Appendix A.

Status of the Species—Species Accounts

Percidae

SLACKWATER DARTER
Etheostoma boschungi

STATUS:
The slackwater darter was federally listed as threatened on September 9, 1977 (42 FR 45526). Critical habitat was designated for the slackwater darter on September 9, 1977 (42 FR 45526). The *Recovery Plan for the Slackwater Darter* was approved March 8, 1984.

SPECIES DESCRIPTION:
The slackwater darter is a member of the Percidae family. It is a medium-sized darter, reaching between 40-70mm at maturity, and living up to 3 years. The slackwater darter feeds on crustaceans and insects.

REPRODUCTION AND DEVELOPMENT:
Slackwater darters reach sexual maturity at age 2. Spawning occurs in late January to early April at temperatures no less than 14ºC. Spawning sites consist of pastures and woods that have winter seepage water running through vegetation such as Juncus and Elecharis. At these sites the water is usually about 4-8cm deep and flows slowly into an adjacent stream.

RANGE AND POPULATION LEVEL:
The area occupied by the slackwater darter is the Highland Rim of the Nashville Basin. Presently it occupies headwater streams arising from the highlands of Lawrence and Wayne counties, Tennessee. The darter is not known from the Elk River, the largest tributary in the south bend of the Tennessee River. However, the Elk interposes the Buffalo and Flint rivers, two streams where slackwater darters are found. They are also absent from Bear Creek, the largest north-flowing tributary.

HABITAT:
The slackwater darter occurs in two distinctly different, but necessarily adjacent, habitats: non-breeding and breeding habitats. The two distinctly different habitats must be adjacent and the fish must be able to swim from stream to spawning area and vice versa. The species typically inhabits gentle riffles and slackwater areas of small to medium-sized shallow, upland tributary streams no more than 40ft wide and less than 7ft deep (Williams and Robinson 1980).

Breeding sites are usually 30-45cm above the adjacent streams, and therefore depend on heavy rains to raise the stream level and allow the darters access to the sites. Breeding site substrates are characterized by Lee cherty silt loams, Lobelville cherty loam, and Staffell, Bodine and Etowah silt loams. At these sites the water is usually about 4-8cm deep and flows slowly into an adjacent stream.

CRITICAL HABITAT:
In Lauderdale County, Alabama, all permanent and intermittent streams with flowing water from December to June tributary to Cypress Creek and its tributaries upstream from the junction of Burcham Creek, including Burcham Creek, excluding Threet Creek and its tributaries. In Wayne County, Tennessee, all permanent and intermittent streams with flowing water from December to June tributary to Cypress and Middle Cypress Creek drainage.

The Final Rule designating critical habitat did not identify the physical and biological features essential to the conservation of the slackwater darter. These features are presumed to include undisturbed substrate, normal aquatic and riparian vegetation, and water of sufficient depth, flow, temperature and quality (including freedom from excessive pollution) for slackwater darters to carry out normal feeding, breeding, movement and sheltering behaviors.

PAST THREATS:
Slackwater darter populations are affected by any factor that negatively influences their habitat, both breeding and non-breeding habitat. Increased development has caused erosion and draining of areas with shallow groundwater limiting slackwater darter breeding habitat. Farming and cattle are the principal industries surrounding the darter's habitat, which has exposed darter habitat to pesticides, herbicides, fertilizers, and stockyard runoff. Other threats include degradation of surface and groundwater caused by the intrusion of toxins and industrial and domestic wastes from sewage lines and septic tank seepage.

The slackwater darters are also threatened by predation from the green sunfish, *Lepomis cyanellus,* and the pirate perch, *Aphredoderus sayanus*.

CURRENT THREATS:
Past threats remain. Since breeding sites are located above the stream level any factor that limits accessibility to the sites would be detrimental to the darter population. Factors would include those listed under "Past Threats" with the inclusion of a drought.

RELICT DARTER
Etheostoma chienense

STATUS:
The relict darter (*Etheostoma chienense*) was federally listed as endangered on December 27, 1993 (58 FR 68480). Critical habitat has not been designated for the relict darter. The Service issued a *Relict Darter Technical/Agency Draft Recovery Plan* in July 1994. A 5-year review of the relict darter's status was initiated September 21, 2007.

SPECIES DESCRIPTION:
The relict darter is a small-sized percid fish, adults measuring about 35 to 63 mm (1.25-2.5 in) total length and living 3+ years. The relict darter's food habits are unknown. The diets of

related darters consist mainly of aquatic insects and small crustaceans: juveniles feed on copepods, cladocera, ostracods, and chironomids; large adults feed mainly on amphipods, isopods, chironomids, and caddisflies.

REPRODUCTION AND DEVELOPMENT:
The following is based upon information on other species in the Etheostoma squamiceps complex. The relict darter likely spawns between March and June depositing eggs on the underside of submerged objects, frequently sticks or logs. Several females may spawn with a single male and nests may contain as many as 1,500 eggs. Eggs are guarded by the male and incubation periods vary with temperature ranging from about 125 hours to 270 hours.

RANGE AND POPULATION LEVEL:
The relict darter is known only from the Bayou du Chien system in Fulton, Graves and Hickman Counties in western Kentucky. This watershed drains approximately 554 square kilometers (Burr and Warren 1986). Spawning has been recorded in only one Bayou du Chien tributary.

HABITAT:
The relict darter occupies headwaters and creeks in quiet to gently flowing pools, usually over gravel mixed with sand and under or near cover such as fallen tree branches, undercut banks, or overhanging riparian vegetation (Warren and Burr 1991). At sites along the main stem of the Bayou du Chien, the species showed an affinity for undercut banks and adjacent narrow side channels underlain by gravel mixed with sand.

PAST THREATS:
The relict darter has been impacted by channelization and loss of channel sinuousity that supported preferred habitat features such as undercut banks, in-stream cover and riparian vegetation. Channelization and land-use practices dewatered the floodplain and curtailed perennial flow in many small tributaries, further limiting the species habitat.

CURRENT THREATS:
Channel alteration and loss of perennial flows in stream segments remain threats. The species distribution is very restricted and recruitment may be dependent on the integrity of one small tributary in the Bayou du Chien system.

ETOWAH DARTER
Etheostoma etowahae

STATUS:
The Etowah darter (*Etheostoma etowahae*) was federally listed as endangered on December 20, 1994 (59 FR 65505). A recovery plan, *Recovery Plan for the Mobile River Basin*, was completed November 17, 2000. Critical habitat has not been designated for the Etowah darter.

SPECIES DESCRIPTION:

The Etowah darter is a small-sized percid fish, adults being about *45* to *75* mm *(1.75-3.0* in) total length. Its life history is unknown.

REPRODUCTION AND DEVELOPMENT:
The life history is unknown. However, like most darters, the species spawns in spring, and probably lives two to three years.

RANGE AND POPULATION LEVEL:
The Etowah darter is endemic to the Etowah River system in north Georgia. Historically, it may have occurred further downstream in the Etowah River mainstem. However, pre-impoundment (Allatoona Lake) records are not known. The Etowah darter persists in the uppermost Etowah River mainstem and two headwater tributaries, Amicalola and Long Swamp Creeks. The species is known from a total of 19 sites in these streams. Population size at known sites is generally small. However, total population level is not known.

HABITAT:
The Etowah darter occurs in warm and cool, medium to larger creeks and small rivers of moderate to high gradient in swift current areas in riffles with large gravel, cobble, and small boulder substrates.

PAST THREATS:
The primary causes of habitat loss in the Etowah River system result from impoundments, siltation, point source and nonpoint source pollution which includes, but is not limited to, municipal and industrial waste discharges, agricultural runoff from crop monoculture and poultry farms, poultry processing plants, and silvicultural activities. Much non-agricultural and non-silvicultural habitat degradation in the watershed can be attributed to increased urbanization in the Atlanta metropolitan area.

CURRENT THREATS:
Past threats persist. The Etowah darter is threatened by deteriorating water and benthic habitat quality resulting from siltation and other pollutants.

FOUNTAIN DARTER
Etheostoma fonticola

STATUS:
The fountain darter was federally listed as endangered on October 13, 1970 (35 FR 16047). Its recovery plan, *San Marcos and Comal Springs & Associated Aquatic Ecosystems Recovery Plan*, was completed February 14, 1996. Critical habitat was designated for the fountain darter on July 14, 1980 (45 FR 47355).

SPECIES DESCRIPTION:

The Fountain darter is the smallest species of darter, usually reaching less than 25mm (1in.) at maturity. Based on studies of fountain darters from the San Marcos River, the species feeds on small invertebrates. This species has a life span of 1-2years.

REPRODUCTION AND DEVELOPMENT:
Most darters spawn in the spring or early summer, however, fountain darters appear to spawn year-round and after egg deposition no further care is provided to the young (Strawn 1955, 1956). This may be due to the relatively constant temperature of the San Marcos River. Eggs are deposited and attached to moss and algae. Bonner et al. (1998) reported mean egg production (± 1 SD) is 760 (±310) per two breeding pairs during a 33-day period at 23 degrees C, under laboratory conditions.

RANGE AND POPULATION LEVEL
Historically, the fountain darter range included the headwaters of the San Marcos (to the confluence of the Blanco River) and Comal Rivers in Texas. The present distribution of fountain darter in the San Marcos River is from Spring Lake to an area between the San Marcos wastewater treatment plant outfall and the confluence with the Blanco River. The species is also found virtually throughout the Comal River to its confluence with the Guadalupe River.

In 1976 (Schenck and Whiteside), the population was estimated at 103,000, and in 1993 (Linam), it was estimated to be around 46,000, ranging from 15,900-107,700.

HABITAT:
The fountain darter requires undisturbed stream floor habitats including runs, riffles, and pools), a mix of submergent vegetation (algae, mosses, and vascular plants) in part for cover, clear and clean water, a food supply of living organisms, constant water temperatures within the natural and normal river gradients, and most importantly, adequate springflows. In general, the fountain darter prefers vegetated stream-floor habitats with a constant water temperature. The species is usually found in mats of filamentous green algae and moss, and is occasionally found in areas lacking vegetation.

CRITICAL HABITAT:
Critical habitat was designated in Hays County, Texas, and includes Spring Lake and its outflow, the San Marcos River, downstream approximately 0.5 miles below Interstate Highway 35 bridge. Primary constituent elements were not listed in the Final Rule designating critical habitat, but are presumed to include adequate flows, undisturbed substrate, aquatic vegetation including filamentous green algae, and water quality.

PAST THREATS:
Threats that have contributed to this species being listed as Endangered continue today.

CURRENT THREATS:
This species depends on the San Marcos River and on the Edwards Aquifer, which supplies the springs of the river. Springflows depend upon water usage from the entire Edwards Aquifer, and use of groundwater in that region decreases flow of water from the springs. With the anticipated

increase in development, it is estimated that by 2020 the probability of continuous flow from the San Marcos Spring is only 50-75 percent (U.S. Bureau of Reclamation 1972, 1973, 1974). Another estimate assumed full projected development with average hydrologic conditions, concluded that continuous flow from San Marcos Springs will cease around the year 2010 (Klemt *et al*. 1979).

Past threats remain with the inclusion of increased flooding and erosion, pollution, pesticides and herbicides from runoff, effluent discharge from the secondary sewage treatment plant of the City of San Marcos, and competition and predation from exotic species. Another threat is drought and its impact on spring flow. According to the CN BE, there is one discharger permitted to discharge cyanide within the fountain darter's habitat, but their discharge of cyanide, if any, is below the limit of detection.

NIANGUA DARTER
Etheostoma nianguae

STATUS:
The Niangua darter was listed as threatened and critical habitat was designated on June 12, 1985 (50 FR 24649). The Recovery Plan for the Niangua Darter was completed July 17, 1989.

SPECIES DESCRIPTION:
The Niangua darter is a member of the Percidae family. This species can grow up to 4.5 inches (115mm) and live up to 4 years. The Niangua darter's diet includes nymphs of stoneflies and mayflies gleaned from crevices of the stream bottom.

REPRODUCTION AND DEVELOPMENT:
Spawning has been observed in April and May on swift, gravel riffles, in temperatures ranging from 16-25ºC. The female burrows into gravel substrate and the male takes a position above her as the eggs are deposited and fertilized. The number of mature ova averaged 189.8 for four females of age-group I, 387.5 for two females of age-group II. A female of age-group IV had 748 mature eggs. Both sexes achieve sexual maturity at 1 year of age.

RANGE AND POPULATION LEVEL:
Eight populations of this species were identified in 1978 in the following areas: 1) the Manes River population in the Manes River and lower Manes Creek, Osage County; 2) the Big Tavern Creek population in Big Tavern Creek and upper Little Tavern Creek, Barren Fork, and Brushy Fork, Miller County; 3) the Niangua River population in the Niangua River and Greasy Creek, Dallas County; 4) the Little Niangua River population in the Little Niangua River, Starics Creek, Thomas Creek, and Cahoochie Creek, Hickory and Dallas counties; 5) the Little Pomme de Terre River population, Benton County; 6) the Pomme de Terre River population, Greene and Webster counties; 7) the Brush Creek population, St. Clair County; 8) and the North Dry Sac population, Polk County (Pflieger). This comprises approximately 128 miles of stream. Since then, the Niangua darter has been collected in Bear Creek, a tributary of the Sac River in Cedar County, and Panther Creek, a tributary of Brush Creek. This adds about 14 additional miles to the

species' range as well as adding a ninth population (Bear Creek). However, recently, no evidence of this species has been found at the Little Pomme de Terre River, suggesting that this population is extirpated. The Niangua darter presently encompasses approximately 138 miles of stream.

HABITAT:
The species inhabits clear, medium-sized upland creeks draining hilly areas underlain by chert, dolomitic bedrocks. It prefers the margins of shallow pools or "runs" with silt-free gravelly or rocky bottoms.

CRITICAL HABITAT:
Critical habitat is designated in Missouri. In Miller County, it includes Big Tavern Creek and 50 feet along each side of the creek from Highway 52 upstream to Highwav 17. In Dallas County, it includes the Niangua River and 50 feet on each side of the river from county road K upstream to 1 mile beyond county road M to the Webster County line. In Green County, it includes Pomme de Terre River and 5O feet on each side of the river from Highway 65 upstream to the Webster County line. In Cedar and St. Clair Counties, it includes Brush Creek and 50 feet on each side of the creek from 1000 feet upstream of County Road J to the boundary of Sections 54 and 35. Township 36 N. Range 25 W. In Camden, Dallas. and Hickory Counties, it includes the Little Niangua River and 5O feet on each side of the river from 1 mile below (downstream of) Highway 54, Camden County. to county road E, Dallas County.

Primary constituent elements identified at the time of designation included the designated creeks, their substrate, water flow and water quality.

PAST THREATS:
Reservoir construction, stream channelization, accelerated erosion and sedimentation, nutrient enrichment, and introduction of potential predators are threat to the Niangua darter. The construction of the Truman Reservoir at the Little Pomme de Terre River inundated of all of the known distribution of the species causing its extirpation in this area.

CURRENT THREATS:
The Truman Reservoir continues to present a barrier to the movement of the species between habitable tributary streams. Stream channelization projects straighten and widen stream channels and frequently cause increased erosion and siltation. Channelization by landowners is general and pervasive throughout the Niangua darter's range causing sedimentation and pollution. Removal of organic debris, including woody vegetation, along the stream channels cause erosion, which can lead to increased siltation, changes in the character of the stream substrate, elimination of pools, and the alteration of stream flow.

WATERCRESS DARTER
Etheostoma nuchale

STATUS:

The watercress darter was listed as endangered on October 13, 1970 (35 FR 16047). The Watercress Darter Recovery Plan (2nd revision) was completed March 29, 1993. Critical habitat has not been designated for this species.

SPECIES DESCRIPTION:
The watercress darter is a member of the Percidae family. This species can reach just over 5cm (2in) at maturity, and forages on invertebrates, such as aquatic insects, crustaceans, and snails.

REPRODUCTION AND DEVELOPMENT:
Very little information is known about this species. Related darters spawn from late January to late April. However, gravid watercress darter females have been collected from March through July, indicating a longer spawning season than that of other related darters. The extended spawning season may be a result of the relatively constant environmental conditions under which the watercress darter is found (Howell and Caldwell 1965).

RANGE AND POPULATION LEVEL:
The watercress darter is only known to occur in three springs in Jefferson County, Alabama: Glenn Springs at Bessemer (tributary of Halls Creek), located along county highway 20; Thomas' Spring, located on private property a short distance from Glenn Spring at the headwater of Halls Creek; and Roebuck Springs (tributary of Village Creek), located on the lands of the Alabama State Boys School, east Birmingham. All watercress darter habitats are within the Black Warrior River watershed. In Jefferson County, Alabama, a new population has been successfully established by transplanting individuals from Roebuck Springs to Tapawingo Springs (tributary of Turkey Creek).

HABITAT:
Watercress darters prefer the deeper, slow-moving backwater areas of springs that are choked with aquatic vegetation such as watercress (*Nasturtium*), and algae (*Chara* and *Spirogyra*). Such conditions provide shelter, allow for large populations of aquatic insects, crustaceans, and snails which form this darter's diet (Howell and Caldwell 1965), and act as substrate for spawning (Stiles 1986).

PAST THREATS:
The former owner of Thomas' Spring had introduced grass carp to the spring, which eventually removed most of the springs vegetation and reduced the watercress population to a single female darter (Howell 1989). In 1980, the U.S. Fish and Wildlife Service purchased Thomas's Spring and adjacent downstream habitat and established the Watercress Darter National Wildlife Refuge.

CURRENT THREATS:
The very limited distribution of the watercress darter makes it highly vulnerable to threats. The major threat to the decline of the watercress darter is any factor that reduces the quantity and the quality of its habitat. Factors include habitat alteration due to development and urbanization, drainages preventing recharge of springs, potential chemical spills from highway (all naturally

occurring populations are in close proximity to highways), removal of vegetation necessary for spawning and feeding, and siltation.

OKALOOSA DARTER
Etheostoma okaloosae

STATUS:
The Okaloosa darter was listed as endangered on June 4, 1973 (38 FR 14678). Recovery Plan completed October 26, 1998. The Service completed a 5-year review of the Okaloosa darter's status on July 2, 2007, which recommended downlisting to threatened status. No action has been taken on the recommendation at this time.

SPECIES DESCRIPTION:
The Okaloosa darter is a member of the Percidae family, and reaches up to 49mm at maturity. Okaloosa darters feed primarily on fly (Diptera), mayfly (Ephemeropter), and caddis fly larvae (Ogilvie 1980).

REPRODUCTION AND DEVELOPMENT:
Spawning season extends from late March through October, and usually peaks in April. Fecundity is very low - mean mature ova were only 29 (Ogilvie 1980).

RANGE AND POPULATION LEVEL
The species is restricted to six tributary systems of the lower Choctawhatchee Bay drainage, Okaloosa and Walton counties, western Florida. The tributary systems drain two bayous, Boggy Bayou (Toms, Turkey, and Mill creeks) and Rocky Bayou (Swift, Turkey, and Rocky creeks), totaling 90.9 and 151.9 stream miles, respectively. The area of the watershed in which the Okaloosa darter occurs covers about 113,000 acres. Most of this is on Eglin Air Force Base property, but approximately 12,000 acres are in private ownership, which includes the cities of Niceville and Valparaiso. The darter's exact, current population level is unknown, but estimates range form 1,500-10,000 (Yerger 1978).

HABITAT:
Most of the watershed is not on fertile land and the streams are relatively sterile. The water is cool, with temperatures (Fahrenheit) ranging in the mid-70's in the summer months to the upper 40's in the winter. The main source of water is from small springs and watershed runoff. The creek waters are slightly acid, with the pH ranging from 6.2 to 6.7. Total alkalinity and total hardness are low. The streams are fast flowing and the water is generally clear. The bottoms are mostly sand, with detritus collecting in areas along the edges and eddy areas where the currents are deflected. Darter streams are heavily shade over most of their courses with ti-ti, alder, wax myrtle, oak, pine, juniper, and black gum. The shaded floodplains could be an important factor in maintaining optimum water temperatures. The more common aquatic vegetation found are Scirpus, Mayaca, Sparganium, Juncus, Orontium, Nitella, Eleocharis, Turicularia, Potemogeton, Typha, Panicum, and Nuphar.

The species inhabits areas that are typically the margins of flowing stream where detritus, roots mats, and vegetation are present. Okaloosa darters have not been collected in areas where there is no current nor have they been collected in the open, sandy areas in the middle of stream channels.

PAST THREATS:
With its limited range the effects of erosion, water impoundment, and competition with brown darters are the major threats and cause of decline of this species. The introduction of the brown darter in the lower Rocky Bayou system caused the decline in population levels in this area, as well as habitat degradation from activities at the Eglin Air Force Base.

CURRENT THREATS:
Siltation and impoundment continue to impact the species, but the darter species seem to have reached a tenuous balance. Okaloosa darters dominate Boggy Bayou streams and headwater sections of Rocky Bayou streams, while brown darters occupy the lower reached of Rocky Bayou streams. Additional threats include continued urbanization, ground and surface water withdrawal, and vulnerability to catastrophic, hazardous material spills.

DUSKYTAIL DARTER
Etheostoma percnurum

STATUS:
The duskytail darter was listed as endangered on April 27, 1993 (58 FR 25758). The Duskytail Darter Recovery Plan was completed March 30, 1994. A 5-year review was initiated July 28, 2006 (71 FR 42871). The Service approved establishing non-essential experimental populations in Tennessee in the Telico River in 2002 (67 FR 52420) and in the Lower French Broad River and Lower Holston River in 2007 (72 FR 52433).

SPECIES DESCRIPTION:
The duskytail darter is a member of the Percidae family, and reaches up to 64mm at maturity. The duskytail is primarily an insectivore (Layman 1991). The youngest individuals consume microcrustaceans, chironomid larvae, and sometimes large quantities of heptageniid nymphs. Larger individuals are also mainly benthic insectivores, but they generally feed on larger prey items (chironomid larvae, ephemeropteran nymphs, microcrustaceans, and trichopteran larvae) than the young.

REPRODUCTION AND DEVELOPMENT:
Spawning occurs from late April to late June. Prior to the spawning act, the male chooses and cleans a spawning site under a rock. Males may spawn with multiple females and guard the clutch, which may number from 23 to 150 eggs. Duskytail darters can spawn as 1-year-olds. Estimates of spawning frequency ranged from 5-7 clutches per year, and fecundity from 135-189 (Layman 1991). Layman (1984b) found that less than half of the individuals in one population survived to age 2 and that most individuals that survive to spawn as 2-year-olds die shortly after spawning. A very small percentage of the population survived to age 3 (Layman 1984b).

RANGE AND POPULATION LEVEL:
Although likely once more widespread in the upper Tennessee and middle Cumberland River systems, duskytail darters were historically known from six populations: Little River and Abrams Creek, Blount County, Tennessee; Citico Creek, Monroe County, Tennessee; Big South Fork Cumberland River, Scott County, Tennessee, and McCreary County, Kentucky; Copper Creek and the Clinch River (this is one population), Scott County, Virginia; and the South Fork Holston River, Sullivan County, Virginia (Service 1994). The South Fork Holston River population is apparently extirpated (Service 1994). The Little River, Copper Creek/Clinch River, and Big South Fork Cumberland River populations are extant but small and their viability is uncertain (Service 1994). The Citico Creek population is healthy and viable (Shute 2005). The duskytail darter has been reintroduced into Abrams Creek in Tennessee, and there are indications that it is becoming reestablished (Rakes et al. 2005). The Service is attempting to establish non-essential experimental populations in the Telico River, Lower French Broad River, and Lower Holston River, Tennessee. No historical records exist for the fish in the lower French Broad or lower Holston Rivers. However, it is likely that the species once inhabited these waters.

HABITAT:
This small darter inhabits rocky areas in gently flowing shallow pools and runs (deep water areas with moderate to fast current but where the water surface generally remains unbroken, as in riffles) in large creeks and moderately large rivers in the Tennessee and Cumberland River systems.

PAST THREATS:
Duskytail darter populations have been impacted by sport-fish introductions, impoundments, water withdrawals, and urban and agricultural developments.

CURRENT THREATS:
Past threats persist and remaining darter populations are small and isolated.

BAYOU DARTER
Etheostoma rubrum

STATUS:
The Bayou darter was listed as threatened September 25, 1975 (40 FR 44149). The *Bayou Darter Recovery Plan* was completed July 10, 1990. A 5-year review was initiated on September 8, 2006.

SPECIES DESCRIPTION:
The Bayou darter is a member of the Percidae family, under the subgenus *Nothonotus*. This species reaches a maximum length of only about 50mm. The Bayou darters feeds primarily on midges, blackflies, water mites, caddisflies, and mayflies.

REPRODUCTION AND DEVELOPMENT:

Spawning occurs between April and May, or early June during a period of rising water temperatures (22-29ºC or 72-84ºC). Most Bayou darters start spawning after their first year and do not live beyond the age of three. Depending on the size of the female, clutches can range from 20-75 ova. Based on the size classes of ova, a single female likely spawns at least twice per reproductive season.

RANGE AND POPULATION LEVEL:
The Bayou darter is endemic to the Bayou Pierre and the lower reaches of its tributaries: White Oak Creek, Foster Creek, and Turkey Creek in Mississippi.

Population densities of Bayou darter have been monitored from 1986-88 (Ross *et al.* 1989b). The density of E. rubrum differed between Bayou Peirre (2.6 fish per m^2) and Foster Creek (3.4 fish per m^2). Only several estimates were obtained for Turkey Creek (0.6 fish per m^2). No Bayou darter were collected during this period in White Oak Creek although it has been collected in that tributary. Population density did not differ over 3 years.

HABITAT:
The source of Bayou Pierre is a small seep area near Brookhaven, Lincoln County, Mississippi. The portion of the Bayou Pierre serving as habitat for the Bayou darter is a meandering stream with stable gravel riffles or sandstone exposures. The extent and quality of the habitat appears to be related to headcutting. Upstream of the headcutting, very little stream meandering occurs and there is generally a well-developed forest canopy. The upstream distribution of Bayou darter seems to be limited by low water flow during the summer and fall (Ross *et al.* 1989a,b). Downstream of the headcutting area, stream meandering begins, riffles become numerous and the stream's bank widen considerably. It is in this shallow (less than 6 inches deep), meandering section with its riffles and runs and moderate to swift flow that the best Bayou darter habitat occurs (Ross *et al.* 1989b).

PAST THREATS:
The major threat to the Bayou darter is man-induced alteration of its habitat including flood plain/channel modification, petroleum exploration and transportation, and farming and silviculture.

CURRENT THREATS:
Past threats remain.

CHEROKEEE DARTER
Etheostoma scotti

STATUS:
The Cherokee darter was listed as threatened on June 29, 1994 (59 FR 65505). Its recovery plan, the Mobile River Basin Aquatic Ecosystem Recovery Plan, was completed November 20, 2000.

SPECIES DESCRIPTION:

The Cherokee darter is a member of the Percidae family, of the subgenus Ulocentra. This species usually reaches only 40-65mm in length. The Cherokee darter is an obligate benthic species living, foraging, and spawning on the stream bottom.

REPRODUCTION AND DEVELOPMENT:
The life history is unknown. Most darters spawn in the spring, and live two to three years.

RANGE AND POPULATION LEVEL:
The Cherokee darter is now known from approximately 20 small tributary systems of the Etowah River in north Georgia, but healthy populations are known from only a few sites. It is endemic to the Etowah River systems, where it is primarily restricted to stream draining the Piedmont physiographic province, and to a lesser extent, the Blue Ridge physiographic province.

Due to the construction of the Allatoona Dam, Cherokee darter populations are fragmented and isolated. The largest populations of Cherokee darter occur in the northern tributaries upstream of the Allatoona Reservoir. Downstream of the dam, populations are restricted to two tributary systems, the Pumpkinvine and Raccoon creeks in Paulding County.

HABITAT:
Cherokee darters inhabit small to medium size warm-water creeks of moderate gradient, with predominately rocky bottoms. It is usually found in shallow water in sections of reduced current, typically in runs above and below riffles and at the ecotones of riffles and backwaters. The Cherokee darter is associated with large gravel, cobble, and small boulder substrates, and is uncommonly or rarely found over bedrock, fine gravel, or sand. It is most abundant in stream sections with relatively clear water and clean substrates (little silt deposition). The Cherokee darter is intolerant of moderate of heavy siltation and impoundment.

PAST THREATS:
Impoundments, deteriorating water, and benthic habitat quality resulting from siltation, agricultural runoff, other pollutants, poor land use practices, increased urbanization, and waste discharges have resulted in the restriction and fragmentation of the species' current range.

CURRENT THREATS:
Past threats remain. As mentioned before, the Cherokee darter is an obligate benthic species, and thus its well-being is directly related to the quality of its benthic habitat.

MARYLAND DARTER
Etheostoma sellare

STATUS:
The Maryland darter was listed as endangered on March 11, 1967 (32 FR 4001). Critical Habitat was designated August 28, 1984 (49 FR 34228). The Maryland Darter Recovery Plan was completed in 1985.

SPECIES DESCRIPTION:
The Maryland darter is a member of the Percidae family. It can grow up to 75mm, and is extremely rare. This species is carnivorous eating arthropods and mollusks.

REPRODUCTION AND DEVELOPMENT:
The rarity of this species has made it difficult to study and therefore little is known of the specifics of its life history and habitat requirements (Frisbie, C.M. 1983). Most darters spawn in the spring, and live two to three years.

RANGE AND POPULATION LEVEL:
The Maryland darter is endemic to Maryland and was once believed to have been abundant in the lower Susquehanna River basin near Aberdeen and Havre de Grace, Maryland in the Deer Creek, Swan Creek, and Gasheys Run. Its Critical Habitat includes portions of Deer Creek and Gasheys Run, Harford, MD.

The lower portions of Swan Creek are now heavily silted over, and the only known permanent population of the Maryland darter now resides in a short (approx. 25 x 100m) riffle segment of Deer Creek, about a mile upstream from the Creek's junction with the Susquehanna River (Knapp, L.W. 1976; Frisbie, C.M. 1983; USFWS 1985).

HABITAT:
Like other darters, this species prefers rock crevices and similar shelters in clean, well-oxygenated, swiftly flowing parts of streams (Frisbie, C.M. 1983; USFWS 1980a; USFWS 1980b). Deer Creek substrate is composed of rocks, rubble and gravel (USFWS 1985).

PAST THREATS:
The construction of the Susquehanna River Dam significantly reduced the Maryland darters range. The dam impounded much of the species' former habitat and caused extensive siltation. The municipality of Stewartstown, Pennsylvania's sewage treatment plant is permitted by the EPA to release chlorinated wastes in to Ebaugh's Creek, a headwater tributary of Deer Creek. Specific effects sustained by the Maryland darter due to the Stewartstown sewage treatment plant releases have yet to be identified.

CURRENT THREATS:
Past threats remain. Additional threats include pesticides, herbicides, and excessive nutrients from runoff, long-term effect of chloramines, reduced stream flow due to water diversion and use, and the potential for spills and lethal runoff from development.

BLUEMASK DARTER
Etheostoma (*doration*) *sp*.

STATUS:

The bluemask darter was listed as endangered on December 27, 1993 (58 FR 68480). The Recovery Plan for the Bluemask (=Jewel) Darter (*Etheostoma* (*Doration*) sp.) was completed in 1997 (Service 1997). Critical Habitat has not been designated for this species.

SPECIES DESCRIPTION:
The bluemask darter is a member of the Percidae family. It can grow up to 48 millimeters.

REPRODUCTION AND DEVELOPMENT:
There is little published information on the life history and ecology of the bluemask darter (Layman *et al.* 1993, Etnier and Starnes 1993). Most darters spawn in the spring, and live two to three years. Spawning males were collected from the Collins River in April. The closely related *E. stiginaeurn*, which shares an affinity for sand and gravel substrates, spawns in early spring by burying eggs in gravel (Winn 1958).

RANGE AND POPULATION LEVEL:
This small darter is endemic to the Caney Fork River system (above the Great Falls Reservoir), Cumberland River basin, in central Tennessee. The species was historically known from five rivers and is still known from four of these rivers. One population inhabits about 23 stream miles. The other three populations inhabit less than 2.8 stream miles.

HABITAT:
The bluemask darter inhabits slow to moderate current over clean sand and fine gravel at depths of 10 to 50 centimeters (cm); it typically occurs just downstream of riffles or along the margins of pools and runs.). It inhabited the lower free-flowing reaches ofstreams on the Highland Rim (Layman 1991 b), which are characterized by moderate gradient; waters of low to moderate productivity; and substrates of limestone or chert bedrock, coarse chert gravel, and sand (Starnes and Etnier 1986).

The upper reaches of all four streams that support the bluemask darter flow underground during summer, with little to no surface flow. This limits perennial habitat for the species to the lower stream reaches.

PAST THREATS:
The bluemask darter's distribution has been reduced by impoundments, habitat alteration from gravel dredging, water withdrawal, and the general deterioration of water quality resulting from siltation and other pollutants contributed by coal mining, gravel mining, poor land-use practices, and waste discharges.

CURRENT THREATS:
These factors continue to impact the species and its habitat. The species' present limited distribution also makes it vulnerable to extirpation from stochastic events such as chemical spills. Also, the species' preferred habitat (sand and fine gravel substrates) is scarce in many inhabited reaches. All four bluemask darter populations are vulnerable to streambed modifications occurring as a result ofgravel-dredging operations in their upper reaches. Sand and gravel substrates have been removed, eliminating potentially suitable habitat for bluemask darters

during higher flows, including spawning habitat. These reaches, while often dry during the summer, may contain isolated spring-fed pools that are critical to the survival of bluemask darters during low flow periods. The destruction of hydrologic controls, creating summer hold-over pools, could dramatically reduce or eliminate bluemask darter populations.

Because the existing bluemask darter populations inhabit only short stream reaches, they are vulnerable to extirpation from stochastic events, such as accidental toxic chemical spills. The valley along the Collins River is used extensively for commercial plant nurseries; this increases the chances of a toxic agricultural chemical spill and the buildup of contaminants in the stream sediment that could impact this population. Additionally, all existing bluemask darter populations are now isolated by the Great Falls Reservoir. Because the Cane Creek and upper Caney Fork River populations are extremely small and the Great Falls Reservoir presumably restricts gene flow among populations, the long-term genetic viability of all the populations is questionable.

BOULDER DARTER
Etheostoma wapiti

STATUS:
The boulder darter was listed as endangered on September 1, 1988 (53 FR 33996). The Boulder Darter Recovery Plan was completed July 27, 1989. A 5-year review was initiated September 21, 2007.

SPECIES DESCRIPTION:
The boulder darter is a member of the Percidae family of the subgenus *Nothonotus*. This species grows to a maximum of 7.6 centimeters. This species' diet is not exactly known, however, other members of the subgenus *Nothonotus* feed primarily on immature aquatic insects (Stiles 1972). The species is likely a sight feeder and is therefore probably diurnally active.

REPRODUCTION AND DEVELOPMENT:
No life history studies have been conducted on this species. Spawning likely occurs in large boulder/slab rock habitat in areas with moderate to fast current (O'Bara and Etnier 1987; Etnier, personal communication, 1988). In related species, spawning occurs in late May to early August; the eggs are attached to the undersides of rocks, and the males guard the eggs (Stiles 1972).

RANGE AND POPULATION LEVEL:
The boulder darter has historically been collected from the Elk River as far upstream as Fayetteville, Lincoln County, Tennessee, and downstream through Gile County, Tennessee, into Limestone County, Alabama; from two Elk River tributaries, Indian Creek and Richland Creek, Giles County, Tennessee; and from Shoal Creek, Lauderdale County, Alabama (O'Bara and Etnier 1987). Prior to listing, only 50 specimens were collected.

This species is presently known to occur in nine river reaches over about 96 kilometers of the Elk River in Giles and Lincoln Counties, Tennessee, and Limestone County, Alabama, and about 3 kilometers total in two Elk River tributaries (Richland Creek and Indian Creek) in Giles County, Tennessee (O'Bara and Etnier 1987; James Williams and Noel Burkhead).

HABITAT:
No life history studies have been conducted on the fish. However, it has been collected for taxonomic evaluation and status information and observations gathered do shed some light on the species' biology. This species prefers fast-moving water runs over large boulder and slab rock substrate in water over 2 feet deep (O'Bara and Etnier 1987). The fish has not been taken in pool habitats or gravel runs lacking in boulder substrate.

PAST THREATS:
Extirpation from the upper Elk River, Lincoln County, Tennessee, was likely due to the impacts of cold water releases from Tims Ford Reservoir. Loss of the Shoal Creek population was due to flooding of lower Shoal Creek by Wilson Dam and due to pollution from an upstream industrial complex. The water quality in Shoal Creek has been substantially improved, but the boulder darter apparently has not recolonized the creek.

CURRENT THREATS:
Factors such as the present high silt levels of streams in the watershed, potential increased siltation from major land use changes, improper pesticide use, toxic chemical spills, the cold-water releases from Tims Ford Reservoir, and /or uncontrolled mining of phosphate in the watershed, could further threaten the species in the limited number of short river reaches it now occupies.

AMBER DARTER
Percina antesella

STATUS:
The amber darter was listed as endangered and critical habitat was designated on August 5, 1985 (50 FR 31597). The Conasauga Logperch and Amber Darter Recovery Plan was completed December 1985.

SPECIES DESCRIPTION:
Percina antesella is a member of the Percidae family. This species rarely exceeds 63mm. Stomach analysis indicates that this species feeds primarily on invertebrates.

