the following: improving wastewater treatment plants, reestablishing protective riparian corridors to reduce sedimentation; stabilizing stream banks; reducing sheet run-off; using no-till agricultural methods; controlling nutrient enrichment by carefully planning heavy livestock use areas; excluding cattle from streams by erecting fences and providing alternative water supplies; development of gravel mining guidelines; and implementing voluntary best management practices to control run-off for a variety of agricultural, silvicultural, and construction activities.

Other factors that potentially will affect the scaleshell in the future include the introduction of non-native species, predation by small mammals, and mussel die-offs due to drought, contaminant spills, and disease. The scaleshell recovery implementation team will call on the nation's leading experts to devise methods to reduce the likelihood of zebra mussel or black carp invasions into streams occupied by the scaleshell. Emergency response strategies will be developed that will outline response protocols to effectively deal with mussel kills and invasions of non-native species that do occur. Measures will also be taken to control predators at select sites where it is identified as a significant factor contributing to the scaleshell's decline.

Because only a small number of scaleshell populations exist, it is essential that they all be protected. Utilizing existing legislation, regulations, and programs (i.e., ESA, CWA, FWCA, wetland and water quality regulations, stream alteration regulations, FERC relicensing, etc.) to protect the scaleshell and its habitat is a reasonable means to protect remaining scaleshell populations.

Sound science: Achieving the recovery goals and criteria outlined in this plan will also be dependent upon the application of sound science to make informed management decisions. Because the recovery implementation team will include species experts and experts in conservation science, it will serve in this capacity as well. The recovery implementation team will coordinate and oversee the implementation of the recovery objectives outlined in this plan. Other roles of the team include, but are not limited to the following: 1) determine the effectiveness of recovery actions and adapt management measures accordingly, 2) determine ongoing research needs, 3) interpret and apply scientific information and consult with appropriate experts to make sound and scientifically-based management decisions, 4) assist FWS in determining when reclassification/delisting is appropriate, and 5) assist FWS in conducting five-year reviews.

Artificial propagation: The remaining populations of the scaleshell are also in imminent danger of extirpation because of their extremely small size and isolated distribution. The small number and low density of remaining populations exacerbate threats to its survival posed by natural and manmade factors. Recruitment failures could lead to their extirpation, with little chance of recolonization, in a relatively short period of time because of the short life-span of the species. Therefore, augmenting existing populations through artificial propagation is considered necessary for the continued existence of the scaleshell. This is the most urgent recovery action at this time. The goal of a propagation program for the scaleshell is to augment and stabilize populations. Augmenting existing populations will help ensure populations persist long enough to allow habitat improvements to take effect and to permit further scientific study. Preventing further loss of populations may also preserve genetic diversity of the species.

Research: The successful recovery of the scaleshell mussel will depend on the extent of our knowledge of the species and the causes of its decline. Critical aspects of the biology, ecology, and genetics of the species will be investigated, the results of which will direct recovery actions and inform management decisions. Data will be collected on the tolerance of the scaleshell to specific pollutants and the occurrence of these chemicals in watersheds in order to focus efforts to minimize or eliminate them. Lastly, how various water quality and environmental impacts associated with the operation of dams will be investigated to inform conservation efforts to recover populations located downstream of these operations.

Recovery in historical range: Initial recovery efforts will focus on watersheds with extant populations in order protect and stabilize those populations. Once the recovery requirements are met to downlist the species to threatened, more efforts will be shifted to additional areas of the scaleshell's historical range to meet the recovery objectives to delist the species. Because improvements need to take place throughout entire watersheds, a long period of time will be required for habitat improvements to begin to have beneficial effects on populations and the habitat they depend on.

Public outreach: An outreach and education program will be carried out to heighten awareness of the scaleshell as an endangered species and to solicit outside help with recovery actions. Outreach material will be developed and produced to target the general public, schools, government agencies, congressionals, businesses, landowners, and other key partners needed to carry out the recovery actions. The goal of this outreach program is to increase appreciation for the scaleshell and provide information on how to become involved in recovery efforts. To increase the willingness of potential partners to participate in the recovery of the scaleshell, materials will highlight the many benefits of the scaleshell recovery actions such as cleaner water and improved health of the stream ecosystem overall.

Recovery Goals and Objectives

The ultimate goal of the actions outlined in this plan is to reclassify and eventually delist the scaleshell. The objectives are to ensure the long-term viability of the scaleshell by stabilizing and protecting existing populations and restoring habitat and watersheds it depends on. Recovery of the scaleshell in the near future is not likely because of the extreme rarity of the species, the extent of the decline that has occurred, and the large-scale the habitat restoration required to have a positive effect on populations.

Recovery Criteria

In the criteria for downlisting and delisting the scaleshell, populations are either referred to as a local population (=deme) or stream population. A local population is defined as an assemblage of individuals that live in the same habitat patch and more or less interact with each other in the course of their routine feeding and breeding activities (e.g. mussel bed) (Vaughn 1993). Local populations may be in relatively close proximity to each other within the same stream, and thus may interbreed. A "stream population" is a term used in a geographical sense and is defined as all individuals living in one river or stream. By using this term it is not implied that a mussel population is currently reproducing or that it is a distinct genetic unit. This term was created to divide scaleshell populations into manageable, geographical units so measurable recovery criteria could be created and applied to downlist and delist the species.

As previously discussed (see habitat Characteristics/Ecosystem section), mussels naturally occur in relatively small patches of suitable habitat separated by typically longer reaches of unsuitable habitat. This trait lends itself to defining more protective and measurable recovery criteria for the scaleshell because more than one local population is required for a given stream to meet the criteria as described below. Requiring multiple local populations to meet recovery criteria ensures the persistence of each stream population because the scaleshell is naturally rare and thus susceptible to local extirpation.

The scaleshell will be considered for downlisting to threatened status when the following criteria are achieved:

1. Through protection of existing populations, successful establishment of reintroduced populations, or the discovery of additional populations, four stream populations exist, each in a separate watershed and each made up of at least four local populations located in distinct portions of the stream. Each stream population must exist in a separate watershed so that a single stochastic event, such as a toxic spill or disease outbreak, will not affect more than one of the four stream populations. This criterion is based on the available information and the best professional judgment of species experts (see Appendix v), and may be revised based on additional biological, demographic, or genetic information obtained through Recovery Actions 3.1 and 3.4.

2. Each local population in Criteria 1 is viable in terms of population size, age structure, recruitment, and persistence. Currently, what constitutes a viable population of the scaleshell is not known. Population viability will be defined when Action 3.4.2 is completed. In the future, this criterion will be revised to incorporate the definition of population viability resulting from this recovery action (3.4.2).

3. Threats to local populations in Criterion 1 have been identified and addressed per measurable criteria developed in Action 2.3. Currently it is not feasible to identify in this criterion the specific threats to populations and thresholds at which those threats are reduced to the level where criteria 1 and 2 are achieved. However, the thresholds for this criterion will be defined through the implementation of key actions in the plan as follows. <u>Step 1</u>: Identify and map present and foreseeable threats to local populations in a GIS database (Action 2.2). <u>Step 2</u>: Define measurable criteria for alleviating/reducing each of those threats and prioritize threats according to effects to local populations (Action 2.3). <u>Step 3</u>: Apply the appropriate recovery actions outlined in this plan to alleviate/reduce threats. <u>Step 4</u>: Track the progress of recovery implementation (Action 7.2).

The scaleshell will be considered for removal from the protection of the Endangered Species Act when the following criteria have been achieved:

1. Through protection of existing populations, successful establishment of reintroduced populations, or the discovery of additional populations, a total of eight stream populations exist, each in a separate watershed and each made up of at least four local and geographically distinct populations. At a minimum, one stream population must be located in the Upper Mississippi River Basin, four in the Middle Mississippi River Basin (two of these must exist east of the Mississippi River), and three in the Lower Mississippi River Basin. Completion of Action 3.4.2 or 3.4.3 may indicate more local populations, streams, or geographical regions are required. This criterion is based on the available

information and the best professional judgment of species experts (see Appendix v), and may be revised based on additional biological, demographic, or genetic information obtained through Recovery Actions 3.1 and 3.4.

2. Each local population in Criteria 1 is viable in terms of population size, age structure, recruitment, and persistence. Currently, what constitutes a viable population of the scaleshell is not known. Population viability will be defined when Action 3.4.2 (Research Population Dynamics of the Scaleshell) is completed. In the future, this criterion will be revised to incorporate the definition of population viability resulting from this recovery action (3.4.2).

3. Threats to local populations in Criterion 1 have been identified and addressed per measurable criteria developed in Action 2.3. Currently it is not feasible to identify in this criterion the specific threats to populations and thresholds at which those threats are reduced to the level where criteria 1 and 2 are achieved. However, the thresholds for this criterion will be defined through the implementation of key actions in the plan as follows. Step 1: Identify and map present and foreseeable threats to local populations in a GIS database (Action 2.2). Step 2: Define measurable criteria for alleviating/reducing each of those threats and prioritize threats according to effects to local populations (Action 2.3). Step 3: Apply the appropriate recovery actions outlined in this plan to alleviate/reduce threats. Step 4: Track the progress of recovery implementation (Action 7.2).

Step-down Outline

Action 1. Assemble a working group to assist in implementation of the recovery actions outlined in this plan.

1.1 Assemble a scaleshell recovery implementation team.

Action 2. Protect, restore, and maintain existing populations and habitat.

2.1 Further delineate the current status and distribution of the scaleshell.

2.1.1 Conduct surveys in rivers in which the status of the scaleshell is unknown.

2.1.2 Conduct searches for additional populations within historic range where the species may potentially occur.

2.2 Develop and maintain a Geographic Information System (GIS) database to map threats, habitat conditions, land use, and existing conservation efforts with respect to the location and status of scaleshell populations within each watershed.

2.3 Develop a strategic recovery implementation database

2.4 Carry out cooperative regulatory and voluntary projects using existing programs to protect the species and habitat, restore degraded habitat, and improve surface lands in occupied watersheds.

2.5 Augment and stabilize populations by artificial propagation.

2.5.1 Develop and implement a propagation plan.

2.5.2 Improve methodologies for artificial propagation, rearing and maintenance of brood stock, and monitoring techniques at release sites.

2.6 Conduct water quality studies.

2.6.1 Determine tolerance to various contaminants suspected to have adverse affects to the scaleshell (e.g. ammonia, chlorine, and heavy metals).

2.6.2 Conduct field studies to determine seasonal ambient exposure conditions of contaminants evaluated in Action 2.6.1.

2.6.3 Determine tolerance to changes in stream flow and increases in turbidity and sedimentation.

2.6.4 Determine tolerance to low dissolved oxygen and extremes in pH.

2.7 Develop an emergency response strategy for mussel kills and major drought conditions for extant populations.

2.8 Develop management options to reduce or eliminate the threat of non-native introduced aquatic species.

2.8.1 Distribute (or create where needed) education materials to help prevent the spread of non-native species.

2.8.2 Identify and investigate methods to prevent the spread of non-native species.

2.8.3 Track the spread of non-native species within the range of the scaleshell.

2.8.4 Create an emergency response plan to protect scaleshell populations from zebra mussel invasion.

2.8.5 Determine densities and track population trends of non-native species at historical and extant scaleshell sites.

2.9 Determine the impact of predator populations on local populations, and, if necessary, implement local predator control measures.

2.10 Preserve genetic material via cryogenic preservation.

Action 3. Improve understanding of the biology and ecology of the scaleshell.

3.1 Life history.

3.1.1 Conduct research on reproductive biology.

3.1.2 Investigate age and growth characteristics of the scaleshell including male/female life spans.

3.1.3 Investigate the biology of the symbiotic relationship between the scaleshell and its confirmed host(s).

3.2 Ecology.

3.2.1 Investigate the biology, habitat use, and ecology of the juvenile stage.
3.2.2 Investigate burrowing behaviors and seasonal movements.
3.2.3 Further define habitat use and requirements of adults.

3.3 Summarize abundance, distribution, and habitat requirements of host(s) within the historical and extant range of the scaleshell.

3.4 Research population biology.

3.4.1 Determine genetic differentiation among and within populations.
3.4.2 Research population dynamics of the scaleshell
3.4.3 Determine the number of local and stream populations needed to maintain the species and the optimal geographic distribution for those populations.

Action 4. Identify suitable reintroduction sites and restore habitat in those areas.

4.1 Identify suitable streams for future reintroductions within the historical range.

4.2 Develop a GIS database of threats, habitat conditions, land use, and existing conservation efforts with respect to the location suitable habitat within each stream identified for reintroduction.

4.3 Develop a strategic recovery implementation database for streams identified for reintroduction.

4.4 Carry out cooperative projects to protect, improve, or restore unoccupied scaleshell habitat in target historical watersheds.

Action 5. Reintroduce the scaleshell into portions of its former range.

5.1 Develop and implement a reintroduction plan.

Action 6. Initiate educational and public outreach actions to heighten awareness of the scaleshell as an endangered species and solicit help with recovery actions.

6.1 Develop outreach materials (e.g. brochures, web pages, videos, posters) on the scaleshell for general distribution.

6.2 Develop and distribute a handout on all available land owner cost share incentive programs that could be applied to the scaleshell in critical watersheds.

6.3 Develop and implement outreach programs that will request assistance in the recovery of the scaleshell from land owners, businesses, and government agencies.

6.4 Develop and give presentations to targeted local schools, stream teams, and other interested groups.

6.5 Publish articles on the scaleshell, and the ecosystem it depends on, in state conservation magazines, local and regional newspapers, magazines, and local business newsletters.

Action 7. Conduct periodic reviews and track recovery.

7.1 Evaluate status of species, in terms of recovery criteria.
- 7.1.1 Conduct surveys to determine persistence and viability of local populations.
- 7.1.2 Demonstrate that local populations are protected from threats.

7.2 Maintain a database of completed recovery actions.

7.3 Review new information every five years and update the plan as needed.

7.4 Develop a post-delisting monitoring plan.

Recovery Narrative

Action 1. Assemble a working group to assist in implementation of the recovery actions outlined in this plan.

1.1 Assemble a scaleshell recovery implementation team. This team will be made up of species experts and representatives from federal and state wildlife agencies, other federal and state agencies, non-government organizations, academia, and other concerned groups with a diversity of expertise on conservation science and public relations in extant (and eventually historical) watersheds of the scaleshell. This group will meet periodically (not usually as a whole depending on meeting objectives) to coordinate and oversee the implementation of the recovery objectives outlined in this plan by using good science. The team will be instrumental in identifying and fostering the diverse partnerships needed to successfully complete recovery objectives for the scaleshell. Other roles of the team include, but are not limited to the following: 1) assisting with development of the GIS threat database and habitat protection and restoration strategies for individual watersheds (see Actions 2.2, 2.3, 4.2, 4.3), 2) identify and pursue funding sources to complete recovery actions, 3) determine the effectiveness of recovery actions and adapt management measures accordingly, 4) determine ongoing research needs, 5) interpret and apply scientific information and consult with appropriate experts to make sound and scientifically based management decisions, 6) provide guidance to FWS in determining when reclassification/delisting is appropriate, and 7) assist FWS in conducting periodic status reviews of the species (see Action 7.1).

Action 2. **Protect, restore, and maintain existing populations and habitat.**

2.1 Further delineate the current status and distribution of the scaleshell. A relatively complete knowledge of the status and distribution of the scaleshell is necessary to protect extant sites and focus recovery efforts.

2.1.1 Conduct surveys in rivers in which the status of the scaleshell is unknown. If new extant populations are discovered, actions can be taken to protect them and ensure they persist.

2.1.2 Conduct searches for additional populations within historic range where the species may potentially occur. Locating additional populations may play an important role in meeting recovery criteria and preserving genetically distinct populations.

2.2 Develop and maintain a Geographic Information System (GIS) database to map threats, habitat conditions, land use, and existing conservation efforts with respect to the location of populations of the scaleshell within each watershed. The creation of this database will include assessments to determine the distribution of threats in watersheds relative to existing populations. This database is required for Action 2.3 and will help the scaleshell recovery implementation team to prioritize threats before coordinating actions to alleviate them and focus efforts to restore habitat in key areas within watersheds. This database will also provide mapping for completed recovery actions to help track recovery (see Action 7.2).

2.3 Develop a strategic recovery implementation database. Because threats to the scaleshell vary widely among occupied sites, a database is needed to guide and track recovery implementation. The database will help organize recovery to focus the most appropriate recovery efforts on the most important populations. The objectives of developing this strategic document are to 1) prioritize the specific threats to individual populations identified in Action 2.2 according to magnitude, 2) develop measurable criteria (as discussed in Criteria 3 above) that will define the thresholds at which those threats will be reduced to the level where Recovery Criteria 1 and 2 are achieved, 3) identify which recovery actions within this plan are needed to address those threats, and 4) serve to track and document recovery implementation for future status reviews as described in Action 7.2. The strategic recovery implementation database will be maintained as a living document throughout the recovery process and will be a matrix consisting of key extant and historical populations (those required to meet Recovery Criteria 1) verses identified threats, criteria for reducing threats, needed recovery actions, and completed recovery actions.

2.4 Carry out cooperative regulatory and voluntary projects using existing programs to protect the species and habitat, restore degraded habitat, and improve surface lands in occupied watersheds.

Regulatory: Because only a small number of populations exist, it is essential that they all be protected. The USFWS will continue to work with others by using existing legislation, regulations, and programs (e.g. ESA, CWA, FWCA, wetland and water quality regulations, stream alteration regulations, FERC relicensing, etc.) to protect the scaleshell and its habitat.

Non-regulatory: The recovery of the scaleshell will not be possible without soliciting outside help. The assistance of federal and state agencies, conservation groups, and local governments will be essential in implementing the recovery of the scaleshell. Of equal importance is the assistance of private landowners, local industries, businesses, and farming communities to meet recovery goals. The role played by the scaleshell recovery implementation team (Action 1) will be vital in fostering diverse partnerships needed to restore habitat and improve surface lands, through the existing programs outlined below, to the extent that the scaleshell mussel will benefit. The role of private landowners and businesses cannot be emphasized enough as most of the land in watersheds occupied by the scaleshell are privately owned.

Section 7 (a) (1) of the ESA authorizes federal agencies to carry out programs to conserve listed species such as the scaleshell. The FWS will assist other federal agencies in developing and carrying out such programs, as well as undertake its own programs, to conserve this species. Section 6 of the ESA provides for the FWS to grant funds to states for management actions aiding the protection and recovery of listed species including the acquisition of land from willing sellers. Section 6 funds should continue to be made available to Arkansas, Missouri, and Oklahoma for scaleshell recovery.

There are various means to acquire land from willing sellers to help recover federally listed species. In general, land acquisition has proven not to be an effective means to recover endangered mussel species due to the need to restore large surface areas. However, it could be an effective recovery strategy under some circumstances such as protecting high priority mussel beds that contain the scaleshell. Other programs (e.g., FWS Partners for Fish and Wildlife Program; USEPA Non point Source Program; and USDA's CRP, EQIP, FIP, Stewardship Incentive Program, and WRP) provide additional means of developing cooperative projects that could be used to protect the river environment, while retaining lands in private ownership. These programs differ somewhat in the objectives and practices they support; consequently, development of individual projects to benefit the scaleshell will require consideration of program differences as well as environmental objectives. Participants in cooperative programs may include a broad variety of public and private parties. The total cost of action completion will be determined by the amount of private and governmental participation. These activities will be done in conjunction with outreach described under Action 6.

2.5 Augment and stabilize populations by artificial propagation. The remaining populations of the scaleshell are in imminent danger of extirpation because of their extremely small size and the short life span of this species. Augmenting existing populations will help ensure populations persist long enough to allow habitat improvements to take effect and to permit further scientific study. Preventing further loss of populations may also preserve genetic diversity of the species. Additionally, propagation work increases our knowledge of the species and offers opportunities to conduct research including toxicity, life history, ecology, and physiological studies on glochidia and juveniles.

2.5.1 Develop and implement a propagation plan. The success of a propagation program depends on careful planning and consideration of issues such as genetics and site selection criteria. This plan will include monitoring protocol as it is necessary to determine the survival rate of released juveniles and assess the effectiveness of current propagation methods.

2.5.2 Improve methodologies for artificial propagation, rearing and maintenance of brood stock, and monitoring techniques at release sites. Despite the high fecundity of the scaleshell, propagation efforts have been limited. Several problems have been identified with production including low transformation success on freshwater drum and destruction of juveniles by macroinvertebrate predators. More efficient juvenile production will facilitate population augmentation and reintroductions and allow small numbers to be used for research. Improved rearing methods will allow larger individuals to be released into the wild increasing the chances of survival. Larger animals can also be tagged and monitored.