REPRODUCTION AND DEVELOPMENT:
Little information is available on life history. Limited data indicate that spawning may occur from late fall to early spring. Maximum life span may be around 3 years.

RANGE AND POPULATION LEVEL:

This species is currently known only from 33 miles of the Conasauga River in Polk County and Bradley Counties, Tennessee, and Murray and Whitfield Counties, Georgia (Freeman, 1983). The amber darter was once found in Shoal Creek in Cherokee County, Georgia.

HABITAT:
This species requires unpolluted, clean water systems, and is found inhabiting gentle riffle areas over sand, gravel, and cobble substrates. This species has not been observed in slackwater areas over silty substrate with detritus or mud bottoms. Aquatic vegetation is used for both cover and as a food source.

CRITICAL HABITAT:
In Tennessee and Georgia: Conasauga River from the U.S. Route 411 bridge in Polk County, Tennesee, downstream approximately 33.5 miles through Bradley County, Tennessee, and Murray and Whitfield Counties, Georgia, to the Tibbs Bridge Road bridge (Murray County Road 109 and Whitfield County Road 100). Constituent elements include high quality water, riffle areas (free of silt) composed of sand, gravel, and cobble, which becomes vegetated primarily with Podostemum during the summer.

PAST THREATS:
The decline of this species is due to habitat degradation and decreased water quality from siltation. Silt from land clearing for agriculture or other land uses cover the stream substrate, creating an undesirable habitat for amber darters.

CURRENT THREATS:
The threat of agricultural and urban runoff from the development section of the watershed remains. There is also the potential threat of a toxic chemical spill that could eliminate a major portion of the species' population. An additional threat comes from a water supply project being studied for the Conasauga River near Dalton, Georgia. This project, depending on type and extent, could severely impact the species if the biological requirements of these fishes are not considered in the project's development, construction, and operation.

GOLDLINE DARTER
Percina aurolineata

STATUS:
The goldline darter was listed as threatened on April 22, 1992 (57 FR 14786). This species is included in the Recovery Plan for the Mobile River Basin, completed on November 17, 2000.

SPECIES DESCRIPTION:
The goldline darter is a member of the subgenus *Hadropterus*, under the family Percidae. The goldline darter grows to about 75mm. No information regarding feeding preferences is available.

REPRODUCTION AND DEVELOPMENT:

No reproduction and development data is available. Populations appear to be small and localized.

RANGE AND POPULATION LEVEL:
Historically, the darter range included 49 miles of the Cahaba River, almost 7 miles of the Little Cahaba River, and from Schultz Creek, a Cahaba River tributary, in Alabama; Coosawattee and its tributary Talking Rock Creek, Ellijay River and its tributaries Mountaintown and Boardtown Creeks, and the Cartecay River, Georgia. It is suspected that this species once ranged throughout the upper Alabama River drainage of Alabama and Georgia. The upper Coosa River drainage and the Cartecay Rivers are tributaries that form the Coosawattee River.

The goldline darter continues to exist in fragmented populations in the Coosawattee River, Georgia, in about 7 miles of the Little Cahaba River, and in 27 miles of the 49 miles of historic range in the Cahaba River, Alabama (Howell *et al*. 1982, Stiles 1990).

HABITAT:
This species prefers moderate to swift currents and water depths greater than 2 feet. It is found over sand or gravel substrata interspersed among cobble and small boulders.

PAST THREATS:
Historic populations of the goldline darter have been seriously affected by urbanization, sewage pollution, and strip-mining activities in the upper Cahaba River basin. Population decline is due to the loss of habitat from reservoir construction and degradation of water quality, as well as the effects of habitat fragmentation. Losses of vascular plants and an increase in blue-green algae along the Cahaba River since 1962 correlates with the extirpation of the goldline darter in a location just below the Shelby County Highway 52 bridge (Ramsey 1982). An indicator of water quality degradation is an increase in blue-green algae on the rock and rubble substrate (Ramsey 1982).

CURRENT THREATS:
Past threats remain. There are 10 municipal wastewater treatment plants, 35 surface mining areas, one methane coalbed and 67 other permitted discharges in the Cahaba River basin (Alabama Department of Environmental Management *in litt.* 1990). Inorganic nitrogen and phosphorous, from the discharges, accumulate in the basin and can lead to increased algal blooms that can be magnified when water levels and flows are low and temperatures are high.

CONASAUGA LOGPERCH
Percina jenkinsi

STATUS:
The Conasauga logperch was listed as endangered and critical habitat was designated on August 5, 1985 (50 FR 31597). The Conasauga Logperch and Amber Darter Recovery Plan was completed December 1985. A 5-year review was initiated July 26, 2005 (70 FR 43171).

SPECIES DESCRIPTION:
This species is a member of the Percidae family. The Conasauga logperch is a larger darter, sometimes exceeds 6 inches in length. This species feeds on aquatic invertebrates by flipping over stones with its snout (Starnes and Etnier 1980).

REPRODUCTION AND DEVELOPMENT:
No studies regarding life history have been conducted. Available information indicates that spawning occurs in the spring, in fast riffles over gravel substrate. The fish probably reaches sexual maturity after 1 year and has a maximum life span of at least 4 years.

RANGE AND POPULATION LEVEL:
The species is currently known only from the upper Conasauga River basin in Georgia and Tennessee. This species is apparently restricted to about 11 miles of the upper Conasauga River in Tennessee and Georgia. Specifically, it has been observed in the Conasauga River from approximately ¼ mile above the junction of Minnewauga Creek, Polk County, Tennessee, downstream through Bradley County, Tennessee, to the Georgia State Highway 2 Bridge, Murray County.

HABITAT:
This species occurs in flowing pool areas and riffles over clean substrate of rubble, sand, and gravel (Starnes and Etnier, 1980). The Conasauga logperch requires unpolluted, clean water streams.

CRITICAL HABITAT:
In Tennessee and Georgia: the Conasauga River from the confluence of Halfway Branch with the Conasauga River in Polk County, Tennessee, downstream approximately 11 miles to the Georgia State Highway 2 bridge, Murray County, Georgia. Constituent elements include high quality water, pool areas with flowing water and silt free riffles with gravel and rubble substrate, and fast riffle areas and deeper chutes with gravel and small rubble.

PAST THREATS:
Due to the species' limited distribution, any factor that degrades habitat or water quality in these short river reaches could threaten the fish's survival. The major threat to the species has been siltation resulting from land clearing from agriculture or other land uses. Another factor limiting the species' distribution is thought to be the presence of "…the Mobile logperch, occupying the entire upper Coosa system…resulting in the surviving species residing in a very small section of the Conasauga River (Thompson 1985)" (USFWS 1986). Just upstream of Murray County Road 173 Bridge, Murray County, Georgia, an island was removed in 1982 at a site that was inhabited by Conasauga logperch. Six to nine moths after the area was modified, the Conasauga logperch was not seen at the site.

CURRENT THREATS:
The continued existence of the species is jeopardized if water development projects now being considered for the Conasauga River basin are implemented without adequately considering the requirements of these species. Fish species common to reservoirs, including carp, generally

respond to reservoir construction by dramatically increasing their population levels. Periodic upstream movement of these fishes could be expected to reduce the Consasauga logperch's chances of survival through competition, predation, and changes in the habitat caused by some of the fishes' feeding behavior (e.g., carp stirring up the substrate during feeding). Other threats would include siltation and habitat modification from the construction of the projects, and major land use changes, chemical spills, and significant increases in agricultural and urban runoff.

LEOPARD DARTER
Percina pantherina

STATUS:
Listed Threatened with Critical Habitat on January 27, 1978 (43 FR 3711 3716). Recovery Plan completed on May 3, 1993.

SPECIES DESCRIPTION:
The leopard darter is a member of the Percidae family. It grows to approximately 3 inches, and typically lives less than two years, but can live up to 3-4 years. The leopard darter diet includes aquatic insects and microcrustaceans.

REPRODUCTION AND DEVELOPMENT:
Spawning occurs in March and April, but may occur as early as February, when temperatures reach 10-12ºC. Spawning occurs on gravel-bottomed riffles. Eggs are buried in gravel, and the average clutch size is about 65 eggs. The only available data on fecundity are those of Robison (1978) who examined 7 specimens and reported the number of mature ova ranged from 260 to 418, with immature ova from 510 to 2302.

RANGE AND POPULATION LEVEL:
The leopard darter is endemic to streams in the Little River drainage of Oklahoma and Arkansas (Miller and Robinson 1973). Historically, the leopard darter was found throughout most of the upland large stream habitats of the Little River Drainage of Arkansas and Oklahoma.

The present distribution is Little River above Pine Creek Reservoir, Glover Creek, and Mountain Fork above Broken Bow Reservoir. Leopard darters have also been found at two localities below the recently completed Gillham Dam on the Cassatot River.

HABITAT:
The leopard darter prefers swift shoal areas in moderate to large streams. In these streams, it is most frequently found in gravel areas with some sand intermixed. It also occurs along the borders of stream channels. From May to February, this species prefers large, quiet pools with a rubble and boulder substrate.

CRITICAL HABITAT:
Oklahoma: McCurtain and Pushmataha Counties. Little River, main channel in Pushmataha County from mouth of Cloudy Creek (T. 3 S.; R. 20 E.; Section 3) upstream to the Pushmataha-

Le Flore County line. Black Fork Creek in Pushmataha County from its junction with Little River (T.1 S.; R. 20 E.; Section 22) upstream to Oklahoma Highway 144 crossing (T. 1 S.; R. 19 E.; Section 12). Glover Creek, main channel in Pushmataha County from Oklahoma Highway 7 crossing (T. 5 S.; R. 23 E,; Section 28) upstream to the junction of the East Fork and West Fork of Glover Creek. East Fork and West Fork of Glover Creek. East Fork of Glover Creek, main channel in Pushmataha County from its junction with the West Fork Glover Creek (T. 3 S.: R. 23 E.; Section 7) upstream to 4 air miles north-northeast of the community of Bethel (T. 2 S.; R. 24 E.; Section 5). West Fork Glover Creek, main channel in Pushmataha County from its junction with the East Fork Glover Creek upstream to the community of Battiest (T. 2 S.; R. 23 E.; Section 7). Mountain Fork Creek, main channel in McCurtain County, from the mouth of Boktukola Creek (T. 2 S.; R. 25 E.; Section 9), 6 air miles southsouthwest of Smithville, upstream to the Oklahoma-Arkansas State line. Arkansas: Polk County. Mountain ' Fork Creek, main channel from the Arkansas-Oklahoma State line upstream to the community of Mountain Fork (T. 1 S.; R. 32 W.; Section 29). Constituent elements were not identified at the time critical habitat was designated, but is presumed to include the aquatic substrate, flows, and water quality.

PAST THREATS:
Several anthropogenic activities have resulted in the destruction or modification of leopard habitat. Factors include siltation from agricultural operations, commercial gravel operations, industrial and municipal effluents, road construction, and impoundments in the Little River Drainage. Impoundment has had the most detrimental affect on leopard darter populations by eliminating crucial spawning and rearing habitat.

CURRENT THREATS:
Past threats remain.

ROANOKE LOGPERCH
Percina rex

STATUS:
The Roanoke logperch was listed as endangered on August 18, 1989 (54 FR 34468). The Roanoke Logperch Recovery Plan was completed on March 20, 1992. A 5-year review was completed in 2007 and recommended continued classification as endangered.

SPECIES DESCRIPTION:
The Roanoke logperch is a member of the Percidae family. The species can grow up to 14cm, and can live up to 6.5 years. Young Roanoke logperch feed primarily on chironomid larvae, while adults consume mainly caddisfly larvae of the *Hydropsychidae* and chironomids.

REPRODUCTION AND DEVELOPMENT:
Males reach sexual maturity in two years, and most females mature in three (Burkhead and Jenkins 1991). Spawning occurs in April or May at 12-14ºC in deep runs and mature ova (180-640) are buried in gravel and small cobble (Jenkins and Burkhead 1994).

RANGE AND POPULATION LEVEL:
The Roanoke logperch is endemic to two river systems in Virginia-The Roanoke River drainage (including the Pigg and Smith rivers) and the Nottoway River drainage. Its range extends from the Ridge and valley province through the Blue Ridge to the lower Piedmont. It now occurs in four disjunct populations located in widely separated segments of four rivers: the upper Roanoke River, the Pigg River, the Nottoway River and the Smith River. It is probable that these represent remnants of a single much larger population that once occupied much of the Roanoke drainage upstream of the fall line.

Recent survey data (Simonson and Neves 1986) indicate that the largest population of *P. rex* inhabits the Upper Roanoke River. The Pigg River system is rather sparsely inhabited by the logperch, while the Nottoway River has even lower population densities of the species. The Smith River logperch population appears to be extremely small.

HABITAT:
The Roanoke logperch occupies medium to large warm-water streams and rivers of moderate gradient with relatively unsilted substrata. During different phases of life history and season, every major riverine habitat is exploited by the logperch. Except in winter, all age classes are intolerant of moderately to heavily silted substrata (Burkhead 1983).

PAST THREATS:
Factors that have adversely affected the Roanoke logperch in various locations include: turbidity and siltation, chemical spills and organic pollution, channelization, impoundments, and cold-water releases.

CURRENT THREATS:
Continuing development and urbanization in the Roanoke River watershed threatens the population of *P. rex* in the upper Roanoke River. Urban runoff containing silt, oil, fertilizer and a variety of chemical pollutants degrade the species habitat. Chemical spills have occurred resulting in fish kills extending up to six miles or more in logperch habitat. The upper Roanoke River population of the logperch will also be affected by a pending Roanoke County water supply project and a U.S. Army Corps of Engineers flood control project. The Pigg and Smith River populations exhibited low genetic diversity and a relatively high potential for inbreeding depression (George and Mayden 2003).

Most of the rivers supporting the logperch are subject to siltation resulting from agricultural activities and other developments in their watersheds. The Pigg River and the North Fork of the Roanoke, in particular, are impacted by silt generated from agriculture.

SNAIL DARTER
Percina tanasi

STATUS:

The snail darter was listed as endangered on October 9, 1975 (40 FR 47505) and reclassified as threatened on July 5, 1984 (49 FR 27510). The Snail Darter Recovery Plan was completed May 5, 1983. A 5-year review was initiated July 28, 2006 (71 FR 42871).

SPECIES DESCRIPTION:
The snail darter is of the subgenus *Imostoma*, genus *Percina*, under the Percidae family. The species rarely exceeds 85mm in length, and has a lifespan of only one to three years (Starnes 1977). The snail darter feeds primarily on aquatic gastropods (*Anculosa sublobosa*, *Physa* spp., and *Ferrissia*). Clam (*Sphaerium*), insects, and *Ephermeropterans* are also consumed.

REPRODUCTION AND DEVELOPMENT:
Spawning occurs from February through April, peaking in late February. Spawning occurs over the shallowest portions of gravel shoals. Substrates at breeding sites consist of smooth gravel impacted in sand. Water clarity appears to be a factor for successful spawning activity. The average fecundity of the snail darter is about 600 eggs (Starnes 1977).

RANGE AND POPULATION LEVEL:
This species was discovered after impoundments along the main channel of the Tennessee River and its major tributaries were constructed. Although it is impossible to determine the former range of the snail darter, it can be speculated that it was confined to upper portions of the Tennessee River drainage, including the main channel and lower reaches of major tributaries.

The snail darter is presently known from only six Tennessee River tributaries and from the main stem of the Tennessee River near the mouth of three tributaries. Five Tennessee River tributaries (Chickamauga Creek, Hamilton County, Tennessee; Catoosa County, Georgia; Sewee Creek, Meigs County, Tennessee; Sequatchie River, Marion County, Tennessee; and Paint Rock River, Jackson and Madison Counties, Alabama), and the main stem of the Tennessee River near the mouth of two tributaries, South Chickamauga Creek (Nickajack Reservoir, Hamilton County, Tennessee), and Sequatchie River (Guntersville Reservoir, Marion County, Tennessee).

HABITAT:
This species prefers two types of habitat: relatively shallow gravel shoal areas with moderate to swift current; and deep slackwater pools in large streams and rivers.

PAST THREATS:
The major factor limiting snail darter populations is the lack of suitable preferred habitat. Although it is impossible to identify the species' historical range, it can be assumed that the species past threats are the same as its current threats.

CURRENT THREATS:
The primary reason for the present status of the snail darter is simply habitat destruction. The fish inhabits relatively silt free gravel shoals in the larger rivers and streams in the upper Tennessee River drainage (Biggins 1984; Starnes 1977; and Etnier 1984), and requires water clarity for successful reproduction (Starnes 1977). Remaining populations are small and threats

to their continued existence include agricultural development, environmental contamination and pollution, pesticides, channel modification, inundation, and siltation.

Cyprinidae

SPOTFIN CHUB
Erimonax monachus

STATUS:
The spotfin chub was federally listed as threatened throughout its present range in the Tennessee River drainage in the States of North Carolina, Tennessee, and Virginia with Critical Habitat (42 FR 45527). Non-essential experimental populations have been established in Shoal Creek in Tennessee and Alabama (70 FR 17916), portions of French Broad and Holston Rivers, Tennessee (72 FR 52433), and Tellico River, Tennessee (67 FR 52420). The *Spotfin Chub Recovery Plan* was completed on November 21, 1983.

SPECIES DESCRIPTION:
The Spotfin chub is a member of the Cyprinidae family. It has a slightly compressed, elongated body ranging in standard length from about 20mm early in the first year to about 85mm in the third year of growth. Young, juveniles, and adults are benthic insectivores, taking 90% immature midge and blackfly larvae; much of the remainder is mayfly nymphs (Jenkins and Burkhead 1994).

REPRODUCTION AND DEVELOPMENT:
Reproduction is described by Jenkins and Burkhead (1994). Males and females mature in 2 years, though some may spawn at 1 year. The oldest fish detected is age 3. Spotfin chub probably has an extended spawning period, between mid-May to mid-August, based on presence of gravid females and highly colored males. Counts of mature ova numbered 157-791, but may greatly underestimate fecundity if this species spawns fractionally.

RANGE AND POPULATION LEVEL:
Once endemic to the Tennessee River drainage in Alabama, Georgia, North Carolina, Tennessee, and Virginia, the spotfin's range included upland-mountain habitats in 4 physiographic provinces encompassing 12 tributary systems: Blue Ridge, Ridge and Valley, Cuumberland Plateau, and Interior Low Plateau. Presently, it survives in some 166 total km of 4 isolated tributary systems: the Duck, Little Tennessee, Emory, and North Fork of Holston River systems (USFWS 1983).

Non-essential experimental populations have been established in Shoal Creek in Tennessee and Alabama, portions of French Broad and Holston Rivers, Tennessee, and Tellico River, Tennessee.

HABITAT:
Spotfin chub typically occupies warm, usually clear, medium streams to medium rivers of moderate gradient. If favors moderate to swift currents and ranges over gravel to bedrock, rarely

occurring on sand and apparently always avoiding appreciably silted areas (Jenkins and Burkhead 1994).

CRITICAL HABITAT:
In North Carolina, Macon and Swain Counties, the Little Tennessee River main channel from the backwaters of Fontana Lake upstream to the North Carolina-Georgia State Line.
In Tennessee, in Cumberland, Fentress, and Morgan Counties, the Emory and Obed Rivers and Clear and Daddys Creek in Morgan County; and Clear Creek in Fentress County. The Obed River upstream to U.S. Interstate Highway 40, Clear Creek upstream to US Interstate Highway 40, and Daddys Creek upstream to U.S. Highway 127 in Cumberland County. In Tennessee, Hawkins and Sullivan Counties, North Fork Holston, main channel upstream from junction with South Fork Holston River to the Tennessee-Virginia State line. In Virginia, in Scott and Washington Counties; the North Fork Holston River, main channel from the Virginia-Tennessee State line up-Stream through Scott and Washington Counties.

The Final Rule designating critical habitat did not identify the physical and biological features essential to the conservation of the spotfin chub that may require special management considerations or protections. The physical and biological features essential to the spotfin chub include appropriate substrate, freedom from physical barriers to movement, normal aquatic and riparian vegetation, healthy invertebrate community, and water of sufficient depth, flow, temperature and quality (including freedom from excessive pollution) for spotfin chub to carry out normal feeding, breeding, movement and sheltering behaviors.

PAST THREATS:
Past threats include runoff from coal mining operations, municipal and industrial wastes, and siltation, impoundments, channelization, temperature change, possibly overcollecting, and interspecies competition as described by Jenkins and Burkhead (1982).

CURRENT THREATS:
Past threats remain.

BONYTAIL CHUB
Gila elegans

STATUS:
The bonytail chub was federally listed as endangered on April 23, 1980 (45 FR 27710). Critical habitat was designated on March 21, 1994 (59 FR 13374). The *Bonytail Recovery Goals: Amendment and Supplement to the Bonytail Chub Recovery Plan* was completed August 1, 2002.

SPECIES DESCRIPTION:
The bonytail chub is a member of the Cyprinidae family. Bonytail can grow to 22 inches or more and have been known to live nearly 50 years. Young fish in riverine habitats eat primarily chironomid larvae and mayfly nymphs. Small fish become more dependant on floating food as they grow, and juvenile chub eat a more diversified diet, including terrestrial and aquatic insects.

Adult bonytail chub feed on terrestrial insects (Vanicek and Kramer 1969), gasteropods and caddis-worms (Kirsch 1888). The diet of bonytail chub in reservoirs appears to be primarily plankton and algae (Minckley 1973), and may also eat rainbow trout fry less than 2.5 inches (Wagner 1955).

REPRODUCTION AND DEVELOPMENT:
Bonytail are thought to spawn during late June and early July. They are capable of spawning at 5 to 7 years of age. No reproducing populations are known in the wild. Bonytail are being raised in fish hatcheries in Utah and Colorado. In hatcheries, females produce between 1,000 and 17,000 eggs and the survival rate of juveniles is 17-38%. No estimates of survival are available for wild bonytail.

RANGE AND POPULATION LEVEL:
The bonytail chub was historically found throughout the Colorado River basin in the larger turbid rivers. In the past it was collected from the Green River in Wyoming and Utah, Yampa and Gunnison Rivers in Colorado, Colorado River in Arizona, Nevada and California and the Gila and Salt Rivers in Arizona. Although bonytail are long-lived fishes (40+ years), persistent reproductive and recruitment failure have depleted and extirpated wild populations. Recent surveys indicate that it is presently found only in Lake Mohave along the Arizona and Nevada border. It is also being raised in hatcheries in Utah and Colorado.

HABITAT:
Bonytail chub are considered big, or mainstream river species, preferring pools and eddies of warm, often heavily silted, swift moving rivers. However, they do occur in reservoir habitats as well.

CRITICAL HABITAT:
Please see the Final Rule for a description of the physical areas designated critical habitat for the bonytail chub in Colorado, Utah, Arizona, Nevada, and California.

The physical and biological features essential to the spotfin chub include the following. A quantity of water of sufficient quality (i.e., temperature, dissolved oxygen, lack of contaminants, nutrients, turbidity, etc.) that is delivered to a specific location in accordance with a hydrologic regime that is required for the particular life stage for each species; areas of the Colorado River system that are inhabited or potentially habitable by fish for use in spawning, nursery, feeding, and rearing, or corridors between these areas. In addition to river channels, these areas also include bottom lands, side channels, secondary channels, oxbows, backwaters, and other areas in the 100- year flood plain, which when inundated provide spawning, nursery, feeding and rearing habitats, or access to these habitats. Food supply, predation, and competition are important elements of the biological environment and are considered components of this constituent element. Food supply is a function of nutrient supply, productivity, and availability to each life stage of the species. Predation and competition, although considered normal components of this environment, are out of balance due to introduced nonnative fish species in many areas.

PAST THREATS:
Habitat degradation as a result of overgrazing of grassland and riparian vegetation and poor land management practices, depletion of ground water, construction of dams, flow depletions from irrigation and mining, and introduction of nonnative species has led to the decline of the species. Construction of dams in the 1900's transformed much of the mainstem Colorado River and some of its major tributaries into either lacustrine environments, dry riverbeds, or rivers with flow and temperature regimes greatly altered from historic conditions. These changes in habitat are thought to be the major cause of decline in the Lower Basin. Decline in the Upper Basin occurred more recently, and is similarly related to water resource development and associated habitat loss and modification. There is no mention of decline due to water quality degradation.

CURRENT THREATS:
The threat of habitat destruction, resulting from diversion and impoundment of rivers, and competition and predation from exotic fish species still remains.

CAPE FEAR SHINER
Notropis mekistocholas

STATUS:
The Cape Fear shiner was federally listed as endangered with critical habitat on September 25, 1987 (52 FR 36034). The *Cape Fear Shiner Recovery Plan* was completed October 7, 1988.

Note: All descriptions are abstracted and taken from the Federal Register (1987) and the Recovery Plan (1988).

SPECIES DESCRIPTION:
The Cape Fear shiner is a member of the Cyprinidae family and rarely exceeds 2 inches in length. The species lives for 2-3 years in the wild. Its exact diet is unknown, but it is believed to be an herbivore.

REPRODUCTION AND DEVELOPMENT:
No information is available regarding reproduction and development.

RANGE AND POPULATION LEVEL:
This fish has been collected from nine stream reaches in North Carolina (Bear Creek, Rocky River, and Robeson Creek, Chatham County; Fork Creek, Randolph County; Deep River, Moore and Randolph Counties; Deep River, Chatham and Lee Counties; and Cape Fear River, Kenneth Creek, and Parkers Creek, Harnett County. It is currently known from only three small populations in the Cape Fear River drainage in Randolph, Moore, Lee, and Chatham Counties, North Carolina.

HABITAT:

The Cape Fear shiner is generally associated with gravel, cobble, and boulder substrate, and it has been observed inhabiting slow pools, riffles, and slow runs often associated with water willow (*Justicia*) beds.

CRITICAL HABITAT:
The critical habitat designation for the Cape Fear shiner consists of about 17 river miles including: (1) Approximately 4 river miles of the Rocky River in Chatham County, North Carolina; (2) approximately 7 river miles of Bear Creek, Rocky River, and Deep River in Chatham and Lee Counties, North Carolina; and (3) approximately 6 river miles of Fork Creek and Deep River in Randolph and Moore Counties, North Carolina.

The physical and biological features essential to the Cape Fear shiner include stream sections that contain gravel, cobble, and boulder substrates with pools, riffles, and shallow runs for adult fish and slackwater areas with large rock outcrops, side channels, and pools for juveniles; and also provide water of good quality with relatively low silt loads.

PAST THREATS:
The Cape Fear shiner may always have existed in low numbers. Dam construction in the Cape Fear River system has probably had the most serious impact on the species by inundating the species' rocky riverine habitat and altering stream flows. However, its recent reduction in range and its small population size (Pottern and Huish 1985, 1986, 1987) increase the species' vulnerability to a catastrophic event, such as a toxic chemical spill.

CURRENT THREATS:
Potential threats to the species and its habitat could come from such activities as land use changes, chemical spills, road construction, stream channel modification, changes in stream flows from hydroelectric power, impoundments, wastewater discharges, increases in agricultural runoff, and other projects in the watershed, if such activities are not planned and implemented with the species' survival and habitat protection in mind.

COLORADO PIKEMINNOW
Ptychocheilus lucius

STATUS:
The Colorado pikeminnow was federally listed as endangered on March 11, 1967 (32 FR 4001). Colorado pikeminnow critical habitat was designated on March 21, 1993 (59 FR 13374). Non-essential experimental populations have been established in the Salt and Verde River drainages, AZ on July 24, 1985 (50 FR 30188). The *Colorado Pikeminnow Recovery Goals: Amendment and Supplement to the Colorado Squawfish Recovery Plan* was completed August 1, 2002, and is the source for this account.

SPECIES DESCRIPTION:

The Colorado pikeminnow is a member of the Cyprinidae family. Adults attain a maximum size of about 1.8 m total length (TL) and 36 kg in weight. Growth-rate data indicate that large fish (e.g., > 900 mm TL) average 47–55 years old with a minimum age of 34 years.

REPRODUCTION AND DEVELOPMENT:
The Colorado pikeminnow is an obligate warm-water species that requires relatively warm temperatures for spawning, egg incubation, and survival of young. These fish spawn between late June and early September and when they are 5-6 years old and at least 16 inches long. Average fecundity of 24, 9-year old females was 77,400 (range, 57,766–113,341) or 55,533 eggs/kg, and average fecundity of 9 ten-year old females was 66,185 (range, 11,977–91,040) or 45,451 eggs/kg.

Survival and recruitment of Colorado pikeminnow is pulsed, as a strong year class appears and is reflected in the size composition of the population over time. This "storage effect" (Gilpin 1993) enables long-lived populations to maintain themselves despite several years of failed or low reproductive success. Greatest cohort strength in the upper Colorado River (i.e., 1986, 1996) and in the Green River (1986, 1988, 1991; McAda et al. 1998) occurred 1–2 years after high river flows. High to moderate flows rework sediment deposit and this reworking seems to increase larval survival and is linked to strong year classes (Van Steeter and Pitlick 1998; Osmundson 1999). Successful cohorts during high flows may be precluded by delayed warming of the river which causes delayed spawning and age-0 fish that lack size and fat content to survive overwinter.

Studies of overwinter survival show a significant relationship between densities of age-0 fish in fall and spring, suggesting that high spawning success and egg and larval survival by fall (i.e., 3–4 months of age) largely determine cohort strength. Survival rates of adults $550 mm TL from the upper Colorado River ranged from 0.83–0.87, with the best fit at 0.85 (Osmundson et al. 1997). Similar survival rate of 0.81 was calculated by Gilpin (1993) for a population viability analysis of Colorado pikeminnow.

RANGE AND POPULATION LEVEL:
The Colorado pikeminnow is endemic to the Colorado River Basin, where it was once widespread and abundant in warm-water rivers and tributaries. Wild populations of Colorado pikeminnow are found only in the upper basin, and the species currently occupies only about 25% of its historic range basin-wide. Natural reproduction of Colorado pikeminnow is currently known from the Green, Yampa, upper Colorado, Gunnison, and San Juan rivers.

HABITAT:
The Colorado pikeminnow is a long-distance migrator; adults move hundreds of kilometers to and from spawning areas, and require long sections of river with unimpeded passage. Adults require pools, deep runs, and eddy habitats maintained by high spring flows. These high spring flows maintain channel and habitat diversity, flush sediments from spawning areas, rejuvenate food production, form gravel and cobble deposits used for spawning, and rejuvenate backwater nursery habitats. Spawning occurs after spring runoff at water temperatures typically between 18 and 23°C. After hatching and emerging from spawning substrate, larvae drift downstream to

nursery backwaters that are restructured by high spring flows and maintained by relatively stable base flows.

CRITICAL HABITAT:
Please see the Final Rule for a description of the physical areas designated critical habitat for the Colorado pikeminnow in Colorado, Utah, and New Mexico.

The primary constituent elements determined necessary for survival and recovery of the Colorado pikeminnow include, but are not limited to the following elements described below. A quantity of water of sufficient quality (i.e., temperature, dissolved oxygen, lack of contaminants, nutrients, turbidity, etc.) that is delivered to a specific location in accordance with a hydrologic regime that is required for the particular life stage for each species; areas of the Colorado River system that are inhabited or potentially habitable by fish for use in spawning, nursery, feeding, and rearing, or corridors between these areas. In addition to river channels, these areas also include bottom lands, side channels, secondary channels, oxbows, backwaters, and other areas in the 100-year flood plain, which when inundated provide spawning, nursery, feeding and rearing habitats, or access to these habitats. Food supply, predation, and competition are important elements of the biological environment and are considered components of this constituent element. Food supply is a function of nutrient supply, productivity, and availability to each life stage of the species. Predation and competition, although considered normal components of this environment, are out of balance due to introduced nonnative fish species in many areas.

PAST THREATS:
Habitat degradation as a result of overgrazing of grassland and riparian vegetation and poor land management practices, depletion of ground water, construction of dams, flow depletions from irrigation and mining, and introduction of nonnative species has led to the decline of the species. Construction of dams in the 1900's transformed much of the mainstem Colorado River and some of its major tributaries into either lacustrine environments, dry riverbeds, or rivers with flow and temperature regimes greatly altered from historic conditions. These changes in habitat are thought to be the major cause of decline in the Lower Basin. Decline in the Upper Basin occurred more recently, and is similarly related to water resource development and associated habitat loss and modification. There is no mention of decline due to water quality degradation.

CURRENT THREATS:
The threat of habitat destruction, resulting from diversion and impoundment of rivers, and competition and predation from exotic fish species still remains.

Salmonids

BULL TROUT
Salvelinus confluentus

STATUS:

Klamath River and Columbia River distinct population segments of the bull trout were listed as threatened on June 10, 1998 (63 FR 31647). The bull trout was eventually listed as threatened throughout the coterminous United States on November 1, 1999 (64 FR 58909). Critical habitat was designated on September 26, 2005 (70 FR 56211). Recovery Plans have been drafted for a majority of the bull trout recovery units (Service 2002; Service 2004). A 5-year review was initiated on April 13, 2004 (69 FR 19449).

SPECIES DESCRIPTION:
The bull trout is a member of the Salmonidae family. Resident bull trout range up to 10 inches long and migratory forms may range up to 35 inches and up to 32 pounds. Resident and juvenile bull trout prey on invertebrates and small fish. Adult migratory bull trout primarily eat fish.

REPRODUCTION AND DEVELOPMENT:
Bull trout typically spawn from August to November during periods of decreasing water temperatures. However, migratory bull trout frequently begin spawning migrations as early as April, and have been known to move upstream as far as 250 kilometers (km) (155 miles (mi)) to spawning grounds (Fraley and Shepard 1989). Preferred spawning habitat generally consists of low gradient stream reaches often found in high gradient streams that have loose, clean gravel (Fraley and Shepard 1989) and water temperatures of 5 to 9° C (41 to 48° F) in late summer to early fall (Goetz 1989). Depending on water temperature, incubation is normally 100 to 145 days (Pratt 1992), and after hatching, juveniles remain in the substrate. Time from egg deposition to emergence may surpass 200 days. Fry normally emerge from early April through May depending upon water temperatures and increasing stream flows (Pratt 1992; Ratliff and Howell 1992). Bull trout normally reach sexual maturity in 4 to 7 years and can live 12 or more years.

RANGE AND POPULATION LEVEL:
Bull trout (*Salvelinus confluentus*, family Salmonidae) are char native to the Pacific Northwest and western Canada. The historical range of bull trout includes major river basins in the Pacific Northwest at about 41 to 60 degrees North latitude, from the southern limits in the McCloud River in northern California and the Jarbidge River in Nevada to the headwaters of the Yukon River in the Northwest Territories, Canada (Cavender 1978; Bond 1992). To the west, bull trout range includes Puget Sound, various coastal rivers of British Columbia, Canada, and southeast Alaska (Bond 1992). Bull trout occur in portions of the Columbia River and tributaries within the basin, including its headwaters in Montana and Canada. Bull trout also occur in the Klamath River basin of south-central Oregon. East of the Continental Divide, bull trout are found in the headwaters of the Saskatchewan River in Alberta and Montana and in the MacKenzie River system in Alberta and British Columbia, Canada, (Cavender 1978; Brewin and Brewin 1997).

Although bull trout are presently widespread within their historical range in the coterminous United States, they have declined in overall distribution and abundance during the last century. For example, bull trout have been extirpated in the McCloud River basin, California, as well as locally in tributaries of other river basins.

Though wide ranging in parts of Oregon, Washington, Idaho and Montana, bull trout have exhibited declining population trends rangewide and several local extirpations have been reported, beginning in the 1950's.

HABITAT:
Compared to other salmonids, bull trout have more specific habitat requirements that appear to influence their distribution and abundance. They need cold water to survive, so they are seldom found in waters where temperatures exceed 59-64 degrees (F). They also require stable stream channels, clean spawning and rearing gravel, complex and diverse cover, and unblocked migratory corridors. Watson and Hillman (1997) concluded that watersheds must have specific physical characteristics to provide the habitat requirements necessary for bull trout to successfully spawn and rear and that these specific characteristics are not necessarily present throughout these watersheds. Bull trout exhibit a patchy distribution, even in pristine habitats (Rieman and McIntyre 1993). Resident bull trout spend their entire lives in the same stream/creek. Migratory bull trout move to larger bodies of water to rear young and then migrate back to smaller waters to reproduce. An anadromous form of bull trout also exists in the Coastal-Puget Sound population, which spawns in rivers and streams but rears young in the ocean.

CRITICAL HABITAT:
We designated critical habitat in 20 units, including bull trout habitat in Idaho, Montana, Oregon, and Washington. Lands adjacent to designated critical habitat are under private, local government, State, Tribal, and Federal ownership.

Within the designated critical habitat areas, the primary constituent elements (PCEs) for bull trout are those habitat components that are essential for the primary biological needs of foraging, reproducing, rearing of young, dispersal, genetic exchange, or sheltering. Note that only the PCEs described in paragraphs (e)(3)(i), (vi), (vii), and (viii) apply to marine nearshore waters identified as critical habitat. The PCEs are as follows: (i) Water temperatures that support bull trout use. Bull trout have been documented in streams with temperatures from 32 to 72 °F (0 to 22°C) but are found more frequently in temperatures ranging from 36 to 59 °F (2 to 15 °C). These temperature ranges may vary depending on bull trout lifehistory stage and form, geography, elevation, diurnal and seasonal variation, shade, such as that provided by riparian habitat, and local groundwater influence. Stream reaches with temperatures that preclude bull trout use are specifically excluded from designation; (ii) Complex stream channels with features such as woody debris, side channels, pools, and undercut banks to provide a variety of depths, velocities, and instream structures; (iii) Substrates of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. This should include a minimal amount of fine substrate less than 0.25 inch (0.63 centimeter) in diameter; (iv) A natural hydrograph, including peak, high, low, and base flows within historic ranges or, if regulated, currently operate under a biological opinion that addresses bull trout, or a hydrograph that demonstrates the ability to support bull trout populations by minimizing daily and day-to-day fluctuations and minimizing departures from the natural cycle of flow levels corresponding with seasonal variation: This rule finds that reservoirs currently operating under a biological opinion that addresses bull trout provides management for PCEs as currently operated; (v) Springs, seeps, groundwater sources, and subsurface water to

contribute to water quality and quantity as a cold water source; (vi) Migratory corridors with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and foraging habitats, including intermittent or seasonal barriers induced by high water temperatures or low flows; (vii) An abundant food base including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish; and (viii) Permanent water of sufficient quantity and quality such that normal reproduction, growth, and survival are not inhibited.

PAST THREATS:
As cited in the recovery plans, declines resulted largely from habitat degradation and fragmentation, blockage of migratory corridors, poor water quality, past fisheries management practices, and the introduction of nonnative species. These factors resulted in the reduction or elimination of migratory bull trout. Retaining migratory forms of bull trout in a population is important because these forms allow fish access to more resources (*i.e.*, food and habitat), opportunities for genetic exchange, and the ability to recolonize habitats after local extirpations (*e.g.*, by a watershed-wide disturbance affecting all bull trout in a resident population).

Habitat alteration, primarily through the construction of impoundments, dams, and water diversions that create unsuitable conditions, has fragmented habitats, eliminated migratory corridors, and isolated bull trout often in the headwaters of tributaries.

CURRENT THREATS:
Threats to bull trout in the coterminous United States fall into several categories including habitat isolation, loss or blockage of migratory corridors, poor water quality, and the introduction of nonnative species (63 FR 31647, 64 FR 17110, 64 FR 58910).

APACHE TROUT
Oncorhynchus apache

STATUS:
The Apache trout was listed as endangered on March 11, 1967 (32 FR 4001) and downlisted to threatened on July 16, 1975 (40 FR 29863). The Draft Revised Recovery Plan for the Apache Trout was noticed on July 27, 2007 (72 FR 41350). Critical habitat has not been designated for the Apache trout.

SPECIES DESCRIPTION:
The Apache trout is a member of the Salmonidae family. The Apache trout is a largely opportunistic feeder that eats a variety of aquatic and terrestrial organisms, the utilization of which can vary with the season and fish size.

REPRODUCTION AND DEVELOPMENT:
Trout spawning in White Mountain streams occurs from March through mid-June, and varies with stream elevation. Apache trout begin redd construction and associated spawning during

receding flows in the spring, at approximately 8°C (USFWS 2007). Spawning maturation is estimated to begin at 3 years of age, with eggs hatching in approximately 30 days, and emergence occurring about 60 days after deposition (USFWS 2007). Apache trout fry were 20-22 mm TL upon emergence, growing to between 31-51 mm TL by the first annulus.

RANGE AND POPULATION LEVEL:
Apache trout historically inhabited approximately 1,320 km (820 miles) of streams in east central Arizona's White Mountains above 1,800 meters (6,000 feet) elevation in the upper White and Black rivers and Little Colorado River basins. Currently, 25 pure Apache trout populations exist within historic range in Gila, Apache, and Greenlee counties of Arizona, on lands of the Fort Apache Indian Reservation and Apache-Sitgreaves National Forest. Also, several populations were introduced beyond what is now considered the species' historic range. Population estimates for Apache trout are widely variable and dependent upon stream size/length, habitat quality, stream discharge, species assemblage, food availability, and other natural environmental fluctuations.

HABITAT:
Apache trout currently exist mainly in headwater areas upstream from natural and artificial barriers. This environment is subject to extreme variations in both temperature and flow. Apache trout occur in small, cold, high-gradient streams flowing through conifer forests with substrates consisting of boulders, rocks, gravel, and sand.

PAST THREATS:
Watershed alterations related primarily to forestry, livestock grazing, reservoir construction, agriculture, road construction, and mining have been identified as causes for reduction of Apache trout habitat in the White Mountains of Arizona (USFWS 2007). In addition, introductions of non-native trout [i.e., brook (*Salvelinus fontinalis*) and brown trout (*Salmo trutta*)] have led to competition for resources and predation, or hybridization with congeneric rainbow trout or cutthroat trout.

CURRENT THREATS:
Competition, predation, and hybridization continue to threaten the Apache trout. Other major threats include loss of habitat.

GILA TROUT
Oncorhynchus gilae

STATUS:
The gila trout was listed as endangered on March 11, 1967 (32 FR 4001). The Gila Trout Recovery Plan was completed on December 8, 1993. Critical habitat has not been designated for the gila trout.

SPECIES DESCRIPTION:

The Gila trout is a member of the Salmonidae family. Trout are opportunistic feeders, feeding on adult dipterans, trichopteran larvae, ephermeropteran nymphs, and aquatic coleopterans. The species typically reaches between 14 and 20 inches in length.

REPRODUCTION AND DEVELOPMENT:
Spawning occurs from early April through June, when water temperatures reach about 8°C. Nests (redds) are 3-4cm deep in fine gravel and coarse sand (0.2-3.8cm) substrate. Growth depends not only on food supply, but also on inter- and intraspecific competition, water temperature, length of growing season, and physical habitat characteristics. Females reach maturity at age 2 to age 4, with a minimum length of about 130 mm (5 in) reported for mature fish. However, most individuals are mature at a length of 150 mm (6 in) or greater. Males mature around age 2 to 3. Fecundity is dependent upon body size and condition. Gila trout had an average of 2.54 to 3.33 ova per gram of body weight in Main Diamond and McKnight Creek, respectively. Brown et al. (2001) reported individual fecundity of about 62 for Gila trout 100 to 150 mm total length and 197 for Gila trout greater than 150 mm total length. Most adult Gila trout live to about age 5 (Turner, 1986), with a maximum age of 9 reported by Nankervis (1988). Thus, the majority of adult female Gila trout only spawn twice before dying and most adult males only spawn three or four times before dying. Mean survival rates for life stages of Gila trout range from 0.128 to 0.497 (Table 3; Brown et al., 2001). Survival rate is defined as the proportion of individuals of age x that survive to age $x + 1$ (Ricklefs, 1990:296-297).

Table 3. Life-stage specific survival rates for Gila trout (from Brown et al., 2001).

Life Stage	**Total Length**	**Survival Rate (mean ± one standard deviation)**
Juvenile	<100 mm (<4 in)	0.497 ± 0.445
Subadult	100 to 150 mm (4 to 6 in)	0.128 ± 0.063
Adult	>150 mm (>6 in)	0.430 ± 0.068

On the average, for every 100 eggs that hatch about half will survive to the juvenile life stage. Of those approximately 50 fish, only about six will survive to the subadult stage and of those six subadults, only two will survive to the adult life stage.

RANGE AND POPULATION LEVEL:
Gila trout were historically the only native trout in the headwaters of the Gila River drainage, New Mexico. The species probably inhabited the Gila River and most of its tributaries upstream from the confluence of Mogollon Creek and the Gila River, and possibly the San Francisco drainage in Arizona, and the Verde and Agua Fria drainages in Arizona (Minckley 1973, Behnke and Zarn 1976).

By 1950, the range of Gila trout had severely decline to small, isolated headwater streams (Sublette *et al*. 1990, Propst *et al*. 1992). Presently, the range has expanded due to relocation and stocking. Only five historical populations exist, the Main Diamond, South Diamond, McKenna, Spruce, and Iron creeks. All reintroduced populations are within the presumed historic range of Gila trout except the McKnight Creek population, which is in the Mimbres River drainage and outside the presumed native range of Gila trout. Hybridized populations of Gila and rainbow trout exist in tributaries of the Gila River in Black, Sycamore, Langstroth, Miller Spring and Trail Canyons, and upper Mogollon, upper Turkey, and West Fork Mogollon Creeks. Through stream renovation and reintroduction twelve secure populations presently exits, including five indigenous and seven reintroduced populations. The total population was estimated to be less than 10,000.

POPULATION DYNAMICS:

Regulation of population size and dynamics of populations of Gila trout are not well understood. Inferences about factors that control population size have been made from analysis of time-series data (Turner and McHenry, 1985; Turner, 1989; Propst and Stefferud, 1997). Density-independent factors, namely hydrologic variability, appear to be most important in regulating population size of Gila trout in many of the streams occupied by the species (e.g., McHenry, 1986; Turner, 1989; Brown et al., 2001).

However, density-dependent regulation in the form of competition for space (i.e., territoriality) was suggested as a factor contributing to controlling population size in Main Diamond Creek before that population was extirpated by a stand-replacing forest fire in 1989 (Nankervis, 1988).

The changes in density of Gila trout in McKnight Creek since its establishment provide an example of a population that appears to be regulated primarily by the hydrologic regime, which acts as a major influence on mortality rate. In November 1970, 307 Gila trout were transplanted from Main Diamond Creek to McKnight Creek. The population declined to about 20 fish in 1971, concurrent with a period of low total annual stream discharge (Figure 4A, water years 1969 to 1971). An additional 110 Gila trout were translocated from Main Diamond Creek to McKnight Creek in April 1972 and the population size increased substantially from 1974 to 1976 (Mello and Turner, 1980). The population remained relatively stable from 1977 to 1984 (Turner and McHenry, 1985:47). Flood flows occurred in December 1984 that dramatically reduced the number of age I fish (Turner, 1989:10; Figure 5A). The population of Gila trout then expanded and stabilized following the 1984 flood. Flooding occurred again in August 1988. The 1988 year class was eliminated and the abundance of all other size classes was reduced (Turner, 1989:11; Figure 5A). The population recovered from the 1988 flood impacts by 1992 (Propst and Stefferud, 1997; Figure 5B). The relatively high, consistent flows in 1993 (Figure 4B) resulted in a strong year class and an increase in age I Gila trout in 1994 (Figure 5B).

Fragmentation of the historical distribution of Gila trout has resulted in several populations confined to small, isolated habitats. These remnant populations characteristically have high densities during relatively stable flow periods (Platts and McHenry, 1988). The overall importance of environmental factors, specifically quantity and variability of stream discharge, in

determining persistence of Gila trout populations is evidenced by the effects of fire, flood, and low flow on population size and density of this species. The elimination of the Gila trout population in Main Diamond Creek and extreme reduction of population size in South Diamond Creek following the Divide Fire and subsequent flooding provide a vivid example. Several investigators have indicated the importance of stream discharge in the population dynamics of Gila trout (Regan, 1964; Mello and Turner, 1980; McHenry, 1986; Turner, 1989; Propst and Stefferud, 1997).

Catastrophic events have a much larger influence on the viability of Gila trout populations than do population size, fecundity, or population structure (Brown et al., 2001). High-intensity fires, mainly in the ponderosa pine forest type, have resulted in the extirpation of several populations of Gila trout (Propst et al., 1992). Such stand replacing, high-intensity crown fires in the ponderosa pine forest type were nonexistent before European settlement of the American Southwest (Swetnam, 1990). Reduction of herbaceous vegetation through widespread, intensive livestock grazing since ca. 1900, coupled with decades of fire suppression resulted in radical changes in forest stand structure and fuel loading (Covington and Moore, 1994) Extirpation of fishes from streams following intense forest fires has been documented in other locations in the Southwest and elsewhere in the United States (Hanson, 1971; Novak, 1988; Rinne, 1996; Rieman and Clayton, 1997).

The risk of extinction of Gila trout was also found to be closely related to the number of extant populations. Increasing the number of populations by 11 significantly reduced the probability of extinction from 36% to 12%. The Spruce Creek lineage, which represents the native San Francisco River trout, is at higher risk of extinction than the Gila River lineages due to the small number of populations. Increasing the number of populations in the San Francisco River basin by six reduces the risk of extinction from 81% to 44%. The population viability analysis conducted by Brown et al. (2001) was based on the number of extant populations in 1997 and thus may overestimate risk compared to existing conditions.

Spatial factors have a large influence on population persistence. Habitat complexity and diversity on a spatial scale play an important role in the persistence of salmonid populations subject to catastrophic disturbances such as large, intense forest fires (Rieman and Clayton, 1997). Refuge areas to which fish can disperse and recolonize depopulated reaches are critical to determining the resilience of a population following a catastrophic event. Such refugia are provided when an entire drainage network, consisting of well-dispersed, perennial mainstem and tributary habitats, is inhabited by the population. Propst and Stefferud (1997) found a positive correlation between density of Gila trout and drainage density, which reinforces the importance of spatial habitat complexity on persistence of populations.

Although Brown et al. (2001) found persistence of Gila trout populations to be relatively insensitive to population size, other studies have indicated that small populations (i.e., less than 2,500 individuals, yielding an effective population size [Ne] of less than 500) are subject to increased risk of extinction (Fritz, 1979; Franklin, 1980; Stacey and Taper, 1992; Allendorf et al., 1997). For inland cutthroat trout, Hilderbrand and Kershner (2000) calculated that at least 8.3 km (5.2 mi) of stream length was required to support a population of 2,500 in streams with high

abundance (0.3 trout/m [98.4 trout/100 ft]) and no losses. In situations where trout occurred at low abundance (0.1 trout/m [32.8 trout/100 ft]), at least 25 km (15.5 mi) of stream was required to maintain a population size of 2,500. Hilderbrand and Kershner (2000) concluded that restoration of native trouts to small, isolated segments of headwater streams may result in insufficient space to maintain a population that will persist over the long term. A watershed-level approach with first attention to protection of populations inhabiting long, connected stream reaches was advocated. Within the range of Gila trout, continuous stream segments over 8.3 km (5.2 mi) in length, which provide suitable habitat for salmonids, are rare. Gila trout apparently have persisted in small, isolated stream segments above natural barriers for long periods of time. The resilience of populations following dramatic reductions in population size is a notable characteristic of the population dynamics of the species (Propst and Stefferud, 1997). However, repatriation of the species to connected drainage networks (i.e., a watershed-level approach) would provide spatial diversity and increase population sizes, which in turn would reduce the probability of extinction over the long-term.

HABITAT:
Gila trout habitat currently consists of small headwater streams with limited pool availability and generally low base flows. Substrate composition in Gila trout streams varies with discharge.

PAST THREATS:
The decline of the species is attributed to competition and predation by the brown trout, and hybridization with rainbow trout, as well as changes in stream conditions and habitat loss (Miller 1950). Habitat destruction and loss is due to timber harvesting, mining, cattle grazing, and other watershed disturbances. Other threats to the species include drought, flooding, and fire. These threats have caused erosion and sedimentation, have lowered or increased water levels, and increased water temperatures, which have in the past killed fish and fauna and have rendered spawning habitats unsuitable.

In 1989, the original Main Diamond population was eliminated after the Divide Fire. The fire resulted in increased runoff, erosion, and sedimentation, which destabilized the watershed and stream channel, and adversely affected the water quality. Following the fire, hail and rainstorms washed large amounts of ash and sediment into the stream, which resulted in erratic flows that scoured channel banks and eliminated suitable habitat. However, during the fire, 566 Gila trout were removed to Mescalero Nation Fish Hatchery, and following the events the population was reestablished.

CURRENT THREATS:
Past threats persist. The genetic integrity of the species is also a concern since populations are fragmented and isolated, and hybridization is still occurring. Although there is no mention of chemical pollution as a possible threat to the species in the recovery plan, exposure should be of concern since populations are small, fragmented, and isolated.

LAHONTAN CUTTHROAT TROUT
Oncorhynchus clarkii henshawi

STATUS:
Listed Endangered on October 13, 1970 (35 FR 16047 16048), reclassified as Threatened (40 FR 29863 29864). The Lahontan Cutthroat Trout Recovery Plan was approved on January 30, 1995. Critical habitat has not been designated for the Lahontan cutthroat trout.

SPECIES DESCRIPTION:
The Lahontan cutthroat trout is an inland subspecies of cutthroat trout belonging to the Salmonidae family. Stream-dwellers generally live less than 5 years, and lake-dwellers live between 5 and 9 years. Lahontan cutthroat trout range between 10 and 15 inches in length, and feed on terrestrial and aquatic insects.

REPRODUCTION AND DEVELOPMENT:
Like other cutthroat trout subspecies, Lahontan cutthroat trout is an obligatory stream spawner that spawns between April and July. Spawning depends upon stream flow, elevation, and water temperature. Female sexual maturity is reached between the ages of 3 and 4, while males mature at 2 to 3 years of age. Over 60 percent of male and female Lahontan cutthroat die after their first time spawning, and those that remain usually spawn again two or more years later. Consecutive repeat spawning is very rare.

RANGE AND POPULATION LEVEL:
The Lahontan cutthroat trout is endemic to the physiographic Lahontan basin of northern Nevada, eastern California, and southern Oregon. Lahontan cutthroat trout were once widespread throughout the basins of Pleistocene Lake Lahontan. In 1844, there were 11 lacustrine populations of Lahontan cutthroat trout populations occupying about 334,000 acres of lakes, and 400 to 600 fluvial populations in over 3,600 miles of streams within the major basins of Pleistocene Lake Lahontan.

Lahontan cutthroat trout currently occupy between 155 and 160 streams; 123 to 129 streams within the Lahontan basin and 32 to 34 streams outside the basin, totaling approximately 482 miles of occupied habitat. The subspecies is also found in six lakes and reservoirs, including two small, wild, indigenous populations in Summit and Independence Lakes. Currently, self-sustaining Lahontan cutthroat trout populations occur in 10.7 percent of the historic fluvial and 0.4 percent of the historic lacustrine habitats.

HABITAT:
Lahontan cutthroat trout, like other trout species, are found in a wide variety of cold-water habitats including large terminal alkaline lakes (e.g., Pyramid and Walker lakes); oligotrophic alpine lakes (e.g., Lake Tahoe and Independence Lake); slow meandering low-gradient river (e.g., Humboldt River); moderate gradient montane rivers (e.g., Carson, Truckee, Walker, and Marys Rivers); and small headwater tributary stream (e.g., Donner and Prosser Creeks).

Generally, Lahontan cutthroat trout occur in cool flowing water with available cover, velocity breaks, well-vegetated and stable stream banks, and relatively silt free, rocky substrate in riffle-run areas.

Lacustrine Lahontan cutthroat trout populations have adapted to a wide variety of lake habitats from small alpine lakes to large desert waters. Unlike most freshwater fish species, some Lahontan cutthroat trout tolerate alkalinity and total dissolved solid levels as high as 3,000 mg/L and 10,000 mg/L, respectively (Koch *et al.* 1979). Galat *et al.* (1983) indicated that Lahontan cutthroat trout will develop slight to moderate hyaline degeneration in kidney tubules in lakes where total dissolved solids and sulfates equal or exceed 5,000mg/L and 2,000 mg/L, respectively. This ability to tolerate high alkalinity prompted introductions of Lahontan cutthroat trout into saline-alkaline lakes in Nevada, Oregon, and Washington for recreational purposes (Trotter 1987). Walker Lake, Nevada is the most saline-alkaline water maintaining a Lahontan cutthroat trout sport fishery. In Walker Lake, total alkalinity exceeded 2,800 mg/L HCO 3 in 1975 and total dissolved solids exceeded 11,000 mg/L in 1982 (Sevon 1988).

PAST THREATS:
The arrival of European settlers in the late 19th century lead to habitat alteration and degradation through diversion of water for irrigation, pollution from mining and milling operations, and long-term livestock overgrazing, as well as commercial fishing within lakes Pyramid, Walker and Tahoe, and the rivers Humboldt, Truckee, Carson, and Walker. In the 1880s, introduction of nonnative salmonids began in Nevada, California, and Oregon into the Lahontan cutthroat trout habitat.

Habitat alteration is associated with agricultural use, livestock and feral horse grazing, mining, and urban development, as well as from logging, highway and road construction, dam building, and the discharge of effluent from wastewater treatment facilities.

CURRENT THREATS:
Lahontan cutthroat trout continue to be impacted by degraded and/or limited habitat, displacement and/or hybridization with nonnative trout, and decreased viability.

PAIUTE CUTTHROAT TROUT
Oncorhynchus clarkii seleniris

STATUS:
The Paiute cutthroat trout was listed as endangered on March 11, 1967 (32 FR 4001) and was reclassified as threatened on July 16, 1975 (40 FR 29863). No critical habitat has been designated for this species. The Revised Recovery Plan for the Paiute Cutthroat Trout was completed August 10, 2004.

SPECIES DESCRIPTION:
The Paiute cutthroat trout is a member of the Salmonidae family. In stream environments Paiute cutthroat trout seldom reach sizes in excess of 250 millimeters (10 inches) total length. They attain a maximum size of 342 millimeters (13.5 inches) in Silver King Creek. Paiute cutthroat trout are opportunistic feeders, utilizing whatever aquatic and terrestrial invertebrates occur in the drift.

REPRODUCTION AND DEVELOPMENT:
Paiute cutthroat trout demonstrate fluvial spawning behavior and must have access to flowing waters with clean gravel substrates. Paiute cutthroat trout reach sexual maturity at the age of 2 years. Peak spawning activity occurs in June and July. The eggs hatch in 6 to 8 weeks and the fry emerge from the gravel in another 2 to 3 weeks. Young-of-the-year fish rear in mainstem shoals or backwaters, and often move into intermittent tributary streams until they reach about 50 millimeters (2.0 inches) in length. Growth rates vary with water temperature and the abundance of food organisms.

RANGE AND POPULATION LEVEL:
Paiute cutthroat trout currently occupy approximately 18.6 kilometers (11.5 miles) of historically fishless stream habitat in the Silver King drainage above Llewellyn Falls and above a barrier in Corral and Coyote Creeks (Figures 1 and 2). Four self-sustaining, genetically pure populations of Paiute cutthroat trout are known to occur out-of-basin in the North Fork of Cottonwood Creek, Stairway Creek, Sharktooth Creek, and Cabin Creek.

HABITAT:
All life stages require cool, well-oxygenated waters. Adult fish prefer stream pool habitat in low gradient meadows with undercut or overhanging banks and abundant riparian vegetation. Paiute cutthroat trout can survive in lakes, but there is no evidence that they ever occurred naturally in any of the lakes within the Silver King basin. To spawn successfully, they must have access to flowing waters with clean gravel substrates. Pools are important rearing habitat for juveniles and act as refuge areas during winter.

PAST THREATS:
At the time of their reclassification, Paiute cutthroat trout threats included livestock grazing, recreational development, and hybridization from rainbow trout introduction.

CURRENT THREATS:
Paiute cutthroat trout are threatened by streambank sloughing accelerated by human-caused activities (off-highway vehicle use, grazing, logging, etc.); the introduction of beavers which degrade spawning substrates and water quality; and competition and introgression with nonnative salmonids, which continue to occupy all of the historic habitat of the Paiute cutthroat trout. Its extremely limited distribution makes the Paiute cutthroat trout vulnerable to extinction in the event of a large disturbance.

GREENBACK CUTTHROAT MOUNTAIN TROUT
Oncorhynchus clarki stomias

STATUS:
The greenback cutthroat mountain trout was listed as endangered on March 11, 1967 (32 FR 4001) and was reclassified as threatened on April 18, 1978 (43 FR 16343). The Greenback

Cutthroat Trout Recovery Plan completed on March 3, 1998. Critical habitat has not been designated for the greenback cutthroat mountain trout.

SPECIES DESCRIPTION:
The greenback cutthroat trout is a member of the Salmonidae family, and is a subspecies of *O. clarki*. The subspecies feeds on aquatic insects as well as terrestrial invertebrates.

Historically, greenback cutthroat trout typically weighed between 1 and 2 pounds, and did not exceed 12in in length. Presently, size is dependant upon elevation and population size. In small headwater habitats, the greenback can attain relatively large sizes of 356-380mm as observed in the headwaters of the South Fork, Cache La Poudre River, where it is much larger than most brook trout in similar habitat. Depending upon population density, the growth of reproducing greenbacks at higher elevations can be much less.

REPRODUCTION AND DEVELOPMENT:
Spawning is initiated in the spring when water temperatures reach 5-8°C. Although greenbacks are spring spawners, older greenback males in high elevation streams were observed to be in spawning colors and running milt by mid-September. In the lab, females reach sexual maturity at age 2, however, in the wild maturity is reached at age 3 or 4 when they reach approximately 180mm in length.

RANGE AND POPULATION LEVEL:
Historically, the greenback is the only trout endemic to the headwaters of the South Platte and Arkansas River drainages within Colorado and a small segment of the South Platte drainage within Wyoming. The exact historical distribution of the species is not known. The greenback and the Rio Grande cutthroat trout (*Oncorhynchus clarki virginalis)*, represent the easternmost limits of native trout distribution in the western United States (Behnke 1984).

The greenback cutthroat trout currently occurs in 61 sites that total 166 hectare of lake and 165 kilometers of stream habitat. Nine “historic” populations remain and pure greenbacks have been introduced into 52 additional streams and lakes within the species historic range. At present, twenty populations (including both historic and restoration populations) are believed to be stable self-sustaining population, but only three of these stable populations occur in the Arkansas River drainage.

HABITAT:
Greenback cutthroat trout require clear, swift-flowing mountain streams with cover such as overhanging banks and vegetation. Riffle areas are used for spawning. Juveniles tend to shelter in shallow backwaters until large enough to fend fro themselves in the mainstream. (Mathews and Moseley 1990)

Presently, criteria for suitable habitat includes: the presence of barriers preventing invasion by nonnative trout; the ability to remove nonnative fish must be accomplished with relative ease; water temperatures must reach 5-8°C by early July for suitable spawning; adequate water flows;

the habitat must be able to sustain more than 500 adult fish and 22kg/ha of biomass; and it must have the ability to sustain reproduction.

PAST THREATS:
The greenback cutthroat trout is less tolerant of adverse conditions than are other trout such as brown trout or rainbow trout. The decline of the greenback cutthroat trout is attributed to anthropological influences leading to habitat loss, modification, water diversion, water pollution, sedimentation, and the introduction of nonnative fish. Land and water exploitation, mining, logging and unregulated fishing all took their toll in reducing the numbers and habitat of endemic trout populations. However, the major factor in the decline of the greenback cutthroat was the introduction of nonnative salmonid species (rainbow trout, brook trout, brown trout and Yellowstone cutthroat trout), within the South Platte and Arkansas River drainages. Greenback cutthroat trout readily hybridize with rainbow trout and other subspecies of cutthroat, and are outcompeted by brook and brown trout. The greenback cutthroat trout had declined so severely that by the early 1900's the species was thought to be extinct (Greene 1937).

CURRENT THREATS:
Past threats persist.

LITTLE KERN GOLDEN TROUT
Oncorhynchus aquabonita whitei

STATUS:
The Little Kern golden trout was listed as threatened and critical habitat was designated concurrently on April 13, 1978 (43 FR 15427).

SPECIES DESCRIPTION:
The Little Kern golden trout is a member of the Salmonidae family, and a subspecies within the golden trout family. Little Kern golden trout averages between 20-31cm (8-12 in) at maturity and weighs up to 0.45kg (1lb). Trout forage on a variety of invertebrates, eating whatever is most abundant in the water column. Diet includes larval and adult insects and planktonic crustaceans.

REPRODUCTION AND DEVELOPMENT:
Very little information is available regarding reproduction and development of Little Kern golden trout. Spawning occurs in the spring.

RANGE AND POPULATION LEVEL:
The Little Kern golden trout occurs only in the Little Kern River, Tulare County, California. This subspecies is native to high elevation streams and lakes in the Little Kern River, a major tributary to the Kern River in the southern Sierra Nevada.

Genetically pure populations of Little Kern golden trout now survive in Soda Spring Creek, Deadman Creek, Wet Meadows Creek, Willow Creek, Fish Creek and Coyote Creek. All of these streams except Coyote Creek are within the native drainage.

HABITAT:
Little Kern golden trout inhabit clear, cool, swift-flowing streams and lakes in high elevation (6000-10000ft.) (DFG 2000). Water quality of the stream and lakes inhabited by this fish is considered generally good.

CRITICAL HABITAT:
Critical habitat encompasses the following segments of the Little Kern River, Tulare County, California: the main channel and all streams tributary to the Little Kern River above a barrier falls located on the Little Kern River one mile below the mouth of Trout Meadows creek. The streams included in the Little Kern River watershed determined to be Critical Habitat include sufficient area for individual and population growth and dispersal of the Little Kern golden trout. The cobbles and larger rocks provide cover for both juvenile and adult fish. The gravel bottom in pool areas of the Critical Habitat streams provides proper substrate for the excavation of nest.

PAST THREATS:
At the time of listing, the Little Kern golden trout's distribution had been drastically altered from historical conditions by early unofficial transplants that established it in some waters outside its historic range, and later by authorized introduction of nonnative trout into the Little Kern River basin that displaced it from many of its historical habitats. The fishes' decline within its range is also attributed to stream sedimentation following uncontrolled off-road vehicle activities, improper road construction or careless logging; stream pollution due to extraction and milling of minerals; activities associated with recreation development in adjacent Mineral King and Jordan Peak area; and impacts from livestock.

CURRENT THREATS:
Ongoing activities that continue to affect golden trout and their habitat include livestock grazing, nonnative fish eradications, recreation including hiking trail creation and maintenance, camping, and fishing.

Sturgeon

PALLID STURGEON
Scaphirhynchus albus

STATUS:
The pallid sturgeon was listed as endangered on September 6, 1990 (55 FR 36641). Critical habitat has not been designated for the pallid sturgeon. The Pallid Sturgeon Recovery Plan was completed on November 7, 1993. A 5-year review was completed June 13, 2007, and concluded that criteria for downlisting had not been met.

SPECIES DESCRIPTION:
The pallid sturgeon is a member of the Acipenseridae family. The upper Missouri River pallid sturgeon are characterized by large sizes in excess of 60 lb, and large pointed snouts, while pallid sturgeon from the lower Missouri, Mississippi, and Atchafalaya Rivers typically have shorter and rounder snouts and fish size rarely exceeds 15 lb. Food habits of this species range from aquatic insects to fish depending on life stage.

REPRODUCTION AND DEVELOPMENT:
The species can be long lived with females reaching sexual maturity later than males (Kallemeyn 1983). Pallid sturgeon are thought to spawn in the spring or early summer like other sturgeon species. However, the capture of *Scaphirhynchus* larvae and postlarvae in the Mississippi River during fall months, as well as spring, could be interpreted as an extended season or a second spawn in the lower latitudes of distribution (Paul Hartfield, USFWS, pers. comm., 2006). Females may not spawn each year (Kallemeyn 1983). Larval fish produced from the spawning event drift downstream from the hatching site (Kynard et al. 2002), and begin to settle from the lower portion of the water column 11 to 17 days post hatch (Braaten et al. in review). Hatchery raised fish represent.

RANGE AND POPULATION LEVEL:
This species inhabits the Missouri and Mississippi Rivers from Montana to Louisiana (Kallemeyn 1983) and the Atchafalaya River (Reed and Ewing 1993). The Recovery Plan recognizes 6 Recovery Priority Management Areas (RPMA). There is an obvious absence of smaller sized wild pallid sturgeon. The size and age of surviving fish suggest that spawning, recruitment, or both, are severely limited or absent within each RPMA. However, the populations are being supplemented with hatchery produced fish in efforts to prevent local extirpations and these efforts are contributing to the current population structure.

HABITAT:
This species is a bottom-oriented, large rivers obligate and tends to select main channel habitats (Sheehan et al., 1998) in the Mississippi River and main channel areas with islands or sand bars in the upper Missouri River (Bramblett 1996).

PAST THREATS:
Pallid sturgeon habitat has been dramatically altered during the past 60 years. Approximately 51% of the pallid sturgeon's historical range has been affected to some degree by channelization, 28% has been impounded, and the remaining 21% is affected by upstream impoundments that alter flow regimes, depress both turbidity and water temperatures, and have continuing bank stabilization activities that limit channel meandering. The primary threats identified for pallid sturgeon in the final rule and in the Recovery Plan (USFWS 1993) were curtailment of range, habitat destruction and modification, low population size, lack of recruitment, commercial harvest, pollution/contaminants, and hybridization.

CURRENT THREATS:
Past threats persist, with the possible exception of hybridization.

Currently there are several fish consumption advisories for shovelnose sturgeon attributable to contaminants. Contaminant levels in pallid sturgeon also have been noted, but data are minimal. Elevated levels of polychlorinated biphenyls (PCBs), cadmium, mercury, and selenium have been detected in tissue samples from three pallid sturgeon collected from the Missouri River in North Dakota and Nebraska (Ruelle and Keenlyne 1992). Ruelle and Keenlyne (1992) also noted detectable concentrations of chlordane, DDE, DDT, and dieldrin.

The effects of contaminants on pallid sturgeon reproduction also are poorly understood. However, research involving white sturgeon (*Acipenser transmontanus*) in the Columbia River found lower condition factors, gonadal abnormalities, and hermaphrodism in fishes with elevated levels of metabolites of DDT (DDE and DDD) as well as total PCBs and mercury (Feist et al. 2005). Shovelnose sturgeon collected from the lower Missouri River have a consumption advisory because of concerns relating to overelevated levels of PCB and chlordane (DHSS 2006), and also lower Missouri River shovelnose sturgeon have been noted to exhibit intersexual characteristics (Wildhaber et al. 2005). Intersexual shovelnose sturgeon from the middle Mississippi River were found to have higher concentrations of organochlorine compounds when compared against male shovelnose sturgeon (Koch et al. 2006).

The prolonged egg maturation cycle of the pallid sturgeon (Conte et al. 1988), combined with an inclination for certain contaminants to be concentrated in eggs (Ohlendorf et al. 1981; Eisler 1986), could make contaminants a likely agent adversely affecting developing eggs, development of embryos, or survival of fry, and thereby reduce reproductive success (Ruelle and Keenlyne 1991). Data continue to be incomplete regarding the effects of contaminants on pallid sturgeon viability or rates of hermaphrodism.

ALABAMA STURGEON

Scaphirhynchus suttkusi

STATUS:

The Alabama sturgeon was listed as endangered on May 5, 2000 (65 FR 26437). Critical habitat has not been designated for the Alabama sturgeon.

SPECIES DESCRIPTION:

The Alabama sturgeon is a member of the Acipenseridae family. This sturgeon is an elongate, slender fish growing to about 80 centimeters (cm) (31 inches (in)) in length. A mature fish weighs 1 to 2 kilograms (kg) (2 to 4 pounds (lb)), and may live 15+ years. The species is an opportunistic feeder, preying primarily on aquatic insect larvae, as well as fish eggs, snails, mussels, fish, and plant material.

REPRODUCTION AND DEVELOPMENT:

Very little is known of the life history, habitat, or other ecological requirements of the Alabama sturgeon. Mayden and Kuhajda (1996) deduced aspects of Alabama sturgeon life history by a review of spawning habits of its better known congener (a species that is a member of the same genus), the shovelnose sturgeon. Life history of the shovelnose sturgeon has also been recently

summarized by Keenlyne (1997). These data indicate that Alabama sturgeon are likely to migrate upstream during late winter and spring to spawn. Downstream migrations may occur to search for feeding areas and/or deeper, cooler waters during the summer. Eggs are probably deposited on hard bottom substrates such as bedrock, armored gravel, or channel training works in deep water habitats, and possibly in tributaries to major rivers. The eggs are adhesive and require current for proper development. Sturgeon larvae are planktonic, drifting with river currents, with postlarval stages eventually settling out to the river bottom. Sexual maturity is believed to occur at 5 to 7 years of age. Spawning frequency of both sexes is influenced by food supply and fish condition, and may occur every 1 to 3 years. Alabama sturgeon may live up to 15 or more years of age.

RANGE AND POPULATION LEVEL:
The Alabama sturgeon's historic range once included about 1,600 kilometers (km) (1,000 miles (mi)) of the Mobile River system in Alabama (Black Warrior, Tombigbee, Alabama, Coosa, Tallapoosa, Mobile, Tensaw, and Cahaba Rivers) and Mississippi (Tombigbee River). The species is now restricted to a 216-km (134-mi) reach of the Alabama River below Millers Ferry Lock and Dam, downstream to the mouth of the Tombigbee River. Since 1985, all confirmed captures have been from a short, free-flowing reach of the Alabama River below Millers Ferry and Claiborne Locks and Dams in Clarke, Monroe, and Wilcox Counties, Alabama.

HABITAT:
The species prefers relatively stable gravel and sand substrates in flowing river channels. Verified captures of Alabama sturgeon have primarily occurred in large channels of big rivers; however, at least two historic records were from oxbow lakes (Williams and Clemmer 1991). Riverine (flowing water) habitats are required by the Alabama sturgeon to successfully complete its life cycle.

PAST THREATS:
The decline of the Alabama sturgeon is attributed to over-fishing, loss and fragmentation of habitat as a result of historical navigation-related development, and water quality degradation. The Alabama sturgeon has disappeared from 85 percent of its historic range. Its decline has been associated with construction of dams, flow regulation, navigation channel development, other forms of channel modification, and pollution. Dams in the Alabama River have reduced the amount of riverine habitat, impeded migration of Alabama sturgeon for feeding and spawning needs, and changed the river's flow patterns.

The historic population decline of the Alabama sturgeon was probably initiated by unrestricted harvesting near the turn of the 20th century. Although the Alabama sturgeon's capture is currently prohibited, the species has and still is affected by incidental capture from commercial and sport fishery.