2.6 Conduct water quality studies. Water quality degradation is believed to be a major threat to the scaleshell. Managers need information on the effects of specific pollutants to the scaleshell and the occurrence of these pollutants in watersheds in order to focus efforts to minimize or eliminate them. Likewise, specific information is needed to determine if EPA's current national water quality criteria or state standards are protective of all life stages of the scaleshell. Last, the recovery of habitat and populations located downstream of dams will be dependent on knowledge of how various water quality and environmental changes associated with the operation of dams affect the scaleshell.

2.6.1 Determine tolerance to various contaminants suspected to have adverse affects to the scaleshell (e.g. ammonia, chlorine, and heavy metals). These studies will include an analysis of acute and chronic effects to all life stages including glochidia, artificially propagated juveniles, and adults (or adult surrogate species).

2.6.2 Conduct field studies to determine seasonal ambient exposure conditions of contaminants evaluated in Action 2.6.1. These studies will be conducted within stream reaches currently occupied by the scaleshell. Results will be entered into the GIS database discussed in Action 2.2 and used to map sources of contaminants within specific watersheds.

2.6.3 Determine tolerance to changes in stream flow and increases in turbidity and sedimentation. These studies will include an analysis of short-term, long-term, and indirect effects of these stressors on reproduction and all life stages.

2.6.4 Determine tolerance to low dissolved oxygen and extremes in pH. These studies will include an analysis of long-term, short-term, and indirect effects of these stressors and all life stages.

2.7 Develop an emergency response strategy for mussel kills and major drought conditions for extant populations. Mussel kills have been reported periodically throughout the range of the scaleshell due to natural causes and spills of contaminants. The development of an emergency response strategy is important not only to prevent spills, but establish a protocol for the quick response needed to contain spills and possibly remove surviving scaleshell from affected areas. The strategy will also call for the investigation of kills where the cause is unknown, which may allow these events to be prevented in the future. Some local populations of the scaleshell are susceptible to emersion during drought periods. Local populations that might be susceptible to drought will be identified in the plan. Additionally, water levels that begin to expose the scaleshell sites will be identified for specific sites identified in the GIS database described in Action 2.2. The emergency response protocol to protect populations from zebra mussel invasions as described in Action 2.8.4 could also be included in this strategy. This emergency response strategy can be developed by the recovery implementation team (see Action 1).

2.8 Develop management options to reduce or eliminate the threat of non-native introduced aquatic species. The introduction of non-native aquatic species including zebra mussels, Asian clam, and black carp pose a significant risk to the scaleshell. The technology does not currently exist to eliminate the effect of these species once they are established. However, the development of certain management options will help reduce the likelihood of these species spreading and can help prevent the extirpation of scaleshell populations from this threat.

2.8.1 Distribute (or create where needed) education materials to help prevent the spread of non-native species. The spread of non-native species such as zebra mussels and black carp can be prevented or delayed through education of the public because they are introduced and dispersed through the activities of humans. Many of these educational materials and efforts already exist and need to be applied to portions of the scaleshell's range.

2.8.2 Identify and investigate methods to prevent the spread of non-native species. It may be possible to prevent the colonization of some non-native species into certain streams. For example, the impending invasion of the zebra mussel may be prevented in some streams by implementing breaks in boat traffic.

2.8.3 Track the spread of non-native species within the range of the scaleshell. The early detection of non-native species such as the zebra mussel will allow the implementation of the emergency response plan developed in Action 2.8.4. Reports of non-native species in the range of the scaleshell would be recorded in the GIS database developed in Action 2.2.

2.8.4 Create an emergency response strategy to protect scaleshell populations from zebra mussel invasion. Zebra mussel populations tend to die off after the initial population explosion following colonization of new areas. This offers an opportunity to conserve the scaleshell through relocation efforts or protect populations by the development of temporary holding facilities. This strategy and the emergency response strategies described in Action 2.7 can be combined into one document.

2.8.5 Determine densities and track population trends of non-native species at historical and extant scaleshell sites. Knowing current densities and population trends of non-native species in specific areas will help determine suitable augmentation and reintroduction sites for the scaleshell. This action can be accomplished through existing monitoring efforts of scaleshell populations and information can be managed in the GIS database described in Action 2.2.

2.9 Determine the impact of predator populations on local populations and, if necessary, implement local predator control measures. The small size and thin, fragile shell of the scaleshell makes them easy prey for raccoons, muskrats, river otters, and other predators. The scaleshell, despite its rarity, has often been observed in shell piles that have been produced by feeding mammals, particularly during low water conditions. Although natural predation is usually not a factor for stable, healthy mussel populations, it could pose a problem for scaleshell populations because of their small size. Local populations may vary in their susceptibility to predation. For example, some scaleshell sites can become extremely shallow during dry periods making the habitat accessible to raccoons. A report will be produced that assesses the potential of various forms of predation for each local population, will allow managers to focus control efforts on areas where this threat is significantly affecting the species.

2.10 Preserve genetic material via cryogenic preservation. The remaining populations of the scaleshell are extremely small, and most appear to be declining. Therefore, the species is believed to be at high risk of extinction. Cryogenic preservation could maintain genetic material (much like seeds banks for plants) from extant populations. If the species or a population is lost, this preservation technique may allow for eventual establishment using the preserved genetic material.

Action 3. Improve understanding of the biology and ecology of the scaleshell. Critical aspects regarding the biology and life history remain unknown. The following actions will provide information critical to recover and manage the scaleshell.

3.1 Life history.

3.1.1 Conduct research on reproductive biology. An improved knowledge of the reproductive biology of the scaleshell is required to make sound management decisions and to determine additional recovery actions needed in the future. These studies will include additional host work and defining the reproductive season, recruitment patterns, age at sexual maturity, life-time fecundity, and sex ratio of sample populations.

3.1.2 Investigate age and growth characteristics of the scaleshell including male/female life spans. Current information on age and growth of the scaleshell is based on observations in the field and has not been validated. More formal studies are needed to understand the population dynamics of the species.

3.1.3 Investigate the biology of the symbiotic relationship between the scaleshell and its confirmed host(s). The successful transfer of mature glochidia to a suitable host constitutes one of the critical events of the life cycle of freshwater mussels. A major bottleneck in recruitment occurs during the parasitic phase, which offers many opportunities for reproduction to fail. Investigating the intricacy of the initial parasite/host interaction that results in glochidial attachment on the host may shed light on what seasonal environmental factors may limit recruitment and management actions needed for the scaleshell and its host. These studies will also include investigating factors that affect the suitability of drum to serve as hosts.

3.2 Ecology.

3.2.1 Investigate the biology, habitat use, and ecology of the juvenile stage. Virtually nothing is known about the juvenile phase of the scaleshell including habitat requirements. These studies will include investigation of natural factors that limit recruitment of juveniles in the wild such as macroinvertebrate predators.

3.2.2 Investigate burrowing behaviors and seasonal movements. The scaleshell has frequently been observed completely buried. In other circumstances it has been seen actively moving on the surface of the substrate. An improved understanding of their seasonal burrowing behaviors will increase effectiveness of surveys, allow more accurate estimates of population size, and increase chances of locating gravid females for propagation efforts.

3.2.3 Further define habitat use and requirements of adults. This information is vital for Section 7 consultations, Habitat Protection Plans, and other management programs.

3.3 Summarize abundance, distribution, and habitat requirements of host(s) within the historical and extant range of the scaleshell. The life cycle of the scaleshell includes a brief, obligatory parasitic stage on freshwater drum. Therefore, the host fish is considered an essential part of scaleshell's habitat. Knowledge of the abundance, distribution, and habitat requirements of drum is necessary for management of the species and habitat restoration. Much of this data already exists, but needs to be summarized for the range of the scaleshell.

3.4 Research population biology. An improved knowledge of the population biology of the scaleshell is necessary to further define recovery criteria in this plan and to make informed management decisions.

3.4.1 Determine genetic differentiation among and within populations. It is important to characterize the genetic structure and diversity of the scaleshell as a basis for conservation and management. Augmentation and reestablishment of populations in restored habitats will require artificial propagation of individuals from existing populations. It will be important to know the genetic composition of each population before using them as stock. This action will analyze the genetic composition and diversity of extant populations. In addition, studies will evaluate the value of different populations as sources from which to reestablish or augment populations, and the potential for unaided genetic exchange among populations.

3.4.2 Research population dynamics of the scaleshell. To effectively recover the species, information is needed on the demography of populations including describing the population size, age structure, and natural recruitment required to sustain populations. This information is also needed to refine the number of local and stream populations required by recovery criteria and describe population viability .

3.4.3 Determine the number of local and stream populations needed to maintain the species and the optimal geographic distribution for those populations. The recovery criteria outlined in this plan requires that eight stream populations exist to delist the species. This number is based on the available information and the best professional judgment of the species experts (see Appendix v). Once recovery actions are completed to generate more biological, population dynamics, and genetic information, the number of populations needed to recovery the species can be refined. This analysis of current information may be similar to a Population Viability Analysis (PVA).

<u>Action 4</u>. Identify suitable reintroduction sites and restore habitat in those areas. The recovery criteria require that the scaleshell become established into portions of its former range. While there are many restoration efforts currently underway (including specifically for other federally listed mussel species) within the historical range of the scaleshell, some of these areas may need additional habitat restoration to allow the natural or artificial colonization of the species.

4.1 Identify suitable streams for future reintroductions within the historical range. This action may include habitat studies to assess the suitability of sites considered for reintroductions and rely on criteria for suitable release sites developed in the propagation plan (see action 2.5.1). Streams considered for the reintroduction are likely to be high quality streams where habitat and water quality conditions have improved since the extirpation of the scaleshell and have high potential for restoration. The status of existing zebra mussel populations and the potential for colonization will also be a major consideration for reintroduction areas. Rivers supporting existing populations of federally listed species will be favored to take advantage of watershed and habitat restoration efforts that have already been implemented for those species.

4.2 Develop a GIS database of existing threats, habitat conditions, land use, and existing conservation efforts with respect to the location of suitable habitat within each stream identified for reintroduction. Data layers will be added to the GIS database developed in Action 2.2 and will include studies to determine the distribution of threats in watersheds relative to suitable habitat. This data will be used when assessing the suitability of specific reintroduction sites (see Action 5) and allow the scaleshell recovery implementation teams to prioritize threats before taking action to alleviate them and focus efforts to restore habitat in key areas within historical watersheds.

4.3 Develop a strategic recovery implementation database for streams identified for reintroduction. Information will be added to the recovery implementation database developed in Action 2.3 for streams chosen for reintroduction. This activity will be carried out by the scaleshell recovery implementation team to use the GIS database **(**Action 4.2) to ensure that threats and habitat protection are addressed at sites with the highest potential for reintroduction within streams identified in Action 4.1.

4.4 Perform cooperative projects to protect, improve, or restore unoccupied scaleshell habitat in target historical watersheds. See discussion of Action 2.4.

<u>Action 5</u>. Reintroduce the scaleshell into portions of its former range. Given the current range of the scaleshell, it is unlikely that the species will naturally colonize many portions of its historical range within a reasonable amount of time, particularly east of the Mississippi River and the Upper Mississippi River region as required by the recovery criteria. This program will review and apply all information generated by genetic studies described in Action 3 in assessing the location of source populations and appropriate numbers of brood stock. Artificially propagated juveniles will most likely be used for reintroductions due to the small size of scaleshell populations.

5.1 Develop and implement a reintroduction plan. The reestablishment of the scaleshell can be accomplished by several different methods including the relocation of adults from a source population, release of propagated juveniles, or release of propagated juveniles that have been reared in captivity for a period of time. This plan will include an analysis to determine the most appropriate method to use for establishing populations and development of the most appropriate monitoring techniques and protocols. When the reintroduction plan is developed, the USFWS will weigh the costs and benefits of reintroducing this species as an experimental population, under Secion 10(j) of the ESA.

Action 6. Initiate educational and public outreach actions to heighten awareness of the scaleshell as an endangered species and solicit help with recovery actions. Outreach to government agencies, federal and state congressionals, businesses, landowners, stream teams, schools, and other interested parties within the range of the scaleshell will facilitate the development of partnerships and recovery actions needed for recovery. The development of outreach materials will be coordinated among the scaleshell recovery implementation team and appropriate federal and state outreach specialists.

6.1 Develop outreach materials (e.g. brochures, web pages, videos, posters) on the scaleshell for general distribution. These materials will include information on the species, best management practices that benefit the species, and what people can do to help recover the scaleshell.

6.2 Develop and distribute a handout on all available land owner cost share incentive programs that could be applied to the scaleshell in critical watersheds. Numerous landowner incentive programs are available to private landowners through such programs as the USFWS's Partners for Fish and Wildlife and Private Land Owner Incentive programs; and NRCS's CRP, WRP, FIP, EQIP, and WHIP programs. A short handout should be developed that outlines responsibilities of each program, funding availability, application procedures, and possible examples of successful agreements in place.

6.3 Develop and implement outreach programs that will request assistance in the recovery of the scaleshell from landowners, businesses, and government agencies. These programs will be tailored for each watershed in the range of the scaleshell and may focus on stakeholders key to the recovery of the species to help foster these partnerships. The programs will ensure that stakeholders are aware of the scaleshell's status, need for protection of the species and its habitat, recovery efforts underway and proposed, the role of stakeholders in the species protection and recovery, available incentive programs that would benefit the scaleshell, and examples of cooperative programs underway in their watershed. Additionally, these outreach efforts will inform stakeholders of how the ESA protects and recovers species and how it applies to them.

6.4 Develop and give presentations to targeted local schools, stream teams, and other interested groups. A power point presentation will be developed that includes information on the scaleshell and other mussel species, reasons for federal listing, threats to the species, best management practices that benefit the species (and other aquatic species), and its link to the overall health of streams. This presentation would be made available to individuals asked to give talks to various interested parties.

6.5 Publish articles on the scaleshell, and the ecosystem it depends on, in state conservation magazines, local and regional newspapers, magazines, and local business newsletters. These articles will highlight the unique and interesting life history of the scaleshell, reasons for its decline, current recovery projects and how they benefit the overall health of streams, and what people can do to contribute to its conservation. Reprints of articles will be made available for general distribution.

<u>Action 7</u>. Conduct periodic reviews and track recovery. Under Sections 4 (c)(2)(A) & (B) of the ESA, the USFWS is required to conduct five-year reviews of all federally listed species to determine if such species should: 1) be removed from the list, 2) be changed in status form an endangered to a threatened species, or 3) be changed in status from a threatened to an endangered species.

7.1 Evaluate status of species, in terms of recovery criteria. Recovery Criterion 2 requires that local populations are persistent and viable in terms of size, recruitment, and age structure. A population may be counted toward reclassification or delisting only after surveys (Action 7.1.1) demonstrate its viability and persistence. Action 7.1.2 addresses the need to document that threats have been alleviated and provide reasonable assurance that populations will be protected from foreseeable threats as required by Recovery Criterion 3.

7.1.1 Conduct surveys to determine viability of local populations. Surveys will be conducted to collect the necessary information at the appropriate time intervals to determine population viability as defined by Action 3.4.2 (Research Population Dynamics of the Scaleshell). Population size, age structure, recruitment, and persistence are basic parameters that will be assessed by surveys.

7.1.2 Demonstrate that local populations are protected from threats. The strategic recovery implementation database developed in Action 2.3 will contain the data needed to document when threats have been alleviated per Recovery Criterion 3. This information will be summarized with any additional documentation necessary to show that scaleshell populations will be protected from future threats and habitat loss after it is downlisted or delisted.

7.2 Maintain a database of completed recovery actions. To evaluate the success of recovery actions and progress in meeting the recovery criteria, recovery implementation will be tracked in the strategic recovery implementation database described in Action 2.3 where completed recovery actions will be listed next to threats affecting scaleshell populations. Information on completed recovery actions will be mapped in the GIS threat database described in Action 2.2. This database will be updated annually and copies provided to appropriate USFWS field offices for their assistance in tracking recovery actions.

7.3 Review new information every five years and update the plan as needed. New information will be reviewed to determine the current status of the scaleshell and if downlisting or delisting is appropriate. These five-year reviews will be conducted by the USFWS in consultation with the scaleshell recovery implementation team to examine distribution and population trends, appraise threats and recovery efforts, and reevaluate downlisting and delisting criteria. The recovery plan may be updated or revised based on new information. Minor changes to the recovery plan would necessitate an update to the document while any major changes would require a revision (USFWS 1990). A revision to the recovery plan may address: 1) any new data collected in the next five years on the scaleshell, 2) any necessary refinement to the recovery criteria, and 3) the status of the scaleshell Recovery Implementation Plans (Action 2.3 or 4.3).

7.4 Develop a post-delisting monitoring plan. Once a species is removed from the list of threatened and endangered species, Section 4(g)(1) of the ESA requires the USFWS to monitor the status of the species for a minimum of 5 years. A plan shall be developed to describe how the status of the scaleshell will be monitored once the species has been delisted.

PART III. IMPLEMENTATION SCHEDULE

The Implementation Schedule lists the actions and estimated costs for the recovery program for the scaleshell mussel. It is a guide for meeting the recovery goals outlined in this plan. This schedule indicates action priorities, action numbers, action descriptions, duration of actions, and estimated costs to fulfill the recovery objective outlined in part II of this plan. These actions, when accomplished, should bring about the recovery of the scaleshell and protect its essential habitat. The estimated funding needs for all parties anticipated to be involved in recovery are identified. The estimate recovery cost for the 50 year program is $31,044,000. The costs presented are the estimates of the contributors and the USFWS, based on experience with costs of similar work. They are not based on budgets prepared for individual sub-actions. Actual costs may be higher or lower than costs indicated in the implementation schedule.

Potential partners with authority, responsibility, or expressed interest to implement a specific recovery action are also identified in the Implementation Schedule. The listing of a potential partner in the Implementation Schedule does not require, nor imply a requirement, that the identified party has agreed to implement the action(s) or to secure funding for implementing the action(s). However, parties willing to participate may benefit by being able to show in their own budgets that their funding request is for a recovery action identified in an approved recovery plan and is therefore considered a necessary action for the overall coordinated effort to recover the scaleshell. Also, Section 7(a)(1) of the ESA directs all federal agencies to utilize their authorities in furtherance of the purposes of the ESA by carrying out programs for the conservation of threatened and endangered species.

Recovery actions for the scaleshell are outlined in multiple priority levels defined as follows:

> **Priority 1**. An action 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 meet the recovery objectives.
> Action numbers are taken from the recovery step-down outline and narrative.