Other than harvesting, and more importantly, the decline in the Alabama sturgeon's range is the result of 100 years of cumulative impact to the rivers of the Mobile River Basin as they were developed for navigation, especially during the last 50 years. The deepening and destruction of shoals and shallow runs or other historic feeding and spawning sites as a result of navigation

development likely contributed to local and overall historic declines in range and abundance of the Alabama sturgeon. These modifications have also caused siltation, creating an unsuitable habitat for spawning and foraging.

Construction of dams and locks fragmented the range and created metapopulations between the dams where migration was inhibited. Fragmentation created metapopulations where all the species' habitat needs were not necessarily met, and where the species became more vulnerable to local declines in water and habitat quality caused by riverine and land management practices and/or polluting discharges.

CURRENT THREATS:
Threats include operation of hydroelectric dams which change natural river flow regimes; and activities that could reduce the abundance and distribution of stable benthic (bottom) habitats in the riverine portions of the Alabama River, including existing maintenance dredging of navigation channels and dredged material disposal, or gravel and sand mining activities. Water pollution may adversely impact sturgeon and was likely a factor in the decline of the Alabama sturgeon. Currently, the major sources of water pollution in Alabama are agriculture, municipal point sources, resource extraction, and contaminated sediments, in decreasing order based on numbers of miles impaired. Sturgeon species may be especially vulnerable to small population size because age at first spawning (ranging from 5 to 7 years for shovelnose sturgeon) is much delayed in comparison to many other fishes, female sturgeons may not spawn for intervals of several years, recruitment can vary significantly between years, and successful spawning by one or few individuals can result in reduced genetic diversity. The lack of information on Alabama sturgeon habitat and life history requirements poses challenges to conservation efforts.

GULF STURGEON
Acipenser oxyrinchus desotoi

STATUS:
The Gulf sturgeon was listed as endangered on Septembeer 30, 1991 (56 FR 49653) and critical habitat was designated on March 13, 2003 (68 FR 13369). The Gulf Sturgeon Recovery Plan was completed September 22, 1995.

SPECIES DESCRIPTION:
The Gulf sturgeon is a member of the Acipenseridae family. This sturgeon is an anadromous fish, breeding in freshwater after migrating up rivers from marine and estuarine environments. Adults range from 1.2 to 2.4 meters (m) (4 to 8 feet (ft)) in length, with adult females larger than males. The species is an opportunistic feeder, preying primarily on aquatic insect larvae, as well as fish eggs, snails, mussels, fish, and plant material.

Gulf sturgeon feeding habits in freshwater vary depending on the fish's life history stage (i.e., young-of-the-year, juvenile, subadult, adult). Young-of-the-year Gulf sturgeon remain in freshwater feeding on aquatic invertebrates and detritus approximately 10 to 12 months after spawning occurs (Mason and Clugston, 1993; and Sulak and Clugston, 1999). Juveniles (less

than 5 kg (11 lbs)) are believed to forage extensively and exploit scarce food resources throughout the river, including aquatic insects (e.g., mayflies and caddisflies), worms (oligochaetes), and bivalve molluscs (Huff, 1975; and Mason and Clugston, 1993). Juvenile (ages 1 to 6) Gulf sturgeon summer in freshwater environments where they are trophically inactive (do not forage) and winter in estuaries. Adult and subadult Gulf sturgeon, while in marine and estuarine habitat, are thought to forage opportunistically (Huff, 1975), primarily on benthic (bottom dwelling) invertebrates. Gut content analyses have indicated that the Gulf sturgeon's diet is predominantly amphipods, lancelets, polychaetes, gastropods, shrimp, isopods, molluscs, and crustaceans (Huff, 1975; Mason and Clugston, 1993; Carr et al., 1996b; Fox et al., 2000; and Fox et al., 2002).

REPRODUCTION AND DEVELOPMENT:
Gulf sturgeon are long-lived, with some individuals reaching at least 42 years in age (Huff, 1975). Age at sexual maturity for females ranges from 8 to 17 years, and for males from 7 to 21 years (Huff, 1975). Gulf sturgeon eggs are demersal (they are heavy and sink to the bottom), adhesive, and vary in color from gray to brown to black. Chapman et al. (1993) estimated that mature female Gulf sturgeon weighing between 29 and 51 kg (64 and 112 lb) produce an average of 400,000 eggs.

RANGE AND POPULATION LEVEL:
Historically, the Gulf sturgeon occurred from the Mississippi River east to Tampa Bay. Its present range extends from Lake Pontchartrain and the Pearl River system in Louisiana and Mississippi east to the Suwannee River in Florida. Sporadic occurrences have been recorded as far west as the Rio Grande River between Texas and Mexico, and as far east and south as Florida Bay (Wooley and Crateau, 1985; and Reynolds, 1993).

HABITAT:
Gulf sturgeon are classified as anadromous. Subadults and adults spend eight to nine months each year in rivers and three to four of the coolest months in estuaries or Gulf waters. Young-of-the-year Gulf sturgeon remain in freshwater.

CRITICAL HABITAT:
There are 14 critical habitat units encompassing riverine, estuarine, and marine environments in Florida, Alabama, Mississippi, and Louisiana. They include portions of (1) the Pearl River System (LA, MS); (2) the Pascagoula River System (MS); (3) the Escambia River System (FL, AL); (4) the Yellow River System (FL, AL); (5) the Choctawhatchee River System (FL, AL); (6) the Apalachicola River System (FL); and (7) the Suwanee River System (FL). They also include portions of (8) Lake Pontchartrain, Lake St. Catherine, The Rigolets, Little Lake, Lake Borgne, and Mississippi Sound (LA, MS, AL); (9) the Pensacola Bay system (FL); (10) Santa Rosa Sound (FL); (11) Florida Nearshore Gulf of Mexico (FL); (12) Choctawhatchee Bay (FL); (13) Apalachicola Bay (FL); and (14) Suwanee Sound (FL). See the Final Rule for detailed descriptions of designated critical habitat.

The primary constituent elements include:

(i) Abundant prey items within riverine habitats for larval and juvenile life stages, and within estuarine and marine habitats and substrates for juvenile, subadult, and adult life stages;

(ii) Riverine spawning sites with substrates suitable for egg deposition and development, such as limestone outcrops and cut limestone banks, bedrock, large gravel or cobble beds, marl, soapstone or hard clay;

(iii) Riverine aggregation areas, also referred to as resting, holding, and staging areas, used by adult, subadult, and/or juveniles, generally, but not always, located in holes below normal riverbed depths, believed necessary for minimizing energy expenditures during fresh water residency and possibly for osmoregulatory functions;

(iv) A flow regime (i.e,. the magnitude, frequency, duration, seasonality, and rate-of-change of fresh water discharge over time) necessary for normal behavior, growth, and survival of all life stages in the riverine environment, including migration, breeding site selection, courtship, egg fertilization, resting, and staging; and necessary for maintaining spawning sites in suitable condition for egg attachment, egg sheltering, resting, and larvae staging;

(v) Water quality, including temperature, salinity, pH, hardness, turbidity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages;

(vi) Sediment quality, including texture and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages; and

(vii) Safe and unobstructed migratory pathways necessary for passage within and between riverine, estuarine, and marine habitats (e.g. a river unobstructed by any permanent structure, or a dammed river that still allows for passage).

PAST THREATS:

Gulf sturgeon numbers declined due to overfishing throughout most of the 20th century. The decline was exacerbated by habitat loss associated with the construction of water control structures, such as dams and sills (submerged ridge or vertical wall of relatively shallow depth separating two bodies of water), mostly after 1950. In several rivers throughout the species' range, dams have severely restricted sturgeon access to historic migration routes and spawning areas (Boschung, 1976; Wooley and Crateau, 1985; and McDowall, 1988).

CURRENT THREATS:

In addition to past threats, the Gulf sturgeon is threatened by modifications to habitat associated with dredged material disposal, desnagging (removal of trees and their roots), and other navigation maintenance activities; incidental take by commercial fishermen; poor water quality associated with contamination by pesticides, heavy metals, and industrial contaminants; aquaculture and incidental or accidental introductions; and the Gulf sturgeon's slow growth and late maturation.

KOOTENAI RIVER WHITE STURGEON

Acipenser transmontanus

STATUS:

The Kootenai River population of the white sturgeon was listed as endangered on Septembeer 6, 1994 (59 FR 45989). Critical habitat was designated on September 6, 2001 (66 FR 46548) and modified in an Interim Rule on February 8, 2006 (71 FR 6383). The Recovery Plan for the Kootenai River Population of the White Sturgeon was completed September 30, 1999.

SPECIES DESCRIPTION:
The white sturgeon is a member of the Acipenseridae family. White sturgeon are generally long-lived, with females living from 34 to 70 years (PSMFC 1992). The largest white sturgeon reported from the Kootenai River basin is a 159 kilograms (350 pounds). The Kootenai River population is one of several land-locked populations of white sturgeon, having been isolated since the last glacial age, approximately 10,000 years ago (Northcote 1973). It migrates freely in the Kootenai River from Kootenai Falls in Montana downstream into Kootenay Lake, British Columbia, Canada. White sturgeon in the Kootenai River system and elsewhere are considered opportunistic feeders. Partridge (1983) found white sturgeon more than 70 centimeters (28 inches) in length feeding on a variety of prey items including clams, snails, aquatic insects, and fish. Andrusak (MELP, pers. comm., 1993) noted that kokanee *(Oncorhynchus nerka)* in Kootenay Lake, prior to a dramatic population crash beginning in the mid-1970's, were once considered an important prey item for adult white sturgeon.

REPRODUCTION AND DEVELOPMENT:
The size or age at first maturity for white sturgeon in the wild is quite variable (PSMFC 1992). In the Kootenai River system, females have been documented to mature as early as age 22 and males at age 16 (Paragamian et al. 1997). Only a portion of adult white sturgeon are reproductive or spawn each year, with the spawning frequency for females estimated at 2 to 11 years (PSMFC 1992). White sturgeon spawn within a 19 river-kilometer (12 river-mile) stretch of the Kootenai River, primarily from Bonners Ferry downstream to the lower end of Shorty's Island. Spawning occurs when the physical environment permits egg development and cues ovulation. White sturgeon are broadcast spawners, releasing their eggs and sperm in fast water. Based upon recent studies, Kootenai River white sturgeon spawn during the period of historical peak flows from May through July 3 (Apperson and Anders 1991; Marcuson 1994). Spawning at peak flows with high water velocities disperses and prevents clumping of the adhesive eggs. Following fertilization, eggs adhere to the river substrate and hatch after a relatively brief incubation period of 8 to 15 days, depending on water temperature (Brannon et al. 1984). Recently hatched yolk-sac larvae swim or drift in the current for a period of several hours and then settle back into interstitial spaces in the substrate. Larval white sturgeon require an additional 20 to 30 days to metamorphose into juveniles with a full complement of fin rays and scutes.

RANGE AND POPULATION LEVEL:
This white sturgeon population inhabits and migrates freely in the Kootenai River from Kootenai Falls in Montana downstream into Kootenay Lake, British Columbia, Canada. A white sturgeon population analysis using capture information collected from the Kootenai River and Kootenay Lake over a 4-year period estimated 1,468 adult fish (95 percent confidence interval: 740 to 2,197) and 87 wild juveniles (Service 1999). The population is reproductively mature, with few of the remaining white sturgeon younger than 25 years old.

HABITAT:
Based on tagging studies, Kootenai River white sturgeon are relatively sedentary during the summer and inhabit the deepest holes of the Kootenai River and Kootenay Lake (Apperson and Ariders 1990). Kootenai River locations used by white sturgeon were generally sites over 20 feet (ft) (6 meters (m)) deep with colunm velocities less than 0.77 ft per second (fps) (less than 0.24 m per second (mps)) and water temperature of 57 to 68°F (14 to 20°C) (PSMFC 1992), while depths utilized in Kootenay Lake ranged from 30 to over 300 ft (10 to 100.5 m) (Apperson and Anders 1991). Compared with other waters containing white sturgeon, the Kootenal River is a relatively cool river with summer high temperatures of 68 to 72°F (20 to 22°C).

CRITICAL HABITAT:
There are two critical habitat units on the Kootenai River in Idaho: Unit 1, Braided Reach, extends from Bonners Ferry to the confluence with the Moyie River; Unit 2, extends from Shorty's Island to Bonners Ferry. The primary constituent elements of critical habitat for the Kootenai sturgeon are: (i) During the spawning season of May through July, a flow regime that periodically (not necessarily annually) produces flood flows capable of producing intermittent depths of at least 5 meters (Paragamian and Duehr 2005, Barton *et al.* 2005), and mean water column velocities of at least 3.3 ft/s (1.0 m/s) (Anders *et al.* 2002, Schafter 1997, Berenbrock 2005) throughout, but not uniformly within the braided reach. (ii) Stable, temperatures of roughly 50 degrees F in May into July with no sudden drops in temperature exceeding 3.6 degrees F at Bonners Ferry during the spawning season and water temperatures suitable for natural rates of development of embryos. (iii) Presence of approximately 5 miles of continuous submerged rocky substrates for normal free embryo redistribution behavior and downstream movement (Brannon et al. 1985). (iv) A flow regime that limits sediment deposition and maintains appropriate rocky substrate for sturgeon egg adhesion, incubation, escape cover, and free embryo development (Stockley 1981, Parsley et al. 1993, Parsley and Beckman 1994).

PAST THREATS:
Flow regulation at Libby Dam is considered to be a primary reason for the Kootenai River white sturgeon's continuing lack of recruitment and declining numbers. Beginning in 1972, average spring peak flows in the Kootenai River have been reduced by more than 50 percent, and winter flows have increased by 300 percent compared to predam values. The natural high spring flows thought to be required by white sturgeon for reproduction rarely occurred during the May to July spawning season after construction of Libby Dam. In addition, cessation of periodic flushing flows has allowed fine sediments to build up in the Kootenai River bottom substrates. This sediment fills the spaces between riverbed cobbles, reducing fish egg survival, larval and juvenile fish security cover, and insect production.

CURRENT THREATS:
Apperson (1992) noted detectable levels of aluminum, copper, lead, zinc, and strontium, along with polychlorinated biphenyls (PCB) and pesticides, in white sturgeon egg samples from the Kootenai River. However, other than copper, detectable levels ofthese compounds, e.g. polychlorinated biphenyls, organochlorides, and zinc, were lower than levels found in other Columbia River basin white sturgeon that successfully reproduce. Ultimately, the overall effects

of these pollutants on sturgeon reproduction and survival are unknown. Kootenai River white sturgeon eggs have been hatched under experimental hatchery conditions using both Kootenai River water and domestic city water, however the chronic effects of heavy metals on egg hatching success and the dietary pathways of larvae and young-of-the-year white sturgeon have not been investigated. Georgi (1993) noted that the chronic effects on wild sturgeon spawning in "chemically polluted" water and rearing over contaminated sediments, in combination with bioaccumulation of contaminants in the food chain, is possibly reducing the successful reproduction and early-age recruitment to the Kootenai River white sturgeon population.

Amphipods

ILLINOIS CAVE AMPHIPOD
Gammarus acherondytes

STATUS:
The Illinois cave amphipod was listed as endangered on September 3, 1998 (63 FR 46900). The Illinois Cave Amphipod (*Gammarus acherondytes*) Recovery Plan was completed September 20, 2002. Critical habitat has not been designated for this species.

SPECIES DESCRIPTION:
The Illinois cave amphipod is a member of the crustacean order Amphipoda (commonly called scuds or sideswimmers). Amphipods commonly range in size from about 13 - 55 mm (0.5 – 2 in.) in length. Food consists of bits of dead vegetation washed into the caves and thin bacterial scum covering submerged surfaces. Densities of cave invertebrates have been found to be correlated with fungal populations (Dickson 1975), suggesting fungi as an important food source.

REPRODUCTION AND DEVELOPMENT:
After fertilization, eggs are released into the brood pouch of the female, and young are generally released about a month later for Gammerid species (Jones *et al.* 1992). For at least some Gammaridae, the incubation period varies with temperature (Hynes 1954, Steele and Steele 1972). Depressed oxygen levels can interfere with mate-guarding behavior in freshwater *Gammarus* (Hoback and Barnhart 1994, 1996). Taylor and Webb (2000) showed size distribution of *G. acherondytes* can be explained in part by seasonal variation, probably indicating there is a seasonal component to reproduction in this species. Young are generally more abundant in springtime, but size of individuals varies widely within all seasons. In the Illinois cave amphipod up to 21 eggs were reported by Holsinger (1972). No information exists on the lifespan of the Illinois cave amphipod.

RANGE AND POPULATION LEVEL:
Historically, it was known to occur in six cave systems in Monroe and St. Clair Counties, Illinois. Its presence has not been reconfirmed in Madonnaville Cave, Monroe County and it appears to be extirpated from Stemler Cave, St. Clair County. Additional populations have been found in eight groundwater systems in Monroe County.

HABITAT:
The Illinois cave amphipod is a species that lives in streams primarily in the dark zone of caves in parts of the Salem Plateau of Illinois. Little is known of the biology and habitat requirements of this species although it has been collected in mainstream gravel riffles, smaller tributary streams, rimstone pools, and from streams with silt overlying bedrock. As a group, amphipods require cool water temperatures and are intolerant of wide ranges in temperature.

PAST THREATS:
Illinois cave amphipod due to degradation of habitat through groundwater contamination resulting from agricultural practices and urbanization. At the time of listing, the amphipod was known to occur in only four of six historical cave systems. Also, inadequate protection of water quality in a sensitive geological formation (karst topography) through current state and local regulations offered little hope of reducing these threats.

CURRENT THREATS:
The species survival is threatened by factors affecting shallow karst groundwater. These include agricultural and residential pesticides and fertilizers; human and animal wastes from residential sewage disposal systems and livestock; sedimentation from agricultural and residential runoff; oil well production; surface runoff from roads, storm sewers, and increased surface paving due to urban development; sinkhole dumping of solid waste; and disruption of groundwater flow paths from quarry operations. Excessive visitation to caves and over-collecting for scientific purposes may also threaten the species.

NOEL'S AMPHIPOD
Gammarus desperatus

STATUS:
Noel's amphipod was listed as endangered on August 9, 2005 (70 FR 46303). Critical habitat has not been designated for this species.

SPECIES DESCRIPTION:
Noel's amphipod is a small freshwater crustacean from the order Amphipoda (commonly called scuds or sideswimmers). Individuals range in size from about 8.5 – 14.8 mm in length, and males are slightly larger than females. Gammerid food generally consists of algae, submergent vegetation, and decaying organic matter. Young depend on microbial food, such as algae and bacteria associated with aquatic plants. Noel's amphipod has been found in beds of submerged aquatic plants, indicating the likelihood that they browse on the surface film of algae diatoms, bacteria, and fungi.

REPRODUCTION AND DEVELOPMENT:
Most gammerids complete their life cycle in one year, breeding between February and October. After fertilization, eggs are released into the brood pouch of the female, and between 15 and 50 young are released about a month later (Jones *et al.* 1992). Most amphipods produce a single brood, but some can produce multiple broods during the breeding season (Pennak 1978). For at

least some Gammaridae, breeding time and incubation period varies with temperature (Hynes 1954, Steele and Steele 1972). Depressed oxygen levels can interfere with mate-guarding behavior in freshwater *Gammarus* (Hoback and Barnhart 1994, 1996).

RANGE AND POPULATION LEVEL:
Noel's amphipod is one of three endemic amphipods of the Pecos River Basin from Roswell, New Mexico, south to Fort Stockton, Texas collectively known as the *Gammarus pecos* complex. At the time of listing, Noel's amphipod was known at the following sites in the Bitter Lake National Wildlife Refuge: Sago Springs Complex, Biter Creek, along the western boundary of Area 6, Area 7 spring-ditch, and Hunter Marsh. It was also found at one site outside the refuge boundary on property owned by the City of Roswell. Historically, the amphipod had been identified in North Spring, east of Roswell, and Lander Springbrook, near Roswell. The North Spring population was extirpated between 1978 and 1988 from groundwater depletion and the Lander Creek population extirpated between 1951 and 1960 from habitat alterations.

HABITAT:
Gammerids generally inhabit cool, shallow, well-oxygenated waters of streams, ponds, sloughs, ditches, and springs. Water quality parameters usually require high dissolved oxygen concentrations, relatively high calcium concentrations, and a pH between 6.0 and 8.0. Noel's amphipod has been found on rubble and rubble-sand substrate, and less frequently on silt substrate or vegetation. Standing water and silt accumulation appear to be unsuitable habitat. On Bitter Lake NWR, habitats ranged from dense beds of emergent aquatic macrophytes to clear, flowing springbrooks with submerged aquatic vegetation, vegetated banks and margins, and clean substrates.

PAST THREATS:
Habitat degradation, drought, and reduced water flow have been significant factors in the decline of Noel's amphipod. Groundwater depletion and alteration of habitat were cited as the reasons the amphipod was extirpated from the North Spring and Lander Springbrook, two historic locations. Curtailment of range and habitat has occurred primarily through the loss of spring habitat. Limited mobility of the amphipod and fragmented habitat restricts their ability to find and disperse to other suitable habitats and leaves them vulnerable to unfavorable changes.

CURRENT THREATS:
The species' survival continues to be threatened by habitat alteration and changes to water flow. Degradation of current habitat is also a threat, with a variey of contaminants from industry and commercial operations detected in nearby waterways. Urban development continues to pose a risk to ground and surface water quality from septic discharge, and contaminants discharged from concentratred animal areas and oil and gas operations may enter springs inhabited byt his species. Noel's amphipod, because of its limited distribution and restricted habitat, may also be threatened by the introduction of a non-native species into their habitat

Mussels

General Mussel Information

BACKGROUND

The North American mussel fauna includes at least 304 taxa (Turgeon et al. 1998) and represents the greatest diversity in the world (Williams and Neves 1995). More than 90 percent of the species inhabit the Southeastern United States (Neves et al. 1997).

No other wide-ranging faunal group in North America has experienced, or is undergoing, as profound a degree of imperilment as are the freshwater mussels (Stein and Flack 1997, Abell et al. 2000). As many as 36 taxa (13 percent) are presumed extinct (Howells et al. 1997, Neves et al. 1997, Neves 1999), and 69 taxa (21 percent) are classified as federally endangered or threatened species, with some of these latter species considered extinct (Neves 1999). The primary causes of this decline are loss of suitable habitat caused by impoundments, channelization, pollution, sedimentation, and other factors (Ortmann 1909, Fuller 1974, Williams et al. 1993, Williams and Neves 1995).

HABITAT

Adult mussels are ideally found in localized patches (beds) in streams, almost completely burrowed in the substrate with only the area around the siphons exposed (Balfour and Smock 1995). The composition and abundance of mussels are directly linked to bed sediment distributions (Vannote and Minshall 1982, Neves and Widlak 1987, Leff et al. 1990, Strayer 1997). Physical qualities of the sediment (e.g., texture, particle size) may be important in allowing the mussels to firmly burrow in the substrate (Lewis and Riebel 1984). These and other aspects of substrate composition, including bulk density (mass/volume), porosity (ratio of void space to volume), sediment sorting, and the percentage of fine sediment, may also influence mussel densities (Brim Box 1999, Brim Box and Mossa 1999). Water velocity may be a better predictor than substrate for determining where certain mussel species are found in streams (Huehner 1987). In general, heavy-shelled species occur in stream channels with currents, while thin-shelled species occur in more backwater areas.

Stream geomorphic and substrate stability is especially crucial for mussel species and for maintaining diverse, viable mussel beds (Vannote and Minshall 1982, Hartfield 1993, Di Maio and Corkum 1995). Where substrates are unstable, conditions are generally poor for mussel habitation. The most stable portion of the bottom of a stream is oftentimes under slab boulders, an excellent microhabitat to search for numerous mussel species (Ahlstedt, pers. comm., 1999).

Strayer (1999) demonstrated in field trials that mussels in streams occur chiefly in flow refuges, or relatively stable areas that displayed little movement of particles during flood events. Flow refuges conceivably allow relatively immobile mussels to remain in the same general location throughout their entire lives. He thought that features commonly used in the past to explain the spatial patchiness of mussels (e.g., water depth, current speed, sediment grain size) were poor predictors of where mussels actually occur in streams.

Habitat and stream parameter preferences for juveniles are largely unknown (Neves and Widlak 1987). This is possibly due to a prevalent lack of evidence of recruitment, inadequate sampling methods, or reproductive failure (Coon et al. 1977; Strayer 1981; Moore 1995; McMurray et al. 1999a, 1999b). Isley (1911) stated that juveniles may prefer habitats that have sufficient oxygen, are frequented by fish, and are free of shifting sand and silt accumulation. Neves and Widlak (1987) suggested that juveniles inhabit depositional areas with low flow, where they can feed pedally (see "Food Habits") and siphon water from interstitial spaces among substrate particles (Yeager et al. 1994). Recent laboratory experiments determined that the juvenile wavyrayed lampmussel (Lampsilis fasciola [Rafinesque, 1820]) generally congregated in the top 0.8 inch of substrate (Neves, pers. comm., 2000). Juvenile mussels of certain species stabilize themselves by attaching to rocky and other substrates with a byssus (Frierson 1905, Isley 1911, Howard 1922).

Neves and Widlak (1987) summarized stream parameter preferences of habitat, substrate, current velocity, and presence of other bivalves for juvenile unionids. Initially, juveniles were clumped in runs and riffles, occurred primarily behind boulders, and were significantly correlated with the presence of the fingernail clam. They surmised that the habitat of older juveniles (i.e., ages 2 to 3 years) was similar to that of adults. Nevertheless, it remains unknown if juveniles of most species experience differential survival rates among different habitat parameters, if they remain in the habitat of the host fish, or if they exhibit any habitat preference (Neves and Widlak 1987).

LIFE HISTORY

Food Habits

Adult freshwater mussels are filter feeders, orienting themselves in the substrate to facilitate the siphoning of the water column for oxygen and food (Kraemer 1979). Mussels are known to consume bacteria, detritus, assimilated organic material, diatoms, phytoplankton, zooplankton, phagotrophic protozoans, and other microorganisms (Coker et al. 1921, Churchill and Lewis 1924, Ukeles 1971, Fuller 1974, Baldwin and Newell 1991, Neves et al. 1996). Churchill (1916) concluded that mussels could absorb various sources of fat, protein, and starch dissolved in the water. An omnivorous opportunistic diet would allow mussels to take advantage of whatever food type happens to be abundant (Baldwin and Newell 1991, Neves et al. 1996).

Although algae forms a conspicuous component of adult mussel gut contents and contributes key nutrients such as vitamins A and D and phytosterols, algal carbons do not dominate soft-tissue stores (Nichols and Garling 2000). Recent evidence emphasizes the importance to riverine mussels of the uptake and assimilation of detritus and bacteria over that of algae (Silverman et al. 1997, Nichols and Garling 2000. Earlier references suggesting the importance of detritus (e.g., Gordon 1991, Neves et al. 1996) may have been partially correct in that the mussels may have been assimilating the bacteria associated with detritus to meet their nutritional needs (Johnson, letter dated June 22, 2003). Cholesterol and vitamin B_{12} are also key dietary compounds for mussels (Nichols and Garling 2000), but high levels of protein appear to be unhealthy (Nichols and Garling 2002).

Juvenile mussels employ foot (pedal) feeding and are thus suspension/deposit feeders (Yeager et al. 1994). Video observations of rainbow mussel (Villosa iris [Lea, 1829]) by Yeager et al. (1994) revealed juveniles occupying the top 0.4 inch of sediment and employing the following two types of feeding mechanisms: (1) collecting organic and inorganic particles that adhere to the foot and conveying them to the pedal valve gape with sweeping motions and (2) extending the foot anteriorly, pulling themselves along while picking up organic and inorganic particles on the foot. These methods of suspension feeding have been termed pedal sweep feeding and pedal locomotory feeding, respectively (Reid et al. 1992). The juvenile diet (up to 2 weeks of age) includes bacteria, algae (i.e., nonfilamentous, non-blue green), and diatoms, with some detrital and inorganic colloidal particles (Yeager et al. 1994). In juvenile freshwater mussel feeding experiments, Neves et al. (1996) found that algae were suitable as food but that a tri-algal diet high in oils resulted in better growth (Gatenby et al.1996, 1997). Silt provided some nutritional value (Gatenby et al.1996, 1997), which was also observed by Hudson and Isom (1984). Contrary to its importance for adults (Silverman et al. 1997, Nichols and Garling 2000), bacteria in riverine sediments were not deemed essential to juvenile growth and survival (Gatenby et al.1996, 1997; Neves et al. 1996).

Growth and Longevity

Growth rates for freshwater mussels tend to be relatively rapid for the first few years (Chamberlain 1931, Scruggs 1960, Negus 1966) then slow appreciably (Bruenderman and Neves 1993, Hove and Neves 1994). The relatively abrupt slowing in growth rate occurs at sexual maturity, probably as a result of energy being diverted from growth to gamete production. Growth rates vary among species; heavy-shelled species grow slowly relative to thin-shelled species (Coon et al. 1977, Hove and Neves 1994). Under shoal habitat conditions, where high water velocities (approximately one foot per second or more) in river shallows are characterized by increased oxygen levels and food availability per unit time, growth rates are probably higher (Bruenderman and Neves 1993).

As a group, mussels are extremely long-lived, with maximum life spans of 100 to 200-plus years for certain species (Neves and Moyer 1988, Bauer 1992, Ziuganov et al. 2000). Heavy-shelled species, which includes many riverine forms, tend to reach higher maximum ages (Stansbery 1961).

General Reproductive Biology of Mussels

Freshwater mussels generally have separate sexes, although hermaphroditism is known for some species (van der Schalie 1970, Bauer 1987, Downing et al. 1989). Bauer (1987) conducted an experiment with the eastern pearlshell (Margaritifera margaritifera [Linnaeus, 1758]), which determined that some specimens (mostly females) changed sex to hermaphrodites when moved from dense populations to unpopulated areas. He concluded that hermaphroditism may be rare in dense mussel populations but more prevalent in sparse populations, perhaps as an adaptive response to a paucity or lack of sexual counterparts. If true, this phenomenon may help explain

why perpetually sparse populations of certain extremely rare species have been known to persist for decades (Neves, pers. comm., 1997).

The age of sexual maturity for mussels is variable, usually requiring from 3 years to about 10 years, when complete maturity is reached (Zale and Neves 1982; Haag and Staton, in press), and may be sex dependent (Smith 1979). Males expel clouds of sperm into the water column, although some species expel spermatozeugmata (sperm balls), which consist of thousands of sperm (Barnhart and Roberts 1997). Females draw in sperm with the incurrent water flow. Fertilization takes place in their suprabranchial chambers, and the resulting zygotes develop into specialized veliger larvae, termed "glochidia," in the water tubes of the gills.

Depending on the subfamily, all four gills or just the outer gills are used as marsupia, or brood chambers, for glochidia. Spawning appears to be dependent on the temperature (i.e., spawning is initiated when the water temperature reaches a certain point; Zale and Neves 1982, Bruenderman and Neves 1993) but may also be influenced by stream discharge (Hove and Neves 1994). Fertilization rates are dependent on the spatial aggregation of reproductive adults (Downing et al. 1993).

Mussels are generally categorized as either short-term summer brooders (tachytictic) or long-term winter brooders (bradytictic) (Neves and Widlak 1988). Tachytictic species have a spring fertilization period; the glochidia are then incubated for a few months and are expelled during the summer or early fall. Bradytictic species have a late summer or early fall fertilization period, with the glochidia incubating over the winter, and are expelled the following spring or early summer.

The fact that some species have glochidia that overwinter on hosts (e.g., Watters and O=Dee 1997) indicates that they do not clearly fall into either the tachytictic or bradytictic reproductive strategy. This has led Watters and O=Dee (2000) to believe that glochidial release is more a function of water temperature. Winter releasers expel glochidia when water temperatures dip below a given point, while summer releasers expel glochidia when water temperatures rise above a threshold level.

Glochidia may number in the tens of thousands to several million (Surber 1912, Coker et al. 1921, Yeager and Neves 1986). Mussel fecundity is thought to be positively related to body size and inversely related to glochidia size (Bauer 1994). Haag and Staton (2003) determined that fecundity was best related to shell length, but also to age. They posited that large individuals are therefore particularly important in the maintenance of mussel populations. However, based on their study, very large or old individuals tend to exhibit a decline in fecundity. Extant populations of mussels tend to be skewed toward larger adults, strongly indicating that survival rates to the adult stage must be very low.

After a variable incubation period, glochidia are expelled into the water column. The temporal release of glochidia is thought to be behavioral rather than developmental (Gordon and Layzer 1993) and may be elicited by physical contact (Haag and Warren 1999). Glochidia must come into contact with specific species of fish whose gills and fins they temporarily parasitize,

although two species have been shown to possibly utilize amphibian hosts (Howard 1915, 1951; Watters 1997). Some mussel species, such as the green floater (Lasmigona subviridis [Conrad, 1835]), creeper (Strophitus undulatus [Say, 1817]), and paper pondshell (Utterbackia imbecillis [Say, 1829]), may not require a host fish to complete their life cycle (Lefevre and Curtis 1912, Howard 1914; G. T. Watters, Ohio Biological Survey, pers. comm., 1998). Glochidia failing to come into contact with a suitable host will drift through the water column, surviving until their energy reserves are exhausted or for only a few days (Sylvester et al. 1984, Neves and Widlak 1988, Jansen 1990, O'Brien and Williams 2002) to a week or two (Zimmerman and Neves 2002).

Glochidia are generally released individually in netlike mucoid strands that entangles fishes (Haag and Warren 1997) or as discreet packets, termed "conglutinates," which represent all the glochidial contents (and sometimes eggs) of a single water tube packaged in a mucilaginous capsule (Ortmann 1910, 1911). A newly described method, termed a "superconglutinate" by Williams and Butler (1994), involves the expulsion of the sum of the conglutinates from discreet portions of both outer gills that are packaged in a single glochidial mass (Haag et al. 1995, Hartfield and Butler 1997, Haag et al. 1999, O'Brien and Brim Box 1999).

Each of the three basic methods of glochidial expulsion and glochidial shape facilitates attachment to specific host fish and to specific fish structures (fin versus gill), respectively (Lefevre and Curtis 1910, 1912). Although supported by field observations (Lefevre and Curtis 1912, Neves and Widlak 1988), the fish structure parasitized may, in some cases, be due to fish behavior rather than morphology (Gordon and Layzer 1989).

Mantle displays have been shown to actively elicit attacks from fish (Haag and Warren 1999), and mantle lures potentially reduce the chances that glochidia will infest an unsuitable fish host (Haag et al. 1999). Laboratory tests have demonstrated that the presence of fish, and especially direct physical contact of host fish with mantle lures, stimulated larger releases of glochidia than when fish were absent or no physical contact occurred (Haag and Warren 2000). In the presence of fish, the swollen marsupialized gills are often extruded well beyond the edge of the shell margins between the mantle "lures" (Kraemer and Swanson 1985). Light-sensitive areas on the mantle may be stimulated by the shadow of a passing fish (Kraemer 1970, Jansen 1990, Weiss and Layzer 1995).

A small group of lampsilines expel superconglutinates (Haag et al. 1995, Hartfield and Butler 1997, Haag et al. 1999, O'Brien and Brim Box 1999). The superconglutinate, which is tethered by a secreted transparent mucilaginous strand that may reach 8 feet in length, resembles a fish in size, shape, and coloration, complete with stripes and an eyespot. During the production of the superconglutinate, the water currents move the fish mimic in motions that are similar to a small fish (Haag et al. 1995, Hartfield and Butler 1997). Once detached from the female, the fate of the superconglutinate depends on the chance that the current will wrap it around a rock, branch, or any structure in the stream where it will continue to mimic prey for a piscivorous host fish (Haag et al. 1995).

As few as 1 to as many as 25 fish species are known to serve as suitable hosts for particular species of mussels (Fuller 1974, Gordon and Layzer 1989). Host specificity appears to be common in mussels (Neves 1993), with most species utilizing only a few host fishes (Lefevre and Curtis 1912; Zale and Neves 1982; Yeager and Saylor 1995; Haag and Warren 1997, 2003a).

Glochidia also have been shown to display a chemosensory ability to respond positively to chemical stimuli such as fibrinogen (a blood protein crucial in coagulation and tissue repair) in fish (Henley and Neves 2001). This behavior serves to enhance infestation rates and transformation success on host species. Despite the potential for high infestation intensities, particularly from specialized lures, infestation rates tend to be very low, with few glochidia typically parasitizing an individual host fish (Haag and Warren 1999, Layzer et al. 2003).

The parasitic stage generally lasts a few weeks (Neves et al. 1985, O'Brien and Williams 2002), but can last up to six weeks or so (Yeager and Saylor 1995, Haag and Warren 1997, Zimmerman and Neves 2002), and is dependent on temperature and the species (Watters and O'Dee 2000, Zimmerman and Neves 2002). After dropping from fish hosts, newly metamorphosed juveniles passively drift with currents and ultimately settle in depositional areas with other suspended solids (Neves and Widlak 1987, Yeager et al. 1994). Juveniles must, however, come into contact with suitable habitat to begin their free-living existence (Howard 1922).

Glochidial parasitism serves as a means of dispersal for this relatively sedentary group (Neves 1993). The intimate relationship between mussels and their host fish has therefore played a major role in mussel distributions on both a geographic (Watters 1992) and community (Haag and Warren 1998) scale. Additional research into host fish/mussel community relationships appears warranted.

Knowledge about the reproductive biology of many freshwater mussels remains incomplete (Jansen 1990). For example, host fish for only one-third of the 300 mussel species in North America have been identified (O'Dee and Watters 2000), although subsequent studies are gradually expanding that number (e.g., O'Brien and Williams 2002, Haag and Warren 2003a, Layzer et al. 2003). Host fish information is lacking most in the Southeast, where more than 90 percent of the freshwater mussel species occur (Neves et al. 1997).

REASONS FOR DECLINE

Past and Present Threats

Two general categories of factors have impacted freshwater mussel resources for the past 500 years in Eastern North America--exploitation and habitat alteration. The former category primarily includes activities associated with the post-Mississippian Culture; pearling; the pearl button industry; and, more recently, the cultured pearl industry. The latter category includes a variety of anthropogenic activities prevalent during the past two centuries and is detailed below.

HABITAT ALTERATION

Resource managers should realize that, in the majority of cases, mussel resources were widely sustained during human interactions throughout history despite the widespread, prolonged, and sometimes dramatic exploitation events. Rather, the collapse of the mussel fauna is, by and large, the result of the second broad category of impacts--habitat loss from human-induced degradation (Williams et al. 1993, Neves 1993). Principal causes include impoundments, channelization, pollution, and sedimentation that have altered or eliminated those habitats that are essential to the long-term viability of many riverine mussel populations.

Impoundments

The decline, extirpation, and extinction of mussel species is overwhelmingly attributed to habitat alteration and destruction (Neves 1993), primarily manifest in the conversion of riverine systems to impoundments (Yeager 1993 1994). Impoundments result in the elimination of riffle and shoal habitats and the subsequent loss of mussel resources (Ortmann 1925; van der Schalie 1938a; Scruggs 1960; Bates 1962; Neel 1963; Isom 1969, 1971; Stansbery 1970, 1973b; Fuller 1974; Schmidt et al. 1989; Williams et al. 1992; Layzer et al. 1993; Parmalee and Hughes 1993; Lydeard and Mayden 1995; Sickel and Chandler 1996; Watters 1996). Most of a river's ecological processes are also disrupted, for example, by modifying flood pulses; controlling impounded water elevations; increasing depth; decreasing habitat heterogeneity; altering water flow, sediment, nutrients, energy input and output, and the riverine biota; and causing the loss of bottom stability due to subsequent sedimentation (Williams et al. 1992, Ligon et al. 1995, Sparks 1995, Watters 2000). The elimination of current and the covering of rocky and sand substrates by fine sediments alters the habitat of riverine to the point where they can no longer reproduce, recruit, and survive under impoundment conditions (Fuller 1974, Neves et al. 1997, Hughes and Parmalee 1999).

In addition, dams can seriously alter downstream water quality and riverine habitat (Allan and Flecker 1993, Ligon et al. 1995, Collier et al. 1996) and negatively impact mussel populations in tailwaters (Cahn 1936, Hickman 1937, Ahlstedt 1983, Miller et al. 1984, Layzer et al. 1993, Heinricher and Layzer 1999, McMurray et al. 1999b, Vaughn and Taylor 1999). These changes include thermal alterations (Neves 1993), channel characteristics, habitat availability, and flow regimes that have drastic effects on the stream biota (Krenkel et al. 1979, Allan and Flecker 1993). Altered effects also include fish community shifts (Brim 1991) and the resultant colonization by fewer native species and more alien species (Williams and Neves 1992). Daily discharge fluctuations, bank sloughing, seasonal oxygen deficiencies, cold-water releases, turbulence, high silt loads, and altered host fish distribution have contributed to limited mussel recruitment and skewed demographics (Sickel 1982, Ahlstedt 1983, Miller et al. 1984, Layzer et al. 1993, McMurray et al. 1999b).

Cold-water releases from large nonnavigational dams are the result of placing water intake structures low on the dam to increase hydropower efficiency (Krenkel et al. 1979). The release of cold water and scouring of the riverbed from highly fluctuating, turbulent flows in tailwaters have also been implicated in the demise of mussel faunas (Miller et al. 1984, Layzer et al. 1993, Heinricher and Layzer 1999). Specifically, tachytictic species, which depend on warm summer temperatures to initiate gametogenesis, spawning, glochidia release, and the proper host fish

being present, experience reproductive failure below dams (Heinricher and Layzer 1999). Bradytictic species are also negatively affected, and the decline of mussel populations has been manifested over a period of several decades (Neves 1999).

Channelization

Dredging and channelization activities have profoundly altered riverine habitats nationwide, with effects on streams summarized by Simons (1981), Bhowmik (1989), and Hubbard et al. (1993). Channelization impacts a stream=s physical (e.g., accelerated erosion, reduced depth, decreased habitat diversity, geomorphic instability, riparian canopy loss) and biological (e.g., decreased fish and mussel diversity, changed species composition and abundance, decreased biomass and growth rates) characteristics (Stansbery and Stein 1971, Hartfield 1993, Hubbard et al. 1993). Since mussels need stable substrates to survive (Strayer 1999a), channel instability is probably the single most detrimental aspect of channelization (Hartfield 1993). Channel construction for navigation has been shown to increase flood heights (Belt 1975), thus exacerbating flood events that convey to streams large quantities of sediment with adsorbed contaminants. Channel maintenance may also result in downstream impacts (Stansbery 1970), such as increases in turbidity and sedimentation, which may smother benthic organisms. Impacts associated with barge traffic--the construction of fleeting areas, mooring cells, docking facilities, and propeller wash--also disrupt habitat. Although the volume of literature demonstrating the on-site and off-site environmental and economic consequences of dredging for navigation and flood control is substantial (Smith and Patrick 1991, Watters 2000), these activities continue.

Mineral Extraction

Heavy metal-rich drainage from coal mining and associated sedimentation has adversely impacted many stream reaches (Barnhisel and Massey 1969, Ahmad 1973, Curry and Fowler 1978), destroying mussel beds and preventing natural recolonization (Simmons and Reed 1973, McCann and Neves 1992). Neves et al. (1997) reviewed the effects of various mining activities on freshwater mollusks. The low pH commonly associated with mine runoff can lead to an inability of glochidia to clamp their valves on host tissues, thus preventing proper encystment (Huebner and Pynnönen 1992). In addition, interstitial spaces in streams, which provides habitat critical for juvenile mussels, are clogged by sediment runoff from mines (Branson and Batch 1972). Circumstantial evidence indicates that salinity, a by-product of oil exploration activities, is lethal to some glochidia (Liquori and Insler 1985). Increased sedimentation and turbidity (see ASedimentation,@ in this section, for its effects on mussels), reduction in pH from chemicals associated with acid mine drainage, and heavy metals (see “Contaminants,” in this section, for their effects on mussels) have altered habitat in many streams to the point where mussels are unable to reproduce, recruit, and survive these conditions.

Polycyclic aromatic compounds (PAHs) are indicative of coal fines in the bottom sediments of streams. PAHs are known to be toxic to mussels and fishes. In a quantitative study in the Powell River, Ahlstedt and Tuberville (1997) attributed a 15-year decline of the oyster mussel, Cumberlandian combshell, and rough rabbitsfoot and the long-term decrease in species diversity (from 30 in 1979 to 21 in 1994) to general stream degradation due primarily to coal mining activities in the headwaters. Mining activities also likely contributed to the extirpation of the purple bean from the Powell River several decades ago. Iron and phosphate mining in the Duck River watershed was thought to have caused mussel declines in the early 1900s (Ortmann 1924).

Gravel Mining

In-stream gravel mining has been implicated in the destruction of mussel populations (Stansbery 1970, Yokley and Gooch 1976, Grace and Buchanan 1981, Hartfield and Ebert 1986, Schuster et al. 1989, Hartfield 1993, Howard 1997). Lagasse et al. (1980), Kanehl and Lyons (1992), and Roell (1999) reviewed the physical and biological effects of mining sediment from streams. Negative impacts include riparian forest clearing (e.g., mine site establishment, access roads, lowered floodplain water table); stream channel modifications (e.g., geomorphic instability, altered habitat, disrupted flow patterns [including lowered elevation of stream flow], sediment transport); water quality modifications (e.g., increased turbidity, reduced light penetration, increased temperature); macroinvertebrate population changes (e.g., elimination, habitat disruption, increased sedimentation); and changes in fish populations (e.g., impacts to spawning and nursery habitat, food web disruptions) (see discussion in “Sedimentation”). Once mussels have been eliminated, a decade or more may pass before recolonization occurs (Stansbery 1970, Grace and Buchanan 1981). Substrate disturbance and sedimentation impacts can also be realized for considerable distances downstream (Stansbery 1970), and possibly upstream (Hartfield 1993).

Contaminants

Contaminants contained in point and nonpoint discharges can degrade water and substrate quality and adversely impact, if not destroy, mussel populations (Horne and McIntosh 1979, Neves and Zale 1982, McCann and Neves 1992, Havlik and Marking 1987). Although chemical spills and other point sources (e.g., ditch, swale, artificial channel, drainage pipe) of contaminants may directly result in mussel mortality, widespread decreases in density and diversity may result, in part, from the subtle, pervasive effects of chronic low-level contamination (Naimo 1995).

Mussels appear to be among the most intolerant organisms to heavy metals (Keller and Zam 1991), several of which are lethal, even at relatively low levels (Havlik and Marking 1987). Cadmium appears to be the heavy metal most toxic to mussels (Havlik and Marking 1987), although chromium, copper, mercury, and zinc also negatively affect biological processes (Jacobson et al. 1993, Naimo 1995, Keller and Zam 1991, Keller and Lydy 1997). In laboratory experiments, mussels suffered mortality when exposed to 2.0 parts per million (ppm) cadmium, 12.4 ppm chromium, 19.0 ppm copper, and 66.0 ppm zinc (Mellinger 1972, Havlik and Marking 1987). Most metals are persistent in the environment (Miettinen 1977), remaining available for

uptake, transportation, and transformation by organisms for long periods (Hoover 1978). Metals stored in mussel tissues indicate recent or current exposure (Havlik and Marking 1987), while concentrations in shell material indicate past exposure (Imlay 1982, Mutvei et al. 1994). Highly acidic pollutants such as metals are capable of contributing to mortality by dissolving mussel shells (Stansbery 1995).

Among other pollutants, ammonia has been shown to be lethal to mussels at concentrations of 5.0 ppm (Havlik and Marking 1987). Ammonia is oftentimes associated with animal feedlots, nitrogenous fertilizers, and the effluents of older municipal wastewater treatment plants (Goudreau et al. 1993). This contaminant may become more problematic for juvenile mussels during periods of low flow, when water temperatures increase (Newton et al. 2003). In stream systems, ammonia is most prevalent at the substrate/water interface (Frazier et al. 1996). Due to its high level of toxicity and the fact that the highest concentrations occur in the microhabitat, where mussels live, ammonia should be considered among the factors potentially limiting the survival and recovery of mussels at some locations (Augspurger et al., 2003).

Certain adult species may tolerate short-term exposure (Keller 1993). However, the effects of heavy metals and other toxicants are especially profound on juvenile mussels (Robison et al. 1996) and on the glochidia, which appear to be very sensitive to toxicants such as ammonia (Goudreau et al. 1993). Low levels of some metals may inhibit glochidial attachment (Huebner and Pynnönen 1992). Juvenile mussels may inadvertently ingest contaminated silt particles while feeding (see “Food Habits”). Mussel recruitment may therefore be reduced in habitats with low but chronic heavy metal and other toxicant inputs (Yeager et al. 1994, Naimo 1995, Ahlstedt and Tuberville 1997).

Secondly, pesticides, primarily from row crops, are a major source of agricultural contaminants. Pesticide runoff that commonly ends up in streams may have effects (based on studies with laboratory-tested mussels) that are particularly profound (Fuller 1974, Havlik and Marking 1987, Moulton et al. 1996). Once widely used in the Southeast, organochlorine pesticides are still detected in streams and aquatic organisms decades after their use has been banned and may still be found in streams at levels that often exceed the chronic exposure criteria for the protection of aquatic life (Buell and Couch 1995, Frick et al. 1998). These highly toxic compounds are partitioned into both the sediment and the lipid reservoir of organisms (Day 1990, Burton 1992). Erosion from areas of past use is a continuing source of organochlorine pesticides in some streams. One of the most important pesticides used in cotton farming, malathion, is known to inhibit the physiological activities of mussels (Kabeer et al. 1979) and may decrease the ability of a mussel to respire and obtain food.

Toxic Spills

Numerous Cumberlandian Region streams have experienced mussel kills from toxic chemical spills and other causes (Cairns et al. 1971, Crossman et al. 1973, Neves 1986, Wolcott and Neves 1994). The high number of jeopardized species in the upper Tennessee River system make accidental spills a particular concern to conservationists and resource managers (Hampson et al. 2000). The dramatic impact the chlor-alkali chemical plant in Saltville, Virginia, has had on the

aquatic fauna in the North Fork Holston River is well documented (Adams 1915; Cairns et al. 1971; Stansbery and Clench 1974; Hill et al. 1975; Ahlstedt 1980, 1991c; Neves and Zale 1982; Sheehan et al. 1989; Hampson et al. 2000). Although it is considered a chronic episode, and not an "event" like most other toxic spills, it is discussed in this section simply because of the tremendous impact it has had on the river.

Sedimentation

Sedimentation, including siltation runoff, has been implicated as the number one factor in water quality impairment in the United States (EPA 1990). Although the specific associations that mussels have with stream substrates are poorly understood (Brim Box and Mossa 1999), sedimentation is widely thought to have contributed to the decline of mussel populations (Kunz 1898; Ellis 1931, 1936; Cordone and Kelly 1961; Imlay 1972; Coon et al. 1977; Marking and Bills 1979; Wilber 1983; Dennis 1985; Schuster et al. 1989; Wolcott and Neves 1990; Houp 1993; Richter et al. 1997, Brim Box 1999; Henley et al. 2000; Fraley and Ahlstedt 2000).

Specific biological impacts on mussels from excessive sediment include reduced feeding and respiratory efficiency from clogged gills, disrupted metabolic processes, reduced growth rates, increased substrate instability, limited burrowing activity, and physical smothering (Ellis 1936, Stansbery 1971, Markings and Bills 1979, Kat 1982, Vannote and Minshall 1982, Aldridge et al. 1987, Waters 1995). Brim Box (1999) showed that burying adult mussels under 5.5 inches of sediment in the Apalachicola, Chattahoochee, and Flint River basin significantly decreased their chances of surviving. Intuitively, much thinner layers of sediment may result in juvenile mortality. Such studies tend to indicate that the primary impacts of excess sediment on mussels are sublethal, with detrimental effects not immediately apparent (Brim Box and Mossa 1999). The physical effects of sediment on mussels appear to be multifold (Brim Box and Mossa 1999). They are potentially impacted by changes in suspended and bed material load; bed sediment composition associated with increased sediment production and runoff in the watershed; channel changes in form, position, and degree of stability; changes in depth or the width/depth ratio, which affects light penetration and flow regime; actively aggrading (filling) or degrading (scouring) channels; and changes in channel position that may leave them high and dry (Vannote and Minshall 1982, Kanehl and Lyons 1992, Hartfield 1993, Brim Box and Mossa 1999; see earlier discussion on "Gravel Mining").

Interstitial spaces in mixed substrates may become clogged with sediment (Gordon et al. 1992). When clogged, interstitial flow rates and spaces may become reduced (Brim Box and Mossa 1999), thus reducing habitat for juvenile mussels and some adults as well. Salomons et al. (1987) and the National Research Council (1992) indicated that sediment may act as a vector for delivering contaminants such as nutrients and pesticides to streams. Juveniles can readily ingest contaminants adsorbed to silt particles during normal feeding activities (see "Food Habits"). These factors may help explain, in part, why so many mussel populations appear to be experiencing recruitment failure.

Host fish/mussel interactions may be indirectly impacted by changes in stream sediment regimes through three mechanisms (Brim Box and Mossa 1999). First, fish abundance (Berkman and

Rabeni 1987), diversity (Waters 1995), and reproduction (Muncy et al. 1979) may be reduced with increased sedimentation. Second, excessive sedimentation likely impedes host fish attractant mechanisms (e.g., mantle flaps, conglutinates, superconglutinates that mimic fish prey items) (Haag et al. 1995, Burkhead et al. 1997). Third, sedimentation on shoal substrates may interfere with the ability of some species' adhesive conglutinates to adhere to rock particles (Hartfield and Hartfield 1996).

Many Southeastern streams have increased turbidity levels due to siltation (van der Schalie 1938a). Some species attract host fishes with visual cues, luring fish into perceiving that their glochidia are prey items. Such a reproductive strategy depends on clear water during the critical time of the year when mussels are releasing their glochidia (Hartfield and Hartfield 1996). Turbidity is a limiting factor impeding sight-feeding fishes (Burkhead and Jenkins 1991). In addition, mussels may be indirectly affected when turbidity levels significantly reduce the amount of light available for photosynthesis and the production of unionid food items (Kanehl and Lyons 1992).

Erosion from silvicultural activities accounts for 6 percent of the nation=s sediment pollution (Henley et al. 2000). Sedimentation impacts are more the result of logging roads than the actual harvesting of timber (Waters 1995, Brim Box and Mossa 1999). Annual runoff and/or peak flow volumes increase with timber harvests, particularly during the wet season (Allan 1995). This is partially due to the construction of logging roads, and vegetation removal tends to compact soils, reduce infiltration rates, and increase soil erosion. Increased flows and improper harvesting within stream-side management zones may result in stream channel changes (Brim Box and Mossa 1999) that may ultimately affect mussel beds.

Maintaining vegetated riparian buffers is a well-known method of reducing stream sedimentation and other runoff (USFWS 1980, Allan and Flecker 1993, Lenat and Crawford 1994). Buffers reduce impacts to fish and other aquatic faunas (Naiman et al. 1988, Osborne and Kovacic 1993, Belt and O'Laughlin 1994, Penczak 1995, Rabeni and Smale 1995) and are particularly crucial for mussels (Neves et al. 1997). Riparian forest removal in Southern Appalachian streams and subsequent sedimentation has been shown to be detrimental to fish communities (Burkhead et al. 1997, Jones et al. 1999). Particularly affected in the study by Jones et al. (1999) were benthic-dependent species (e.g., darters, benthic minnows, sculpins), which were found to decrease in abundance with longer deforested patches of riparian area. Benthic-dependent fishes, themselves disproportionately imperiled (Burkhead et al. 1997, Warren et al. 2000), commonly serve as hosts for numerous imperiled mussel species (Watters 1994).

Summary

Currently, the species and their habitats continue to be impacted by excessive sediment bed loads of smaller sediment particles, changes in turbidity, increased suspended solids (primarily resulting from nonpoint-source loading from poor land-use practices, lack of BMPs, and maintenance of existing BMPs), and pesticides. Other primarily localized impacts include coal mining, gravel mining, reduced water quality below dams, developmental activities, water

withdrawal, impoundments, and alien species. Toxic spills are also a possibility in all extant populations.

PATTERNS OF IMPERILMENT

The fate of freshwater mussel populations is influenced by a number of complex biological and ecological factors that are, in turn, ultimately affected by anthropogenic forces (Neves 1993). In addition, the elaborate life cycle of mussels increases the probability that weak links in their life history will preclude successful reproduction and recruitment. Following is an attempt to explain the consequences of the many factors that have contributed to the demise of mussel populations.

Reproductive Biology

Egg formation and fertilization are critical phases in the life history, as many mussels fail to form eggs (Downing et al. 1989), or fertilization is incomplete (Matteson 1948). Fertilization success has been shown to be strongly correlated with spatial aggregation, and either influences the rate of egg formation, or improves fertilization rates of individuals, or both (Downing et al. 1993).

A study of Elliptio complanata (Lightfoot, 1786) in a Canadian lake (Downing et al. 1993) suggested that the fertilization success of sparse populations of species having separate sexes (i.e., nonhermaphroditic) is extremely low. Population viability in mussel beds with low densities may be intuitively questionable, and where fertilization does occur, recruits may be more homozygous than those in denser populations. Populations with cohort dominance skewed toward only old, large mussels will have limited reproductive success due to senescence. The occurrence of large numbers of gonad-destroying trematode parasites in old individuals of some mussel species (Zale and Neves 1982) might indicate senescence is partially a result of gonadal infestation.

The fluvial nature of riverine ecosystems would likely indicate that mussel beds would not need to be as aggregated for successful reproduction, as stream flow patterns would potentially disperse sperm over long linear distances. Where very low densities occur, however, reproductive success would probably be minimal. There is some evidence that hermaphroditism in certain mussel species may allow even minuscule populations to enjoy some level of reproductive viability (Neves, pers. comm., 1996). Females changing to hermaphrodites may be an adaptive response (Bauer 1987), assuring that a recruitment class may not be lost in small populations.

Host Fish Connection

Host fish availability and density are significant factors influencing where certain mussel populations can persist (Haag and Warren 1998). The apparently inefficient reproductive cycle involving obligate fish hosts would appear to be a weak link in population recruitment (Bogan 1993). Despite the high number of glochidia produced, contact between glochidia and host fishes is a low-probability event (Neves et al. 1997), promoted by the respiratory and feeding behavior of fishes (Dartnall and Walkey 1979, Neves et al. 1985) and the behavioral

characteristics of some mussel species (Davenport and Warmuth 1965, Kraemer 1970). Infestation rates are therefore generally low for riverine mussels (Neves and Widlak 1988, Bruenderman and Neves 1993), but there are some exceptions (e.g., Michaelson and Neves 1995). Although glochidia may initially attach to many fish species, immune system incompatibility results in unsuitable fish hosts quickly sloughing off the parasites (Zale and Neves 1982).

Recruitment Failure

Strong recruitment is a common characteristic of healthy viable mussel populations (Haag and Warren 2003b). Newly recruited individuals may even constitute a large percentage of the total population. Conversely, the sporadic or low levels of recruitment that are characteristic of many populations are likely not sustainable and are indicative of declining populations (Haag and Warren 2003b).

Despite the dearth of available quantitative information, the evidence is overwhelming that individual and combined stressors resulting from anthropogenic forces have been responsible for the demise of mussel faunas (Havlik and Marking 1987, Neves et al. 1997). Gradual reductions in recruitment and survival of vulnerable mussel species occur when anthropogenic factors act insidiously in altering sediment and water quality (Fleming et al. 1995).

Susceptibility of glochidia and host fish to altered and degraded habitats, coupled with the chance encounter between glochidia and host, can contribute to periodic recruitment failures (Zale and Neves 1982, McMurray et al. 1999a) and relic populations dominated by cohorts of older adults (Neves 1993, Stansbery 1995). Juveniles appear to be more susceptible to perturbations than adults (Ortmann 1909) and are hypothesized to be more susceptible to competitive interactions with the Asian clam for space or food (Neves and Widlak 1987). Lack of recent recruitment is apparent in many mussel populations (McMurray et al. 1999a, 1999b). It is possible that pedal-feeding juveniles that ingest contaminated sediment (see “Habitat Alteration”) are precluding recruitment in some otherwise reproducing mussel populations. Unfortunately, many mussel populations are characterized by large, old, and spatially separated individuals that are commonly on their way toward extirpation (Stansbery 1995).

Mussel recolonization of impacted river reaches is achieved by dispersal of newly metamorphosed juveniles via infested host fish, passive adult movement downstream (Neves 1993), and active migration or passive movement downstream of juveniles (Kat 1982). Due to slow growth and relative immobility, however, the establishment of self-sustaining populations requires decades of immigration and recruitment, even where suitable habitat exists for common species that may occur in high densities (Neves 1993). Mussel recruitment is typically low and sporadic, with population stability and viability being maintained by numerous slow-growing cohorts and occasionally good year classes (Neves and Widlak 1987). Only when a significant number of viable populations have been verified should that species be considered stable (A. E. Bogan, North Carolina State Museum of Natural Sciences, in litt., 1995).

Due to their extreme longevity, direct effects of some anthropogenic factors on mussels may not be evident for years and, in some cases, not until the species has disappeared or experienced significant range reduction (Bogan, in litt., 1995). Studies suggest that although individual impacts may be minor, cumulative effects may become lethal over time (Bogan 1993).

Determination of the relative rarity of species has been divided by Rabinowitz et al. (1986) into the following three factors: (1) geographic range, (2) habitat specificity, and (3) population abundance.

Summary

In summary, mussels are jeopardized when their population size is diminished by any factor that reduces glochidial or juvenile survivability, adult spawning stocks, and host fish abundance (Neves 1993). Furthermore, any perturbation that limits fertilization rates and survivability of the glochidia; decreases host fish abundance; decreases fish community composition; and/or alters density, aggregation, or size distribution of mussel populations is detrimental to population viability and, ultimately, the species as a whole (Downing et al. 1993, Neves 1993, Neves et al. 1997).

CUMBERLAND ELKTOE
Alasmidonta atropurpurea

STATUS:
On January 10, 1997, the Cumberland elktoe (*Alasmidonta atropurpurea)* was designated as Endangered throughout its entire range (USFWS 1997). Critical habitat was designated for the Cumberland Elktoe on August 31, 2004 (69 FR 53135). The *Recovery Plan for the Cumberland Elktoe, Oyster Mussel, Cumberlandian Combshell, Purple Bean, and Rough Rabbitsfoot* was approved on May 4, 200 4(69 FR 29569). A 5-year review of the Cumberland Elkoe's status was approved on January 4, 2007.

SPECIES DESCRIPTION:
The Cumberland elktoe has a thin, but not fragile, shell.

REPRODUCTION AND DEVELOPMENT:
Gordon and Layzer (1993) summarized the reproductive biology and identified fish hosts of the Cumberland elktoe. This anodontine species was found gravid from October through May, but they observed no fish infested with its glochidia until March. They found Cumberland elktoe glochidia to develop equally well on both fin and gill surfaces. Five native fish species were parasitized by Cumberland elktoe glochidia--whitetail shiner (*Cyprinella galactura*), northern hogsucker (*Hypentelium nigricans*), rock bass (*Ambloplites rupestris*), longear sunfish (*Lepomis megalotis*), and rainbow darter (*Etheostoma caeruleum*). However, under laboratory conditions, juvenile specimens transformed only on the northern hogsucker (Gordon and Layzer 1993). In a recent study, active pedal-feeding juveniles excysted on the northern hogsucker, banded sculpin (*Cottus carolinae*), redline darter (*E. rufilineatum*) and fantail darter (*E. flabellare*). The period

of glochidial encystment (i.e., until transformation into free-living juveniles) took 24 days, at 66.2E ∀ 5.4EF.

RANGE AND POPULATION LEVEL:
The Cumberland elktoe is limited in distribution to the upper Cumberland River system in southeast Kentucky and north-central Tennessee, occupying streams both above and below Cumberland Falls (Table 1, USFWS 2003). A single record exists for the Collins River, in the upper Caney Fork River system above Great Falls. This species appears to have occurred only in the main stem of the Cumberland River and primarily its southern tributaries upstream from the hypothesized original location of Cumberland Falls near Burnside, Pulaski County, Kentucky (Cicerello and Laudermilk 2001). The original type locality was simply Ariver Cumberland,@ according to Clarke (1981), who, upon ascertaining that the type specimen was lost, designated a neotype from the Clear Fork, a tributary to the Big South Fork, in Fentress County, Tennessee (see Table 1, Footnote 2). All verified sites of occurrence are in the Cumberland Plateau Physiographic Province, giving it one of the most restricted ranges of any Cumberlandian species.

There has been confusion about the historical distribution of this species because of its similarity to a congener--the elktoe (Cicerello and Laudermilk 2001). Museum and literature records of *A. marginata* from the Cumberland River drainage on the Cumberland Plateau should be verified, because they may actually represent the Cumberland elktoe (see ANote@ for Table 1 in USFWS 2003). There is still controversy as to the proper identity of the specimen known from the upper Caney Fork system in central Tennessee (see Table 1, Footnote 5 in USFWS 2003). Apparently, these two species occur sympatrically in the Rockcastle River (Cicerello and Laudermilk 2001) and Big South Fork (Ahlstedt, USGS, pers. comm., 2003), contrary to the assertion by Gordon and Layzer (1993) that they are allopatric. Although no syntopic records are known, they may occur together in the Big South Fork, where both have been collected in recent years.

The Cumberland elktoe has apparently been extirpated from the main stems of the Cumberland and Laurel Rivers (and its tributary, Lynn Camp Creek). In addition, no recent records are available for the Collins River. However, it was recently rediscovered in the heavily coal-mined New River in 2002 (Ahlstedt, pers. comm., 2003). Based on recent records, populations of the Cumberland elktoe persist in 12 tributaries--Laurel Fork, Claiborne County, Tennessee and Whitley County, Kentucky and Marsh Creek, McCreary County, Kentucky ; Sinking Creek, Laurel County, Kentucky; Big South Fork, Scott County, Tennessee, and McCreary County, Kentucky; Rock Creek, McCreary County, Kentucky; North White Oak Creek, Fentress County, Tennessee; Clear Fork, Fentress, Morgan, and Scott Counties, Tennessee; North Prong Clear Fork and Crooked Creek, Fentress County, Tennessee; White Oak Creek, Scott County, Tennessee; Bone Camp Creek, Morgan County, Tennessee; and New River, Scott County, Tennessee (Table 1, USFWS 2003). The latter nine streams, which comprise the Big South Fork system, may represent a single, viable metapopulation of the Cumberland elktoe; there may be suitable habitat for the species and/or its fish hosts in intervening stream reaches, potentially allowing for natural genetic interchange to occur.

Considered a Arare species@ by Clarke (1981), few sites are known to have ever harbored the Cumberland elktoe. Marsh Creek harbors the largest population known in Kentucky (Cicerello 1995), and the population in Rock Creek is also sizable (Cicerello 1996). In both streams the Cumberland elktoe represented the second most abundant unionid species (Cicerello 1995, 1996). The Marsh Creek population, with at least three year classes present, is viable, but the viability of the Rock Creek population is questionable 7. R. Cicerello, Kentucky State Nature Preserves Commission, pers. comm., 2000). The population in Laurel Fork is small, difficult to find, and of questionable viability. Though larger, the status of the Sinking Creek population is unknown (Cicerello, pers. comm., 2003). The largest populations in Tennessee are in the Big South Fork system in the headwaters of the Clear Fork system, where several hundred specimens were found in muskrat middens in the late 1980s (Bakaletz 1991; Layzer, pers. comm., 1998). Several age classes of the Cumberland elktoe were represented in samples taken from throughout the larger tributaries of the Big South Fork system metapopulation in Tennessee during a 1985-86 survey (Bakaletz 1991). Based on sampling conducted in 2002, the populations in White Oak and North White Oak Creeks are among the largest viable populations rangewide (Ahlstedt, pers. comm., 2003).

HABITAT:
This Cumberland elktoe inhabits medium-sized rivers and may extend into headwater streams where it is often the only mussel present (Gordon and Layzer 1989, Gordon 1991). Gordon and Layzer (1989) reported that the species appears to be most abundant in flats, which were described by Gordon (1991) as shallow pool areas lacking the bottom contour development of typical pools, with sand and scattered cobble/boulder material, relatively shallow depths, and slow (almost imperceptible) currents. They also report the species from swifter currents and in areas with mud, sand, and gravel substrates.

CRITICAL HABITAT:
In McCreary County, Kentuckey, all stream and river channels within the ordinary high-water line of the main stem of Rock Creek beginning at the Rock Creek/White Oak Creek confluence and extending upstream to the low water crossing approximately 1.6 mi southwest of Bell Farm. In Fentress, Morgan, and Scott Counties, Tennessee, and McCreary County, Kentucky, all stream and river channels within the ordinary high-water line of the Big South Fork of the Cumberland River main stem from its confluence with Laurel Crossing Branch downstream of Big Shoals, McCreary County, Kentucky, upstream to its confluence with the New River and Clear Fork, Scott County, Tennessee; 11 rkm (7 rmi) of North White Oak Creek from its confluence with the Big South Fork upstream to Panther Branch, Fentress County, Tennessee; 14.5 rkm (9.0 rmi) of the New River from its confluence with Clear Fork upstream to U.S. Highway 27, Scott County, Tennessee; 40 rkm (25 rmi) of Clear Fork from its confluence with the New River upstream to its confluence with North Prong Clear Fork, Morgan and Fentress Counties, Tennessee; 10 rkm (6 rmi) of White Oak Creek from its confluence with Clear Fork upstream to its confluence with Bone Camp Creek, Morgan County, Tennessee; 6 rkm (4 rmi) of Bone Camp Creek from its confluence with White Oak Creek upstream to Massengale Branch, Morgan County, Tennessee; 14.5 rkm (9.0 rmi) of Crooked Creek from its confluence with Clear

Fork upstream to Buttermilk Branch, Fentress County, Tennessee; and 14.5 rkm (9 rmi) of North Prong Clear Fork from its confluence with Clear Fork upstream to Shoal Creek. In Laurel County, Kentucky, all stream and river channels within the ordinary high-water line from the Sinking Creek/Rockcastle River confluence upstream to Sinking Creek's confluence with Laurel Branch in Laurel County, Kentucky. In McCreary County, Kentucky, all stream and river channels within the ordinary high-water line of Marsh Creek from its confluence with the Cumberland River upstream to the State Road 92 Bridge in McCreary County, Kentucky. In Claiborne County, Tennessee, and Whitley County, Kentucky, all stream and river channels within the ordinary high-water line, of Laurel Fork of the Cumberland River from the Campbell/Claiborne County line upstream 11.0 rkm (6.9 rmi) through Claiborne County, Tennessee, to Whitley County, Kentucky.

Primary constituent elements identified at the time of designation included: 1. Permanent, flowing stream reaches with a flow regime (i.e, the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of the mussel and its host fish; 2. Geomorphically stable stream and river channels and banks (structurally stable stream cross section); 3. Stable substrates, consisting of mud, sand, gravel, and/or cobble/boulder, with low amounts of fine sediments or attached filamentous algae; 4. Water quality (including temperature, turbidity, oxygen content, and other characteristics) necessary for the normal behavior, growth, and survival of all life stages of the five mussels and their host fish; and 5. Fish hosts with adequate living, foraging, and spawning areas for them.

PAST THREATS:
The abundance and distribution of the Cumberland elktoe decreased historically from human-induced habitat loss and degradation (Williams et al. 1993, Neves 1993) caused by impoundments (e.g., TVA impoundments on the Tennessee and Cumberland Rivers and their tributaries, Laurel River, Obey River, Caney Fork, Stones River), sedimentation and turbidity, channelization, and contaminants contained in numerous point and nonpoint sources. A comprehensive review of these past threats is provided elsewhere (USFWS 2003, Williams et al. 1993, Neves 1993, Neves 1991, Neves et al. 1997, Watters 2000, Richter et al. 1997). These habitat changes have resulted in significant extirpations (localized loss of populations), restricted and fragmented distributions, and poor recruitment of young.

CURRENT THREATS:
The Cumberland elktoe and its habitat is currently being impacted by excessive sediment bed loads of smaller sediment particles, changes in turbidity, increased suspended solids (primarily resulting from nonpoint-source loading from poor land-use practices and lack of, or maintenance of, existing best management practices), and pesticides (USFWS 2003, Neves 1991, Neves et al. 1997, Watters 2000). Other primarily localized impacts include coal mining, gravel mining, reduced water quality below dams, developmental activities, water withdrawal, impoundments, and alien species. Their restricted ranges and low population levels also increase their vulnerability to toxic chemical spills and the deleterious effects of genetic isolation.

Strip mining and acid mine runoff may be having local impacts on the recruitment of the Cumberland elktoe, since most of its range (e.g., upper Cumberland River system) is within

watersheds where coal mining is still occurring (Anderson 1989, Warren et al. 1999). In addition, interstitial spaces in streams, which is habitat critical for juvenile mussels, are clogged by sediment runoff from mines (Branson and Batch 1972). Circumstantial evidence indicates that salinity, a by-product of oil exploration activities, is lethal to some glochidia (Liquori and Insler 1985). Overall, the increased sedimentation and turbidity, reduction in pH from chemicals associated with acid mine drainage, and heavy metals have altered habitat in many streams to the point where these mussels are unable to reproduce, recruit, and survive in these conditions. The Marsh Creek population of the Cumberland elktoe has also been adversely affected and is still threatened by potential spills from oil exploration activities.

Water withdrawals for agricultural irrigation and municipal and industrial water supplies are an increasing concern for all aquatic resources and are directly correlated with expanding human populations. This impact has the potential to be a particular problem for the Cumberland elktoe population in the Big South Fork system. Droughts may also be a threat to these species, particularly populations occurring in smaller streams. Impacts include decreased flow velocities and depressed dissolved oxygen levels (Johnson et al. 2001). Stochastic events, such as droughts, may be exacerbated by global warming and water withdrawals. These anthropogenic activities act insidiously to lower water tables, thus making mussel populations susceptible to depressed stream levels.

Exposure Scenario Summary Table for the Cumberland Elktoe

Species	**Life Stage**	**Habitat Type**	**Exposure Route**	**Diet**	**Significant Interspecies Relationships**
Cumberland Elktoe	glochidia	parasite	contact with water, diet	fish body fluids	Whitetail shiner Rock bass Longear sunfish Rainbow darter Redline darter Fantail darter Fantail darter Redline darter Northern hogsucker Banded sculpin
	juvenile/ adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

DWARF WEDGEMUSSEL
Alasmidonta heterodon

STATUS:
On March 14, 1990, the dwarf wedgemussel was designated as endangered throughout its entire range (USFWS 1990). Within the area covered by this listing, this species is known to occur in Connecticut, Massachusetts, Maryland, North Carolina, New Hampshire, New Jersey, New York, Pennsylvania, Virginia, Vermont as well as Canada (New Brunswick). A recovery plan for the dwarf wedge mussel was approved on February 8, 1993 (USFWS 1993).