Key to acronyms used in implementation schedule

FA	Other Federal Agencies – (e.g., U.S. Army Corps of Engineers, U.S. Forest Service, U.S. Environmental Protection Agency, Office of Surface Mining, U.S. Geological Survey, U.S. Department of Transportation, Tennessee Valley Authority)
USFWS	U.S. Fish and Wildlife Service

SCA	State Conservation Agencies (e.g., Arkansas Fish and Game Commission; Oklahoma Department of Wildlife Conservation; Missouri Department of Conservation; Missouri Department of Natural Resources; Illinois Department of Natural Resources; Iowa Department of Natural Resources; Indiana Department of Natural Resources; Ohio Department of Natural Resources; Minnesota Department of Natural Resources; Kentucky State Nature Preserves Commission; Tennessee Wildlife Resources Agency; Tennessee Department of Environment and Conservation; Alabama Division of Wildlife and Freshwater Fisheries; Dakota Department of Game, Fish, and Parks; Wisconsin Department of Natural Resources)
RSU	Research and State University Institutions
PL	Private Landowners
CCG	County and City Governments
BI	Businesses and Industries
SDOT	State Transportation Departments
NGO	Non-governmental Organizations (e.g., Freshwater Mollusk Conservation Society, The Nature Conservancy, Fish and Wildlife Foundation, World Wildlife Fund)
SRIT	Scaleshell Recovery Implementation Team

Implementation schedule for the scaleshell mussel (*Leptodea leptodon*) recovery plan (FY = Fiscal Year)

Priority Number	Action Number	Action Description	Action Duration (Years)	Potential Partners	Total Cost ($1000's)	Cost Estimates ($1000's) FY 1	FY 2	FY 3	FY 4	FY 5 – 50	Comments
1	1.1	Assemble a scaleshell recovery implementation team	Continuous	USFWS, FA, SCA, RSU, PL, NGO	900	36	-	36	-	828	Team meets biennially
1	2.2	Develop and maintain a GIS database	Continuous	USFWS, SCA	123	50	1	1	1	100	
1	2.3	Develop a strategic recovery implementation database	Continuous	SRIT	50	-	-	10	10	30	Starts 3rd year to allow SRITs to become established
1	2.4	Carry out cooperative projects to protect the species and its habitat, restore degraded habitat, and improve surface lands	Continuous	SRIT, USFWS, FA, SCA, RSU, PL, CCG, BI, SDOT, NGO	13000	2240	2400	2400	2400	11960	
1	2.5.1	Develop and implement a propagation plan	15	USFWS, SRIT, RSU, SCA	418	40	27	27	27	297	
1	2.5.2	Improve methodologies for artificial propagation, rearing and maintenance of brood stock, and monitoring techniques	2	USFWS, SRIT, SCA, RSU	26	13	13	-	-	-	
1	2.6.1	Determine tolerance to various contaminants	2	USFWS, SCA, RSU, BI	400	100	100	100	100	-	
1	2.6.2	Conduct field studies to determine seasonal ambient exposure conditions of contaminants evaluated in Action 2.6.1	2	USFWS, SCA, RSU, BI	130	40	30	30	30	-	

Implementation schedule for the scaleshell mussel (*Leptodea leptodon*) recovery plan (FY = Fiscal Year)

Priority Number	Action Number	Action Description	Action Duration (Years)	Potential Partners	Total Cost ($1000's)	Cost Estimates ($1000's) FY 1	FY 2	FY 3	FY 4	FY 5 – 50	Comments
1	2.6.3	Determine tolerance to changes in stream flow and increases in turbidity and sedimentation	1	USFWS, SCA, RSU, BI	85	85	-	-	-	-	
1	2.7	Develop an emergency response strategy for mussel kills and major drought conditions for extant populations	1	SRIT	13	13	-	-	-	-	
1	2.8.2	Identify and investigate methods to prevent the spread of non-native species	2	USFWS, RSU, SRIT, NGO, SCA, FA	100	50	50	-	-	-	
1	2.8.4	Create an emergency response plan to protect scaleshell populations from zebra mussel invasion	1	SRIT, SCA	3	3	-	-	-	-	
1	3.1.1	Conduct research on reproductive biology	3	USFWS, SCA, RSU	30	10	10	10	-	-	
1	3.1.3	Investigate the biology of the symbiotic relationship between the scaleshell and its confirmed host(s)	2	USFWS, SCA, RSU	50	25	25	-	-	-	
1	3.2.3	Further define habitat use and requirements of adults	1	USFWS, SCA, RSU	30	10	10	10	-	-	
1	3.4.1	Determine genetic differentiation among and within populations	2	USFWS, SCA, RSU	26	-	-	13	13	-	

Implementation schedule for the scaleshell mussel (*Leptodea leptodon*) recovery plan (FY = Fiscal Year)

Priority Number	Action Number	Action Description	Action Duration (Years)	Potential Partners	Total Cost ($1000's)	Cost Estimates ($1000's) FY 1	FY 2	FY 3	FY 4	FY 5 – 50	Comments
1	3.4.3	Determine number of local and stream populations needed to maintain the species and optimal geographic distribution for those populations	1	USFWS, SCA, RSU	15	-	-	-	15	15	
2	2.1.1	Conduct surveys in rivers in which the status of the scaleshell is unknown	2	USFWS, SCA, RSU, SRIT	60	-	-	-	-	60	
2	2.1.2	Conduct searches for additional populations within historic range where the species may potentially occur	1	USFWS, SCA, RSU, SRIT	60	-	-	-	-	60	
2	2.6.4	Determine tolerance to low dissolved oxygen and extremes in pH	1	USFWS, SCA, RSU, BI	57	-	-	-	-	57	
2	2.8.1	Distribute (or create where needed) education materials to help prevent the spread of non-native species	1	USFWS, SCA, SRIT	75	-	-	-	-	75	
2	2.8.3	Track the spread of non-native species within the range of the scaleshell	Continuous	USFWS, SCA	-	-	-	-	-	-	Cost is included with existing scaleshell population monitoring
2	2.9	Determine the impact of predator populations on local populations, and, if necessary, implement local predator control measures	1	USFWS, SCA, SRIT	21	-	21	-	-	-	

Implementation schedule for the scaleshell mussel (*Leptodea leptodon*) recovery plan (FY = Fiscal Year)

Priority Number	Action Number	Action Description	Action Duration (Years)	Potential Partners	Total Cost ($1000's)	Cost Estimates ($1000's) FY 1	FY 2	FY 3	FY 4	FY 5 – 50	Comments
2	2.10	Preserve genetic material via cryogenic preservation	2	USFWS, SCA, RSU	100	-	-	-	-	100	
2	3.1.2	Investigate age and growth characteristics of populations	3	USFWS, SCA, RSU	75	-	-	-	-	75	
2	3.2.1	Investigate the biology, habitat use, and ecology of the juvenile stage	2	USFWS, SCA, RSU	50	25	25	-	-	-	
2	3.2.2	Investigate burrowing behaviors and seasonal movements	2	USFWS, SCA, RSU	50	25	25	-	-	-	
2	3.3	Summarize abundance, distribution, and habitat requirements of host(s) within the historical and extant range	1	USFWS, SCA, RSU	13	-	-	-	-	13	
2	3.4.2	Research population dynamics of the scaleshell	1	USFWS, SCA, RSU	15	-	-	-	-	15	
2	6.1	Develop outreach materials on the scaleshell for general distribution	1	USFWS, SCA, SRIT	100	15	-	-	-	80	
2	6.2	Develop and distribute a handout on all available land owner cost share incentive programs	1	USFWS, SCA, SRIT	1	1	-	-	-	-	
2	6.3	Develop and implement outreach programs that will request land owner assistance in the recovery of the scaleshell	1	USFWS, SCA, SRIT	10	10	-	-	-	-	

Implementation schedule for the scaleshell mussel (*Leptodea leptodon*) recovery plan (FY = Fiscal Year)

Priority Number	Action Number	Action Description	Action Duration (Years)	Potential Partners	Total Cost ($1000's)	Cost Estimates ($1000's) FY 1	FY 2	FY 3	FY 4	FY 5 – 50	Comments
3	2.8.5	Determine densities and track population trends of non-native species at historical and extant scaleshell sites	Continuous	USFWS, SCA	-	-	-	-	-	-	Cost is included in existing scaleshell population monitoring efforts
3	4.1	Identify suitable streams for future reintroductions within the historical range	1	FA, USFWS, SCA, RSU, PL, CCG, BI, SDOT, NGO, SRIT	40	-	-	-	-	40	
3	4.2	Develop GIS database of existing threats, habitat conditions, land use, and existing conservation efforts with respect to the location of suitable habitat within each stream identified for reintroduction	1	USFWS, SCA	92	-	-	-	-	92	
3	4.3	Develop a strategic recovery implementation database for streams identified for reintroduction	Continuous	FA, USFWS, SCA, RSU, PL, CCG, BI, SDOT, NGO, SRIT	5	-	-	-	-	5	
3	4.4	Carry out cooperative projects to protect, improve, or restore unoccupied scaleshell habitat in target historical watersheds	Continuous	FA, USFWS, SCA, RSU, PL, CCG, BI, SDOT, NGO, SRIT	1000	-	-	-	-	1000	Restoration of unoccupied habitat will depend upon existing programs

Implementation schedule for the scaleshell mussel (*Leptodea leptodon*) recovery plan (FY = Fiscal Year)

Priority Number	Action Number	Action Description	Action Duration (Years)	Potential Partners	Total Cost ($1000's)	Cost Estimates ($1000's)					Comments
						FY 1	FY 2	FY 3	FY 4	FY 5 – 50	
3	5.1	Develop and implement a reintroduction plan	1	USFWS, SCA, RSU, SRIT	143	-	-	-	-	143	
3	6.4	Develop and give presentations to targeted local schools, stream teams, and other interested groups	Continuous	USFWS, SCA, SRIT	50	1	1	1	1	46	
3	6.5	Publish articles on the scaleshell mussel and the ecosystem it depends on	Continuous	USFWS, SCA, SRIT	10	-	1	-	-	9	
3	7.1.1	Conduct surveys to determine persistence and viability of local populations	10	USFWS, SCA, RSU, SRIT	440	-	-	-	-	440	
3	7.1.2	Demonstrate that local populations are protected from threats	1	USFWS, SCA, RSU, SRIT	1	-	-	-	-	1	
3	7.2	Maintain database of recovery actions	Continuous	USFWS	50	1	1	1	1	50	
3	7.3	Review new information and update the plan as needed	Continuous	USFWS, SCA, SRIT	20	-	-	-	-	20	
3	7.4	Develop a post monitoring plan	1	USFWS, SCA, SRIT	2	-	-	-	-	-	

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Table 1a. Distribution and status of the scaleshell (*Leptodea leptodon*) in the Upper Mississippi River Basin (upstream from confluence of Mississippi and Missouri rivers) organized by watershed[1].

Major Watersheds	**Stream Populations** (tributaries indented)	**State**	**Counties of Occurrences**	**Last Date Found**[2]
Upper Mississippi River	Mississippi River mainstem	Illinois, Iowa, Wisconsin	Carroll, Hancock, Mercer (IL); Lee, Clayton, Scott (IA)	Pre-1958
	Burdett's Slough	Iowa	Muscatine	1890
Minnesota River	Minnesota River	Minnesota	Dakota	1800's
Iowa River Basin	Iowa River mainstem	Iowa	Johnson	Pre-1944
	Cedar River	Iowa	Linn	1882
Illinois River Basin	Illinois River mainstem	Illinois	Peoria	Pre-1887
	Sanagamon River	Illinois	Menard	Pre-1944
	Pecatonica River	Illinois	Stephenson	Pre-1944

1 = Table summarizes data from Appendix I [Detailed historical and current distribution of the scaleshell (*Leptodea leptodon*)].

2 = Based on living and dead shell material.

Table 1b. Distribution and status of the scaleshell (*Leptodea leptodon*) in the Middle Mississippi River Basin (between the Missouri and Ohio River confluences with the Mississippi River) organized by watershed[1].

Major Watersheds	Stream Populations (tributaries indented)	State	Counties of Occurrences	Last Date Found[2]
Kaskaskia River Basin	Kaskaskia River mainstem	Illinois	Washington	1921
Ohio River Basin	Ohio River mainstem	Kentucky, Ohio	Boone, Kenton (KY); Hamilton, Washington (OH)	1897
	Wabash River	Illinois, Indiana	White (IL); Carroll, Posey, Tippecanoe, Vigo (IN)	Pre-1919
	White River	Indiana	Marion	Pre-1919
	Sugar Creek	Indiana	Parke	1925
	Green River	Kentucky	Hart	1964
	Licking River	Kentucky	unknown	Pre-1950
	Scioto River	Ohio	unknown	1838
	St. Mary's River	Ohio	unknown	1930
	East Fork Little Miami River	Ohio	unknown	~1900
	Cumberland River	Kentucky, Tennessee	Cumberland, Russell (KY); Clay (TN)	1964
	East Fork Obey River	Tennessee	Maury	Pre-1941
	Beaver Creek	Kentucky	Russell	1948
	Caney Fork	Tennessee	Smith	Pre-1950
	Tennessee River	Alabama, Tennessee	Colbert, Lauderdale (AL), Florence, Knox (TN)	Pre-1950
	Clinch River	Tennessee	Union, Anderson	Pre-1950
	Holston River	Tennessee	Knox, Grainger	Pre-1950
	Duck River	Tennessee	Maury	Pre-1950

[1] = This table summarizes data from Appendix I [(Detailed historical and current distribution of the scaleshell (*Leptodea leptodon*)].

[2] = Based on living and dead shell material.

Table 1b continued. Distribution and status of the scaleshell (*Leptodea leptodon*) in the Middle Mississippi River Basin (between the Missouri and Ohio River confluences with the Mississippi River) organized by watershed[1].

Major Watersheds	**Stream Populations (tributaries indented)**	**State**	**Counties of Occurrences**	**Last Date Found**[2]
Meramec River Basin	Meramec River mainstem	Missouri	Crawford, Jefferson, St. Louis	2008
	Big River	Missouri	Jefferson	2008
	Bourbeuse River	Missouri	Franklin, Jefferson, St. Louis	2007
Missouri River Basin	Missouri River mainstem	South Dakota, Missouri	Yankton (SD), Gasconade (MO)	2005
	Gasconade River	Missouri	Gasconade, Laclede, Maries, Osage, Pulaski, Wright	2007
	Big Piney River	Missouri	Pulaski	1981
	Osage River	Missouri	Osage	2001
	South Grand River	Missouri	Benton	Early 1970's
	Auxvasse Creek	Missouri	Callaway	Late 1960's

1 = This table summarizes data from Appendix I [(Detailed historical and current distribution of the scaleshell (*Leptodea leptodon*)].

2 = Based on living and dead shell material.

Table 1c. Distribution and status of the scaleshell (*Leptodea leptodon*) in the Lower Mississippi River Basin (downstream from confluence of Mississippi and Ohio rivers) organized by watershed[1].

Major Watersheds	Stream Populations (tributaries indented)	State	Counties of Occurrences	Last Date Found[2]
St. Francis River Basin	St. Francis River mainstem	Arkansas	Cross, Lee, St. Francis	1985
White River Basin	White River mainstem	Arkansas	Benton, Jackson	1999
	James River	Missouri	Stone	Pre-1950
	Spring River	Arkansas	Lawrence, Randolph, Sharpe	1991
	South Fork Spring River	Arkansas	Fulton	1990
	Myatt Creek	Arkansas	Fulton	1996
	Strawberry River	Arkansas	Lawrence	1996
	Middle Fork Little Red River	Arkansas	Van Buren	1967
Arkansas River Basin	Mulberry River	Arkansas	unknown	old museum record
	Frog Bayou	Arkansas	Sevier	1979
	Poteau River	Oklahoma	LeFlore	Pre-1980
	South Fourche LaFave River	Arkansas	Perry	1991
Red River Basin	Kiamichi River	Oklahoma	Choctaw, Pushmataha	2004
	Gates Creek	Oklahoma	Pushmataha	Pre-1971
	Little River	Oklahoma	McCurtain	1960
	Mountain Fork	Oklahoma	McCurtain	Pre-1971
	Cassatot River	Arkansas	Sevier	1983
	Saline River	Arkansas	Howard, Sevier	1987
	Ouachita River	Arkansas	Clark	old museum specimen
	Little Missouri River	Arkansas	Clark	1995
	Saline River	Arkansas	Cleveland	1964

1 = This table summarizes data from Appendix I [(Detailed historical and current distribution of the scaleshell (*Leptodea leptodon*)].

2 = Based on living and dead shell material.

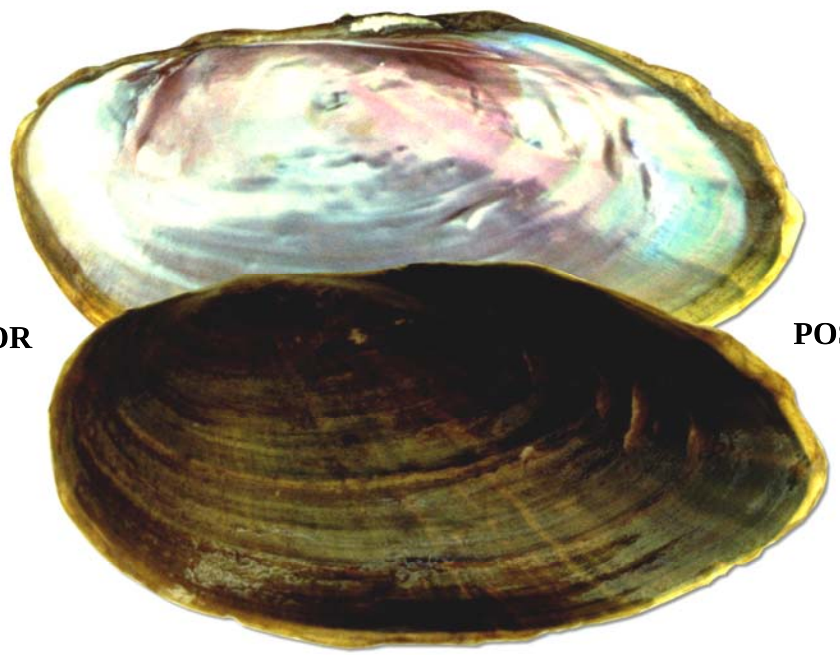


Figure 1. Shell of a male scaleshell (*Leptodea leptodon*). Photo taken by Dr. M.C. Barnhart, Southwest Missouri State University.

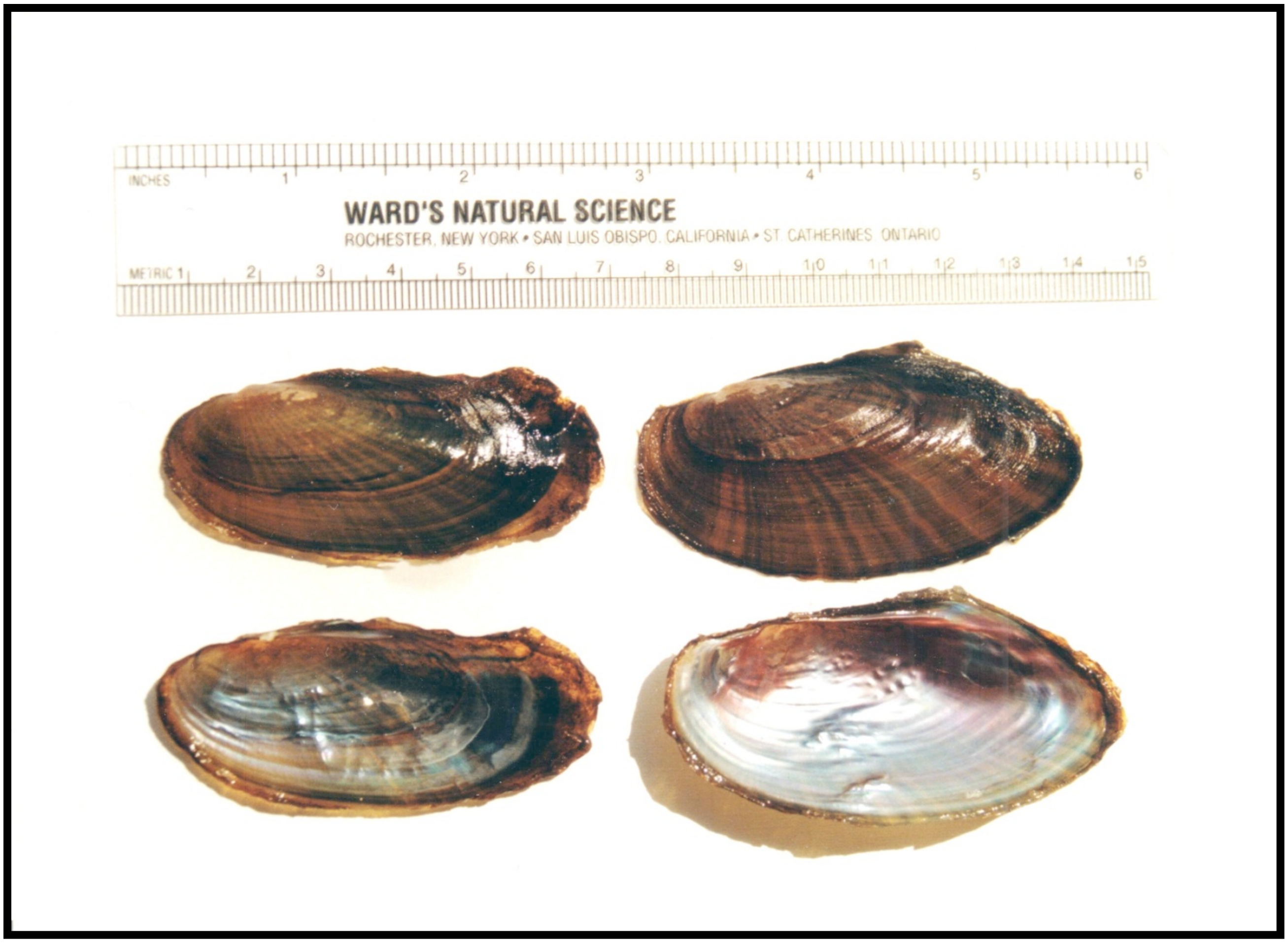


Figure 2. Female (left) and male scaleshell (*Leptodea leptodon*). Photo taken by Dr. M.C. Barnhart, Southwest Missouri State University.

Figure 3. Dorsal view of female (left) and side view of male scaleshell (*Leptodea leptodon*) actively siphoning water and showing external portions of the nutritive anatomy. Photo by Dr. M.C. Barnhart.