SPECIES DESCRIPTION:
The chief distinguishing characteristic of this species, which is the only North American freshwater mussel that consistently has two lateral teeth on the right valve, but only one on the left (Fuller 1977). It is a small mussel whose shell rarely exceeds 1.5 inches in length. The species exhibits strong sexual dimorphism. Like other freshwater mussels, the dwarf wedge mussel feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of dwarf wedgemussel glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the dwarf wedge mussel is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. They then detach from their fish host and sink to the stream bottom or other substrate where they continue to develop, provided they land in a suitable substratum with the correct water conditions. Clarke (1981) indicates that the dwarf wedge mussel is a long-term brooder. Three potential glochidial host species have been identified in laboratory studies for the dwarf wedge mussel including the tesselated darter (*Etheostoma olmstedti*), Johnny darter (*Etheostoma nigrum*), and mottled sculpin (*Cottus bairdi*) (Michaelson and Neves 1995). The slimy sculpin (*Cottus cognatus*) and juvenile Atlantic salmon (*Salmo salar*) have also been identified as hosts (USFWS file information).

RANGE AND POPULATION LEVEL:
The dwarf-wedge mussel occurs in at least 25 stream reaches along the Atlantic Coast from New Brunswick, Canada, to North Carolina (USFWS 2003). The recovery plan documents 20 populations of the species in eight river systems. According to that plan (USFWS 1993), the dwarf wedge mussel is known in the Connecticut River drainage in the Connecticut River (Sullivan County, NH and Windsor County, VT), the Ashuelot River (Cheshire County, NH), and Muddy Brook (Hartford County, CT); in the Delaware River drainage in Neversink River (Orange County, NY); in the Tuckahoe Creek drainage in Norwich Creek (Queen Anne and Talbot Counties, MD) and Long Marsh Ditch (Queen Anne and Caroline Counties, MD); in the Potomac River drainage in McIntosh Run (St. Mary's County, MD), Nanjemoy Creek (Charles

County, MD), and Aquia Creek (Stafford County, VA); in the York River drainage in South Anna River (Louisa County, VA); in the Nottoway River drainage in Nottoway River (Nottoway and Lunenberg Counties, VA); in the Tar River drainage in the Tar River (Granville County, NC), Cedar Creek (Franklin County, NC), Crooked Creek (Franklin County, NC), Shelton Creek (Granville County, NC), Cub Creek (Granville County, NC), Fox Creek (Franklin County, NC), Shocco Creek, Little Shocco Creek and an unnamed tributary to Shocco Creek (Warren and Franklin County, NC), Red Bud Creek (Franklin County, NC), Maple Branch (Warren County, NC), Long Branch (Warren County, NC), Rocky Swamp Creek (Halifax County, NC), Ruin Creek (Vance County, NC, and Stony Creek (Nash County, NC); and in the Neuse River drainage in the Little River (Johnston and Wake Counties, NC), Swift Creek (Johnston County, NC), Middle Creek (Johnston County, NC), Turkey Creek (Wilson and Nash Counties, NC), Eno River (Orange County, NC), Buffalo Creek (Johnston County, NC), and Moccasin Creek (Nash, Wilson, and Johnston Counties, NC). Since the approval of the recovery plan, additional populations have been identified. According to Strayer et al. (1996), populations in the Neuse River basin in North Carolina in particular exhibited exceedingly low densities (less than 100 adults) while the most viable populations occurred in the Connecticut River (NH), Ashuelot River (NH), Neversink River (NY), Po River (VA), Shelton Creek / Tar River (NC), and the Little River (NC).

HABITAT:
The dwarf wedge mussel lives on muddy sand, sand, and gravel bottoms in creeks and rivers of varying sizes, in areas of slow to moderate current and little silt deposition (USFWS 1990).
In the southern portion of its range, it is often concentrated in areas along logs or in root mats. In the upper Connecticut River system in New Hampshire, it occurs in shallow water (generally less than one-meter depth during low water) with a firm substrate of sandy mud and gravel, scattered patches of wild celery (*Valisneria americana*), and little silt deposition (Master 1986).
Individuals can often be found along stream banks, amongst submerged aquatic vegetation, and under overhanging debris (NatureServe 2003).

PAST THREATS:
Toxic effects from industrial, domestic and agricultural pollution are the primary threats to this mussel's survival (USFWS 2003). Increased acidity, caused by the mobilization of toxic metals by acid rain, is thought to be one of the chief causes of the species' extirpation from the Fort River in Massachusetts. One of the largest remaining populations has declined dramatically in the Ashuelot River, downstream of a golf course. This population probably has been affected by fungicides, herbicides, insecticides, and fertilizers which have been applied to the golf course. Agricultural runoff from adjacent corn fields and pastures also is contributing to this population's decline (Masters 1986).

CURRENT THREATS:
Current threats to freshwater mussels are described in the general Mussel Document.

Exposure Scenario Summary Table for the Dwarf Wedge Mussel

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
dwarf wedge mussel	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	tesselated darter Johnny darter slimy sculpin mottled sculpin juvenile Atlantic salmon
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

APPALACHIAN ELKTOE
Alasmidonta raveneliana

STATUS:
On November, 1994, the Appalachian elktoe mussel was designated as Endangered throughout its entire range (USFWS 1994). A recovery plan for the Appalachian elktoe was approved on August 26, 1996 (USFWS 1996). Critical habitat was designated for the Appalachian elktoe on September 27, 2002 (67 FR 61016).

SPECIES DESCRIPTION:
The Appalachian elktoe has a thin, but not fragile, kidney-shaped shell, reaching up to about 3.2 inches in length, 1.4 inches in height, and one inch in width (Clarke 1981). Like other freshwater mussels, the Appalachian elktoe feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The mussel=s life span is unknown (USFWS 1994).

REPRODUCTION AND DEVELOPMENT:
The only published account concerning reproduction in this species is of a gravid female recorded on May 14, 1914 (Ortmann, 1921). Its reproductive cycle probably is similar to closely-related species (e.g. *Alasmidonta marginata*) which spawn in the summer (July or August) and retain glochidia in the branchial marsupia until spring (April or May) (see Gordon and Layzer 1989). The reproductive cycle of the Appalachian elktoe is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are

released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. They then detach from their fish host and sink to the stream bottom or other substrate where they continue to develop, provided they land in a suitable substratum with the correct water conditions. Recent studies have identified the banded sculpin (*Cottus carolinae*) and the mottled sculpin (*Cottus bairdi*) as glochidial hosts (USFWS 2002).

RANGE AND POPULATION LEVEL:
The Appalachian elktoe is known to be endemic to the upper Tennessee River system in western North Carolina and eastern Tennessee. Currently, the Appalachian elktoe has a very fragmented, relict distribution. The species still survives in scattered pockets of suitable habitat in portions of the Little Tennessee River system, Pigeon River system, Mills River, and the Little River in North Carolina and the Nolichucky River system in North Carolina and Tennessee. In the Little Tennessee River system in North Carolina, populations survive in the reach of the main stem of the Little Tennessee River, between the city of Franklin and Fontana Reservoir, in Swain and Macon Counties, and in scattered reaches of the main stem of the Tuckasegee River in Jackson and Swain Counties, from below the town of Cullowhee downstream to Bryson City. The species was recently discovered (in 2000) in the Cheoah River, below Santeetlah Lake, in Graham County. In the Pigeon River system in North Carolina, a small population of the Appalachian elktoe occurs in small, scattered sites in the West Fork Pigeon River and in the main stem of the Pigeon River, above Canton, in Haywood County. The Little River (upper French Broad River system) population of the species, in Transylvania County, NC, is restricted to small, scattered pockets of suitable habitat downstream of Cascade Lake. The species has been recorded from a single site in the Mills River in Henderson County, NC. In the Nolichucky River system, the Appalachian elktoe survives in a few scattered areas of suitable habitat in the Toe River, Yancey and Mitchell Counties, NC; Cane River, Yancey County, NC; and the main stem of the Nolichucky River, Yancey and Mitchell Counties, NC, extending downstream to the vicinity of Erwin in Unicoi County, TN (USFWS 1994, 1996). Two individuals have been found recently in the North Toe River, Yancey and Mitchell Counties, NC, below the confluence of Crabtree Creek (McGrath 1999), and 15 live individuals, with no more than 2 to 3 at each site have been recorded from the South Toe River, Yancy County, NC (USFWS 2002).

HABITAT:
The species has been reported from relatively shallow medium-sized creeks and rivers with cool, well-oxygenated, and moderate- to fast-flowing water. It has been observed in gravelly substrata, often mixed with cobble and boulders; in cracks in bedrock (Gordon 1991); and occasionally in relatively silt-free, coarse, and sandy substrata (J. Alderman, North Carolina Wildlife Resources Commission, personal communication, 1992; personal observations, 1989, 1991). Stability of the substrate appears to be critical to the Appalachian elktoe, and the species is seldom found in stream reaches with accumulations of silt or shifting sand, gravel, or cobble (USFWS 2002).

CRITICAL HABITAT:
In Macon County and Swain County, NC, stream and river channels within the ordinary high water line on each bank of the main stem of the Little Tennessee River, from the Lake Emory Dam at Franklin, Macon County, NC, downstream to the backwaters of Fontana Reservoir in

Swain County, NC. In Jackson County and Swain County, NC, stream and river channels within the ordinary high water line on each bank of the main stem of the Tuckasegee River (Little Tennessee River system), from the N.C. State Route 1002 Bridge in Cullowhee, Jackson County, NC, downstream to the N.C. Highway 19 Bridge, north of Bryson City, Swain County, NC. In Graham County, NC, stream and river channels within the ordinary high water line on each bank of the main stem of the Cheoah River (Little Tennessee River system), from the Santeetlah Dam, downstream to its confluence with the Little Tennessee River. In Transylvania County, NC, stream and river channels within the ordinary high water line on each bank of the main stem of the Little River (French Broad River system), from the Cascade Lake Power Plant, downstream to its confluence with the French Broad River. In Haywood County, NC, stream and river channels within the ordinary high water line on each bank of the main stem of the West Fork Pigeon River (French Broad River system), from the confluence of the Little East Fork Pigeon River, downstream to the confluence of the East Fork Pigeon River, and the main stem of the Pigeon River, from the confluence of the West Fork Pigeon River and the East Fork Pigeon River, downstream to the N.C. Highway 215 Bridge crossing, south of Canton, NC. In Yancey County and Mitchell County, NC, and Unicoi County, TN, stream and river channels within the ordinary high water line on each bank of the main stem of the North Toe River, Yancey and Mitchell Counties, NC, from the confluence of Big Crabtree Creek, downstream to the confluence of the South Toe River; approximately 22.6 km (14.1 mi) of the main stem of the South Toe River, Yancey County, NC, from the N.C. State Route 1152 Bridge, downstream to its confluence with the North Toe River; approximately 34.6 km (21.6 mi) of the main stem of the Toe River, Yancey and Mitchell Counties, NC, from the confluence of the North Toe River and the South Toe River, downstream to the confluence of the Cane River; approximately 26.4 km (16.5 mi) of the main stem of the Cane River, Yancey County, NC, from the N.C. State Route 1381 Bridge, downstream to its confluence with the Toe River; and approximately 21.6 km (13.5 mi) of the main stem of the Nolichucky River from the confluence of the Toe River and the Cane River in Yancey County and Mitchell County, NC, downstream to the U.S. Highway 23/19W Bridge southwest of Erwin, Unicoi County, TN.

Primary constituent elements identified at the time of designation included: 1. Permanent, flowing, cool, clean water; 2. Geomorphically stable stream channels and banks; 3. Pool, riffle, and run sequences within the channel; 4. Stable sand, gravel, cobble, and boulder or bedrock substrates with no more than low amounts of fine sediment; 5. Moderate to high stream gradient; 6. Periodic natural flooding; and 7. Fish hosts, with adequate living, foraging, and spawning areas for them.

PAST THREATS:

The available evidence demonstrates that habitat deterioration resulting from sedimentation and pollution from numerous point and nonpoint sources, when combined with the effects of other factors (including habitat destruction/alteration resulting from impoundments, channelization projects, dredging, and runoff of silt and other pollutants from poorly implemented mining, construction/development, agricultural, and past logging activities), has played a significant role in the decline of the Appalachian elktoe (USFWS 2002). The Service believes this is particularly true of the extirpation of the species from the Pigeon, Swannanoa, and French Broad Rivers, and Talula Creek.

CURRENT THREATS:
The most immediate threats to the remaining populations of the Appalachian elktoe are associated with sedimentation and other pollutants (i.e., fertilizers, pesticides, heavy metals, oil, salts, organic wastes, etc.) from nonpoint sources (USFWS 2002). Much of the Nolichucky River in North Carolina contains heavy loads of sediment, primarily from past land disturbance activities within its watershed, and suitable habitat for the Appalachian elktoe appears to be very limited in this river system. The species has not been found in the Nolichucky River system in substrates with accumulations of silt and shifting sand; it is restricted to small, scattered pockets of stable, relatively clean, and gravelly substrates. The same is true of the other surviving populations of the species.

Exposure Scenario Summary Table for the Appalachian elktoe

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
Appalachian elktoe	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	banded sculpin mottled sculpin
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

FAT THREERIDGE
Amblema neislerii

STATUS:
On March 16, 1998, the fat threeridge was designated as Endangered throughout its entire range (USFWS 1998). A recovery plan for the fat threeridge was finalized on October 1, 2003 (USFWS 2003). A 5-Year Review was approved for the fat threeridge on September 17, 2007. Critical habitat was designated for the fat threeridge on November 15, 2007 (72 FR 64285).

SPECIES DESCRIPTION:
The fat threeridge is a medium-sized to large, subquadrate, inflated, solid, and heavy-shelled mussel that reaches a length of 10.2 centimeters (4.0 inches). Large specimens are so inflated that their width approximates their height. Brim Box and Williams (2000) outlined various aspects of the species soft anatomy and provided the only published color photographs of the

species. This taxon was originally described as *Unio neislerii* (Lea, 1858), and has been assigned to the genera *Quadrula* and *Crenodonta* by Simpson (1914) and Clench and Turner (1956), respectively. Subsequent investigators (e.g., Mulvey et al. 1997, Turgeon et al. 1998) have placed the fat threeridge in the genus *Amblema.*

Like other freshwater mussels, adults are filter-feeders, orienting themselves in the substrate to facilitate siphoning of the water column for oxygen and food (Kraemer 1979). Mussels have been reported to consume detritus, diatoms, phytoplankton, zooplankton, and other microorganisms (Coker et al. 1921, Churchill and Lewis 1924, Fuller 1974). Juvenile mussels employ foot (pedal) feeding, and are thus suspension feeders (Yeager et al. 1994). Foods of juvenile freshwater mussels up to two weeks old include bacteria, algae, and diatoms with amounts of detrital and inorganic colloidal particles (Yeager et al. 1994). Specific food habits of the fat threeridge are unknown, but are likely similar to those of other freshwater mussels.

REPRODUCTION AND DEVELOPMENT:
O'Brien and Williams (2002) studied various aspects of the life history of the fat threeridge. A tachytictic species, it appears to be gravid in Florida when water temperatures reach 75.2°F, in late May or June. This release period would suggest that this species is a summer releaser. Fat threeridge glochidia are released in a white, sticky, web-like mass, which expands and wraps around a fish, thus facilitating attachment. Viability is maintained for two days after release (O'Brien and Williams 2002). The glochidia were described and figured by Brien and Williams (2002). Five potential host fishes have been identified: weed shiner (*Notropis texanus*), bluegill (*Lepomis macrochirus*), redear sunfish (*L. microlophus*), largemouth bass (*Micropterus salmonides*), and blackbanded darter (*Percina nigrofaciata*). Transformation of the glochidia on host fishes required 10 to 14 days at approximately 73.4 $\pm$ 2.7°F (O'Brien and Williams 2002).

RANGE AND POPULATION LEVEL:
The type locality of the fat threeridge is the Flint River, Macon County, Georgia. Records for this species are limited to the Apalachicola-Chattahoochee-Flint (ACF) River system main stems of the Flint, Apalachicola, and Chipola rivers in southwest Georgia and north Florida (Clench and Turner 1956, Williams and Butler 1994), all below the Fall Line (Brim Box and Williams 2000). This species has never been recorded from the Chattahoochee River, and thus is absent from Alabama. Two historical records from the Escambia River (van der Schalie 1940, Heard 1979) are considered erroneous (Williams and Butler 1994).

Apparently, the fat threeridge has been extirpated from the main stem of the Flint River (and thus from Georgia), and from Dead lake in the Chipola River. It is documented in recent collections from 15 main stem sites on the Apalachicola River and lowermost portion of the Chipola River in Florida (Table 1, USFWS, 2003).

The status survey (USFWS 1998) produced an average of 6.4 live specimens of the fat threeridge from six sites of occurrence in the ACF Basin. Brim Box and Williams (2000) reported a subpopulation of approximately 100 specimens located on the Chipola River below Dead Lake in 1988. Relatively large subpopulations are currently known in the lower Apalachicola River,

where scores of specimens could be found in the mid-1990s (J. Brim Box, USGS, pers. comm., 1994); and a distributary (a side channel whose origin is the river main stem), Swift Slough. The latter site apparently serves as a nursery; 17 specimens, 2.5 to 5.0 cm (1.0 to 2.0 inches) long, were discovered in 2000 (J.D. Williams, USGS, pers. comm., 2000). Limited quadrat sampling at one main stem site (six 2.7 square feet samples) conducted by Richardson and Yokley (1996) determined the fat threeridge to be the second most abundant of four species encountered (25 percent relative abundance). Although their data are unclear, it would appear that this species occurred at a density of less than 0.4 specimens per square foot in this bed (Richardson and Yokley 1996), in what may represent the largest known subpopulation.

The Corps has completed mussel surveys at potential dredged material disposal sites, slough locations, and other main channel areas within the Apalachicola and Chipola rivers (Miller 1998, Miller 2000, Miller, US Army Engineer Research and Development Center [ERDC], pers. comm. 2003). During these surveys, approximately 100 sites were examined over 30 river miles. The fat threeridge was detected at 22 locations and recruitment was documented at several of these locations. At the Chipola River cutoff (nautical mile 41.6) a “dense band” of mussels was located, which more than 60 percent were fat threeridge. At the same location, 10 percent of the fat threeridge were less than 30 mm in total shell length, representing recent recruitment (Miller, ERDC, pers. comm. 2003).

HABITAT:
The fat threeridge inhabits that main channel of small to large rivers in slow to moderate current. Substrate used by this mussel varies from gravel to cobble to a mixture of sand and sandy mud (Williams and Butler 1994). Brim Box and Williams (2000) found 60 percent of the specimens were located in a sandy silt substrate.

CRITICAL HABITAT:
In Houston County, Alabama, and in Calhoun, Gulf, and Jackson counties, Florida, stream and river channels within the ordinary high water line of the main stem of the Chipola River and seven of its tributaries.

In Baker, Calhoun, Decatur, Dougherty, Early, Miller, Mitchell, and Terrell counties, Georgia, stream and river channels within the ordinary high water line of the Flint River from its confluence with Big Slough , Decatur County, Georgia, upstream 116.4 km through Baker and Mitchell Counties, Georgia, to the Flint River Dam, Dougherty County, Georgia; Spring Creek, from its confluence with Lake Seminole at Smith Landing, Decatur County, Georgia, upstream 74.2 km to County Road 35, Early County, Georgia; Aycocks Creek from Spring Creek upstream 15.9 km to Cypress Creek, Miller County, Georgia; Dry Creek from Spring Creek upstream 9.9 km to Wamble Creek , Early County, Georgia; Ichawaynochaway Creek from the Flint River, Baker County, Georgia, upstream 68.6 km to Merrett Creek, Calhoun County, Georgia; Mill Creek from Ichawaynochaway Creek upstream 7.4 km to County Road 163, Baker County, Georgia; Pachitla Creek, from Ichawaynochaway Creek upstream 18.9 km to Little Pachitla Creek, Calhoun County, Georgia; Little Pachitla Creek from Pachitla Creek upstream 5.8 km to Bear Branch, Calhoun County, Georgia; Chickasawhatchee Creek from Ichawaynochaway Creek, Baker County, Georgia, upstream 64.5 km to U.S. Highway 82,

Terrell County, Georgia; and Cooleewahee Creek from the Flint River upstream 15.1 km to Piney Woods Branch, Baker County, Georgia.

In Calhoun, Franklin, Gadsden, Gulf, Jackson, and Liberty Counties, Florida, stream and river channels within the ordinary high water line of the main stem of the Apalachicola River, two of its distributaries, Chipola Cutoff and Swift Slough, and three of its tributaries, River Styx, Kennedy Slough, and Kennedy Creek.

Primary constituent elements identified at the time of designation included: (1) Space for individual and population growth and for normal behavior; (2) Food, water, air, light, minerals, or other nutritional or physiological requirements; (3) Cover or shelter; (4) Sites for breeding, reproduction, or rearing (or development) of offspring; and (5) Habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species.

PAST THREATS:
The abundance and distribution of the fat threeridge decreased historically from habitat loss from habitat loss and degradation (Williams et al. 1993, Neves 1993), caused by impoundments, sedimentation and turbidity, dredging and channelization, and contaminants contained in numerous point and nonpoint sources. A comprehensive review of these past threats is provided elsewhere (USFWS 2003, Brim Box and Williams 2000, Butler 1993, Howard 1997, Frick et al. 1998, Buell and Couch 1995, Richter 1997, Watters 1997, Neves et al. 1997). These habitat changes have resulted in significant extirpations (localized loss of populations), restricted and fragmented distributions, and poor recruitment of young.

CURRENT THREATS:
Habitat loss and degradation (Williams et al. 1993, Neves 1993) primarily caused by contaminants contained in point and nonpoint source discharges, sedimentation and erosive land practices, water quantity and withdrawal, construction of new impoundments, and alien species are primary threats to the fat threeridge (USFWS 2003).

Sediment samples from various ACF Basin streams tested for heavy metals that are known to be deleterious to mussels had concentrations markedly above background levels (Frick et al. 1998), among those were copper (throughout the Piedmont), and cadmium (large Coastal Plain tributaries of the Flint River). Past episodes of significant heavy metal contamination of ACF Basin streams may continue to impact mussel faunas. An estimated 950 million gallons of chemical-laden rinse, stripping, cleaning, and plating solutions were discharged indirectly into the Flint River (P. Laumeyer, USFWS, pers. comm., 1994) over a several year period. Concentrations of heavy metals (e.g., chromium and cadmium) in Asian clam, *Corbicula fluminea* (Muller 1774), and sediment samples were elevated downstream from two abandoned battery salvage operations on the Chipola River (Winger et al. 1985). Chromium concentrations found in sediments from Dead Lake downstream in the Chipola River (Winger et al. 1985) are known to be toxic to mussels (Havlik and Marking 1987).

Agricultural sources of contaminants in the ACF and Suwannee basins include nutrient enrichment from poultry farms and livestock feedlots, and pesticides and fertilizers from row crop agriculture (Couch et al. 1996, Frick et al. 1998, Berndt et al. 1998). Nitrate concentrations are particularly high in surface waters downstream of agricultural areas (Mueller et al. 1995; Berndt et al. 1998). A study by the U.S. Soil Conservation Service (USSCS; now the Natural Resources Conservation Service [NRCS]) in the Flint River system determined that between 72 and 75 percent of the nutrients entering Lake Blackshear were derived from agricultural sources (USSCS 1993). Stream ecosystems are impacted when nutrients are added at concentrations that cannot be assimilated (Stansbery 1995). The effects of pesticides on mussels may be particularly profound (Fuller 1974, Havlik and Marking 1987, Moulton et al. 1996, Fleming et al. 1995). Organochlorine pesticides were found at levels in ACF Basin streams that often exceeded chronic exposure criteria for the protection of aquatic life (Buell and Couch 1995, Frick et al. 1998). Once widely used in the ACF Basin (Buell and Couch 1995), these highly toxic compounds are persistent in the environment, and are found in both sediments and the lipid reservoir of organisms (Day 1990, Burton 1992). Commonly used pesticides have been directly implicated in a North Carolina mussel dieoff (Fleming et al. 1995). Cotton is raised extensively in much of the Apalachicolan Region inhabited by these mussels. One of the most important pesticides used in cotton farming, malathion, is known to inhibit physiological activities of mussels (Kabeer et al. 1979) that may decrease the ability of a mussel to respire and obtain food. This chemical may pose a continuing threat to some populations of these mussels.

Many pollutants in the ACF Basin originate from urban stormwater runoff, development activities, and municipal waste water facilities, primarily in the Piedmont (Frick et al. 1998). Urban catchments in Piedmont drainages have higher concentrations of nutrients, heavy metals, pesticides, and organic compounds than do agricultural or forested ones (Lenat and Crawford 1994, Frick et al. 1998), and at levels sufficient to significantly affect fish health (Ostrander et al. 1995). Within the Suwannee River basin, nutrient concentrations were greater in agricultural areas and nitrates were found to exceed U.S. Environmental Protection Agency (EPA) drinking water standards in 20 percent of the surficial aquifer groundwater samples (Berndt et al. 1998). Pesticide concentrations were found to exceed criteria for protection of aquatic life mostly in urban areas. Currently, there are discharges from 137 municipal waste water treatment facilities in the ACF River basin alone (Couch et al. 1996). Although effluent quality has improved with modern treatment technologies and a phosphate detergent ban, hundreds of miles of streams in the ACF and Ochlockonee basins in Alabama, Florida, and Georgia, as identified in reports prepared by the water quality agencies of these states under Section 305(b) of the Clean Water Act, do not meet water use classifications.

Since approximately 29 percent of the ACF Basin is in agriculture (Frick et al. 1998), sedimentation from agricultural sources is probably significant. According to USSCS (1993), 89 percent of the sediments entering Lake Blackshear on the Flint River are derived from agricultural sources. The lower Flint River system serves as the heart of numerous mussel species range and is a major agricultural center. This area has experienced “severe losses of topsoil and nutrient additions to local streams due to agriculture” (Neves et al. 1997), and has profoundly affected the biota of surface and ground waters there (Patrick 1992). Despite the implications, only a few studies (e.g., Cooper 1987, Stewart and Swinford 1995) have

specifically attributed changes in mussel populations to sediments derived from agricultural practices.

Many southern streams have increased turbidity levels due to siltation (van der Schalie 1938a). The fat threeridge attracts host fishes with visual cues, luring fish into perceiving that their glochidia are prey items. Such a reproductive strategy depends on clear water during the critical time of the year when mussels are releasing their glochidia (Hartfield and Hartfield 1996). Turbidity is a limiting factor impeding sight-feeding fishes (Burkhead and Jenkins 1991). In addition, mussels may be indirectly affected when turbidity levels significantly reduce light available for photosynthesis and the production of unionid food items (Kanehl and Lyons 1992).

Water quantity is becoming more of a concern in maintaining mussel habitat in the Apalachicolan Region. The potential impacts to mussels, their host fishes, and their respective habitats from ground water withdrawal may be profound. Within the Flint River basin, decreases in flow velocity and dissolved oxygen were highly correlated to mussel mortality (Johnson et al. 2001). Low DO conditions in stagnating stream pools due to drought conditions are having a disastrous effect on these mussels. Mussel mortality increases dramatically as DO decreases below 5 mg/L (Johnson et al. 2001).

Nonnative aquatic species invasions may also impact the fat threeridge. For example, the nonindigenous Asian clam (*Corbicula fluminea*) has been implicated as a competitor with native mussels for resources such as food, nutrients, and space (Heard 1977, Kraemer 1979, Clarke 1986), particularly as juveniles (Neves and Widlak 1987). Densities of Asian clams are sometimes high in Apalachicolan Region streams (Stringfellow and Stanton 1998), with estimates from approximately 9 per square foot (Flint River, Sickel 1973) to over 195 per square foot (Santa Fe River, Bass and Hitt 1974).

Exposure Scenario Summary Table for the Fat Threeridge

Species	**Life Stage**	**Habitat Type**	**Exposure Route**	**Diet**	**Significant Interspecies Relationships**
Fat Threeridge	glochidia	parasite	contact with water, diet	fish body fluids	weed shiner, bluegill, redear sunfish, largemouth bass, blackbanded darter
	juvenile/ adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

OUACHITA ROCK POCKETBOOK

Arkansia wheeleri

STATUS:

On October 23, 1991, the Ouachita rock pocketbook was designated as endangered throughout its entire range in Arkansas and Oklahoma (USFWS 1991). A recovery plan for the Ouachita rock pocketbook was approved September 27, 2002.

SPECIES DESCRIPTION:

The Ouachita rock pocketbook, previously known as Wheeler=s pearly mussel, is a large freshwater mussel (reaching approximately 110 mm in length) with a silky, chestnut brown to black shell (USFWS 1991). Like other freshwater mussels, the Ouachita rock pocketbook feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of

Ouachita rock pocketbook glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the Ouachita rock pocketbook is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. The life history of this species is largely unknown. A recent study of the life history and habitat of the species was conducted with the goal of determining the glochidial host species and the gravidity and glochidial release periods for the species was the subject of a recent presentation; however, results of this work have not yet been published (Seagraves et al. 2002).

RANGE AND POPULATION LEVEL:
This species once inhabited the Kiamichi River in Oklahoma, the Little River in southwestern Arkansas, and the Ouachita River in central Arkansas. Historic records for the species from the Ouachita River stated it was rare in that area. Ortmann (1921) and Isely (1925) reported specimens being collected in the Kiamichi River, Pushmataha County, Oklahoma, near Antlers and Tuskahoma, respectively. Few other records were reported until recently. Valentine and Stansbery (1971) reported the mussel from the Kiamichi River at Spencerville Crossing, Choctaw County, Oklahoma, a site since flooded by Hugo Reservoir. Review of museum records added two additional localities in the Little River (White Cliffs, Little River County, Arkansas) and the Kiamichi River (1.9 kilometers south of Clayton, Pushmataha County, Oklahoma) (USFWS 1991). Harris and Gordon (1987) found several empty shells on the Little River in Arkansas. They also found relict shells on the Ouachita River near the mouth of Saline Bayou in Clark County and at Malvern, Hot Spring County, Arkansas.

Living populations have been found recently only in the Kiamichi River (estimated to be about 1,000 individuals) in Oklahoma (Oklahoma Natural Heritage inventory 1989); and in the Little River (less than 100 individuals) in Arkansas (Clarke 1987). The Ouachita rock-pocketbook has also been documented in a 50- kilometer (30-mile) stretch of the river not previously known to be inhabited, for a total range in the Kiamichi River of 130 river-kilometers (80 river-miles) (Mehlhop- Cifelli and Miller 1989). One live individual was recently found in the Ouachita River near Camden (Posey et al. 1996). In addition, two fresh dead individuals were collected in two creeks in Lamar County, Texas (NatureServe 2003). The Ouachita rock pocketbook has occurred in very low densities at all documented sites. Surveyors have recently examined other sites for mussels but found no individuals at any other locality. The species has apparently been eliminated from the the lower Kiamichi River, (USFWS 1991). A recent investigation resulted in the discovery of a new population on the Little River in Arkansas below Millwood Dam (Seagraves et al. 2002). Beyond the records discussed, it has not been found in other portions of the streams it inhabits, nor in any other streams or waters, including tributaries (USFWS 1991).

HABITAT:

Little is known about the habitat requirements of the Ouachita rock pocketbook. Historically, it has been found in muddy or rocky substrate, in stream-side channels and backwaters with little or no flow, and near riffles. Mehlhop-Cifelli and Miller (1989) found that backwater areas in the Kiamichi River were usually next to sand/gravel/cobble bars that either were scoured clean or supported emergent aquatic vegetation. They also found *A. wheeleri* in pools with rock substrate. The species appears to be more abundant in pools than in backwaters and to prefer a stable substratum containing a mixture of cobble and gravel. Backwaters inhabited by the Ouachita rock pocketbook had a substratum of gravel and sand and the species always occurred within large mussel beds containing a diversity of mussel species (Vaughnn 1991).

PAST THREATS:
The species' range has been seriously reduced by the construction of reservoirs, water quality degradation, and other impacts to its habitat (USFWS 1991). Ouachita rock pocketbook habitat has been greatly restricted by the construction of reservoirs, and in one case, a site that was known to be occupied by the species was flooded by establishment of Hugo Reservoir (NatureServe 2003). Other past threats to freshwater mussels are described in the General Mussel Document.

CURRENT THREATS:
Current threats to the species include the continued development of impoundments, water quality degradation resulting from nonpoint sources such as agriculture and industrial development, hydropower proposals, gravel mining, and infestation by the Asiatic clam (NatureServe 2003). Also, the Corps is studying navigation in the Red River, which would more than likely impact the lower Little River population that was recently discovered. Owing to the species' limited distribution, any factors that adversely modify habitat or water quality in these stream segments could further reduce the species and the habitat it occupies (USFWS 1991). Other current threats to freshwater mussels are described in the General Mussel Document.

CONSERVATION MEASURES:
Conservation measures are described in the General Mussel Document.

Exposure Scenario Summary Table for the Ouachita rock pocketbook

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
Ouachita rock pocketbook	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	
	juvenile / adult	sediment dweller	contact & ingestion of	filter feeder (bacteria,	

			water, diet, sediment	algae, detritus, sediment)

BIRDWING PEARLYMUSSEL
Conradilla caelata

STATUS:
On June 14, 1976, the birdwing pearlymussel was designated as endangered throughout its entire range in Tennessee and Virginia (USFWS 1976), except where listed as experimental populations (in the free-flowing reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, AL) (USFWS 2001). A recovery plan for the birdwing pearlymussel was approved in 1984 (USFWS 1984).

SPECIES DESCRIPTION:
The birdwing pearlymussel is a small freshwater mussel (reaching up to 50 mm in length) with an olive-green shell. The life span of the species is greater than 50 years (USFWS 1984, VFWIS 2003). Like other freshwater mussels, the birdwing pearlymussel feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of birdwing pearlymussel glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the birdwing pearlymussel is similar to that of other mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. They then detach from their fish host and sink to the stream bottom or other substrate where they continue to develop, provided they land in a suitable substratum with the correct water conditions. Recent studies have identified two percids, the Tennessee snubnose darter (*Etheostoma simoterum simoterum*) and the greenside darter (*Etheostoma blennioides*) as a glochidial host and a potential host, respectively, for the birdwing pearlymussel (Watson and Neves 1998). In addition, the banded darter (*Etheostoma zonale*) was previously identified as a suitable host (NatureServe 2003).

RANGE AND POPULATION LEVEL:
The birdwing pearlymussel was originally known from 11 rivers in the Tennessee River system, and one record exists from an unknown location in the lower Cumberland River. It was last collected from Mussel Shoals, historically an 85 km reach of the Tennessee River in Alabama (that is now reduced to a few kilometers of riverine habitat due to construction of three dams), prior to 1925 (Ortmann 1925) and is presumed to be extirpated from the shoal. It currently survives in the Clinch River in Tennessee and Virginia and in the Duck River in Tennessee (USFWS 1984). The Clinch River population appears to be viable, and the Powell River

population of the species may be viable but is declining. The species is extirpated from the Elk River in Tennessee.

HABITAT:
The birdwing pearlymussel inhabits small to medium, low turbidity, cool-water, high to moderate gradient streams in the Cumberland and Tennessee River basins (Bogan and Parmalee 1983, Parmalee and Bogan 1998). The species is commonly found near riffles on sand and gravel substrates with firm rubble (USFWS 1984). Individuals have been found in waters ranging from six to seven feet deep (USFWS 1984, Terwilliger 1991).

PAST THREATS:
Many of the historic populations of the birdwing pearlymussel were apparently lost when the river sections they inhabited were impounded. Over 50 impoundments on the Tennessee and Cumberland Rivers have eliminated the majority of riverine habitat for the species in its historic range (ESIS 1996, USFWS 1984). The Powell River and upper tributaries of the Clinch River, in particular, are also subject to sediment and particulate matter loading from coal mining activities (Stansbery 1973). Habitat in Duck River and Buffalo River, its major tributary, has been significantly impacted in the past 50 years by the factors listed above as well as completion of the Normandy Dam (ESIS 1996). Other threats that are attributed to population declines are described in the General Mussel Document.

CURRENT THREATS:
The most immediate threat to the birdwing pearlymussel is the Columbia Dam project on the Duck River, which could eliminate the largest known population of the species (ESIS 1996). Other current threats to freshwater mussels are described in the General Mussel Document.

CONSERVATION MEASURES:
Conservation measures are described in the General Mussel document.

Exposure Scenario Summary Table for the Birdwing Pearlymussel

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
birdwing pearlymussel	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	greenside darter Tennessee snubnose darter banded darter
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus,	

sediment)

FANSHELL
Cyprogenia stegaria

STATUS:
On June 21, 1990 the fanshell was designated as endangered throughout its entire range in Alabama, Illinois, Indiana, Kentucky, Ohio, Tennessee, Virginia, and West Virginia (USFWS 1990). A recovery plan for the fanshell was approved in July 9, 1991 (USFWS 1991).