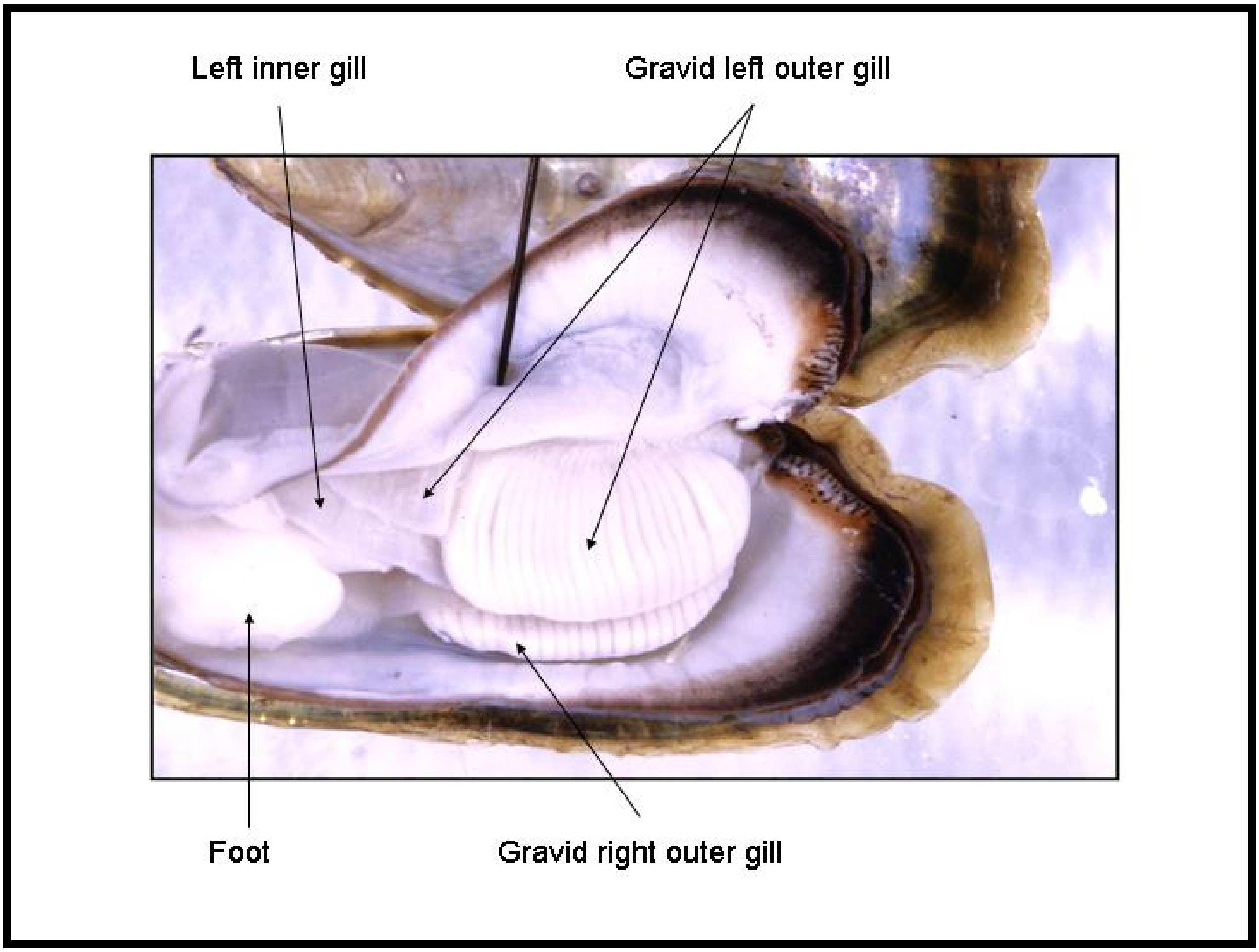
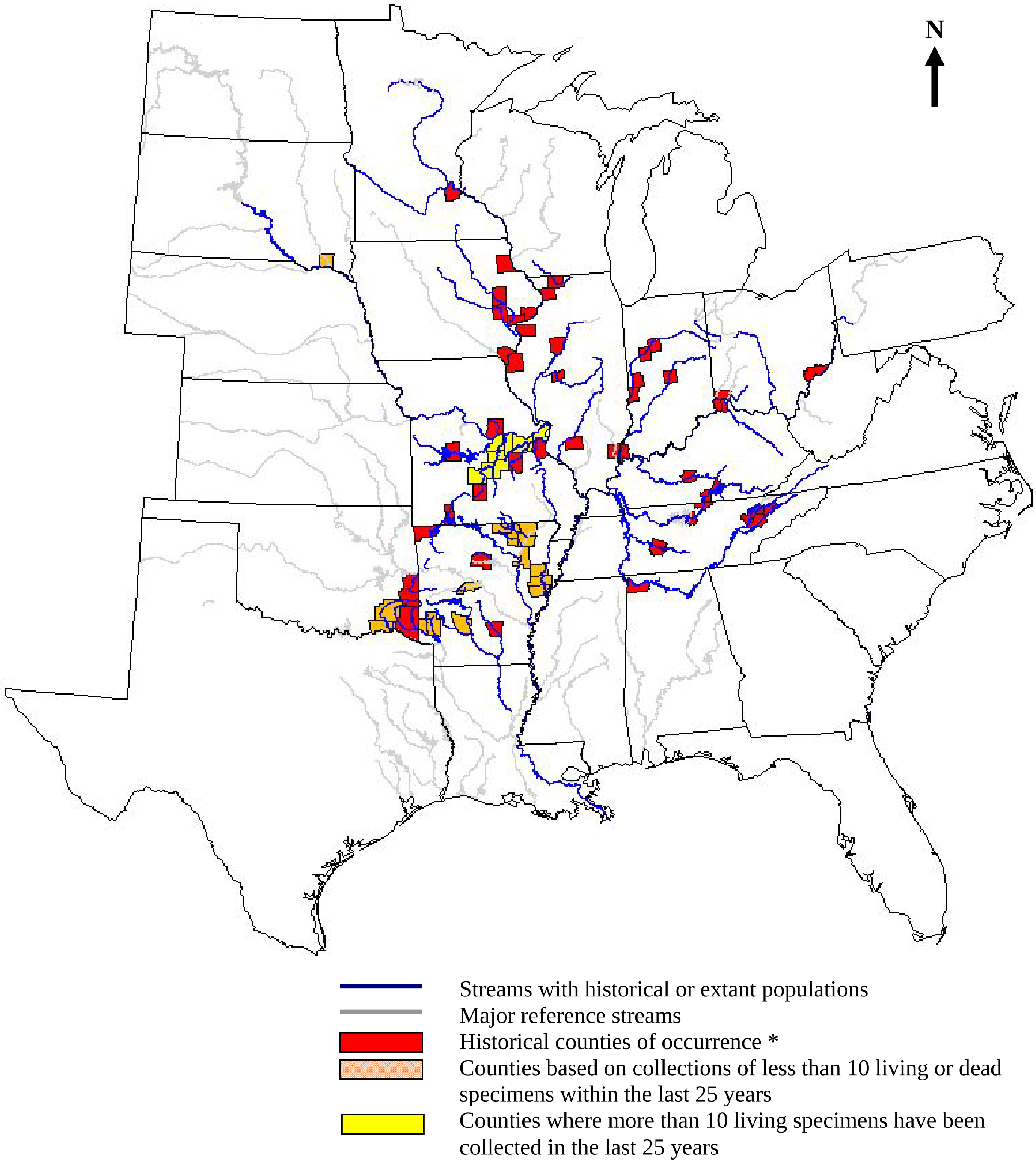


Figure 4. Gravid gill of a scaleshell (*Leptodea leptodon*). Photo taken by Dr. M.C. Barnhart, Southwest Missouri State University.



* Not all historical counties are shown. In some cases, geographical information of historical records is limited to stream names. In those cases, only the stream is depicted in blue and no county information is provided. These streams include the Licking River in Kentucky; Scioto, St. Mary's, and East Fork Little Miami rivers in Ohio; and Mulberry River in Arkansas.

Figure 5. Historical and extant distribution of the scaleshell (*Leptodea leptodon*).

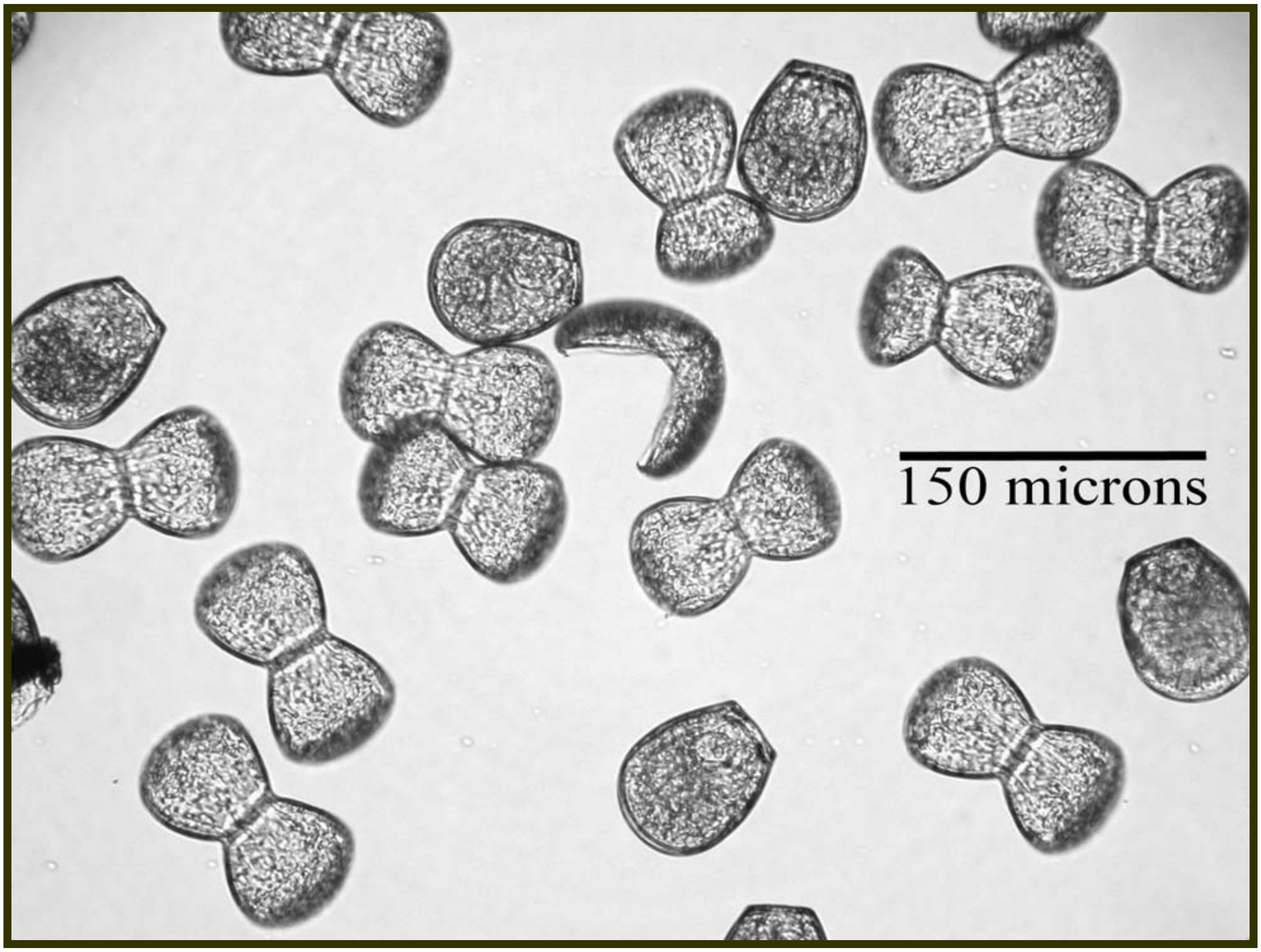


Figure 6. Live glochidia of the scaleshell (*Leptodea leptodon*). Photo taken by Dr. M.C. Barnhart, Southwest Missouri State University.

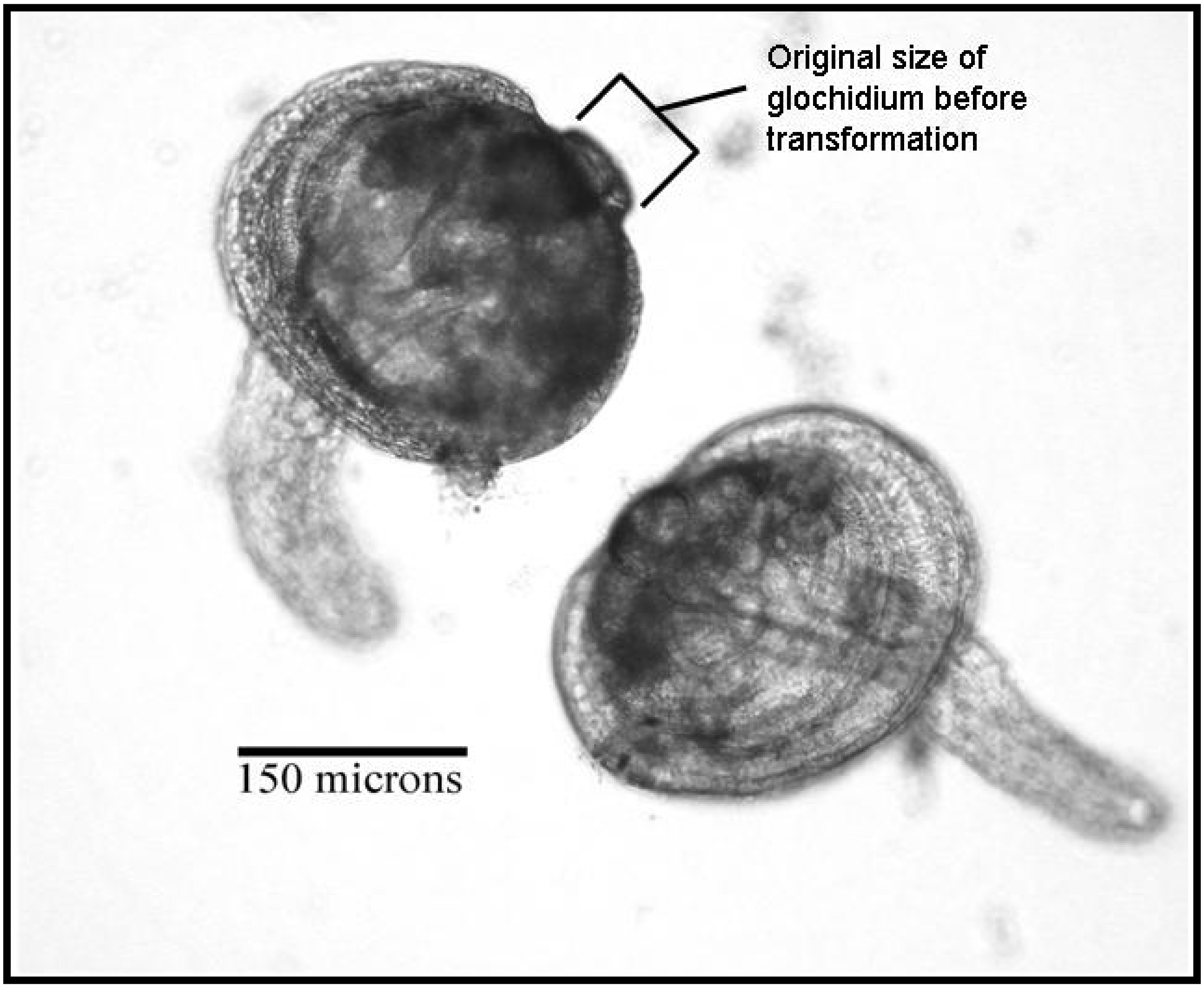


Figure 7. Newly transformed juveniles of the scaleshell (*Leptodea leptodon*) showing growth that occurred during encystment on freshwater drum (*Aplodinotus grunniens*). Photo taken by Dr. M.C. Barnhart, Southwest Missouri State University.

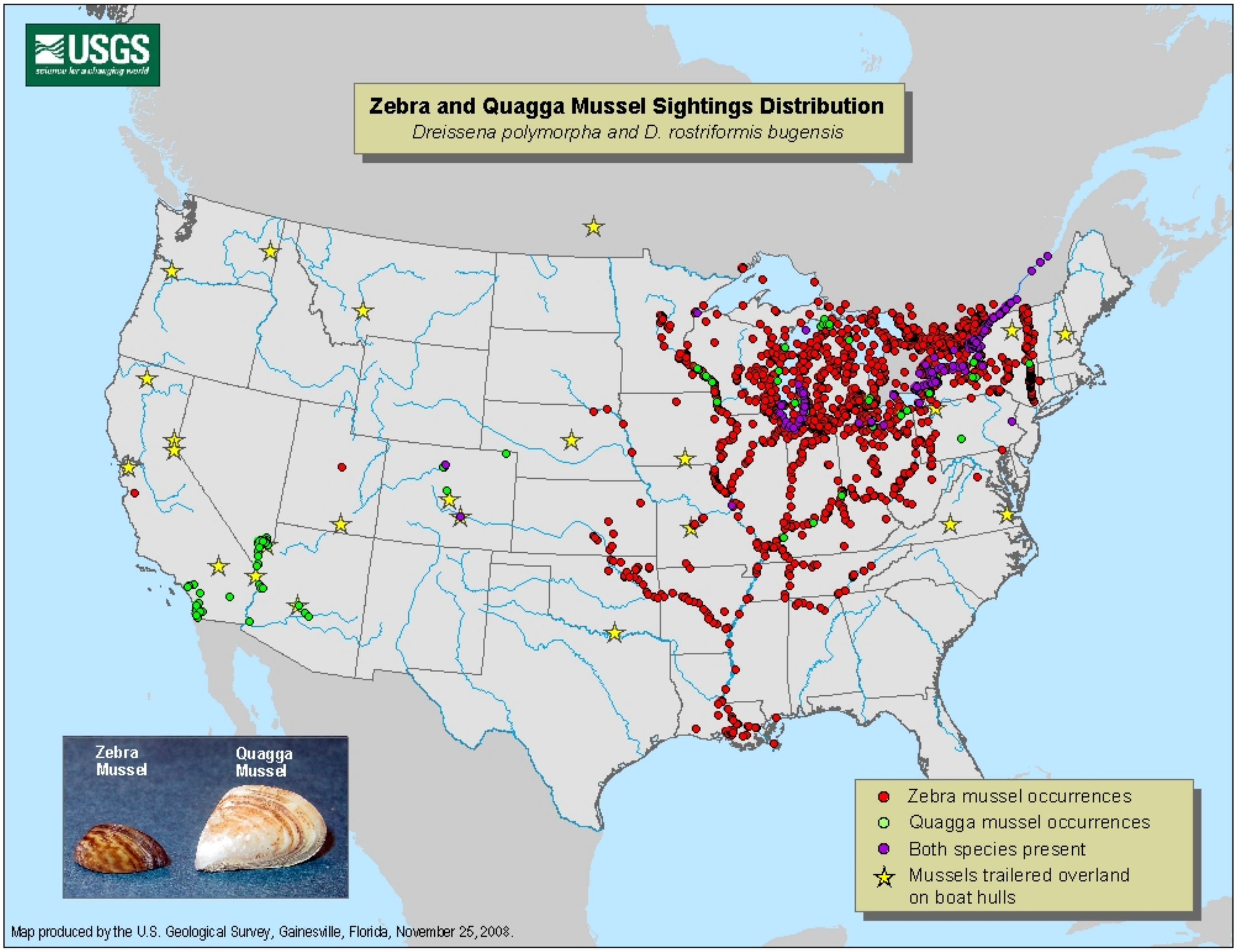


Figure 8. Distribution and sightings of the zebra mussel (*Dreissena polymorpha*) as of 2008 (Taken from U.S. Geological Survey web site: "Zebra and Quagga Mussel Page", http://nas.er.usgs.gov/taxgroup/mollusks/zebramussel/).

APPENDIX I: Detailed Historical and Current Distribution of the Scaleshell (*Leptodea leptodon*)

The following is a more detailed discussion of the distribution and abundance of the scaleshell organized by region and river basin. This information is summarized in Table 1.

<u>Upper Mississippi River Basin (upstream from confluence of Mississippi and Missouri rivers)</u>

The scaleshell formerly occurred in eight rivers and tributaries within the upper Mississippi River Basin, including the Mississippi River in Illinois, Iowa, and Wisconsin; the Minnesota River in Minnesota; Burdett's Slough in Iowa; the Iowa and Cedar Rivers in Iowa; and the Illinois, Sangamon, and Pecatonica Rivers in Illinois. It has not been found for more than 50 years in the upper Mississippi River Basin and is believed extirpated from that region (Kevin Cummings, Illinois Natural History Survey, in litt. 1994).

<u>Middle Mississippi River Basin (between Missouri and Ohio River confluences with the Mississippi River)</u>

Historically, the scaleshell occurred in 27 rivers and tributaries within the middle Mississippi River Basin including the Kaskaskia River in Illinois; the mainstem Ohio River in Kentucky and Ohio; the Wabash River in Illinois and Indiana; the White River and Sugar Creek in Indiana; the Green and Licking rivers in Kentucky; the Scioto, St. Mary's, and East Fork Little Miami rivers in Ohio; the Cumberland River in Kentucky and Tennessee; Beaver Creek in Kentucky; Caney Fork in Tennessee; the Tennessee River in Alabama and Tennessee; the Clinch, Holston, Duck, and East Fork Obey rivers in Tennessee; Auxvasse Creek in Missouri; the Meramec, Bourbeuse, South Grand, Gasconade, Big, Osage, and Big Piney rivers in Missouri; and the mainstem Missouri River in South Dakota and Missouri. The scaleshell is believed to have been extirpated from most of the middle Mississippi River Basin including all streams east of the Mississippi River. Of the 27 streams listed above, the scaleshell has only been documented from seven in the last 25 years. These include the Meramec, Big, Bourbeuse, Missouri, Gasconade, Big Piney, and Osage rivers in Missouri and the Missouri River in South Dakota (Table 1b).

Ohio River Drainage - The scaleshell has been extirpated from the entire Ohio River system. The most recent collection from the Ohio River Basin was in 1964 from the Green River (Wayne Davis, Kentucky Department of Fish and Wildlife, in litt. 1994). All other records are pre-1950 (Kevin Cummings, in litt. 1994; Catherine Gremillion-Smith, Indiana Department of Natural Resources, in litt. 1994; Ron Cicerello, Kentucky Department of Fish and Wildlife, in litt., 1994; Paul Parmalee, University of Tennessee, pers. comm. 1995).

Meramec River Basin (Missouri) – In 1979, Buchanan surveyed mussels at 198 sites within the Meramec River Basin (Buchanan 1979, 1980). Of these sites, 14 had evidence of live or dead scaleshells. Seven of the 14 sites were in the lower 180 kilometers (km) [112 miles (mi)] of the Meramec River, five in the lower 87 km (54 mi) of the Bourbeuse River, and two in the lower 16 km (10 mi) of the Big River. Buchanan found that the species comprised less than 0.1 percent of the 20,589 living mussels he examined in the basin. He collected live scaleshells at only four sites, three in the Meramec and one in the Bourbeuse. Although the lower 174 km (108 mi) of the Meramec River had suitable habitat for many rare species, live scaleshells were found only in the lower 64 km (40 mi) (Buchanan 1980). Both the Bourbeuse and Big rivers had lower species diversity and less suitable habitat than the Meramec River. In 1979, suitable habitat occurred in only the lower 87 km (54 mi) of the Bourbeuse River and lower 16 km (10 mi) of the Big River (Buchanan 1980).

The Missouri Department of Conservation (MDC) sampled 78 sites in an intensive resurvey of the Meramec River Basin in 1997 (Roberts and Bruenderman 2000). Similar to Buchanan's (1979, 1980) findings, the scaleshell represented only 0.4 percent of all living mussels collected. Live specimens were collected from the mainstem Meramec River (34 specimens from 9 sites), Bourbeuse River (10 specimens from 5 sites), and Big River (2 specimens from 1 site). In addition to the nine sites surveyed by Buchanan (1979, 1980), new sites were included in the 1997 survey. Living or dead scaleshell were found at four of five new sites in the Meramec River and two of four new sites in the Bourbeuse River. The three sites where the presence of the scaleshell was not reconfirmed no longer support mussels due to stream bed degradation. Other species that were found in mussel beds at those sites in the earlier surveys were no longer present in 1997. Although portions of the Meramec River basin continue to provide suitable habitat, mussel species diversity and abundance have declined noticeably since 1980 and significant losses of mussel habitat have occurred (Roberts and Bruenderman 2000).

The number of scaleshell specimens MDC collected in 1997 in the Meramec Basin is greater than that reported by Buchanan (1980). The small number of specimens collected however, especially from the Bourbeuse and Big rivers, indicates that the long-term viability of these populations is tenuous. Moreover, the long-term persistence of populations in the Meramec Basin is in question because of the limited availability of mussel habitat and the loss of mussel beds since 1980 from bank and channel degradation, sedimentation, lead mining and eutrophication (Roberts and Bruenderman 2000; Alan Buchanan, MDC, in litt. 1997; Sue Bruenderman, MDC, pers. comm. 1998). Select sites in the Meramec and Bourbeuse rivers have been monitored annually for the scaleshell since 1997, and live specimens have been consistently found each year at several sites.

Missouri River Drainage (South Dakota and Missouri) - Within the Missouri River Drainage, Buchanan (1980, 1994) and Oesch (1995) reported the occurrence of the scaleshell from the Missouri, Gasconade, Big Piney, South Grand, Osage rivers, and Auxvasse Creek. The last collection of the scaleshell in Auxvasse Creek was in the late 1960s (Alan Buchanan, in litt. 1997). Similarly, the last known scaleshell collection in the South Grand was in the early 1970s, at a site now inundated by Truman Lake and unsuitable for the scaleshell (Alan Buchanan, in litt. 1997). A single, fresh dead specimen was collected from Big Piney River in 1981 (Sue Bruenderman, in litt. 1998). However, the scaleshell has not been found in recent surveys of this river. Between 1994 and 1996, 70 sites were sampled in the Big Piney River from the mouth to the headwaters. While 3,331 mussels of 26 species were collected, no evidence of the scaleshell was found (Janet Sternberg, MDC, pers. comm. 2000). Another survey was conducted in 1998 in which 10 sites were sampled between river miles 53.6 and 96.0. Over 1,000 living mussels were collected representing 15 species, but no living or dead scaleshell was found (Bruenderman *et al*. 2001).

Scaleshell has only recently been documented from two areas of the mainstem of the Missouri River. In 1981 and 1982, the Missouri River was surveyed from Santee to Omaha, Nebraska (Hoke 1983). One fresh dead shell was found during this study just below Gavin's Point Dam, South Dakota. This occurrence is the first known record for scaleshell in the Missouri River and represents the westernmost record in North America. The species has not been found consistently, however, in subsequent surveys in the same area indicating that it is very rare. In 1995, Clarke (1996) found no evidence of the scaleshell in a survey conducted from Gavin's Point Dam to 48 river km (30 mi) downstream, but high water conditions limited Clark's search efforts, and only 10 individual mussels were found. In 1999, the Omaha District of the U.S. Army Corps of Engineers (Corps) funded a mussel survey between Gavin's Point Dam and Ponca, Nebraska, a distance of 96 river km (60 mi). In all, 355 live and 1,709 dead individual mussels were collected representing 16 species, but no living or dead scaleshell were found (Perkins and Backlund 2000). Ecological Specialists, Inc. (2005) extensively surveyed three sites below Gavin's Point Dam at river miles 810.0, 769.8, and 761.5 and also did not find the species. Upstream from Gavin's Point Dam, a comprehensive survey was conducted in 2004 and 2005 between Fort Randall Dam near Pickstown, South Dakota and Running Water, South Dakota by Shearer et al. (2005). This survey effort did not find any evidence of the scaleshell. Then in 2005, another fresh-dead scaleshell was recovered near Gavin's Point Dam during low water conditions (Dr. Keith Perkins III, University of Nebraska, in litt. 2005). The scaleshell has not been consistently found in this reach of the Missouri River during these survey efforts indicating that this species is very rare in this reach of the Missouri River.

The second scaleshell record from the mainstem of the Missouri River is a single fresh dead individual that was collected in 1990 from Gasconade County, Missouri. This specimen was found during an extensive survey conducted from Gavin's Point Dam to St. Louis (Hoke 2000*b*). However, the site of this collection was subsequently destroyed by development. Because no living scaleshell have been found in the Missouri River, its habitat is difficult to determine. However, both dead shells were collected from areas shielded from the main flow of the river in relatively stable, sandy bottoms with moderate current (Hoke 2000). Hoke (2000) described the scaleshell as "extremely rare" and its habitat "very uncommon . . . and existing in only widely separated locales" in the Missouri River. This population is currently considered extirpated (USFWS 2001).

The Gasconade River in Missouri supports one of the largest populations of the scaleshell remaining. Buchanan (1994) surveyed the lower 137 km (85 mi) of the Gasconade River, and documented 36 species of freshwater mussels. He collected the scaleshell at eight sites between river miles 6.0 and 57.7. Buchanan found only dead shells at two sites and eight live specimens from the remaining six sites. Overall, the scaleshell comprised less than 0.1 percent of all mussels collected. In 1998-1999, the Gasconade River was surveyed at 46 sites from mile 92 to 256. A total of 15 living scaleshells were found at 9 sites, and dead shells were found at an additional 10 sites between river miles 92.0 and 231. At sites where the scaleshell were collected, living individuals represented less than 0.5 percent of the total number of mussels found. Catch per unit effort of the scaleshell was 0.1 individuals per hour of sampling (Bruenderman *et al.* 2001). The Gasconade River continues to support the largest scaleshell populations next to the Meramec and Bourbeuse rivers. Select site have been monitored for the species since 1999 and the species has been consistently found.

The scaleshell has recently been discovered in the lower Osage River in Osage County, Missouri. One live male was found in 2001 near river mile 20 (Heidi Dunn, pers. comm.). This individual was found during an intensive mussel survey in the lower 80 miles of the Osage River and several tributaries (Ecological Specialists, Inc. 2003). In this survey, mussels were collected at 34 sites including 25 in the mainstem Osage River. A total of 8,000 living mussels were collected representing 28 living species. No other evidence of the scaleshell was found during the survey. The scaleshell has not been previously reported from the Osage Basin and may indicate that the species is extremely rare. Utterback (1917) reported 49 species in the basin and 33 species in the Osage River. Oesch (1995) collected mussels in the 1970s at a number of sites in the basin and reported 39 species. In 1980, a detailed study of mussel distribution was conducted by Grace and Buchanan (1981) in the lower 129 km (80 miles) of the Osage River and two tributaries below Bagnell Dam. A total of 43 sites were surveyed and 21,593 living mussels were found representing 36 species. No evidence of the scaleshell was found in any of these surveys.

Middle Mississippi River Basin summary - Of the 27 rivers and tributaries in the middle Mississippi River Basin that historically supported the scaleshell, the species has been collected within the last 25 years from seven streams including the Meramec, Bourbeuse, Big, Missouri, Osage, Gasconade, and Big Piney rivers in Missouri, and the Missouri River in South Dakota. The Meramec, Bourbeuse, and Gasconade rivers support the largest known populations remaining within its extant range.

Lower Mississippi River Basin (downstream from confluence of Mississippi and Ohio rivers)

The scaleshell historically occupied 21 rivers and tributaries in the lower Mississippi River Basin. These include the St. Francis, White, James, Spring, Little Missouri, Middle Fork Little Red, Saline (of the Ouachita River), Ouachita, Cossatot, Saline (of the Little River), South Fourche LaFave, Mulberry, and Strawberry rivers in Arkansas; South Fork Spring, Frog Bayou, and Myatt Creek in Arkansas; Poteau, Little, and Kiamichi rivers in Oklahoma; and Gates Creek and Mountain Fork in Oklahoma. These rivers are discussed below according to drainage (St. Francis, White, Arkansas, and Red River drainages).

St. Francis River Drainage (Arkansas) - Bates and Dennis (1983), Clarke (1985), and Ahlstedt and Jenkinson (1987) conducted mussel surveys on the St. Francis River in Arkansas and Missouri. In these surveys, the scaleshell was only documented from two sites, both of which are single-specimen records (Clarke 1985). Records of dead shells of various species indicate that at one time freshwater mussels occurred throughout the river (Bates and Dennis 1983). Bates and Dennis (1983) determined that of the 54 sites sampled, 15 were productive, 10 marginal, and 29 had either no shells or dead specimens only; the scaleshell was not documented at any of the 54 sites. They identified 77 km (48 mi.) of habitat generally suitable for mussels:

Wappapello Dam to Mingo Ditch, Missouri; Parkin to Madison, Arkansas; and Marianna to the confluence with the Mississippi River at Helena, Arkansas. They indicated that the remaining portions of the river were no longer suitable for mussels. If the scaleshell is extant in the St. Francis River, it is restricted to the few remaining patches of suitable habitat.

White River Drainage (Arkansas) - Clarke (1996) noted a 1902 collection of a single specimen from the White River near Garfield, Arkansas. A late 1970s survey of the White River between Beaver Reservoir and its headwaters failed to relocate live or dead scaleshells. In 1999, however, a single live specimen was collected from the White River near Newport by John Harris (Arkansas Department of Transportation, pers. comm. 2000). Navigation maintenance activities have relegated the mussel fauna to a few refugial sites (Bates and Dennis 1983). Specimens have not been collected from the James River, a tributary of the White River, since before 1950 (Clarke 1996).

An eight-mile section of the Spring River in Arkansas supports a diverse assemblage of freshwater mussels (Gordon *et al.* 1984, Arkansas Highway and Transportation Department 1984, Miller and Hartfield 1986). The collections from this river total eight scaleshell specimens [Kevin Cummings in litt. 1994; Clarke 1996, Arkansas State Highway and Transportation Department 1984]. Gordon *et al.* (1984) surveyed the river and reported suitable mussel habitat between river miles 3.2 and 11.0, although species richness below river mile 9 had declined markedly compared to past surveys. Gordon *et al.* (1984), as well as Miller and Hartfield (1986), reported that the lower 5.0 km (3.0 mi) of the river were completely depleted of mussels and contained no suitable habitat. Harris did not find the scaleshell in a 1993 survey of the Spring River (John Harris, in litt. 1997).

The scaleshell was collected from the South Fork of the Spring River in 1983 and 1990. During the 1983 survey, Harris (in litt. 1997) collected four dead male specimens near Saddle, Arkansas, and one dead male specimen and a single male valve north of Hunt, Arkansas. During a subsequent visit in 1990, Harris collected shells of young adults (Harris, pers. comm. 1995). Although juveniles were not found, the presence of young adults suggested that reproduction had recently occurred.

Records of the scaleshell from the Strawberry River and the Myatt Creek are based on single specimen collections, both made in 1996 (John Harris, in litt. 1997). Harris collected one live specimen from the Strawberry River near the confluence with Clayton Creek in Lawrence County. He also collected a single dead specimen from Myatt Creek in Fulton County (Davidson *et al*. 1997). Comprehensive surveys have not been conducted in these rivers since 1996.

The historical locality (near Shirley, Van Buren County, Arkansas) where a single scaleshell specimen was collected from the Middle Fork of the Little Red River no longer provides mussel habitat. Clarke (1987) stated that suitable mussel habitat was restricted to a 9.6 km (6.0 mi) stretch from the confluence of Tick Creek upstream to the mouth of Meadow Creek.

Arkansas River Drainage (Oklahoma and Arkansas) - The scaleshell has been collected in the following streams from the Arkansas River drainage: Poteau River in Oklahoma (Gordon 1991), Frog Bayou in Arkansas (Harris and Gordon 1987), and the South Fourche LaFave and Mulberry rivers in Arkansas (Gordon 1991; Harris 1992). A single scaleshell specimen was collected in the Poteau River (Gordon 1980). However, it has not been documented in subsequent surveys of this river (Branson 1984; Harris 1994, Vaughn and Spooner 2004). The existence of the scaleshell in Poteau River is doubtful.

Gordon (1980) collected two scaleshell specimens from Frog Bayou. Beaver Reservoir now inundates one of the Frog Bayou collection sites. The most recent record was a fresh dead individual collected during a 1979 survey (Gordon 1980). Gordon noted that stream bank bulldozing upstream recently disturbed this site and other nearby sites. He also reported in-stream gravel mining activities at several sites. Within Frog Bayou, potential habitat is restricted to the area between Rudy and the confluence of the Arkansas River. Above Rudy, two reservoirs impact the river; one near Maddux Spring and the other at Mountainburg. Live mussels have not been found at the confluence of the Arkansas River, likely due to dredging activities (Gordon 1980). Although the current status of the scaleshell in Frog Bayou is uncertain, any remaining individuals are in potential jeopardy due to limited habitat and in-stream mining activities.

The only record of the scaleshell from the South Fourche LaFave River is based on a single live specimen found in 1991 (Harris 1992). No evidence of the scaleshell was found in an intensive, subsequent mussel survey of this stream, which indicates that the species is extremely rare or extirpated from this stream (Stoeckel and Moles 2002). An 86-acre reservoir is approved for construction on Bear Creek approximately six miles upstream from this site. The effect of this impoundment on the scaleshell is uncertain. The potential for discovering additional scaleshell sites in this river is unlikely due to the limited availability of suitable substrate. Similarly, other major tributaries of the South Fourche LaFave River provide little mussel habitat. Like Frog Bayou, the persistence of the scaleshell in this river is in doubt.

Although Gordon (1991) indicated occurrence of the scaleshell in the Mulberry River in a species account, documentation is lacking. In recent mussel surveys of this river, the species was not found (Craig Hilborne, U.S. Forest Service, pers. comm. 1995; Stoeckel *et al.* 1995). The existence of the scaleshell in the Mulberry River is unlikely.

Red River drainage (Oklahoma and Arkansas) - The scaleshell has been documented from the following streams in the Red River drainage: the Kiamichi River, Gates Creek, Little River, Mountain Fork; and the Cossatot, Ouachita, Little Missouri, and Saline Rivers. Isley (1925) first collected the scaleshell from the Kiamichi River in 1925. Based on his account, the Kiamichi River historically supported a diverse and abundant mussel fauna. He collected 36 scaleshell specimens at one of 22 stations visited. A single specimen was also collected from Gates Creek, a tributary of the Kiamichi River, by Valentine and Stansbery (1971). As recently as 1987, Clarke described the Kiamichi River as "in remarkably good condition" and a "faunal treasure" (Clarke 1987). However, despite extensive searches of the Kiamichi River only three fresh dead shells have ever been found with the most recent being in 2004 (Vaughn in litt. 2004) and the other two shells recovered in 1987 (Caryn Vaughn, Oklahoma Biological Survey, pers. comm.

1997; Charles Mather, University of Science and Arts of Oklahoma, in litt. 1984 and 1995) and 2000 (Spooner and Vaughn 2000). Vaughn (pers. comm. 1997) failed to find even a dead shell during three years (1993-1996) of surveys in the Red River Basin. However, the mussel habitat in the Kiamichi River is in relatively good condition above the Hugo Reservoir (Clarke 1987) and may still support a remnant population of the scaleshell.

The scaleshell has not been documented in the Little River in Oklahoma since 1960 (Szymanski 1998). Since 1960, two reservoirs have been constructed that influence mussel populations in the Little River. The mainstem of the river is impounded by Pine Creek Reservoir and the Mountain Fork River, a major tributary to the Little River, is impounded by Broken Bow Reservoir. While mussel habitat is present above Pink Creek Reservoir (Vaughn and Taylor 1999), these populations are isolated from downstream populations and species richness is on the low end (i.e. less than 15 species) of most scaleshell sites. Below Pine Creek Reservoir, the mussel fauna is depleted, but recover with increasing distance from the impoundment. Further downstream, mussel species richness and abundance is greatly reduced after the inflow from Mountain Fork River (Vaughn and Taylor 1999). Although the scaleshell has not been documented during extensive surveys throughout the length of the Little River, suitable habitat remains and the species may persist (Vaughn and Taylor 1999). However, the discharge of reservoir water from Pine Creek and periodic discharge of pollution from Rolling Fork Creek may seriously impact any remaining viable scaleshell population and prohibit any future recolonization (Clarke 1987). Valentine and Stansbery (1971) reported a single specimen from Mountain Fork, a tributary of the Little River. Clarke (1987) hypothesized that, based on the presence of mussels at the confluence of Mountain Fork and beyond the Arkansas border, damage to Mountain Fork from the Broken Bow Reservoir has not occurred. Vaughn (in litt. 1997), however, indicated that these areas have been severely depleted, with most no longer supporting live mussels.

If the scaleshell still occurs in the Red River drainage in Oklahoma, extant populations are probably small and are likely restricted to isolated areas of suitable habitat in the Kiamichi and Mountain Fork Rivers. Given the extensive survey effort over the last decade, long-term survival of the scaleshell in Oklahoma is doubtful.

Harris collected single scaleshell specimens from the Cossatot and Saline Rivers in Arkansas in 1983 (John Harris, in litt. 1997) and 1987 (John Harris, pers. comm. 1995), respectively. No evidence of the scaleshell was found in a recent comprehensive survey of the Saline River (Chris Davidson, USFWS, in litt.). No other information is available for the Cossatot River.

The existence of the scaleshell in the Ouachita River and its two tributaries, the Saline River and Little Missouri River, is questionable as well. Both the Little Missouri and Saline Rivers records are based on single specimens. The Saline River specimen was collected in 1964 (Clarke 1996), and the Little Missouri River collection record is from 1995 (John Harris, in litt. 1997). No evidence of the scaleshell was found in a recent comprehensive mussel survey of the Saline River (Davidson and Gosse 2003). Four undated museum specimens of the scaleshell from the Ouachita River in Arkadelphia, Clark County, Arkansas are listed in Clarke (1996), but details are unavailable. Based on the few collections and the limited available habitat, the long-term persistence of the scaleshell in Cossatot, Saline, Little Missouri, and Ouachita rivers appears precarious.