SPECIES DESCRIPTION:
The fanshell is a medium-sized (reaching up to approximately 80 mm in length) freshwater mussel with light green or yellow with green mottling or rays (USFWS 2003). Like other freshwater mussels, the fanshell feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of fanshell glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the fanshell is similar to that of other mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. The species is a long-term brooder and holds glochidia overwinter for a spring release (Ortmann 1919). Fanshell glochidia are released in the form of a unique spiral worm-like conglutinate suggesting that this species relies on fish hosts that visually search for food (USFWS 1991). Recent induced infestations of glochidia on nine of sixteen fish species tested indicate that the following species are suitable hosts: mottled sculpin (*Cottus bairdi*), banded sculpin (*Cottus carolinae*), greenside darter (*Etheostoma blennioides*), Tennessee snubnose darter (*Etheostoma simoterum simoterum*), banded darter (*Etheostoma zonale*), tangerine darter (*Percina aurantiaca*), blotchside logperch (*Percina burtoni*), logperch *(Percina caprodes*), and Roanoke darter (*Percina roanoka*) (Jones and Neves 2000). The Roanoke darter is not a natural host and does not co-occur with the fanshell.

RANGE AND POPULATION LEVEL:
The fanshell has undergone a substantial range reduction. It was historically distributed in the Ohio, Wabash, Cumberland, and Tennessee Rivers and their larger tributaries in Pennsylvania, Ohio, West Virginia, Illinois, Indiana, Kentucky, Tennessee, Alabama, and Virginia (Johnson 1980, KSNPC 1980, Ahlstedt 1986, Bates and Dennis 1985, Lauritsen 1987, Cummings et al. 1987 and 1988, Starnes and Bogan 1988, USFWS 1991). It is believed that reproducing populations are now present in only three rivers, the Clinch River (Hancock County, TN and Scott County, VA), the Green River (Hart and Edmonson Counties, KY), and the Licking River

(Kenton, Campbell, and Pendleton Counties, KY). In addition, based on collections over the past 20 years, small remnant (many apparently nonreproducing) populations may still persist in the Muskingum River (Morgan and Washington Counties, OH), the Walhonding River (Coshocton County, OH), the Ohio River (Ohio and West Virginia), the Rolling Fork Salt River (Marion County, KY), the Wabash River (White County, IL and Posey and Wabash Counties, IN), the East Fork White River (Martin County, IN), the Tippecanoe River (Tippecanoe County, IN), the Kanawha River (Fayette County, WV), the Barren River (Allen and Barren Counties, KY), and the Tennessee River (Hardin County, TN) (USFWS 1990,1991). Survey information also indicates that the species has been found in the Salt River (tributaries to the Ohio River) and in the Allegheny River in Pennsylvania (NatureServe 2003). The species is extirpated from Tygarts Creek in Kentucky, the Cumberland River in Tennessee, and the Tennessee River (in Rhea and Meigs Counties, Tennessee).

The population in the Green River is likely the best of the three remaining reproducing populations. Fresh-dead fanshells of various age classes from juvenile to adult have recently (1987 and 1988) been found in muskrat middens along the Green River (USFWS 2003). The Clinch River fanshell populations extends over about 86 river miles (Ahlstedt 1986); however, a Tennessee Valley Authority (1988) survey reported that the fanshell comprised less than one percent of the mussels collected at 11 Clinch River quantitative sampling sites in 1979 and 1988. A reproducing population of the fanshell in the Licking River is supported only in the lower portion of the drainage (USFWS 1990, 1991). In the Licking River, live and fresh-dead individuals of several year classes have been collected (USFWS 2003).

HABITAT:
The fanshell inhabits medium to large rivers (Bates and Dennis 1985). It has been reported primarily from relatively deep water in gravelly substrate with moderate current (Gordon and Layzer 1989).

PAST THREATS:
The loss of many historic populations was likely due to the impacts of impoundments, navigation projects, water quality degradation, and other forms of habitat alteration, including gravel and sand dredging, that directly affected the species and reduced or eliminated its fish host(s) (USFWS 1991). The Green River population of the species, though afforded some protected habitat in Mammoth Cave National Park, has been threatened by runoff from oil and gas exploration and production sites and by stream flow alteration from an upstream reservoir (USFWS 1990, 1991). The steady decline of naiads in the Clinch River has been attributed to land use practices along the river as well as impacts from coal mining and spills from a riverside coal fired power plant (resulting in two mussel kills). The Licking River population of the fanshell has been threatened by the effects of wastewater discharges and plans for water supply development. Incidental take of the fanshell where it is co-located with commercially harvested mussel beds is also attributed to its decline (USFWS 1990, 1991).

CURRENT THREATS:

Most fanshell populations are small and are geographically isolated from one another. It is likely that many of the remaining populations are now small enough that they can no longer maintain long-term genetic viability (Soule 1980). Other current threats to freshwater mussels are described in the General Mussel Document.

Exposure Scenario Summary Table for the Fanshell

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
fanshell	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	mottled sculpin banded sculpin greenside darter Tennessee snubnose darter banded darter tangerine darter blotchside logperch logperch Roanoke darter
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

DROMEDARY PEARLYMUSSEL
Dromus dromas

STATUS:
On June 14, 1976, the dromedary pearlymussel was designated as endangered throughout its entire range in Kentucky, Tennessee, and Virginia (USFWS 1976), except where listed as experimental populations (in the free-flowing reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, AL) (USFWS 2001). A recovery plan for the dromedary pearlymussel was approved in July 9, 1984 (USFWS 1984).

SPECIES DESCRIPTION:
The dromedary pearlymussel is a medium-sized (reaching up to 90 mm in length) freshwater mussel with a yellowish green shell with two sets of broken green rays. The life span of the species is greater than 50 years (USFWS 1984, VFWIS 2003). Like other freshwater mussels, the dromedary pearlymussel feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and

Lewis 1924). The diet of dromedary pearlymussel glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the dromedary pearlymussel is similar to that of other mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. The species is bradytictic and glochidia are contained in conglutinates that are similar in appearance to freshwater leeches or flatworms (Jones and Neves 2001). In a recent investigation, a fecundity of approximately 55 to 250,000 glochidia per mussel was estimated for the dromedary pearlymussel by determining the mean number of mature glochidia associated with conglutinates from four females. Ages of valves examined indicate that the species life span is as long as 25 years (Jones and Neves 2001). Recent studies have identified the fantail darter (*Etheostoma flabellare*) as a glochidial host for the dromedary pearlymussel. Laboratory studies also identified the following potential host species: the banded darter (*Etheostoma zonale*), tangerine darter (*Percina aurantiaca*), logperch (*Percina caprodes*), and gilt darter (*Percina evides*) (Watson and Neves 1998). Jones and Neves (2001) recently confirmed the suitability of the banded darter, tangerine darter, and logperch and identified the following additional glochidial host species: black sculpin (*Cottus baileyi*), greenside darter (*Etheostoma blennioides*), Tennessee snubnose darter (*Etheostoma simoterum simoterum*), blotchside logperch (*Percina burtoni*), channel darter (*Percina copelandi*), and Roanoke darter (*Percina roanoka*). The Roanoke darter is not a natural host species and does not co-occur with the dromedary pearlymussel.

RANGE AND POPULATION LEVEL:
This species was historically widespread in and endemic to the Cumberland and Tennessee River systems (Bogan and Parmalee 1983). It was last collected from Mussel Shoals, historically an 85 km reach of the Tennessee River in Alabama (that is now reduced to a few kilometers of riverine habitat due to construction of three dams), prior to 1931 (van der Schalie 1939) and is presumed to be extirpated from the shoal. The species survives at a few shoals in the Powell and Clinch Rivers in Tennessee and Virginia, but is probably extirpated from the Cumberland River in Tennessee (USFWS 1984, Neves 1991). The population in the Clinch River, Tennessee, is viable, but the species is declining in the Powell River (Parmalee and Bogan 1998). Nine occurrences of the species were recorded during a 1980 survey by Virginia Tech and the Tennessee Valley Authority; however, the dromedary pearlymussel is currently believed to be reduced to no more than two populations (NatureServe 2003).

HABITAT:
The dromedary pearlymussel inhabits small to medium, low turbidity, high to moderate gradient streams. The species is commonly found near riffles on sand and gravel substrates with stable rubble (USFWS 1984). Though commonly associated with shallow, high velocity riffles and shoals, individuals have been found in deeper (up to 18 feet in depth), slower waters (USFWS 1984).

PAST THREATS:
Many of the historic populations of the dromedary pearlymussel were apparently lost when the river sections they inhabited were impounded. Over 50 impoundments on the Tennessee and Cumberland Rivers have eliminated the majority of riverine habitat for the species in its historic range (ESIS 1996, USFWS 1984). The Powell River and upper tributaries of the Clinch River, in particular, are also subject to sediment and particulate matter loading from coal mining activities (Stansbery 1973). Other threats that are attributed to population declines are similar to those described in the general mussel description.

CURRENT THREATS:
Other current threats to freshwater mussels are described in the General Mussel Document.

Exposure Scenario Summary Table for the Dromedary Pearlymussel

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
dromedary pearlymussel	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	Fantail darter Banded darter Tangerine darter Gilt darter Greenside darter TN snubnose darter Channel darter Logperch Blotchside logperch Black sculpin
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

CHIPOLA SLABSHELL
Elliptio chipolaensis

STATUS:
On March 16, 1998, the Chipola slabshell was designated as Threatened throughout its range (USFWS 1998). A recovery plan for the Chipola slabshell was finalized on October 1, 2003 (USFWS 2003). A 5-Year Review was approved for the Chipola slabshell on September 17, 2007. Critical habitat was designated for the Chipola slabshell on November 15, 2007 (72 FR 64285).

SPECIES DESCRIPTION:
The Chipola slabshell is a medium-sized species that reaches a length of about 8.4 cm (3.3 in). The shell is ovate to subelliptical, somewhat inflated, and with the posterior ridge starting out rounded, but flattening to form a prominent biangulate margin. As is typical of all *Elliptio* mussels, no sexual dimorphism is displayed in shell characters. The Service currently recognizes *Unio chipolaensis* Walker, 1905, as a synonym of *Elliptio chipolaensis*, Frierson, 1927 (USFWS 2003). Like other freshwater mussels, adults are filter-feeders, orienting themselves in the substrate to facilitate siphoning of the water column for oxygen and food (Kraemer 1979). Mussels have been reported to consume detritus, diatoms, phytoplankton, zooplankton, and other microorganisms (Coker et al. 1921, Churchill and Lewis 1924, Fuller 1974). Juvenile mussels employ foot (pedal) feeding, and are thus suspension feeders (Yeager et al. 1994). Foods of juvenile freshwater mussels up to two weeks old include bacteria, algae, and diatoms with amounts of detrital and inorganic colloidal particles (Yeager et al. 1994). Specific food habits of the Chipola slabshell are unknown, but are likely similar to those of other freshwater mussels.

REPRODUCTION AND DEVELOPMENT:
Little is known about the life history of the Chipola slabshell. A unionine, it is suspected that this species expels conglutinates and is a tachytictic summer releaser. Southeastern congeners of the Chipola slabshell have been documented to use centrarchids (sunfishes) as host fish (Keller and Ruessler 1997), although a relationship between cyprinids and tachytictic brooders has been documented (Bruenderman and Neves 1993). Glochidia have recently been successfully transformed on bluegill (Lepomis macrochirus) suggesting this species as a probable host fish (USFWS 2007).

RANGE AND POPULATION LEVEL:
The type locality is Chipola River, Marianna, Jackson County, Florida. The Chipola slabshell was thought to be endemic to the Chipola River system (van der Schalie 1940, Clench and Turner 1956, Burch 1975, Heard 1979, Williams and Butler 1994) until Brim Box and Williams (2000) located a museum lot (single specimen) from Howards Mill Creek, a Chattahoochee River tributary in southeastern Alabama. The historical range of this Apalachicola-Chattahoochee-Flint (ACF) Basin endemic is centered throughout much of the Chipola River main stem and several of its headwater tributaries. The Chipola slabshell is one of the most narrowly distributed species in the Apalachicolan Region.

The Chipola slabshell is no longer known from Howards Mill Creek. Likewise, this species is probably extirpated from Dead Lake on the lower main stem of the Chipola and in two Chipola River tributaries, Cowarts and Spring Creeks, and thus is considered extirpated from Alabama (Lydeard et al. 1999). Currently, six populations of Chipola slabshell remain in Marshall and Dry Creeks, and from the upper two-thirds of the Chipola River main stem (Table 6, USFWS 2003). The largest remaining subpopulation appears to be on the Chipola River main stem in the vicinity of (but not in) Dead Lake, where the species remains relatively common (J.D. Williams, USGS, unpub. data). An average of 3.7 Chipola slabshell specimens per site of occurrence (3 sites) was found during the status survey (USFWS 1998).

HABITAT:
The Chipola slabshell inhabits silty sand substrates of large creeks and the main channel of the Chipola River in slow to moderate current (Williams and Butler 1994). Specimens are generally found in sloping bank habitats. Nearly 70 percent of the specimens found during the status survey were associated with a sandy substrate (Brim Box and Williams 2000).

CRITICAL HABITAT:
In Houston County, Alabama, and in Calhoun, Gulf, and Jackson counties, Florida, stream and river channels within the ordinary high water line of the main stem of the Chipola River and seven of its tributaries.

Primary constituent elements identified at the time of designation included: (1) Space for individual and population growth and for normal behavior; (2) Food, water, air, light, minerals, or other nutritional or physiological requirements; (3) Cover or shelter; (4) Sites for breeding, reproduction, or rearing (or development) of offspring; and (5) Habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species.

PAST THREATS:
The abundance and distribution of the Chipola slabshell decreased historically from habitat loss and degradation (Williams et al. 1993, Neves 1993) caused by impoundments, sedimentation and turbidity, dredging and channelization, and contaminants contained in numerous point and nonpoint sources. A comprehensive review of these past threats is provided elsewhere (USFWS 2003, Brim Box and Williams 2000, Butler 1993, Howard 1997, Frick et al. 1998, Buell and Couch 1995, Richter 1997, Watters 1997, Neves et al. 1997). These habitat changes have resulted in significant extirpations (localized loss of populations), restricted and fragmented distributions, and poor recruitment of young.

CURRENT THREATS:
Habitat loss and degradation (Williams et al. 1993, Neves 1993) primarily caused by contaminants contained in point and nonpoint source discharges, sedimentation and erosive land practices, water quantity and withdrawal, construction of new impoundments, and alien species are primary threats to the Chipola slabshell (USFWS 2003).

Sediment samples from various ACF Basin streams tested for heavy metals that are known to be deleterious to mussels had concentrations markedly above background levels (Frick et al. 1998), among those were copper (throughout the Piedmont), and cadmium (large Coastal Plain tributaries of the Flint River). Past episodes of significant heavy metal contamination of ACF Basin streams may continue to impact mussel faunas. An estimated 950 million gallons of chemical-laden rinse, stripping, cleaning, and plating solutions were discharged indirectly into the Flint River (P. Laumeyer, USFWS, pers. comm., 1994) over a several year period. Concentrations of heavy metals (e.g., chromium and cadmium) in Asian clam, *Corbicula fluminea* (Muller 1774), and sediment samples were elevated downstream from two abandoned battery salvage operations on the Chipola River (Winger et al. 1985). Chromium concentrations

found in sediments from Dead Lake downstream in the Chipola River (Winger et al. 1985) are known to be toxic to mussels (Havlik and Marking 1987).

Agricultural sources of contaminants in the ACF and Suwannee basins include nutrient enrichment from poultry farms and livestock feedlots, and pesticides and fertilizers from row crop agriculture (Couch et al. 1996, Frick et al. 1998, Berndt et al. 1998). Nitrate concentrations are particularly high in surface waters downstream of agricultural areas (Mueller et al. 1995; Berndt et al. 1998). A study by the U.S. Soil Conservation Service (USSCS; now the Natural Resources Conservation Service [NRCS]) in the Flint River system determined that between 72 and 75 percent of the nutrients entering Lake Blackshear were derived from agricultural sources (USSCS 1993). Stream ecosystems are impacted when nutrients are added at concentrations that cannot be assimilated (Stansbery 1995). The effects of pesticides on mussels may be particularly profound (Fuller 1974, Havlik and Marking 1987, Moulton et al. 1996, Fleming et al. 1995). Organochlorine pesticides were found at levels in ACF Basin streams that often exceeded chronic exposure criteria for the protection of aquatic life (Buell and Couch 1995, Frick et al. 1998). Once widely used in the ACF Basin (Buell and Couch 1995), these highly toxic compounds are persistent in the environment, and are found in both sediments and the lipid reservoir of organisms (Day 1990, Burton 1992). Commonly used pesticides have been directly implicated in a North Carolina mussel dieoff (Fleming et al. 1995). Cotton is raised extensively in much of the Apalachicolan Region inhabited by these mussels. One of the most important pesticides used in cotton farming, malathion, is known to inhibit physiological activities of mussels (Kabeer et al. 1979) that may decrease the ability of a mussel to respire and obtain food. This chemical may pose a continuing threat to some populations of these mussels.

Many pollutants in the ACF Basin originate from urban stormwater runoff, development activities, and municipal waste water facilities, primarily in the Piedmont (Frick et al. 1998). Urban catchments in Piedmont drainages have higher concentrations of nutrients, heavy metals, pesticides, and organic compounds than do agricultural or forested ones (Lenat and Crawford 1994, Frick et al. 1998), and at levels sufficient to significantly affect fish health (Ostrander et al. 1995). Within the Suwannee River basin, nutrient concentrations were greater in agricultural areas and nitrates were found to exceed U.S. Environmental Protection Agency (EPA) drinking water standards in 20 percent of the surficial aquifer groundwater samples (Berndt et al. 1998). Pesticide concentrations were found to exceed criteria for protection of aquatic life mostly in urban areas. Currently, there are discharges from 137 municipal waste water treatment facilities in the ACF River basin alone (Couch et al. 1996). Although effluent quality has improved with modern treatment technologies and a phosphate detergent ban, hundreds of miles of streams in the ACF and Ochlockonee basins in Alabama, Florida, and Georgia, as identified in reports prepared by the water quality agencies of these states under Section 305(b) of the Clean Water Act, do not meet water use classifications.

Since approximately 29 percent of the ACF Basin is in agriculture (Frick et al. 1998), sedimentation from agricultural sources is probably significant. According to USSCS (1993), 89 percent of the sediments entering Lake Blackshear on the Flint River are derived from agricultural sources. The lower Flint River system serves as the heart of numerous mussel species' ranges and is a major agricultural center. This area has experienced "severe losses of

topsoil and nutrient additions to local streams due to agriculture" (Neves et al. 1997), and has profoundly affected the biota of surface and ground waters there (Patrick 1992). Despite the implications, only a few studies (e.g., Cooper 1987, Stewart and Swinford 1995) have specifically attributed changes in mussel populations to sediments derived from agricultural practices.

Many southern streams have increased turbidity levels due to siltation (van der Schalie 1938a). The Chipola slabshell attracts host fishes with visual cues, luring fish into perceiving that their glochidia are prey items. Such a reproductive strategy depends on clear water during the critical time of the year when mussels are releasing their glochidia (Hartfield and Hartfield 1996). Turbidity is a limiting factor impeding sight-feeding fishes (Burkhead and Jenkins 1991). In addition, mussels may be indirectly affected when turbidity levels significantly reduce light available for photosynthesis and the production of unionid food items (Kanehl and Lyons 1992).

Water quantity is becoming more of a concern in maintaining mussel habitat in the Apalachicolan Region. The potential impacts to mussels, their host fishes, and their respective habitats from ground water withdrawal may be profound. Within the Flint River basin, decreases in flow velocity and dissolved oxygen were highly correlated to mussel mortality (Johnson et al. 2001). Low DO conditions in stagnating stream pools due to drought conditions are having a disastrous effect on these mussels. Mussel mortality increases dramatically as DO decreases below 5 mg/L (Johnson et al. 2001).

Maintaining vegetated riparian buffer zones adjacent to stream banks is a well-known method of reducing stream sedimentation and other runoff (Allan and Flecker 1993, Lenat and Crawford 1994). Buffers reduce impacts to fish and other aquatic faunas (Armour et al. 1991, Naiman et al. 1988, Osborne and Kovacic 1993, Belt and O'Laughlin 1994, Penczak 1995, Rabeni and Smale 1995), and are particularly crucial for mussels (Neves et al. 1997). Riparian forest removal in southeastern streams and subsequent sedimentation has been shown to be detrimental to fish communities (Burkhead et al. 1997, Jones et al. 1999). Particularly affected in the study by Jones et al. (1999) were benthic-dependent species (e.g., darters, benthic minnows, sculpins), which were found to decrease in abundance with longer deforested patches of riparian area. Benthic-dependent fishes, themselves disproportionately imperiled (Burkhead et al. 1997), commonly serve as hosts for numerous imperiled mussel species (Watters 1994), probably including the Chipola slabshell.

Exposure Scenario Summary Table for the Chipola Slabshell

Species	**Life Stage**	**Habitat Type**	**Exposure Route**	**Diet**	**Significant Interspecies Relationships**
Chipola Slabshell	glochidia	parasite	contact with water, diet	fish body fluids	bluegill

	juvenile/ adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

TAR RIVER SPINYMUSSEL
Elliptio steinstansana

STATUS:
On June 27, 1985, the Tar River spinymussel was designated as endangered throughout its entire range in North Carolina (USFWS 1985). A recovery plan for the Tar River spinymussel was originally approved on January 16, 1987 and a revised recovery plan was approved on May 5, 1992 (USFWS 1987, 1992).

SPECIES DESCRIPTION:
The Tar River spinymussel is a medium-sized mussel reaching about 2.5 inches in length (Johnson and Clarke 1983). Juveniles may have as many as 12 spines, six on each valve. However, adult specimens tend to lose their spines as they mature, and some large adult specimens may not have shell spines (USFWS 1992). Like other freshwater mussels, the Tar spinymussel feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of Tar spinymussel glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the Tar River spinymussel is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. They then detach from their fish host and sink to the stream bottom or other substrate where they continue to develop, provided they land in a suitable substratum with the correct water conditions. In recent host fish studies, glochidial successfully transformed on bluehead chub (*Nocomis leptocephalus*), satinfin shiner (*Cyprinella analostana*), white shiner (*Notropis albelous*) and pinewoods shiner (*Lythrurus matutinus*) (Chris Eads, North Carolina State University College of Veterinary Medicine, unpublished data).

RANGE AND POPULATION LEVEL:
The Tar River spinymussel is known to occupy two river systems in North Carolina. Populations exist in the Tar River drainage in the Tar River (Nash and Edgecombe Counties), Swift Creek

and Sandy Creek (Franklin, Nash, and Edgecombe Counties), Little Fishing Creek (Halifax County), Shocco Creek (Warren and Franklin Counties), and Fishing Creek (Warren County). The species has also been documented in the Little River (Johnston County) in the Neuse River system (USFWS 2003).

HABITAT:
The preferred habitat of the Tar spinymussel appears to be relatively fast-flowing, well-oxygenated water, in sites with a substrate comprised of relatively silt-free, uncompacted gravel and coarse sand (USFWS 1992).

PAST THREATS:
Historically, the Tar River spinymussel likely once existed throughout much of the Tar River system. A decline in the populations likely resulted from water quality degradation in some parts of the system, land clearing for agriculture, impoundments, poor erosion control structures, and point and nonpoint source discharges (USFWS 1994). In 1990, an investigation of a die-off of freshwater mussels, including approximately one hundred Tar spinymussels, implicated anticholinesterase poisoning (Fleming et al. 1995).

CURRENT THREATS:
Current threats to freshwater mussels are described in the general Mussel Document. Given the small size of the Tar River and Shocco Creek populations, any factor that adversely modifies habitat or water quality in the short river reaches that the species inhabits could threaten its survival in these areas. In addition, the mainstem population in the Tar River is threatened by sediment loading, point source discharges, and urban runoff from a large upstream community (Rocky Mount). The Little River drainage is subject to declining habitat quality due to extensive timber harvesting resulting in sediment loading, stream bank instability, and deterioration of riparian buffers (NatureServe 2003).

Exposure Scenario Summary Table for the Tar River Spinymussel

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
Tar River spinymussel	glochidia	parasite	contact with water, diet	(7 cm) fish body fluids (once encysted)	Bluehead chub Satinfin shiner White shiner Pinewoods shiner
	juvenile / adult	sediment dweller	contact & ingestion of water, diet,	filter feeder (bacteria, algae,	

			sediment	detritus, sediment)	

PURPLE BANKCLIMBER
Elliptoideus sloatianus

STATUS:
On March 16, 1998, the purple bankclimber was designated as Threatened throughout its range (USFWS 1998). A recovery plan for the purple bankclimber was finalized on October 1, 2003 (USFWS 2003). A 5-Year Review was approved for the purple bankclimber on September 17, 2007. Critical habitat was designated for the purple bankclimber on November 15, 2007 (72 FR 64285).

SPECIES DESCRIPTION:
The purple bankclimber is a very large, heavy-shelled, strongly sculptured mussel reaching lengths of 20.5 cm (8.0 in). Fuller and Bereza (1973) described aspects of its soft anatomy, and characterized *Elliptoideus* as being an "extremely primitive" genus. The Service currently follows Turgeon et al (1998) and recognizes the purple bankclimber as *Elliptoideus sloatianus* with the following names considered synonyms: *Unio atromarginatus* Lea, 1840, *Unio aratus* Conrad, 1849, and *Unio plectophorus* Conrad, 1850.

Like other freshwater mussels, adults are filter-feeders, orienting themselves in the substrate to facilitate siphoning of the water column for oxygen and food (Kraemer 1979). Mussels have been reported to consume detritus, diatoms, phytoplankton, zooplankton, and other microorganisms (Coker et al. 1921, Churchill and Lewis 1924, Fuller 1974). Juvenile mussels employ foot (pedal) feeding, and are thus suspension feeders (Yeager et al. 1994). Foods of juvenile freshwater mussels up to two weeks old include bacteria, algae, and diatoms with amounts of detrital and inorganic colloidal particles (Yeager et al. 1994). Specific food habits of the purple bankclimber are unknown, but are likely similar to those of other freshwater mussels.

REPRODUCTION AND DEVELOPMENT:
Females of the purple bankclimber with viable glochidia were found in the Ochlockonee River from February through April when water temperatures ranged from 46.4 to 59.0 degrees Fahrenheit (O'Brien and Williams 2002). This indicates that it is a late winter-early spring releaser that may or may not be a parent overwintering species, dependent upon when fertilization takes place. Females expelled narrow lanceolate-shaped conglutinates (1.0 to 1.5 cm (0.4 to 0.6 in)long) that remain viable for three days after release. The white structures, which are two-glochidia thick, are generally released singly although some are paired, being attached at one end (O'Brien and Williams 2002). Rigid when aborted prematurely (containing only eggs), conglutinates with mature glochidia easily disintegrate presumably facilitating host infection. Glochidial morphology was described and figured by O'Brien and Williams (2002).

The eastern mosquitofish *(Gambusia holbrooki)*, blackbanded darter *(Percina nigrofasciata)*, guppy *(Poecilia reticulata)* and greater jumprock transformed glochidia of the purple

bankclimber during laboratory infections (O'Brien and Williams 2002, P.D. Johnson, Tennessee Aquatic Research Institute [TNARI], pers. comm. 2003). Only the eastern mosquitofish was effective at transforming glochidia (100 percent transformation rate), with the percentages for the blackbanded darter and guppy being under 33 percent. Transformation on eastern mosquitofish occurred in 17 to 21 days at temperatures of 68.9 $\pm$ 5.4 degrees Fahrenheit (O'Brien and Williams 2002). Only one glochidium was successfully transformed on the greater jumprock during preliminary trials and occurred after 52 days (Johnson, TNARI, pers. comm. 2003). The eastern mosquitofish occupies stream margins in slower (or slack) currents (Lee et al. 1980), and is considered a secondary host fish since the purple bankclimber is more of a channel species (Williams and Butler 1994). The primary host species for this mussel remains unknown (O'Brien and Williams 2002).

RANGE AND POPULATION LEVEL:

The type locality of the purple bankclimber was restricted to the Chattahoochee River, Columbus, Georgia, by Clench and Turner (1956). This large species is virtually restricted to Apalachicola-Chattahoochee-Flint (ACF) Basin main stems and the Ochlockonee River in Florida and Georgia (Clench and Turner 1956, Williams and Butler 1994, Brim Box and Williams 2000). Generally distributed in the Flint, Apalachicola, and Ochlockonee Rivers, it was also known from the lower halves of the Chattahoochee and Chipola Rivers, and from two tributaries in the Flint River system. Heard (1979) erroneously reported it from the Escambia River system (Williams and Butler 1994).

Subpopulations from the Chattahoochee River have apparently been extirpated save for a single live specimen found in 2000 (C. Stringfellow, Columbus State University, pers. comm., 2000). In addition, it is no longer known from the Line and Ichawaynochaway Creeks, and has not been seen live in the Chipola River since 1988. Within portions of the Flint and Ochlockonee Rivers, the purple bankclimber occurs more sporadically than it did historically. Most occurrences in the Ochlockonee River are above Talquin Reservoir. An anomalous small stream occurrence (a single specimen from an unnamed tributary of Mill Creek, Flint River system) was discovered during the status survey (USFWS 1998). Overall, 34 subpopulations of purple bankclimber currently persist (Table 7, USFWS 2003).

During the status survey, an average of 54 specimens of the purple bankclimber was recorded from 41 sites rangewide (USFWS 1998), 30 sites occurring in the ACF Basin (Brim Box and Williams 2000). The Corps completed mussel surveys at potential dredged material disposal sites, slough locations, and other main channel areas within the Apalachicola and Chipola rivers (Miller 1998, Miller 2000, Miller, ERDC pers. comm. 2003). The purple bankclimber was found at 10 sites. Limited quantitative sampling for the purple bankclimber has been conducted in the upper Apalachicola and Ochlockonee Rivers. Six 2.7 square feet quadrat samples taken below Jim Woodruff Dam on the former river revealed approximately one specimen per square foot of substrate when sieved (Richardson and Yokley 1996). Four 97-square foot quadrat hand-picked samples in the Ochlockonee River in 1993 recorded purple bankclimber densities averaging 0.34 per square foot (J. Brim Box, USGS, unpub.data).

HABITAT:

The purple bankclimber inhabits small to large river channels in slow to moderate current over sand or sand mixed with mud or gravel substrates (Williams and Butler 1994). Over 80 percent of the specimens located during the ACF Basin portion of the status survey were found at sites with a substrate of sand/limestone (Brim Box and Williams 2000). ACF Basin collections were often in waters over 10 feet in depth.

CRITICAL HABITAT:
In Coweta, Crawford, Crisp, Dooly, Fayette, Macon, Meriwether, Peach, Pike, Spalding, Sumter, Talbot, Taylor, Upson, and Worth counties, Georgia, stream and river channels within the ordinary high water line of the Flint River from the State Highway 27 bridge in Dooly and Sumter counties, Georgia, upstream 247.4 km through Macon, Peach, Taylor, Crawford, Talbot, Upson, Pike, Meriwether, and Coweta counties, to Horton Creek in Fayette and Spalding counties, Georgia; Swift Creek from Lake Blackshear upstream 11.3 km to Rattlesnake Branch, Crisp and Worth counties, Georgia; Limestone Creek from Lake Blackshear, Crisp County, Georgia, upstream 8.8 km to County Road 89, Dooly County, Georgia; Turkey Creek from the Flint River upstream 21.7 km to Rogers Branch, in Dooly County, Georgia; Pennahatchee Creek from Turkey Creek upstream 4.8 km to Little Pennahatchee Creek, Dooly County, Georgia; Little Pennahatchee Creek from Pennahatchee Creek upstream 5.8 km to Rock Hill Creek, Dooly County, Georgia; Hogcrawl Creek from the Flint River upstream 21.6 km to Little Creek, Dooly and Macon counties, Georgia; Red Oak Creek from the Flint River upstream 21.7 km to Brittens Creek, Meriwether County, Georgia; Line Creek from the Flint River upstream 15.8 km to Whitewater Creek, Coweta and Fayette counties, Georgia; and Whitewater Creek from Line Creek upstream 21.5 km to Ginger Cake Creek, Fayette County, Georgia.

In Dougherty, Lee, Marion, Schley, Sumter, Terrell, Webster, and Worth counties, Georgia, stream and river channels within the ordinary high water line of the Flint River from Piney Woods Creek in Dougherty County, Georgia, upstream 39.9 km to the Warwick Dam, Lee and Worth counties, Georgia; Kinchafoonee Creek from its confluence with Lake Worth at the Lee--Dougherty county line, upstream 107.6 km through Terrell and Sumter Counties, Georgia, to Dry Creek, Webster County, Georgia; Lanahassee Creek from Kinchafoonee Creek upstream 9.3 km to West Fork Lanahassee Creek, Webster County, Georgia; Muckalee Creek, from its confluence with Lake Worth at the Lee--Dougherty county line, upstream 104.5 km to County Road 114, Marion County, Georgia; Little Muckalee Creek, from Muckalee Creek in Sumter County, Georgia, upstream 7.2 km to Galey Creek, Schley County, Georgia; Mill Creek from the Flint River upstream 3.2 km to Mercer Millpond Creek, Worth County, Georgia; Mercer Millpond Creek from Mill Creek upstream 0.45 km to Mercer Mill Pond, Worth County, Georgia; Abrams Creek from the Flint River upstream 15.9 km to County Road 123, Worth County, Georgia; Jones Creek from the Flint River upstream 3.8 km to County Road 123, Worth County, Georgia; and Chokee Creek, from the Flint River upstream 10.5 km to Dry Branch Creek, Lee County, Georgia.

In Baker, Calhoun, Decatur, Dougherty, Early, Miller, Mitchell, and Terrell counties, Georgia, stream and river channels within the ordinary high water line of the Flint River from its confluence with Big Slough, Decatur County, Georgia, upstream 116.4 km through Baker and Mitchell Counties, Georgia, to the Flint River Dam, Dougherty County, Georgia; Spring Creek,

from its confluence with Lake Seminole at Smith Landing, Decatur County, Georgia, upstream 74.2 km to County Road 35, Early County, Georgia; Aycocks Creek from Spring Creek upstream 15.9 km to Cypress Creek, Miller County, Georgia; Dry Creek from Spring Creek upstream 9.9 km to Wamble Creek , Early County, Georgia; Ichawaynochaway Creek from the Flint River, Baker County, Georgia, upstream 68.6 km to Merrett Creek, Calhoun County, Georgia; Mill Creek from Ichawaynochaway Creek upstream 7.4 km to County Road 163, Baker County, Georgia; Pachitla Creek, from Ichawaynochaway Creek upstream 18.9 km to Little Pachitla Creek, Calhoun County, Georgia; Little Pachitla Creek from Pachitla Creek upstream 5.8 km to Bear Branch, Calhoun County, Georgia; Chickasawhatchee Creek from Ichawaynochaway Creek, Baker County, Georgia, upstream 64.5 km to U.S. Highway 82, Terrell County, Georgia; and Cooleewahee Creek from the Flint River upstream 15.1 km to Piney Woods Branch, Baker County, Georgia.

In Calhoun, Franklin, Gadsden, Gulf, Jackson, and Liberty Counties, Florida, stream and river channels within the ordinary high water line of the main stem of the Apalachicola River, two of its distributaries, Chipola Cutoff and Swift Slough, and three of its tributaries, River Styx, Kennedy Slough, and Kennedy Creek.

In Gadsden and Leon counties, Florida, and in Grady and Thomas counties, Georgia, stream and river channels within the ordinary high water line of the main stem of the Ochlockonee River upstream of Lake Talquin and three tributaries.

In Leon, Liberty, and Wakulla counties, Florida, stream and river channels within the ordinary high water line of the main stem of the Ochlockonee River from its confluence with Syfrett Creek, Wakulla County, Florida, upstream 75.4 km to the Jackson Bluff Dam, Leon and Liberty counties, Florida.

Primary constituent elements identified at the time of designation included: (1) Space for individual and population growth and for normal behavior; (2) Food, water, air, light, minerals, or other nutritional or physiological requirements; (3) Cover or shelter; (4) Sites for breeding, reproduction, or rearing (or development) of offspring; and (5) Habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species.

PAST THREATS:

The abundance and distribution of the purple bankclimber decreased historically from habitat loss and degradation (Williams et al. 1993, Neves 1993) caused by impoundments (Talquin Reservoir), sedimentation and turbidity, dredging and channelization, and contaminants contained in numerous point and nonpoint sources. A comprehensive review of these past threats is provided elsewhere (USFWS 2003, Brim Box and Williams 2000, Butler 1993, Richter et al. 1997, Watters 1997, Neves et al. 1997). However, the histories of anthropogenic impacts specifically to the Ochlockonee River drainage have not been summarized. These habitat changes have resulted in significant extirpations (localized loss of populations), restricted and fragmented distributions, and poor recruitment of young.

CURRENT THREATS:
Habitat loss and degradation (Williams et al. 1993, Neves 1993) primarily caused by contaminants contained in point and nonpoint source discharges, sedimentation and erosive land practices, water quantity and withdrawal, construction of new impoundments, and alien species are primary threats to the purple bankclimber (USFWS 2003).

Sediment samples from various ACF Basin streams tested for heavy metals that are known to be deleterious to mussels had concentrations markedly above background levels (Frick et al. 1998), among those were copper (throughout the Piedmont), and cadmium (large Coastal Plain tributaries of the Flint River). Past episodes of significant heavy metal contamination of ACF Basin streams may continue to impact mussel faunas. An estimated 950 million gallons of chemical-laden rinse, stripping, cleaning, and plating solutions were discharged indirectly into the Flint River (P. Laumeyer, USFWS, pers. comm., 1994) over a several year period. Concentrations of heavy metals (e.g., chromium and cadmium) in Asian clam, *Corbicula fluminea* (Muller 1774), and sediment samples were elevated downstream from two abandoned battery salvage operations on the Chipola River (Winger et al. 1985). Chromium concentrations found in sediments from Dead Lake downstream in the Chipola River (Winger et al. 1985) are known to be toxic to mussels (Havlik and Marking 1987).