Lower Mississippi River Basin Summary – Historically, 21 rivers and tributaries in the lower Mississippi River Basin supported the scaleshell. In the last 25 years, the species has been collected from 11 of these streams. These streams include Myatt Creek and the St. Francis, White, Spring, South Fork Spring, Strawberry, South Fourche LaFave, Cossatot, Saline (a tributary of the Little River), and the Little Missouri rivers in Arkansas; and Kiamichi River in Oklahoma. These streams are included in the range of the scaleshell based on a small number or a single specimen, which reflects the extreme rarity of the species in the Lower Mississippi River basin.

APPENDIX II: Summary of Threats and Recommended Recovery Actions for the Scaleshell (*Leptodea leptodon*)

Listing Factor	Threat	Recovery Criteria	Task Numbers
A	Significant range reduction	1, 2, 3	Utilize: recovery implementation team, GIS database, recovery implementation database; Further delineate current status and distribution, identify suitable reintroduction sites and restore habitat, develop and implement a reintroduction plan, initiate educational and public outreach actions (see tasks 1.1, 2.1, 4.1, 4.2, 4.3, 4.4, 5.1, 6.1, 6.2, 6.3, 6.4, 6.5)
A	Water quality degradation, point source	3	Utilize: recovery implementation team, GIS database, and recovery implementation database; carry out cooperative projects using existing programs, conduct water quality studies, initiate educational and public outreach actions (see tasks: 1.1, 2.3, 2.4, 2.6.1, 2.6.2, 2.6.3, 2.6.4, 4.2, 4.3, 4.4, 6.1, 6.2, 6.3, 6.4, 6.5)
A	Water quality degradation, nonpoint source	3	Utilize: recovery implementation team, GIS database, and recovery implementation database; carry out cooperative projects using existing programs, conduct water quality studies, initiate educational and public outreach actions (see tasks: 1.1, 2.3, 2.4, 2.6.1, 2.6.2, 2.6.3, 2.6.4, 4.2, 4.3, 4.4, 6.1, 6.2, 6.3, 6.4, 6.5)
A	Contaminant spills	3	Utilize: recovery implementation team; develop emergency response strategy, initiate educational and public outreach actions (see tasks 1.1, 2.7, 6.1, 6.2, 6.3, 6.4, 6.5)
A	Sedimentation and eutrophication	3	Utilize: recovery implementation team, GIS database, and recovery implementation database; carry out cooperative projects using existing programs, conduct water quality studies, initiate educational and public outreach actions (see tasks: 1.1, 2.3, 2.4, 2.6.1, 2.6.2, 2.6.3, 2.6.4, 4.2, 4.3, 4.4, 6.1, 6.2, 6.3, 6.4, 6.5)
A	Loss of stable substrates, channel degradation, excessive bank erosion	3	Utilize: recovery implementation team, GIS database, and recovery implementation database; carry out cooperative projects using existing programs, conduct water quality studies, initiate educational and public outreach actions (see tasks: 1.1, 2.3, 2.4, 2.6.1, 2.6.2, 2.6.3, 2.6.4, 4.2, 4.3, 4.4, 6.1, 6.2, 6.3, 6.4, 6.5)

Listing Factor	Threat	Recovery Criteria	Task Numbers
A	Habitat loss and degradation due to channelization, sand and gravel mining, dredging operations, construction and operation of reservoirs, and other construction activities	3	Utilize: recovery implementation team, GIS database, and recovery implementation database; carry out cooperative projects using existing programs, initiate educational and public outreach actions (see tasks: 1.1, 2.3, 2.4, 2.6.1, 2.6.2, 2.6.3, 2.6.4, 4.2, 4.3, 4.4, 6.1, 6.2, 6.3, 6.4, 6.5)
B	Possible disturbance of habitat and trampling from commercial harvesting	3	Utilize existing programs (i.e. ESA) to protect the species, initiate educational and public outreach actions (see task 2.4, 6.1, 6.2, 6.3, 6.4, 6.5)
B	Specimens potentially taken for shell collections, bait, curiosity, or vandalism	3	Utilize existing programs (i.e. ESA) to protect the species, initiate educational and public outreach actions, (see task 2.4, 6.1, 6.2, 6.3, 6.4, 6.5)
C	Mussels kills due to disease	3	Utilize: recovery implementation team; develop emergency response strategy, initiate educational and public outreach actions (see tasks 1.1, 2.7, 6.1, 6.2, 6.3, 6.4, 6.5)
C	Predation by mammals	3	Utilize: recovery implementation team (see tasks 1.1, 2.9)
D	Habitat loss and degradation continues despite existing regulatory mechanisms	3	Utilize: recovery implementation team, GIS database, and recovery implementation database; carry out cooperative projects using existing programs, conduct water quality studies, initiate educational and public outreach actions (see tasks: 1.1, 2.3, 2.4, 2.6.1, 2.6.2, 2.6.3, 2.6.4, 4.2, 4.3, 4.4, 6.1, 6.2, 6.3, 6.4, 6.5)
E	Reduced recruitment due to bottlenecks in life cycle	2	Utilize recovery implementation team; stabilize and establish self-sustaining populations by artificial propagation, which bypasses bottlenecks (see tasks 1.1, 2.5.1, 2.5.2)
E	Reduced reproduction due to habitat fragmentation	2	Utilize: recovery implementation team, GIS database, and recovery implementation database; carry out cooperative projects using existing programs, conduct water quality studies (see tasks: 1.1, 2.3, 2.4, 2.6.1, 2.6.2, 2.6.3, 2.6.4, 4.2, 4.3, 4.4)

Listing Factor	Threat	Recovery Criteria	Task Numbers
E	Extant populations with greater chance of extirpation due to small, isolated populations	1, 2	Utilize recovery implementation team; stabilize and establish self-sustaining populations by artificial propagation (see tasks 1.1, 2.5.1, 2.5.2)
E	Reduction of populations due to drought	3	Utilize recovery implementation team, develop emergency response strategy (see tasks 1.1, 2.7)
E	Threats from non-native species	3	Utilize recovery implementation team, develop management options to reduce or eliminate the threat of non-native species, initiate educational and public outreach actions (See tasks 1.1, 2.8.1, 2.8.2, 2.8.3, 2.8.4, 2.8.5, 6.1, 6.2, 6.3, 6.4, 6.5)

Listing Factors:
A. The Present or Threatened Destruction, Modification, or Curtailment of its Habitat or Range
B. Overutilization for Commercial, Recreational, Scientific, Educational Purposes (not a factor)
C. Disease or Predation
D. The Inadequacy of Existing Regulatory Mechanisms
E. Other Natural or Manmade Factors Affecting Its Continued Existence

Recovery Criteria:
The scaleshell will be considered for downlisting to threatened status when the following criteria are achieved:

1. Through protection of existing populations, successful establishment of reintroduced populations, or the discovery of additional populations, four stream populations exist, each in a separate watershed and each made up of at least four local populations located in distinct portions of the stream. Each stream population must exist in a separate watershed so that a single stochastic event, such as a toxic spill or disease outbreak, will not affect more than one of the four stream populations. This criterion is based on the available information and the best professional judgment of species experts (see Appendix v), and may be revised based on additional biological, demographic, or genetic information obtained through Recovery Actions 3.1 and 3.4.

2. Each local population in Criteria 1 is viable in terms of population size, age structure, recruitment, and persistence. Currently, what constitutes a viable population of the scaleshell is not known. Population viability will be defined when Action 3.4.2 (Research Population Dynamics of the Scaleshell) is completed. In the future, this criterion will be revised to incorporate the definition of population viability resulting from this recovery action (3.4.2).

3. Threats to local populations in Criterion 1 have been identified and addressed per measurable criteria developed in Action 2.3. Currently it is not feasible to identify in this criterion the specific threats to populations and thresholds at which those threats are reduced to the level where criteria 1 and 2 are achieved. However, the thresholds for this criterion will be defined through the implementation of key actions in the plan as follows. <u>Step 1</u>: identify and map present and foreseeable threats to local populations in a GIS database (Action 2.2). <u>Step 2</u>: Define measurable criteria for alleviating/reducing each of those threats and

prioritize threats according to effects to local populations (Action 2.3). Step 3: Apply the appropriate recovery actions outlined in this plan to alleviate/reduce threats. Step 4: Track the progress of recovery implementation (Action 7.2).

The scaleshell will be considered for removal from the ESA protection when the following criteria are achieved:

1. Through protection of existing populations, successful establishment of reintroduced populations, or the discovery of additional populations, a total of eight stream populations exist, each in a separate watershed and each made up of at least four local and geographically distinct populations. At a minimum, one stream population must be located in the Upper Mississippi River Basin, four in the Middle Mississippi River Basin (two of these must exist east of the Mississippi River), and three in the Lower Mississippi River Basin. Completion of action 3.4.2 or 3.4.3 may indicate more local populations, streams, or geographical regions are required. This criterion is based on the available information and the best professional judgment of species experts (see Appendix v), and may be revised based on additional biological, demographic, or genetic information obtained through Recovery Actions 3.1 and 3.4.

2. Each local population in Criteria 1 is viable in terms of population size, age structure, recruitment, and persistence. Currently, what constitutes a viable population of the scaleshell is not known. Population viability will be defined when Action 3.4.2 (Research Population Dynamics of the Scaleshell) is completed. In the future, this criterion will be revised to incorporate the definition of population viability resulting from this recovery action (3.4.2).

3. Threats to local populations in Criterion 1 have been identified and addressed per measurable criteria developed in Action 2.3. Currently it is not feasible to identify in this criterion the specific threats to populations and thresholds at which those threats are reduced to the level where criteria 1 and 2 are achieved. However, the thresholds for this criterion will be defined through the implementation of key actions in the plan as follows: Step 1: identify and map present and foreseeable threats to local populations in a GIS database (Action 2.2), Step 2: Define measurable criteria for alleviating/reducing each of those threats and prioritize threats according to effects to local populations (Action 2.3). Step 3: Apply the appropriate recovery actions outlined in this plan to alleviate/reduce threats. Step 4: Track the progress of recovery implementation (Action 7.2).

APPENDIX III: Glossary of Terms

Adaptive management - habitat management techniques that are updated to incorporate new information.

Ala – wing-like structure on the shell of unionids, usually on the dorsal side.

Anal opening – an opening above the *branchial* opening; waste material from the digestive tract and water leave through this opening.

Anterior – toward the head or front end of an animal.

Anthropogenic – activities involving the impact of man on nature.

Augmentation - moving eggs, larvae, juveniles or adults to a site with an existing *local population*.

Beak - the raised, or inflated portion of a bivalve shell, centrally or *anteriorly* placed along the dorsal margin of the shell.

Beak cavity - a cavity located inside the shell that extends into the *beak*.

Beak sculpture – lines, corrugations or other surface relief seen on the disk in some unionids.

Benthic – refers to the bottom of surface water bodies and the organisms that live there.

Branchial – the lower or ventral siphon.

Conglutinates - small structures made up of gelatinous material that enclose large numbers of glochidia.

Crenulate – having a roughened or scalloped border.

Cryogenic preservation – the solidification of a biological specimen by rapid cooling, while maintaining structural integrity.

Deme - a local population of interbreeding organisms of the same kind or species.

Dorsal – toward the back or top of an animal.

Eutrophication - excessive fertilization caused by pollution of plant nutrients.

Extant – currently existing population of a species.

Extirpation – the local disappearance of a species that does not lead to the range-wide extinction of that species.

Fresh dead – dead mussel specimens that still have soft tissue attached to the shell.

Genetic drift – random changes in gene frequencies in a population.

Glochidia – the bivalve microscopic larvae of freshwater mussels in the superfamily Unionoidea, which are generally parasitic upon vertebrates, usually fish.

Gravid – refers to unionids brooding eggs or glochidia in the gills.

Headcutting - the upstream progression of stream bed destabilization and accelerated bank erosion.

Inbreeding depression – the reduction of population fitness due to inbreeding.

Interstitial water – water found in small spaces beneath the surface of substrate.

Laminae – thin plate or layer.

Lateral teeth - the elongated, raised, and interlocking structures located dorsally along the hinge line of the inside of the valves if freshwater mussels.

Local population - assemblage of individuals that more or less interact with each other in the course of their routine feeding and breeding activities (e.g. mussel bed).

Long-term brooder – unionids that spawn in the fall months, and females brood glochidia until the following spring. Short-term brooders spawn and release glochidia in the spring.

Mantle – outermost part of the soft tissue of unionids; secretes shell at the edges and produces the periostracum.

Mantle cavity – empty space inside the shell between the shell and soft tissues of bivalved mollusks.

Marsupia – the portion of the gills of a female freshwater mussel that are used in brood glochidia.

Midden – pile of discarded mussel shells resulting from feeding activities of small mammals.

Macroinvertebrate – an animal without a backbone large enough to been seen without magnification.

Mussel beds - areas containing a high concentration and diversity of mussels.

Nacre – the interior layer of the shell, made up of crystalline carbonate.

Papillae – small, finger-like projections seen around the siphons of unionids.

Periostracum - the thin, uncalcified outer layer or covering of the shell.

Posterior – toward the tail-end of an animal.

Pseudocardinal teeth - the triangular, often serrated, teeth-like structures located on the upper part of the shell in freshwater mussels.

Reintroduction—moving eggs, larvae, juveniles, or adults from one or more existing populations to help create another population at a separate geographic area within the historic range of the species where there are no existing populations.

Rhomboid - a parallelogram with opposite sides equal.

Sexual dimorphism – exhibiting external morphological characteristics that allow the separation of male from female.

Silviculture – the cultivation of woods or forests.

Siphon – aperture through which water is drawn in or out of a bivalved mollusc.

Status - an assessment of the current existence of a population

Stochastic event – unpredictable, random catastrophic event such as an oil spill, flood, or drought.

Stream population – all individuals living in one river or stream. This is a geographical term that does not imply that a population is currently reproducing or that it is a distinct genetic unit.

Stream team – stream teams are working partnerships of citizens who are concerned about streams and become involved in steam conservation including education, habitat restoration projects, and stream advocacy.

Supra-anal – an opening above the anal opening.

Sympatric – pertaining to populations of two or more species which occupy identical or broadly overlapping geographical areas.

Trend - an assessment of change in a population's numbers and its probable future condition.

Unionid – a freshwater bivalve belonging to the family Unionidae. The larval form is usually parasitic upon a fish; adults do not have proteinaceous threads with which to attach themselves to the substrate. Also called freshwater mussel, freshwater clam, or naiad.

Valve – the left or right half of a bivalve shell such as a freshwater mussel.

Ventral – toward the underside or bottom of an animal.

Watershed – the land area that drains water, sediment, and dissolved materials into a stream.

APPENDIX IV: List of Abbreviations

CWA	Clean Water Act
CRP	Conservation Reserve Program
EQIP	Environmental Quality Incentives Program
EO	Executive Order
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
FIP	Forestry Incentives Program
FMCS	Freshwater Mollusk Conservation Society
FWCA	Fish and Wildlife Coordination Act
GIS	Global Information System
MDC	Missouri Department of Conservation
MDNR	Missouri Department of Natural Resources
MVP	Minimum Viable Population
NANPCA	Nonindigenous Aquatic Nuisance Prevention and Control Act
NNMCC	National Native Mussel Conservation Committee
NRCS	National Resources Conservation Service
ODEQ	Oklahoma Department of Environmental Quality
PVA	Population Viability Analysis
RBP	Rapid Bioassessment Protocol
USEPA	United States Environmental Protection Agency
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WHIP	Wildlife Habitat Incentives Program
WRP	Wetlands Reserve Program

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APPENDIX V: Summary of Comments on August 2004 Draft Recovery Plan and U.S. Fish and Wildlife Service Responses.

The August 2004 draft recovery plan for the scaleshell mussel (*Leptodea leptodon*) was written by the U.S. Fish and Wildlife Service (USFWS) with the individual input of malacologists and other resource professionals that work within the current range of the species in Arkansas, Missouri, and Oklahoma. These individuals reviewed an early draft of the recovery plan and provided written or oral comments to the USFWS. They also met on May 22, 2003 specifically to provide further input on the recovery actions and recovery criteria proposed by the USFWS.

On August 6, 2004, the USFWS released the draft recovery plan for a 30-day review and comment period ending on September 7, 2004. Availability of the plan was announced in the Federal Register (FR 69 47949) and via a news release to media contacts throughout the range of the species. In accordance with USFWS policy, requests for peer review of the August 2004 draft plan were sent to two experts outside the USFWS. Additionally, the USFWS solicited peer review from four other species experts, including one from within the USFWS. In particular, these experts were asked the following questions: 1) does the recovery plan adequately present an ecologically and biologically defensible recovery strategy for the scaleshell mussel; 2) given the data currently available, as presented in the recovery plan, are the recovery criteria as outlined in the plan sufficient to achieve reclassification and eventual delisting; 3) are the proposed research, management, and public outreach actions appropriate and sufficient; and 4) are the recovery actions presented in the plan's Implementation Schedule appropriately prioritized to facilitate recovery for the scaleshell. Requests for peer review were sent to the following individuals:

Dr. Richard J. Neves, Virginia Polytechnic Institute, Blacksburg, Virginia
Dr. Karen Vaughn, Oklahoma Biological Survey, Norman Oklahoma
Dr. Steve Chambers, U.S. Fish and Wildlife Service, Albuquerque, New Mexico
Steven McMurray, Missouri Department of Conservation, Columbia, Missouri
Chris Vetello, Missouri Department of Conservation, Springfield, Missouri
Craig Fuller, Missouri Department of Conservation, Lebanon, Missouri

During the comment period, 144 copies of the Draft Recovery Plan were distributed to government agencies, organizations, and other interested parties within the range of the scaleshell mussel. The Service received one letter from a federal agency representative and seven responses from state agency representatives. Each letter contained one or more comments, with some respondents raising similar issues. Many comments received were either editorial or minor. The majority of these comments were incorporated into the approved recovery plan. Other comments were more substantive and included recommendations to delete or change recovery criteria, add or reword recovery actions, or change the priority number for recovery actions in the Implementation Schedule. Significant comments that were incorporated, not incorporated, or those that require further clarification are addressed below. While the wording of some recovery actions has changed in this document since the August 2004 draft, the numbers and basic concepts of specific actions have not. The wording of recovery actions in the comments below are taken from the August 2004 draft plan.

Comments and USFWS Responses

The set of responses below are in regard to suggested changes to the priority numbers of specific recovery actions found in the Implementation Schedule. The USFWS must assign a priority number of 1, 2, or 3 to each recovery action outlined in recovery plans. Refer to Part III, Implementation Schedule to understand the criteria used to assign priority numbers to recovery actions. Assigning priorities does not imply some recovery actions are of low importance, but they may be deferred while implementing higher priority recovery actions.

- **Comment**: One reviewer suggested changing the priority number of Action 2.3 (Develop a habitat protection and restoration strategy for each watershed occupied by scaleshell) from one to three and Action 2.4 (Carry out cooperative projects using existing programs to protect the species and habitat, restore degraded habitat, and improve surface lands in occupied watersheds) from one to two. The reviewer questioned whether Action 2.3 is practicable within the scope of the plan.

  Response: Actions 2.3 and 2.4 have been given a priority of one because they are necessary actions to prevent extinction or prevent an irreversible decline of the scaleshell in the foreseeable future. The decline of remaining populations is primarily due to threats that cause habitat loss and degradation. If these threats are not alleviated and the species itself is not afforded protection, an irreversible decline or extinction will occur. Therefore, strategic habitat protection and restoration, as well as using existing programs to protect the species, is the central focus of this plan and fundamental part of the recovery strategy. Further, the recovery objectives of this plan cannot be achieved without protection, restoration, and conservation of habitat. Action 2.4 specifically addresses future threats and threats currently affecting scaleshell. Before Action 2.4 is implemented, Action 2.3 is required to focus recovery efforts on the most significant problem areas and address specific threats currently affecting each extant population. Acton 2.3 is within the scope of the plan because it is a prerequisite to Action 2.4. Action 2.3 is not another written plan, but a database that will be used to determine which specific recovery actions are most appropriate to implement at a given site. To improve clarity the wording of Action 2.3 was reworded. Action 2.3 now is referred to as "Develop a strategic recovery implementation database".

- **Comment**: One reviewer stated that the reproductive biology of the scaleshell is already relatively well known, and therefore, the priority of Action 3.1.1 (Conduct research on reproductive biology) should be changed from 1 to 2. Another reviewer stated that, "Accurate life history information is essential for recovering the species."

  Response: The USFWS and species experts believe that critical aspects regarding the biology and life history remain unknown. Much of the biological information known about the scaleshell has been generated by subjective observations in the field rather through formal scientific studies with specific research objectives. More specific data on host use, reproductive season, recruitment patterns, age at sexual maturity, life-time fecundity, and sex ratio of sample populations will provide critical information that will inform and adapt future management and recovery actions as well as inform efforts to utilize existing programs to protect the species.

- **Comment**: One reviewer suggested changing the priority of Action 3.1.3 [Investigate the biology of the symbiotic relationship between scaleshell and confirmed host(s)] from 1 to 3. Another reviewer stated, "The information on drum as hosts for the scaleshell, and the hypothesis that drum may become infected by glochidia while preying on female scaleshell, is intriguing and merits further research. Are drum expanding their range with the construction of reservoirs? If drum prey selectively on female scaleshell, could they be depleting females, and could this be causing a skewed sex ratio and leading to poor recruitment and scaleshell decline?"

  Response: Recovery Action 3.1.3 needs to remain a priority 1 action. Currently, the only known suitable host for the scaleshell is the freshwater drum for which little biological information is available. As previously stated, the successful transfer of mature glochidia to a suitable host constitutes one of the critical events of the life cycle of freshwater mussels. A major bottleneck in recruitment occurs during the parasitic phase, which offers many opportunities for reproduction to fail. Investigating the intricacy of the initial parasite/host interaction leading to glochidial attachment may shed light on what seasonal environmental factors may limit recruitment and what management actions are most needed for the scaleshell and its host. Further, investigating factors (e.g. age of fish, water temperature, genetics) affecting the suitability of drum to serve as hosts could greatly improve propagation efforts.

- **Comment**: One commenter suggested changing the priority of Action 3.2.3 (Further define habitat use and requirements of adults) from 1 to 3. Another reviewer stated that this action is important and more of the budget should be devoted to this area of study.

  Response: The USFWS believes that Action 3.2.3 should remain a priority 1. Most of the information currently available on habitat use for the scaleshell and other freshwater mussels is based on subjective observations by field biologists. Typically, the scaleshell occurs in areas where other mussel species are concentrated. We know several environmental conditions that are common to these areas regarding substrate stability, current velocity during normal flows, substrate composition, etc. However, these same factors also occur in stream reaches without mussels. In other words, many areas appear to provide suitable habitat based on our current knowledge, but do not support mussels. Therefore, there must be unknown factors related to habitat suitability that are vital to scaleshell survival. Until we know the true habitat features responsible for providing the necessary conditions to support the scaleshell, we cannot protect the species from extinction. We agree that more of the budget should be devoted to this action, particularly because of the rarity of the species. The appropriate changes have been made to the implementation schedule.

- **Comment**: Change the priority of Action of 2.8.2 (Identify and investigate methods to prevent the spread of zebra mussels and black carp) from 1 to 2.

  Response: The USFWS believes that Action 2.8.2 should be implemented now to prevent the further spread of zebra mussels spread into portions of the scaleshell's extant range and causing population declines.

- **Comment**: Change the priority of Action of 2.8.4 (Create an emergency response strategy to protect scaleshell populations from zebra mussel and black carp) from 2 to 1.

  Response: The USFWS agrees that Action 2.8.4 may prevent irreversible decline of the species in the event of invasion of zebra mussels or other harmful non-native species into habitat occupied by the scaleshell. This change has been made to the recovery implementation table in Part III above.

- **Comment**: Change the priority of Action of 2.7 (Develop an emergency response strategy for mussel kills and major drought conditions for extant populations) from 1 to 2.

  Response: The USFWS believes that Action 2.7 should remain priority 1. Significant die-offs of the scaleshell have recently been documented in several streams because of drought conditions. Because the species is rare and often found in shallow habitats it is very susceptible to immersion from drought. Identifying significant scaleshell sites with particularly shallow habitat and developing a response strategy for drought is a plausible action that can significantly contribute to recovery of the species by saving individual animals or using them for further research or propagation before they are destroyed.

- **Comment**: Change the priority of Action of 2.6.3 (Determine tolerance to changing stream flow and increasing turbidity and sedimentation) from 2 to 1.

  Response: The USFWS agrees that Action 2.6.3 should have a priority of one because these threats should be better understood so the actions can be taken to alleviate them to prevent further population declines.

- **Comment**: One reviewer stated that Action 2.8.5 (Determine densities and track population trends of the Asian clam at historical and extant scaleshell sites) is not needed unless evidence of competition exists.

  Response: The Asian clam has been known to compete with freshwater mussels for food and space as described in the Reasons for Listing/Current threats section. This action has been given a priority of 3 because not all habitat occupied by the scaleshell is heavily populated with Asian clams. Also, the evaluation of the Asian clam will be done at select historical sites as part of evaluating potential reintroduction sites (Action 5).

- **Comment**: One reviewer stated that the priority of Action of 2.9 (Determine the impact of predators on local populations and, if necessary, implement local predator control measures) should be changed from 2 to 3.

  Response: This Action should remain a priority 2. The thin shell of the scaleshell makes it especially vulnerable to mammalian predators (e.g. muskrats, raccoons, and river otters). The USFWS is aware of several key populations that are located in shallow habitat and thus very accessible to predators. Significant predation of mussels has been observed in these areas, particularly during summer months when water levels are low. We believe that even a small number of resident mammalian predators can do significant damage to these populations in a short period of time. Eliminating some local predators, even temporarily, can have a significant positive effect, particularly if this action is taken in early summer to allow females to infect hosts.

- **Comment** : Change the priority of Action of 6.2 (Develop and distribute a handout on all available land owner cost share incentive programs that could be applied to scaleshell in critical watersheds) from 2 to 3.

  Response: This Action should remain a priority 2. The central focus of this recovery plan is to protect and improve habitat for scaleshell to prevent extinction and recover the species. The USFWS cannot complete this task without outside assistance, particularly from private landowners, as most habitat occurs on private land. This outreach is integral to Action 2.4 (Carry out cooperative projects using existing programs to protect the species and habitat, restore degraded habitat, and improve surface lands in occupied watersheds), which has a priority of 1.

- **Comment**: Change the priority of Action 3.4.1 (Determine genetic differentiation among and within populations) from 3 to 1. Analysis of population genetics should be done in preparation for propagation.

  Response: The USFWS agrees with this comment, and this change was made to the Implementation Schedule.

- **Comment**: Change the priority of Action 3.4.3 (Estimate the number of local and stream populations needed to maintain the species and the optimal geographic distribution for those populations) and Action 3.4.1 (Determine genetic differentiation among and within populations) from 3 to 1. This estimate should be derived at the same time that propagation is pursued.

  Response: The USFWS agrees that these actions should be priority 1 items, and the appropriate changes were made to the Implementation Schedule. Action 3.4.3 will be completed when recovery actions are completed to gather more information on the life history, age and growth, and population dynamics. This will be completed before reintroductions to establish the number of populations needed to achieve the delisting criteria.

- **Comment**: Change the priority of the following actions from 3 to 1: Action 4.1 (Identify suitable reintroduction sites and develop and implement habitat restoration strategies for those areas), Action 4.2 (Map existing threats, habitat conditions, land use, and existing conservation efforts with respect to the location of suitable habitat within each target historical watershed), and Action 5.1 [Develop and implement a reintroduction plan (for historical watersheds)]. Action 4.1 should be identified at the same time that propagation is pursued.

  Response: Action 4.1, 4.2, and 5.1 are actions related to reintroducing scaleshell into historical habitat and are not believed to be actions that will prevent the extinction or irreversible decline of the scaleshell, and therefore, should remain a priority of 3. However, these actions are required to achieve the recovery objectives of this plan and necessary to the full recovery of the species. A propagation plan will be developed for all other propagation of the species as described in Action 2.5.1.

- **Comment**: Change the priority of Action 7.1.1 (Conduct surveys to determine persistence and viability of local populations) from 3 to 1.

  Response: Action 7.1.1 is intended to determine if the recovery criteria outlined in this plan are achieved in order to reclassify the species from endangered to threatened status or for delisting. Therefore, the USFWS does not consider this action to be a priority of 1 because it will not prevent extinction or irreversible decline.

- **Comment**: Several reviewers suggested changing the priority of Action 2.6.1 (Determine tolerance to various contaminants suspected to have adverse affects to scaleshell) from 2 to 1. "Improvements in water quality (i.e. Actions 2.6 and 2.6.1) may have to be realized before the success of releasing propagated mussels (Action 2.5.2) can be monitored, especially given the impact that poor or decreased water quality has had on the scaleshell." Action 2.6.1 "…should run concurrently with, and immediately after completion of, Actions 2.5.1 and 2.5.2. In addition, in order for possible water quality criteria to be effective scaleshell recovery criteria, the link between this recovery criteria and the promulgation of state water quality standards should be described." Other reviewers believed these actions were not a priority or should have a priority of 3.

  Response: The USFWS agrees that Action 2.6.1 should have a priority of 1 instead of 2 and should be implemented concurrently with Actions 2.5.1 and 2.5.2. The appropriate changes have been made to the Implementation Schedule. We also believe that knowledge of the scaleshell's tolerance to various contaminants is needed to inform recovery efforts within watersheds (Actions 2.2, 2.3, 2.4). Contaminants are considered a primary threat to the remaining populations of scaleshell. Knowing ambient exposure conditions of contaminants currently affecting populations is vital to identifying and alleviating this threat to prevent extinction. The ambient exposure data will be mapped with the Geographic Information System database (Action 2.2) so that the source of the contamination can be pinpointed and specific actions taken to reduce the contamination.

- **Comment**: Several reviewers suggested to change the priority of Actions 2.1.1 (Conduct surveys in rivers in which the status of the scaleshell is unknown) and 2.1.2 (Conduct searches for additional populations within the historic range where the species may potentially occur) from 3 to 2 because the recovery criteria could be substantially revised based on rediscovering populations.

  Response: The USFWS agrees with changing the priority of actions 2.1.1 and 2.1.2 from 3 to 2. The discovery of new populations may not lead to the revision of the recovery criteria, but could bring the species closer to meeting the criteria. Further, the discovery of new populations could prevent a significant decline in the species because the new population would be protected and included in the implementation of recovery actions that alleviate threats.

<u>Other Comments on the August 2004 draft plan</u>

- **Comment**: One reviewer suggested including low water crossings to the discussion of examples of specific threats affecting scaleshell in the Meramec Basin. Low water crossings limit fish host movements, which is important for the dispersal of the scaleshell.

  Response: The USFWS agrees that low water crossings should be included as a threat to the scaleshell. The number of low water crossings is undetermined in the Meramec Basin. This threat is also present in streams occupied by the scaleshell outside of the Meramec Basin. Therefore, we have added low water crossings to the discussion of range-wide threats to the scaleshell in the Reason for Listing/Current Threats section.

- **Comment**: Several reviewers felt that the use of the term “watershed” should be defined in the plan to help clarify the use of this word, particularly for understanding the scale needed for recovery at the “watershed” level. Another reviewer requested that the size of the watershed needs to be defined in order to provide clearer guidance on completing habitat protection and restoration strategies.

  Response: A definition of “watershed” as used in this document has been added to the glossary in Appendix II and is defined as the land area that drains water, sediment, and dissolved materials into a stream. Many threats (i.e. non-point source pollution) affecting the scaleshell originate on the land (i.e. watershed), upstream from populations. Therefore, recovery actions are not only required within the stream itself, but also in upstream tributaries and on land that drains into those tributaries. Guidance for completing habitat protection and restoration strategies will be derived through Action 2.2 where threats to scaleshell will be identified upstream of each population. Once these problem areas are identified, the habitat protection and restoration strategy will be tailored to each watershed, as described in Action 2.3, to effectively implement the recovery actions outlined in this plan. The implementation of the restoration plan will narrow the focus of recovery efforts on specific threats or problem areas within a watershed.

- **Comment**: For Action 1.1 (Assemble a scaleshell recovery implementation team), several reviewers suggested, "…we believe the implementation team should be made up of upper level representatives from state and federal agencies, non-government organizations, and private landowner organizations that can facilitate implementation within their agencies and organizations to ensure actions are accomplished on the ground. In addition to an Implementation Team, we also suggest the formation of a Technical Team comprised of biologists from state and federal agencies, universities, non-government organizations and other concerned groups with a diversity of expertise in conservation science. The Technical Team ensures priority actions are based on sound science, develop and review protocols, and methodologies for surveys, monitoring, research, and management guidelines. They would also advise and provide recommendations to the Implementation Team concerning best conservation strategies for implementation. We also support the concept of developing specific Watershed Planning Teams that include the assistance of local landowner groups."

  Response: The USFWS agrees with this approach and intended the Scaleshell Recovery Implementation Team (Action 1.1) to operate exactly as described in the comment above. As stated in the description of Action 1.1, the Scaleshell Recovery Implementation Team, in addition to serving as a technical team, "…will be instrumental in identifying and fostering the diverse partnerships needed to successfully complete recovery objectives for scaleshell". These partnerships will be formed within each watershed where recovery actions will take place, but do not necessarily need to be formed specifically for the scaleshell. In some cases, efforts to recover the scaleshell must mesh with existing conservation programs already underway.

  Comment: In reference to the following statement in the draft plan on page 28, paragraph 4: "Once the recovery requirements are met to downlist…restoration efforts will be expanded to areas of scaleshell's historical range…", the following comment was submitted, "Although we recognize the immediate importance of stabilizing our last remaining known populations, waiting to begin restoration in other part of its range may unnecessarily prolong the species being listed under the ESA. Such delays could hinder long term planning efforts of affected agencies and businesses. Therefore, we recommend that appropriate surveys be conducted in historical ranges as soon as possible (Action 2.1) and if any populations are located, initiate recovery efforts immediately."

Response: Action 2.1 has been given a priority of 2 because this action must be taken to prevent a significant decline of the species. This priority number does not imply that the action is of low importance, but they *may* be deferred while implementing higher recovery actions that must be taken to prevent extinction. Therefore, Action 2.1, as a priority 2 action, can still be carried out in portions of the scaleshell's historical range. In fact, recent surveys have already been conducted within the historical range specifically for the scaleshell (e.g. Schilling and Williams 2002, Minnesota Department of Natural Resources 2004) and for other mussel species. With respect to restoration of habitat, significant efforts are currently underway within the historical range of scaleshell for other federally listed mussel species that require the same or very similar restoration efforts. Some examples include the Mississippi, Illinois, Ohio, Wabash, Cumberland, Tennessee, Clinch, Holston, Duck, St. Francis, and Ouachita rivers. Recovery actions in these streams are improving habitat within the scaleshell's historical range even though these actions may be designated priority 2 or 3. Also, the scaleshell mussel, as an endangered species, further justifies these mussel restoration projects. It is important to note that any restoration effort for the scaleshell should mesh with restoration efforts underway for other federally listed species and other conservation programs for a given stream. Examples of some major stream conservation efforts include: Upper Mississippi River Conservation Committee (http://www.mississippi-river.com/umrcc/), Ohio River Foundation (http://www.ohioriverfdn.org/), The Ohio River Valley Ecosystem Team (http://www.fws.gov/orve/), The Cumberland River Compact (http://www.cumberlandrivercompact.org/), and The Clinch River Environmental Restoration Program (http://research.esd.ornl.gov/CRERP/INDEX.HTM).

- **Comment**: Several reviewers requested adding text that discusses how recovery criteria #1 (page 29 and 30) was determined, regarding the number of populations needed to either downlist to threatened or remove the species from the protection of the ESA.

  Response: The USFWS is required by the ESA to develop objective, measurable recovery criteria for the recovery of species even in the face of limited information needed to develop the criteria. The USFWS used the best available science and professional judgment in determining recovery criteria for the scaleshell. These criteria were also reviewed and accepted by species experts. Specific numbers of stream and local populations needed to reclassify or delist the species were determined by consideration of the number of known extant and historical populations. The four distinct stream populations made up of four local populations are considered to be reasonable and achievable numbers believed to be adequate to downlist the species to threatened status if the remaining recovery criteria are met. Likewise the eight stream populations made up of four local populations are considered a reasonable and achievable numbers believed to be adequate to delist the species if the remaining recovery criteria are met. These numbers can be revised based on future research. Additional text was added to the description of this criterion to better describe the process of updating the criterion based on new information.

- **Comment**: In reference to downlisting and delisting criteria #1 (page 29 and 30) the following comment was received by one reviewer: "We recognize that very little is known about the recovery and delisting requirements of this species and no MVP or PVA studies have been conducted; therefore determining this number is currently not possible. Due to the lack of information, we recommend that specific numbers of recovered populations not be included in delisting criteria and language should be incorporated to state that delisting requirements will be established upon completion of those action items that will provide this necessary information. Although there is language in the document that allows for revision of the recovery plan as new information is provided, experience indicates that revision of recovery plans are often a low priority and lengthy process, and as a result original delisting criteria are often unattainable, and therefore, unmet."

  Response: We recognize that determining the number, size, and viability of stream populations and local populations needed either to reclassify or delist the scaleshell is difficult because the available information to make this determination is limited. However, the USFWS is under a statutory requirement to develop recovery criteria as articulated in the ESA for the recovery of species. The ESA states that each recovery plan shall incorporate, to the maximum extent practicable, "objective, measurable criteria which, when met, would result in a determination…that the species be removed from the list.". Thus, the recovery criteria comprise the standards upon which the judgment or decision to reclassify or delist a species should be based and a target for which recovery by which progress toward achievement of recovery objectives can be measured. Recovery Action 3.4.3 will specifically address updating the number of populations needed for recovery of the species based as new information becomes available for analysis.

- **Comment**: "The delisting criteria requires populations to be distributed throughout its historical range in each of three Mississippi River basin areas. Although we agree that this would be optimum and an excellent conservation objective, we are not certain that re-establishing a population in the Upper Mississippi River basin area, in which no populations have apparently existed for 50 years, is necessary for the long term viability of the scaleshell to maintain itself in perpetuity. If more than 16 populations are stable and viable in the middle and lower Mississippi River basin areas, (the number beyond what is necessary for downlisting) is it necessary to also re-establish them in the upper basin? Unless an existing population is rediscovered there that would enhance genetic diversity, any reintroductions in the upper Mississippi River will rely on genetic stock from the middle Mississippi River, and as such, will not appreciably enhance long term viability of the species. We suggest that delisting criteria, population numbers, and geographic distribution be more flexible so as not to be so strongly associated with specific Mississippi River basin areas, and that the number of populations needed for delisting be based on MVP and PVA data. We also suggest flexibility in the delisting criteria that includes the upper Mississippi River only if an existing population is rediscovered there."

Response: To ensure the long-term sustainability of the scaleshell mussel after it is removed from the list of endangered and threatened species, it is important that stable, reproducing populations exist in geographically distinct areas so that a single stochastic event, such as a chemical spill, disease outbreak, or invasion of zebra mussels, will not affect more than one population resulting in a significant decline. This is especially important because populations of the scaleshell mussel are naturally small, and therefore, are very susceptible to local extirpation from these events leading to local extirpation. Further, several portions of scaleshell's historical range, including the Upper Mississippi River basin and areas east of the Mississippi River, have streams that are prime candidates for reintroduction because of recent, large-scale stream restoration efforts have greatly improved mussel habitat. The scaleshell cannot naturally expand its range into most of these streams because dams pose significant barriers to fish hosts, which is the dispersal mechanism for mussels. Reestablishing populations in these streams would allow the scaleshell to naturally disperse and establish new populations in these regions that otherwise would not be possible. One example is the Duck River in Tennessee where increases in flow and dissolved oxygen from an upstream reservoir and improvements to waste water treatment plants have resulted in significant increases of mussel populations (Ahlstedt *et al.* 2004). The scaleshell could never naturally colonize the Duck River because of several impoundments and dams prevent natural colonization from source populations in other portions of its range.

- **Comment**: In the combined comments from several reviewers, it was noted that the narrative under Action 2.4 (Carry out cooperative projects using existing programs to protect the species and habitat, restore degraded habitat, and improve surface lands in occupied watersheds) alternates between voluntary and regulatory programs. They suggest the text to be more clearly separated and suggested that each of the programs be included as a separate action.

  Response: We agree that voluntary and regulatory programs should be better separated within the narrative of Action 2.4 for clarity, and therefore, the appropriate changes have been made. However, we prefer to include these programs together under the same recovery action to help streamline actions and emphasize the need for both these actions to accomplish the same objectives. For further clarification, we have changed the title of Action 2.4 from "carry out cooperative projects using existing programs to protect the species and habitat, restore degraded habitat, and improve surface lands in occupied watersheds" to "Carry out cooperative regulatory and voluntary projects using existing programs to protect the species and habitat, restore degraded habitat, and improve surface lands in occupied watersheds".

- **Comment**: In combined comments of several reviewers, they suggested that land acquisition be included as a separate action, with a priority of 3, rather than only discussed under Action 2.4 (Carry out cooperative projects using existing programs to protect the species and habitat, restore degraded habitat, and improve surface lands in occupied watersheds). They further stated that Action 2.4 "…is the only place in the document that addresses land acquisition, and it is embedded within a discussion of Section 6 funds. Recently, funds have been made available specifically for land acquisition when it is identified in a recovery plan as an action to achieve recovery. Although land acquisition is not a cost effective mechanism to achieve recovery of this species, due to the need to restore large surface areas, it could still be effective in protecting and managing access to high priority mussel beds that contain the scaleshell."

  Response: The USFWS agrees that land acquisition may be appropriate as a recovery action for the scaleshell in certain situations. However, we feel land acquisition should remain a possible action under Action 2.4 because it involves using existing programs to protect the species and habitat, restore degraded habitat, and improve surface lands. If a land acquisition opportunity arises with willing sellers and that acquisition will significantly protect the species and habitat, restore degraded habitat, or improve surface lands, it will be considered a priority 1 action. We have modified the discussion of Action 2.4 to include the possibility of other land acquisition funding programs other than Section 6 funding under the ESA and describe in more detail under what circumstances land acquisition may be implemented.

- **Comment**: Several reviewers strongly supported the need for Action 6 (Initiate educational and public outreach actions to heighten awareness of the scaleshell as an endangered species and solicit help with recovery actions). In addition to items under Action 6, they suggested, "…adding, prioritizing and estimating funds for a 'human dimensions' survey in each of the targeted watersheds. Before recovery can be prioritized, threats identified, and management implemented in targeted watersheds, it is imperative that the social and economic needs of the people living in the watersheds are known and addressed. Such information will facilitate implementing recovery on the ground and be more cost effective over time."

  Response: The USFWS agrees that there may be a need to evaluate and address the social and economic needs of people living in target watersheds before recovery actions are implemented. We believe this activity falls under Action 2.4 (Carry out cooperative regulatory and voluntary projects using existing programs to protect the species and habitat, restore degraded habitat, and improve surface lands.).

- **Comment**: In combined comments provided by several reviewers they concurred with the need for Actions 3.4.2 (Define what constitutes a viable population of the scaleshell) and 3.4.3 (Estimate the number of local and stream populations needed to maintain the species and the optimal geographic distribution for those populations).

However, they stated the need to identify "species experts" in the following statement found in the narrative of Action 3.4.3: "This number is based on the best professional judgment of species experts".

Response: We agree that this statement needs to be clarified and the necessary changes have been made to the narrative of Action 3.4.3.

- **Comment**: In the combined comments of several reviewers, it was stated that "…there is too little known about this species to develop a recovery plan, as is often the case with many listed species and their recovery plans, and we recognize that FWS must do the best they can with current information." It was recommended that "…the Scaleshell Recovery Plan be a time-limited plan with a defined termination date (i.e 2010) that will require the revision and renewal of the plan based on current information at that time of its termination. Having a termination date will not hinder conservation and recovery efforts, but will help ensure that the recovery plan is relevant and meaningful to recovery in the future."

  Response: The USFWS agrees that updating the plan on a regular basis would ensure that it is relevant and meaningful in the future. However, because the need for plan changes depends on the species and its circumstances and how quickly new information is acquired, the need to update a plan cannot be predicted accurately. Therefore, it is best not to schedule plan changes directly into the recovery plan. However, we recognize the need to have a timeline for review of new information to determine the need to upgrade the plan. Therefore, we have modified the title of Action 7.3 from "Revise or update recovery plan as needed" to "Review new information every 5 years and upgrade the plan as needed". There are three different types of upgrades to approved recovery plans. "Updates" involve relatively minor changes such as changes in the species' status that do not alter the direction of the recovery effort. "Revisions" involve a substantial rewrite of at least a portion of a plan that affects the direction of the recovery effort such as changes to the Recovery Strategy or including new biological information that have significant recovery ramifications. Revisions to recovery plans must include the opportunity for public review. "Addenda" are added to approved recovery plans and can range from implementation strategies to more minor attachments of data. Addendums that represent significant additions to the recovery plan should undergo public review. While major changes require a new draft to be reviewed by the public, minor changes can be tracked in an appendix.

- **Comment**: The word "scaleshell" is a proper noun and should be referred to as "the scaleshell and not "scaleshell".

  Response: This change has been made throughout the document.

- **Comment**: One peer reviewer stated, "There are at least 14 known populations of the species in three states. This number of populations is on the high end of extant populations for most other endangered mussels, such as dwarf wedgemussel and fat pocketbook. Because of this, the current status is borderline threatened versus endangered, without any augmentation or reintroduction. Therefore, reintroduction is a lower priority, verses augmentation or discovery of additional populations."

Response: While there are between 14 and 20 known populations of the scaleshell, this number is misleading because of the small size of these populations. Currently, the only streams the species can be found with any regularity are the Meramec, Bourbeuse, and Gasconade rivers in Missouri. All other populations are based on one or a small number of live or fresh dead specimens that have been found during all past mussel surveys of these streams. The scaleshell was listed as endangered not only because of the limited size of remaining populations but also due to significant range reduction, current threats, and other factors discussed in the final rule to list the scaleshell as endangered (66 FR 51322). Nonetheless, the priority of reintroduction (Action 5) has already been given a lower priority than augmentation (Action 2.5) or discovery of additional populations (Action 2.1.2) in this plan. Augmentation of existing populations has been determined to be a priority 1 action because this action must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future. Discovery of additional populations has been given a priority of 2 because it is an action that may be taken to prevent a significant decline of the species. The reintroduction of scaleshell into portions of its former range is considered a priority 3 action because it necessary to meet recovery objectives.

- **Comment**: One commenter suggested to change the term "local population" to a more common term used in conservation biology such as to either "deme", "subpopulation", or "management unit." Another reviewer requested more clarification in the term because local populations can occur in close proximity and individuals can easily interbreed.

  Response: We have defined the term local population as "an assemblage of individuals that live in the same habitat patch and more or less interact with each other in the course of their routine feeding and breeding activities" as described in Vaughn (1993). We believe that this term best describes the current occurrence of the scaleshell within its extant range, and facilitates management and defining protective recovery criteria. More discussion has been added to the "Recovery Criteria" section to better define and justify the use of this term.

- **Comment**: One reviewer stated that Action 3.4.2 [Define what constitutes a viable population of the scaleshell (including MVP and PVA analyses)] is "…impractical and not quantified. Because PVA is presently ineffective (assumptions violated and untested) for mussel populations, you need to set quantifiable criteria extrapolated from known viable populations of other species, such as percent of population less than age five, evidence of recruitment (age classes less than age five), stable size frequency or age class structure, etc." Another reviewer stated that the scaleshell is too rare to collect the necessary information to determine MVP.

Response: After reviewing the available information on PVA and MVP analyses, particularly for mussel species and consulting PVA and MVP experts, we agree that these analyses may not provide accurate information for the scaleshell. Therefore the Recovery Criteria, Recovery Action, and Implementation schedule have been modified to include the necessary information needed to better determine the population viability of the scaleshell.

- **Comment**: One reviewer disagreed with the concept of specifying four local populations within one stream population in the recovery criteria because "Rare mussels are typically not aggregated in subpopulations [i.e. local populations] but are scattered amongst common species of wider distribution and abundance. In most cases, it is not possible to define demes [i.e. local populations] in extant populations, let alone demes in populations to be augmented or re-established." This reviewer also felt that requiring four local populations within each stream population required in the recovery criteria was not achievable.

  Response: The extant range of the scaleshell indicates that the species does most often naturally occur in relatively isolated patches of suitable habitat where a diversity of other mussel species are concentrated. In some cases, the species may be found in habitat where no or few other species are found. However, this is not normally the case. Recovery of the scaleshell should concentrate on diverse mussel beds that support local populations of the species because these areas are easy to define and the species can be detected if present. Further, concentrating recovery efforts in these areas will benefit other freshwater mussel species. We believe that requiring four local populations within each required stream population is achievable. For example, four geographical distinct stream populations, each made up of four local populations, are required to downlist the scaleshell. There are already two populations meeting these criteria (Meramec and Gasconade rivers). Establishing the scaleshell in two more mussel beds in the Kiamichi River would make three stream populations meeting the criteria. The remaining stream populations have only one site for scaleshell, but if the scaleshell can be established in three mussel beds in one of these streams, then this criterion could be met.

- **Comment**: One reviewer asked if the high cost of recovery estimated for the scaleshell will help or discourage recovery actions for the species.

  Response: The USFWS and other federal government agencies [Section 7(a)(1) of the ESA directs all federal agencies to utilize their authorities in furtherance of the purposes of the ESA by carrying out programs for the conservation of threatened and endangered species] are challenged with the task of recovering our nation's federally listed species as required by the ESA in the face of a budget that is appropriated by Congress. Estimating the recovery costs for a federally listed species in recovery plans will allow willing parties to participate in recovery by being able to show in their own budgets that their funding request is for a recovery action identified in an approved recovery plan and is therefore considered a necessary action for the overall coordinated effort to recover that species. Many of the major recovery actions for the scaleshell (e.g. Action 2.4 Carry out cooperative regulatory and voluntary projects using existing programs to protect the species and habitat, restore degraded habitat, and improve surface lands in occupied watersheds) will also require help from outside organizations, businesses, and citizens. The USFWS strives to find common interests of these private groups to recovery actions needed for federally listed species. The success of the recovery program for the scaleshell will depend upon combining recovery actions for the species with existing watershed restoration efforts, through which the actual cost of recovery of the species is greatly decreased.

- **Comment**: One reviewer suggested integrating the general information provided on freshwater mussels with the specific information known for the scaleshell in the Life History/Ecology section.

  Response: We agree that general information on freshwater mussels should be integrated with that which is known for the scaleshell in the Life History/Ecology section. While this is how the information was presented in the draft plan, there was a paragraph on the general life cycle of freshwater mussels that interrupted the flow of this discussion. We feel it is necessary to include this paragraph on the complex life cycle of freshwater mussels before discussing what is known for the scaleshell. However, we have modified the text to improve the flow and clarity of the discussion.

- **Comment**: One reviewer commented that the actions outlined in this recovery plan for the scaleshell mussel should complement recovery plans for other federally listed mussel species that may occur in the same habitats.

  Response: The USFWS agrees with the above comment. The success of scaleshell's recovery depends on our ability to combine its recovery actions with other restoration efforts. Most freshwater mussel species face the same threats, and thus recovery actions aimed to alleviate those threats are similar. In preparation of this recovery plan, we reviewed many approved recovery plans for other freshwater mussels within the range of the scaleshell. We considered actions outlined in these plans when developing the recovery actions for the scaleshell. In fact, some recovery actions in this plan were taken from other mussel recovery plans.

- **Comment**: One reviewer provided new information of two fresh-dead shells that were found in the Kiamichi River, Oklahoma. One was found in August 2004 and the other was found in July 2000 at two different sites in Pushmataha County.

  Response: These records and other details provided were added to the detailed discussion of scaleshell's historical and current distribution in Appendix I and summarized information in Table 1.

- **Comment**: One reviewer pointed out that the discussions of the Little River in Oklahoma in the Reasons for Listing/Current Threats section (pages 13 and 14) and Appendix I (page 80) are inaccurate and provided updated information on mussel populations in the Little River.

  Response: We have rewritten the discussions of the current status of mussel populations in the Little River according to the information provided.

- **Comment**: One reviewer stated that further delineating the current status and distribution of the scaleshell is essential, but given the small number of populations, GIS mapping is not necessary.

  Response: The objectives of the GIS mapping described in Action 2.2 includes more than just mapping populations. This action will create a database that will also track land use and the locations of threats in watersheds occupied by the scaleshell so recovery actions can focus on problem areas to alleviate those threats. Further, this database will track the location of completed recovery actions and other conservation efforts that benefit the species. This database is important to the recovery and management of scaleshell populations.

- **Comment**: In reference to the downlisting and delisting Recovery Criteria 5 (p. 30 and 31) and Action 2.6.1 (Determine tolerance to various contaminants suspected to have adverse affects to the scaleshell), one reviewer requested the following information: "Describe the mechanism to link recommended water quality criteria developed as recovery criteria for the scaleshell to the promulgation of state water quality standards under the triennial review process. If water quality criteria may be considered recovery criteria in the future, these recovery criteria should then be used as the water quality standard for the parameter in question in the event that the identified recovery criteria are different than existing state water quality standards."

  Response: Action 2.6.1 is intended to generate data that will be used to identify contaminants that pose a threat to the scaleshell and develop a threshold for each. These thresholds will be used to determine where contaminants pose a threat to the species and when it has been alleviated. We did not intend to imply that these thresholds would be developed as an EPA nation-wide standard. Nonetheless, Section 7 of the Endangered Species Act (ESA) could be a mechanism through which water quality data (collected through Action 2.6.1) or water quality criteria developed as criteria to downlist or delist the scaleshell, could potentially be used in the promulgation of state water quality standards. Section 304(a)(1) of the Clean Water Act requires the EPA to develop criteria for water quality that accurately reflects the latest scientific knowledge for the protection of aquatic life. In some states, this task is delegated by EPA to state resource agencies and subject to review and approval by EPA. When the EPA either approves or designates water quality standards, it is considered a federal action and subject to Section 7 of the ESA, which requires action agencies to consult or confer with the USFWS when there is discretionary federal involvement or control over the action, whether apparent (e.g. issuance of a new Federal permit), or less direct (e.g. state operation of a program that retains Federal oversight, such as the National Pollution Discharge Elimination Program). To increase clarity, Recovery Criteria 5 has been included under Recovery Criteria 3, which addresses all threats including water quality criteria.

- **Comment**: One reviewer suggested changing the title of Action 2.6.3 (Determine tolerance to increasing siltation, turbidity, and stream flow) to "Determine tolerance to changes in stream flow and increases in turbidity and sedimentation". The reviewer stated that, "Sedimentation is the more appropriate term since siltation indicates that the impact is solely caused by silt, and not other size classes of sediment. Also, in conjunction with increased rates of sedimentation, decreased stream flows could be observed in some areas. As written, it appears that only increased stream flows would be observed."

  Response: The USFWS agrees and the appropriate changes have been made to the wording and priority of Action 2.6.3.

- **Comment**: In reference to Action 4.1 in the recovery narrative, one commenter suggested that the second sentence read as follows "Historical sites considered for the reintroduction of the scaleshell are likely to be rivers where habitat and water quality conditions have improved since the extirpation of the scaleshell, high quality rivers, or rivers that have high potential for restoration."

  Response: The USFWS agrees with the suggested wording and has made the change to the narrative of Action 4.1.

- **Comment**: One commenter suggested that the implementation schedule, and possibly total costs, for Actions 2.3 (Develop a habitat protection and restoration strategy for each watershed occupied by the scaleshell) and 4.3 (Develop and implement a habitat protection and restoration strategy for each target historical watershed) be modified to allow more time to develop these strategies because it most likely will take longer than two years, depending on the size of the watersheds in question.

  Response: The USFWS agrees with the above comment and changes have been made to the implementation schedule to reflect how this part of recovery implementation will be developed. In this document, the habitat protection and restoration strategy is now referred to as "strategic recovery implementation database" and will serve as a living document to track recovery (see description of Action 2.3). It will be developed within the two year period using the most currently information on each watershed and updated frequently as new information becomes available. The database will be developed according to results of threat analyses conducted as part of Action 2.2 and other available information. This strategic database may include the following categories: population, threats, recovery actions (of this plan) most needed, target areas or specific sites for implementation of recovery actions, thresholds defined to determine when threats are alleviated, completed recovery actions, and documentation of measures taken to protect the species in the future.

- **Comment**: One reviewer suggested that because of the rarity of the scaleshell, at least one year and appropriate cost estimates be added to the Implementation Schedule for Actions 3.1.1 (Conduct research on reproductive biology) and 3.2.3 (Further define habitat use and requirements of adults) to successfully document adult habitat use and requirements.

  Response: The USFWS agrees with the above suggestion and has made the changes to the implementation schedule.

- **Comment**: Part of the Recovery Criteria requires that "…population size and age structure are adequate and populations contain representatives in the 1-3 age class." In reference to this one reviewer stated, "An adequate age structure within a population will include reproducing adults and juveniles, but the range and distribution of cohorts required to maintain a viable population is not well understood. The age at reproductive onset is unknown. It seems as though we are placing a greater emphasis on individuals in the 1-3 age class when we should be emphasizing an even distribution of cohorts, or whatever distribution of cohorts based on life span that is determined to be necessary to maintain a viable population".

  Response: The USFWS agrees with the comment above and reference to the 1-3 age class has been removed from that recovery criteria. This recovery objective will be refined by information gathered in Action 3.4.2 (Research the Population Dynamics of the Scaleshell), which has been added to the plan. Through this action the necessary data will be gathered to determine the appropriate distribution of cohorts is most appropriate for the species. At that time the Recovery Criteria will be modified to include that as a measure to place more emphasis on distribution of cohorts.

- **Comment**: In reference to Recovery Criteria 4, which states, "In streams that might have established zebra mussel populations, they will not be considered a threat to persistent and viable scaleshell populations if their densities have not changed for five consecutive years," one reviewer provided the following comment, "Zebra mussel populations have been documented to fluctuate greatly. While native mussel populations may rebound during zebra mussel population lows, the general trend of native mussel populations has been shown to continue downward over time because native mussel populations are unable to rebound to pre-zebra levels before the next zebra mussel population high. For these reasons, we believe that zebra mussels should remain as a potential threat in infested waters."

Response: The USFWS agrees with the comment above regarding the population dynamics of zebra mussels. This recovery criterion was found to be redundant with Recovery Criteria 3, which addresses threats in a general sense. Therefore, we have removed Recovery Criteria 4 that addressed zebra mussels specifically. Zebra mussels as a future threat will still be analyzed in the recovery process in determining if individual threats have been addressed.

- **Comment**: For recovery actions 2.8.1 to 2.8.5, consider changing references to zebra mussels and black carp to exotic species.

  Response: Changes were made to the wording of these recovery actions in order to be more inclusive for introduced non-native species. Black carp and zebra mussels remain highlighted because of their immediate threat to the scaleshell.

- **Comment**: One reviewer stated, "We have concerns over the feasibility and ability to implement Recovery Action 2.9 [Determine impact of predator populations on local populations and, if necessary, implement local predator control measures]. We recognize that predation at any level on a species that is very rare may have a potential impact on local populations. However, is the species so rare that predation is not likely to occur or that if it does occur that it will be so random and isolated not to impact the population? We can reduce the chance of predation occurring by reducing the number of predators, but at what impact to other local wildlife population dynamics and habitat will occur as a result of predator removal? Short of total eradication of predators (e.g. raccoons, muskrats, and river otters) from a local population, which is unlikely, predation is still a possibility and again poses a potential impact to a local population. Therefore, it seems very difficult to quantify the threat of predation and its significance to the scaleshell."

  Response: While the scaleshell is rare, there are key local populations where the species can be consistently found or is not as rare as other areas of its range. As exemplified in the "Reasons for Listing/Current Threats" section, significant predation by mammals has been observed at some of these sites, particularly during low flows. These are the populations that need to be protected from predation the most and will be the focus of this recovery action, and thus making this action feasible. The scaleshell is probably a preferred mussel species by mammals because it can be easily removed from the substrate. Its small size and thin shell makes it easy to handle and pry or crack open. Further, gravid female scaleshell, which are the most important individuals in a population, have been observed to lie on top of the substrate in June, which makes them easy prey. The purpose of this action is not to eradicate local mammalian populations, but to control predation when it occurs, particularly during low water events, and thus this action will be included in the emergency drought response plans (Action 2.7). It is also believed that a single or few individual mammals can prey heavily on a local population daily. Removing these individuals from certain local areas, thus protecting key populations, can significantly contribute to the recovery of the scaleshell.

- **Comment**: One reviewer felt that a copy of the recovery implementation database under Recovery Action 7.2 (Maintain a database of completed recovery actions) should be provided to each field office of the USFWS where the species occurs annually to aid in recovery tracking.

  Response: We agree with providing a copy of this document to each field office annually and have included wording in the narrative of this action to include this measure as part of this action.

- **Comment**: One reviewer provided recent survey information for the Saline River (a tributary of the Ouachita River) in Cleveland County, Arkansas. A comprehensive survey of this stream has been completed and no scaleshell was found, and therefore, suggested changing the status of the scaleshell listed in Table 1 from unknown to extirpated.

  Response: This information has been incorporated into the plan and the status of the scaleshell changed to extirpated in Table 1 for the Saline River.

- **Comment**: The list of threats in the "Recovery Strategy" section is narrow.

  Response: The reference of threats in the "Recovery Strategy" section is brief because it leads the discussion of the strategy to recover the scaleshell mussel. A complete list of threats is described in detail in the "Reasons for Listing/Current Treats" section.

- **Comment**: Action 7 describes evaluations that will be conducted on a periodic basis. Can the Service be more specific in describing how often these evaluations will take place?

  Response: The USFWS will be conducting evaluations or reviews every five years. Action 7 has been reworded and more detail added to better describe this process.

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