Agricultural sources of contaminants in the ACF and Suwannee basins include nutrient enrichment from poultry farms and livestock feedlots, and pesticides and fertilizers from row crop agriculture (Couch et al. 1996, Frick et al. 1998, Berndt et al. 1998). Nitrate concentrations are particularly high in surface waters downstream of agricultural areas (Mueller et al. 1995; Berndt et al. 1998). A study by the U.S. Soil Conservation Service (USSCS; now the Natural Resources Conservation Service [NRCS]) in the Flint River system determined that between 72 and 75 percent of the nutrients entering Lake Blackshear were derived from agricultural sources (USSCS 1993). Stream ecosystems are impacted when nutrients are added at concentrations that cannot be assimilated (Stansbery 1995). The effects of pesticides on mussels may be particularly profound (Fuller 1974, Havlik and Marking 1987, Moulton et al. 1996, Fleming et al. 1995). Organochlorine pesticides were found at levels in ACF Basin streams that often exceeded chronic exposure criteria for the protection of aquatic life (Buell and Couch 1995, Frick et al. 1998). Once widely used in the ACF Basin (Buell and Couch 1995), these highly toxic compounds are persistent in the environment, and are found in both sediments and the lipid reservoir of organisms (Day 1990, Burton 1992). Commonly used pesticides have been directly implicated in a North Carolina mussel dieoff (Fleming et al. 1995). Cotton is raised extensively in much of the Apalachicolan Region inhabited by these mussels. One of the most important pesticides used in cotton farming, malathion, is known to inhibit physiological activities of mussels (Kabeer et al. 1979) that may decrease the ability of a mussel to respire and obtain food. This chemical may pose a continuing threat to some populations of these mussels.

Many pollutants in the ACF Basin originate from urban stormwater runoff, development activities, and municipal waste water facilities, primarily in the Piedmont (Frick et al. 1998). Urban catchments in Piedmont drainages have higher concentrations of nutrients, heavy metals, pesticides, and organic compounds than do agricultural or forested ones (Lenat and Crawford 1994, Frick et al. 1998), and at levels sufficient to significantly affect fish health (Ostrander et al.

1995). Within the Suwannee River basin, nutrient concentrations were greater in agricultural areas and nitrates were found to exceed U.S. Environmental Protection Agency (EPA) drinking water standards in 20 percent of the surficial aquifer groundwater samples (Berndt et al. 1998). Pesticide concentrations were found to exceed criteria for protection of aquatic life mostly in urban areas. Currently, there are discharges from 137 municipal waste water treatment facilities in the ACF River basin alone (Couch et al. 1996). Although effluent quality has improved with modern treatment technologies and a phosphate detergent ban, hundreds of miles of streams in the ACF and Ochlockonee basins in Alabama, Florida, and Georgia, as identified in reports prepared by the water quality agencies of these states under Section 305(b) of the Clean Water Act, do not meet water use classifications.

Since approximately 29 percent of the ACF Basin is in agriculture (Frick et al. 1998), sedimentation from agricultural sources is probably significant. According to USSCS (1993), 89 percent of the sediments entering Lake Blackshear on the Flint River are derived from agricultural sources. The lower Flint River system serves as the heart of numerous mussel species' range and is a major agricultural center. This area has experienced "severe losses of topsoil and nutrient additions to local streams due to agriculture" (Neves et al. 1997), and has profoundly affected the biota of surface and ground waters there (Patrick 1992). Despite the implications, only a few studies (e.g., Cooper 1987, Stewart and Swinford 1995) have specifically attributed changes in mussel populations to sediments derived from agricultural practices.

Many southern streams have increased turbidity levels due to siltation (van der Schalie 1938a). The purple bankclimber attracts host fishes with visual cues, luring fish into perceiving that their glochidia are prey items. Such a reproductive strategy depends on clear water during the critical time of the year when mussels are releasing their glochidia (Hartfield and Hartfield 1996). Turbidity is a limiting factor impeding sight-feeding fishes (Burkhead and Jenkins 1991). In addition, mussels may be indirectly affected when turbidity levels significantly reduce light available for photosynthesis and the production of unionid food items (Kanehl and Lyons 1992).

Water quantity is becoming more of a concern in maintaining mussel habitat in the Apalachicolan Region. The potential impacts to mussels, their host fishes, and their respective habitats from ground water withdrawal may be profound. Within the Flint River basin, decreases in flow velocity and dissolved oxygen were highly correlated to mussel mortality (Johnson et al. 2001). Low DO conditions in stagnating stream pools due to drought conditions are having a disastrous effect on these mussels. Mussel mortality increases dramatically as DO decreases below 5 mg/L (Johnson et al. 2001).

Maintaining vegetated riparian buffer zones adjacent to stream banks is a well-known method of reducing stream sedimentation and other runoff (Allan and Flecker 1993, Lenat and Crawford 1994). Buffers reduce impacts to fish and other aquatic faunas (Armour et al. 1991, Naiman et al. 1988, Osborne and Kovacic 1993, Belt and O'Laughlin 1994, Penczak 1995, Rabeni and Smale 1995), and are particularly crucial for mussels (Neves et al. 1997). Riparian forest removal in southeastern streams and subsequent sedimentation has been shown to be detrimental to fish communities (Burkhead et al. 1997, Jones et al. 1999). Particularly affected in the study

by Jones et al. (1999) were benthic-dependent species (e.g., darters, benthic minnows, sculpins), which were found to decrease in abundance with longer deforested patches of riparian area. Benthic-dependent fishes, themselves disproportionately imperiled (Burkhead et al. 1997), commonly serve as hosts for numerous imperiled mussel species (Watters 1994), probably including the purple bankclimber.

Exposure Scenario Summary Table for the Purple Bankclimber

Species	**Life Stage**	**Habitat Type**	**Exposure Route**	**Diet**	**Significant Interspecies Relationships**
Purple Bankclimber	glochidia	parasite	contact with water, diet	fish body fluids	host fish(es) unknown
	juvenile/ adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

CUMBERLANDIAN COMBSHELL
Epioblasma brevidens

STATUS:
On January 10, 1997, the Cumberlandian combshell (*Epioblasma brevidens*) was designated as Endangered throughout its entire range (USFWS 1997). The *Recovery Plan for the Cumberland Elktoe, Oyster Mussel, Cumberlandian Combshell, Purple Bean, and Rough Rabbitsfoot* was approved on May 4, 2004 (69 FR 29569). Critical habitat was designated for the Cumberlandian Combshell on August 31, 2004 (69 FR 53135). A 5-Year Review of the Cumberlandian Combshell was approved on September 19, 2007.

SPECIES DESCRIPTION:
The Cumberlandian combshell has a thick solid shell with a smooth to clothlike periostracum, which is yellow to tawny brown in color with narrow green broken rays.

REPRODUCTION AND DEVELOPMENT:
Spawning in the lampsiline Cumberlandian combshell occurs in late summer (Gordon 1991). Females display until the water temperature drops below approximately 50°F in the fall, burrow into the substrate to overwinter, and begin displaying again as early as March (Jones, pers. comm., 2003). Gravid females, qualitatively estimated at 8 to 13 years of age, have been reported from early May to June at water temperatures of 59.0° to 64.0°F (Ahlstedt 1991a, Yeager and Saylor 1995). The female has a complex mantle display that resembles the cercae of

insect larvae (e.g., stoneflies) protruding from under two or three small stones (Jones, pers. comm., 2003). One of its host fishes, the logperch (*Percina caprodes*), has the peculiar habit of flipping small stones in search of food (Etnier and Starnes 1993). Glochidial release generally is complete by mid-June (Jones, pers. comm., 2002). Several other native host fish species have been identified, including the wounded darter, redline darter, bluebreast darter, snubnose darter (*E. simoterum*), greenside darter (*E. blennioides*), banded sculpin, black sculpin, and mottled sculpin (Yeager and Saylor 1995; Jones and Neves, unpub. data). Transformation took from 16 to 48 days, at 60.4° to 62.4°F (Yeager and Saylor 1995).

RANGE AND POPULATION LEVEL:

The Cumberlandian combshell was described from the Cumberland River in Tennessee, possibly from Davidson County (Nashville). Historically, it ranged throughout the Cumberlandian Region (Table 3, USFWS 2003), occurring in three physiographic provinces (i.e., Interior Low Plateau, Cumberland Plateau, Ridge and Valley) and five states (i.e., Alabama, Kentucky, Mississippi, Tennessee, Virginia). In the Cumberland River it occurred from the base of Cumberland Falls, McCreary and Whitley Counties, Kentucky, downstream to Stewart County, Tennessee. In the Tennessee River, it occurred throughout the main stem, downstream to Benton and Humphreys Counties, Tennessee. The Cumberlandian combshell also occurred in numerous tributaries in the Cumberland and Tennessee River systems. The most downstream records in both rivers are from archeological sites (Parmalee and Bogan 1998), indicating that at least in premodern times this species occurred further downstream from the area strictly defined as the Cumberlandian Region.

The Cumberlandian combshell has been extirpated from a large percentage of its former range (Table 3, USFWS 2003). Main-stem populations in both the Cumberland and Tennessee Rivers are now considered extirpated (Ahlstedt, pers. comm., 2003). This species has also apparently been eliminated from numerous tributaries in the Cumberland River system (e.g., Rockcastle River, Beaver Creek, Obey River, Caney Fork, Stones River, Red River) and the Tennessee River system (e.g., Station Creek, Wallen Creek, Holston River, Nolichucky River, West Prong Little Pigeon River, Little Tennessee River, Paint Rock River, Elk River, Little Bear Creek, Cedar Creek, Duck River) (Table 3, USFWS 2003). The Cumberlandian combshell has also been extirpated from large portions of additional tributaries in the Cumberlandian Region (e.g., Clinch River, Powell River, North Fork Holston River, Bear Creek).

Extant Cumberland River system populations occur in Buck Creek, Pulaski County, Kentucky; and Big South Fork, Scott County, Tennessee, and McCreary County, Kentucky (Table 3, USFWS 2003). In the Tennessee River system, populations are thought to remain in the Clinch River, Scott County, Virginia, and Hancock County, Tennessee; Powell River, Lee County, Virginia, and Claiborne and Hancock Counties, Tennessee; and Bear Creek, Colbert County, Alabama, and Tishimingo County, Mississippi (Table 3, USFWS 2003). Although the species was found in Alabama in Cedar Creek (tributary to Bear Creek) in 1988, a recent survey of the entire Bear Creek system failed to reveal even shells of the Cumberlandian combshell at nine sites in Cedar Creek (McGregor and Garner, in press).

A quantitative study by Ahlstedt and Tuberville (1997) in the Powell and Clinch Rivers in Tennessee and Virginia between 1979 and 1994, with subsequent sampling in 1999 (Ahlstedt, unpublished [unpub.] data), provides insight into recent Cumberlandian combshell densities and indicates a general decline in the Powell River. Taking from 432 (1983) to 542 (1999) quadrats (2.7 square feet each) per year in the Powell, they found it at 4 of 15 sites in 1979, for an average density per site of occurrence of 0.03 per square foot; at 3 of 14 sites in 1983, for an average density of 0.02; at 3 of 15 sites in 1988, for an average density of 0.01; and at 1 of 16 sites in 1994, for an average density of 0.01. Wolcott and Neves (1994) conducted both qualitative and limited quantitative sampling for mussels in the Powell River in Virginia during 1988 and 1989. Two of the five sites that qualitatively yielded Cumberlandian combshell specimens had densities of 0.03 and 0.01 per square foot, respectively. Ahlstedt and Tuberville (1997) attributed the decline in Powell River populations of this species to general stream degradation, although a prolonged drought between 1983 and 1988 may also have contributed to the low numbers during the sampling efforts expended in 1988.

Quantitative sampling at 11 to 14 sites in the Clinch River in 1979, 1988, 1994, and 1999 (only 1 site sampled in 1983) revealed the Cumberlandian combshell at slightly higher densities than in the Powell River (Ahlstedt and Tuberville 1997; Ahlstedt, unpub. data). At least 345 quadrats were taken per year. They found it at 3 of 11 sites in 1979, for an average density per site of occurrence of 0.02 per square foot; 3 of 12 sites in 1988, for an average density of 0.02; 3 of 15 sites in 1994, for an average density of 0.03; and 6 of 15 sites (3 in each state) in 1999, for an average density of 0.05. However, it is apparent that the Cumberlandian combshell population in the Clinch River has rebounded, most noticeably in the Virginia portion of the river, although densities are generally higher in Tennessee.

Currently, the largest extant population of the Cumberlandian combshell occurs in the Clinch River in Tennessee (Ahlstedt, pers. comm., 2003). Biologists have recently documented the presence of significant numbers of adults and verified recent recruitment with the presence of juvenile specimens from muskrat middens in the Clinch River. The Big South Fork population is sizable and recruiting (Ahlstedt, pers. comm., 2003). Recent evidence of recruitment has also been detected in the Powell River (Jones, letter dated June 9, 2003), but populations in other stream reaches are small and of questionable long-term viability (e.g., Buck Creek, Bear Creek) (Wolcott and Neves 1994, Hagman 2000, McGregor and Garner, in press; Ahlstedt, pers. comm., 2003).

HABITAT:

This species inhabits medium-sized streams to large rivers on shoals and riffles in coarse sand, gravel, cobble, and boulders (Dennis 1985, Gordon 1991). It is not associated with small stream habitats (Dennis 1985) and tends not to extend as far upstream in tributaries. In general, it occurs in larger tributaries than does its congener the oyster mussel (*Epioblasma capsaeformis)*. Gordon (1991) states that the species prefers depths less than 3 feet, but it appears to persist in the deep-water areas of the Old Hickory Reservoir on the Cumberland River, where there is still fairly strong flow from the Cordell Hull and Center Hill Reservoirs (Gordon and Layzer 1989).

CRITICAL HABITAT:

In Maury and Marshall Counties, Tennessee, all stream and river channels within the ordinary high-water line of the main stem of the Duck River channel from rkm 214 (rmi 133) (0.3 rkm (0.2 rmi) upstream of the First Street Bridge in the City of Columbia, Maury County, Tennessee, upstream to Lillard Mill Dam at rkm 288 (rmi 179), Marshall County, Tennessee. In Colbert County, Alabama, and Tishomingo County, Mississippi, all stream and river channels within the ordinary high-water line of the main stem of Bear Creek from the backwaters of Pickwick Lake at rkm 37 (rmi 23), Colbert County, Alabama, upstream through Tishomingo County, Mississippi, ending at the Mississippi/Alabama State line. In Claiborne and Hancock Counties, Tennessee, and Lee County, Virginia, all stream and river channels within the ordinary high-water line of the Powell River from the U.S. 25E Bridge in Claiborne County, Tennessee, upstream to rkm 256 (rmi 159) (upstream of Rock Island in the vicinity of Pughs), Lee County, Virginia. In Hancock County, Tennessee, and Scott, Russell, and Tazewell Counties, Virginia, all stream and river channels within the ordinary high-water line of the Clinch River from rkm 255 (rmi 159) immediately below Grissom Island, Hancock County, Tennessee, upstream to its confluence with Indian Creek in Cedar Bluff, Tazewell County, Virginia. In Hamblen and Cocke Counties, Tennessee, all stream and river channels within the ordinary high-water line, of the main stem of the Nolichucky River and extends from rkm 14 (rmi 9) (approximately 0.6 rkm (0.4 rmi) upstream of Enka Dam to Susong Bridge in Hamblen and Cocke counties, Tennessee. In Fentress, Morgan, and Scott Counties, Tennessee, and McCreary County, Kentucky, all stream and river channels within the ordinary high-water line of the Big South Fork of the Cumberland River main stem from its confluence with Laurel Crossing Branch downstream of Big Shoals, McCreary County, Kentucky, upstream to its confluence with the New River and Clear Fork, Scott County, Tennessee. In Pulaski County, Kentucky, all stream and river channels within the ordinary high-water line of Buck Creek from the State Route 192 Bridge upstream to the State Route 328 Bridge in Pulaski County, Kentucky.

Primary constituent elements identified at the time of designation included: 1. Permanent, flowing stream reaches with a flow regime (i.e, the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of the mussel and its host fish; 2. Geomorphically stable stream and river channels and banks (structurally stable stream cross section); 3. Stable substrates, consisting of mud, sand, gravel, and/or cobble/boulder, with low amounts of fine sediments or attached filamentous algae; 4. Water quality (including temperature, turbidity, oxygen content, and other characteristics) necessary for the normal behavior, growth, and survival of all life stages of the five mussels and their host fish; and 5. Fish hosts with adequate living, foraging, and spawning areas for them.

PAST THREATS:

The abundance and distribution of the Cumberlandian combshell decreased historically from human-induced habitat loss and degradation (Williams et al. 1993, Neves 1993) caused by impoundments (e.g., TVA impoundments on the Cumberland and Tennessee Rivers and their tributaries, Laurel River, Obey River, Caney Fork, Stones River), sedimentation and turbidity, channelization, and contaminants contained in numerous point and nonpoint sources. A comprehensive review of these past threats is provided elsewhere (USFWS 2003, Williams et al. 1993, Neves 1993, Neves 1991, Neves et al. 1997, Watters 2000, Richter et al. 1997). These

habitat changes have resulted in significant extirpations (localized loss of populations), restricted and fragmented distributions, and poor recruitment of young.

Numerous Cumberlandian Region streams have experienced mussel kills from toxic chemical spills and other causes (Cairns et al. 1971, Crossman et al. 1973, Neves 1986, Wolcott and Neves 1994). The high number of jeopardized species in the upper Tennessee River system make accidental spills a particular concern to conservationists and resource managers (Hampson et al. 2000). The dramatic impact the chlor-alkali chemical plant in Saltville, Virginia, has had on the aquatic fauna in the North Fork Holston River is well documented (Adams 1915; Cairns et al. 1971; Stansbery and Clench 1974; Hill et al. 1975; Ahlstedt 1980, 1991c; Neves and Zale 1982; Sheehan et al. 1989; Hampson et al. 2000). Although it is considered a chronic episode, and not an event like most other toxic spills, it is discussed in this section simply because of the tremendous impact it has had on the river.

Since the plant's opening in 1893, mercury and various salts (e.g., calcium chloride, sodium chloride) from this site have polluted the North Fork Holston River and decimated the entire molluscan fauna all the way to the mouth of the river, a distance of 80 miles (Ahlstedt 1991c). Occurring in this river reach were populations of the Cumberlandian combshell, oyster mussel, purple bean, rough rabbitsfoot, and 34 other mussel species (Neves and Zale 1982). From 1950 to 1971, an estimated 75 pounds of mercury per day were discharged from this facility directly into the North Fork or into unlined floodplain holding ponds (Hampson et al. 2000). The long-term kill was so thorough that only one mussel species was reported in the early 1970s by Hill et al. (1975).

The closing of the plant in 1972 brought about the possible opportunity for natural mussel recolonization in the North Fork Holston River (Stansbery and Clench 1974). Efforts were soon made to help speed up the recovery of mussels in the North Fork. However, the lingering effects of mercury, extremely low numbers of mussels, and possibly low numbers of fish hosts may be responsible for the general lack of mussels observed at sites within 20 miles downstream of Saltville (Henley and Neves 1995).

An alkaline fly ash pond spill in 1967 and a sulfuric acid spill in 1970 on the Clinch River at the power plant at Carbo, Virginia, caused a massive mussel kill for up to 12 miles downstream from the power plant site (Cairns et al. 1971, Crossman et al. 1973, Stansbery 1986, Sheehan et al. 1989, Wilcove and Bean 1994). Populations of the Cumberlandian combshell, oyster mussel, rough rabbitsfoot, and purple bean that may have resided in the affected river reach were undoubtedly impacted by these spill events. Natural recolonization has not occurred in the impacted river reach (Stansbery 1986, Ahlstedt 1991a, Hampson et al. 2000), possibly due to copper contamination from the power plant at Carbo (Wilcove and Bean 1994). An experimental reintroduction of nonlisted mussels in 1981 and 1984 has largely failed (Sheehan et al. 1989).

CURRENT THREATS:

The Cumberlandian combshell and its habitat is currently being impacted by excessive sediment bed loads of smaller sediment particles, changes in turbidity, increased suspended solids

(primarily resulting from nonpoint-source loading from poor land-use practices and lack of, or maintenance of, best management practices [BMPs], and pesticides (USFWS 2003, Williams et al. 1993, Neves 1993, Neves 1991, Neves et al. 1997, Watters 2000, Richter et al. 1997). Other primarily localized impacts include coal mining, gravel mining, reduced water quality below dams, developmental activities, water withdrawal, impoundments, and alien species. Their restricted ranges and low population levels also increase their vulnerability to toxic chemical spills and the deleterious effects of genetic isolation.

Although the dams of the Cumberland and Tennessee Rivers themselves probably contributed more to the destruction of riverine habitat for the Cumberlandian combshell, channel maintenance activities continue to cause substrate instability and alteration in these rivers and may serve to diminish what habitat remains for the recovery of these species. Other streams, notably the lower Paint Rock River (Ahlstedt 1995-96) and portions of the Bear Creek system (McGregor and Garner, in press), have been channelized, primarily during ill-fated attempts to reduce flooding.

Impacts associated with coal mining activities have particularly altered upper Cumberland River system streams with diverse historical mussel faunas (Stansbery 1969, Blankenship 1971, Blankenship and Crockett 1972, Starnes and Starnes 1980, Schuster et al. 1989, Anderson et al. 1991) and have been implicated in the decline of *Epioblasma* species, especially in the Big South Fork (Neel and Allen 1964). Strip mining continues to threaten mussels in coal field drainages of the Cumberland Plateau (Anderson 1989, Warren et al. 1999) with increased sedimentation loads and acid mine drainage, including Cumberlandian combshell populations. Coal mining activities also occur in portions of the upper Powell and Clinch River systems, primarily in Virginia. Scores of active and inactive mines are known from these drainages (Hampson et al. 2000). The role that coal mining has played in the decline of mussel fauna in the Powell River in Virginia was prophesied by Ortmann (1918) and has been briefly summarized by Wolcott and Neves (1990, 1994). Five mine tailings pond spills were reported from 1995 to 1999 in the upper Clinch and Powell River systems (Hampson et al. 2000), at least one of which resulted in a major fish kill (Koch, pers. comm., 1996). Research by Kitchel et al. (1981) indicates that Powell River mussel populations were inversely correlated with coal fines in the substrate. When coal fines were present, decreased filtration times and increased movements were noted in laboratory-held mussels (Kitchel et al. 1981).

Polycyclic aromatic compounds (PAHs) are indicative of coal fines in the bottom sediments of streams. Known to be toxic to mussels and fishes, PAHs have been found at relatively high levels in the upper portions of the Clinch and Powell Rivers in Virginia (Hampson et al. 2000). In fact, Hampson et al. (2000) detected 29 different PAHs in stream sediment samples in the two watersheds. The Clinch River at Pendleton Island had concentrations of two measured PAHs, naphthalene and phenanthrene, at 400 micrograms per kilogram (µg/kg) and 570 µg/kg, respectively, both of which are above the protection guidelines for aquatic life. The Canadian probable-effect levels of 391 µg/kg and 515 µg/kg, respectively, have been established for these compounds. The probable-effect levels define concentrations above which adverse effects to aquatic organisms can be expected. Pendleton Island was once a stronghold for the rough rabbitsfoot and home to the Cumberlandian combshell, oyster mussel, and purple bean as well in

the early 1980s (Ahlstedt 1991a). However, the fauna there was in marked decline less than a decade later. No live oyster mussels or Cumberlandian combshells were found in 1987 (Dennis 1989). Three other sites in the Clinch River system (i.e., lower Clinch River, Guest River, Copper Creek) had concentrations of these two compounds below the probable-effect levels. A site on the Powell River near Arthur, Tennessee, had much higher levels of naphthalene and phenanthrene (1,600 µg/kg and 1,300 µg/kg, respectively) than at Pendleton Island.

In a quantitative study in the Powell River, Ahlstedt and Tuberville (1997) attributed a 15-year decline of the Cumberlandian combshell, oyster mussel and rough rabbitsfoot and the long-term decrease in species diversity (from 30 in 1979 to 21 in 1994) to general stream degradation due primarily to coal mining activities in the headwaters. Iron and phosphate mining in the Duck River watershed was thought to have caused mussel declines in the early 1900s (Ortmann 1924).

Gravel mining activities threaten the Cumberlandian combshell populations in the Powell River and in Buck Creek, the latter stream representing one of only two remaining populations of this species in the entire Cumberland River system. Mining activities on the Elk River (Ahlstedt 1991b) may have played a role in the extirpation Cumberlandian combshell from that river. Gravel removal was apparent at 12 sites along a 40-mile stretch of the lower Elk River during 1999 mussel sampling (Anonymous 1999). Activities that occur without a permit, unless controlled, may prevent the long-term reintroduction of some of the 13 federally listed mussels that are known from the Elk.

Cotton is raised extensively in parts of the middle and lower Tennessee River system. One of the most important pesticides used in cotton farming, malathion, is known to inhibit the physiological activities of mussels (Kabeer et al. 1979) and may decrease the ability of a mussel to respire and obtain food. This particular chemical may pose a continuing threat to the very localized population of the Cumberlandian combshell in the Bear Creek system.

CONSERVATION MEASURES:
Conservation measures are described in the General Mussel Document.

Exposure Scenario Summary Table for the Cumberlandian Combshell

Species	**Life Stage**	**Habitat Type**	**Exposure Route**	**Diet**	**Significant Interspecies Relationships**
Cumberlandian Combshell	glochidia	parasite	contact with water, diet	fish body fluids	Logperch Wounded darter Redline darter Bluebreast darter Snubnose darter Greenside darter Banded sculpin Mottled sculpin

					Black sculpin
	juvenile/ adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

OYSTER MUSSEL
Epioblasma capsaeformis

STATUS:
On January 10, 1997, the oyster mussel was designated as endangered throughout its entire range in Alabama, Kentucky, Tennessee, and Virginia, except where listed as experimental populations (in the free-flowing reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, AL) (USFWS 1997, 2001). The *Recovery Plan for the Cumberland Elktoe, Oyster Mussel, Cumberlandian Combshell, Purple Bean, and Rough Rabbitsfoot* was approved on May 4, 2004 (69 FR 29569). Critical habitat was designated for the Oyster Mussel on August 31, 2004 (69 FR 53135).

SPECIES DESCRIPTION:
According to Parmalee and Bogan (1998), adult oyster mussels can reach lengths of up to 70 mm. The Duck River population achieves nearly twice the size of specimens from other populations. This species is similar to the tan riffleshell (*Epioblasma florentina walkeri*) and is a species complex. Like other freshwater mussels, the oyster mussel feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of oyster mussel glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the oyster mussel is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. They then detach from their fish host and sink to the stream bottom or other substrate where they continue to develop, provided they land in a suitable substratum with the correct water conditions. Spawning probably occurs in the oyster mussel in late spring or early summer (Gordon and Layzer 1989). Glochidia of the oyster mussel have been identified on seven native host fish species, including the wounded darter (*Etheostoma vulneratum*), redline darter (*Etheostoma rufilineatum*), bluebreast darter (*Etheostoma camurum*), dusky darter (*Percina sciera*), banded sculpin (*Cottus carolinae*), black

sculpin (*Cottus baileyi*), and mottled sculpin (*Cottus bairdi*) (Yeager and Saylor 1995; J.W. Jones and R.J. Neves, U.S. Geological Survey [USGS] unpublished data 1998).

RANGE AND POPULATION LEVEL:
The oyster mussel was one of the most widely distributed Cumberlandian mussel species, with historical records existing from Alabama, Georgia, Kentucky, North Carolina, Tennessee, and Virginia. The Duck River form of the species is currently being described and is now restricted to that drainage. "True" *E. capsaeformis* is now restricted to the upper Tennessee River species. This mussel is now only extant in a handful of stream reaches in four states in the Tennessee and Cumberland River systems, including the Duck River (Maury and Marshall Counties); Clinch River, (Hancock County, TN, and Scott, Russell, and Tazewell Counties, VA); and Nolichucky River (Hamblen and Cocke Counties, TN) (Wolcott and Neves 1990; Ahlstedt 1991b; Bakaletz 1991; Gordon 1991; Ahlstedt and Tuberville 1997; S.A. Ahlstedt, pers. comm. 2002; Service 2003). Currently, the Duck River population is viable and healthy while the *E. capsaeformis* population is viable and thriving in the Clinch River with and marginal in the Nolichucky River. All other populations are presumed to be extirpated.

HABITAT:
Oyster mussels typically occur in sand and gravel substrate in streams ranging from medium-sized creeks to large rivers (Gordon 1991; Parmalee and Bogan 1998). They apparently prefer shallow riffles and shoals and have been found associated with water willow (*Justicia americana*) beds (Ortmann 1924; Gordon 1991; Parmalee and Bogan 1998). Oyster mussels have also been found in areas with coarse sand to boulder substratum and in pockets of gravel between bedrock ledges in areas of swift current (Neves 1991).

CRITICAL HABITAT:
In Maury and Marshall Counties, Tennessee, all stream and river channels within the ordinary high-water line of the main stem of the Duck River channel from rkm 214 (rmi 133) (0.3 rkm (0.2 rmi) upstream of the First Street Bridge in the City of Columbia, Maury County, Tennessee, upstream to Lillard Mill Dam at rkm 288 (rmi 179), Marshall County, Tennessee. In Colbert County, Alabama, and Tishomingo County, Mississippi, all stream and river channels within the ordinary high-water line of the main stem of Bear Creek from the backwaters of Pickwick Lake at rkm 37 (rmi 23), Colbert County, Alabama, upstream through Tishomingo County, Mississippi, ending at the Mississippi/Alabama State line. In Claiborne and Hancock Counties, Tennessee, and Lee County, Virginia, all stream and river channels within the ordinary high-water line of the Powell River from the U.S. 25E Bridge in Claiborne County, Tennessee, upstream to rkm 256 (rmi 159) (upstream of Rock Island in the vicinity of Pughs), Lee County, Virginia. In Hancock County, Tennessee, and Scott, Russell, and Tazewell Counties, Virginia, all stream and river channels within the ordinary high-water line of the Clinch River from rkm 255 (rmi 159) immediately below Grissom Island, Hancock County, Tennessee, upstream to its confluence with Indian Creek in Cedar Bluff, Tazewell County, Virginia; 4 rkm (2.5 rmi) of and 21 rkm (13 rmi) of Copper Creek from its confluence with the Clinch River upstream to Virginia State Route 72, Scott County, Virginia. In Hamblen and Cocke Counties, Tennessee, all stream and river channels within the ordinary high-water line, of the main stem of the Nolichucky River and extends from rkm 14 (rmi 9) (approximately 0.6 rkm (0.4 rmi) upstream of Enka Dam to

Susong Bridge in Hamblen and Cocke counties, Tennessee. In Scott County, Tennessee, all stream and river channels within the ordinary high-water line of the Big South Fork of the Cumberland River main stem from its confluence with Laurel Crossing Branch downstream of Big Shoals, McCreary County, Kentucky, upstream to its confluence with the New River and Clear Fork, Scott County, Tennessee. In Pulaski County, Kentucky, all stream and river channels within the ordinary high-water line of Buck Creek from the State Route 192 Bridge upstream to the State Route 328 Bridge.

Primary constituent elements identified at the time of designation included: 1. Permanent, flowing stream reaches with a flow regime (i.e, the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of the mussel and its host fish; 2. Geomorphically stable stream and river channels and banks (structurally stable stream cross section); 3. Stable substrates, consisting of mud, sand, gravel, and/or cobble/boulder, with low amounts of fine sediments or attached filamentous algae; 4. Water quality (including temperature, turbidity, oxygen content, and other characteristics) necessary for the normal behavior, growth, and survival of all life stages of the five mussels and their host fish; and 5. Fish hosts with adequate living, foraging, and spawning areas for them.

PAST THREATS:
Reduction in range and population density of the oyster mussel have resulted from human-induced changes in stream and river channels, including channel modifications (e.g., dams, dredging, mining) and historic or episodic water pollution events (USFWS 2003). The entire length of the main stems of the Tennessee and Cumberland Rivers and many of their largest tributaries are now impounded or greatly modified by the discharge of tailwaters. Much of the oyster mussel's historic range has been impounded by the Tennessee Valley Authority and the U.S. Army Corps of Engineers (USFWS 1997). These impoundments permanently alter the free-flowing aquatic habitat required by the species and its glochidial host species (USFWS 2003).

CURRENT THREATS:
Current threats to mussels are well documented in the general mussel description. In addition, populations in free-flowing river sections below dams can be adversely affected or extirpated from reduced dissolved oxygen levels, unnatural flow regimes, and colder temperature, or greatly modified by the dams or their tailwater releases (Neves et al. 1997). Present populations are also threatened by adverse impacts of coal mining (USFWS 1997).

CONSERVATION MEASURES:
Conservation measures are described in the General Mussel Document.

Exposure Scenario Summary Table for the Oyster Mussel

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships

Oyster Mussel	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	Wounded darter Redline darter Bluebreast darter Dusky darter Greenside darter Fantail darter Banded sculpin Black sculpin Mottled sculpin
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

CURTIS PEARLY MUSSEL
Epioblasma florentina curtisii

STATUS:
On June 14, 1976, the Curtis pearly mussel was designated as endangered throughout its entire range in Arkansas and Missouri (USFWS 1976). A recovery plan addressing the Curtis pearlymussel was approved in February 4, 1986 (USFWS 1986).

SPECIES DESCRIPTION:
The Curtis pearly mussel is a small freshwater mussel with a dark brown shell (USFWS 1986). Like other freshwater mussels, the Curtis pearly mussel feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of Curtis pearly mussel glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the Curtis pearly mussel is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. The life history of this species is largely unknown. The rainbow darter (*Etheostoma caeruleum*) has been identified as potential fish host for the Curtis pearly mussel (Buchanan 1987); however, other darters may be suitable as demonstrated with other *Epioblasma* species (NatureServe 2003). Hill (1986) has also determined that the banded sculpin is a suitable host for three *Epioblasma* species and Buchanan (1987) has suggested that the mottled sculpin, which is found in the Little Black River in low

numbers, is also a likely available host. Spawning has been documented in late March to mid-April (Buchanan 1987).

RANGE AND POPULATION LEVEL:
The Curtis pearly mussel was historically distributed in the White and St. Francis watersheds of southern Missouri and northeastern Arkansas (USFWS 1986). The species was also known from the Spring River drainage in Arkansas (a tributary to the Black River), but may now be extirpated from the state. Missouri records for the Curtis pearly mussel include the White, Black, and Castor River. The species has been eliminated from almost all of its former range and may now be extinct. The last live specimen was collected from the Little Black River in 1994 (NatureServe 2003). Although young individuals have not been found at any sites sampled, Buchanan (1987) reports that due to the small size of the species and very low population densities; however, given the presence of young individuals through the late 1980s, it is probable that the Little Black River population was reproducing at that time.

HABITAT:
The Curtis pearly mussel prefers shallow areas in small streams near transitional areas between headwaters and lowland stream reaches (Buchanan 1982, 1983). It has been found in slow currents in stable sand and gravel to gravel, cobble and boulder substrates (NatureServe 2003).

PAST THREATS:
In Missouri, construction of a dam on the White River in 1913 and subsequent establishment of impoundments throughout that drainage permanently flooded Curtis pearly mussel habitat. Habitat alteration in the form of water quality degradation, flow alteration, impoundments, gravel dredging, and channelization are the principal reasons for the species rapid decline (NatureServe 2003). Other threats to mussels are described in the General Mussel document.

CURRENT THREATS:
Given the small size of the Little Black River population, if it still exists, any factor that adversely modifies habitat or water quality in the limited remaining habitat for the species could threaten its survival in these areas. Other current threats to freshwater mussels are described in the General Mussel document.

Exposure Scenario Summary Table for the Curtis pearlymussel

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
Curtis pearly mussel	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	potentially rainbow darter and/or other darter species, banded sculpin,

mottled sculpin					
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

YELLOW BLOSSOM (PEARLYMUSSEL)

Epioblasma florentina florentina

STATUS:

On June 14, 1976, the yellow blossom was designated as endangered throughout its entire range in Indiana, Kentucky, Tennessee, and West Virginia (USFWS 1976), except where listed as experimental populations (in the free-flowing reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, AL) (USFWS 1976, 2001). The species is possibly extinct and has not been collected anywhere in over 50 years; however, any extant populations discovered may be used for experimental reintroduction efforts. A recovery plan for the yellow blossom was approved in January 1985 (USFWS 1985).

SPECIES DESCRIPTION:

The yellow blossom pearlymussel is a medium-sized Cumberlandian freshwater mussel (reaching up to 60 mm in length) with a yellowish-brown shell and numerous green rays (ESIE 1996, NatureServe 2003). Like other freshwater mussels, the yellow blossom feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of yellow blossom glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:

The reproductive cycle of the yellow blossom is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. They then detach from their fish host and sink to the stream bottom or other substrate where they continue to develop, provided they land in a suitable substratum with the correct water conditions. Adult mussels of this species are sexually dimorphic. Specific glochidial host species for the yellow blossom are not known.

RANGE AND POPULATION LEVEL:

The yellow blossom has been reported historically from 13 rivers in the Cumberland and Tennessee River systems in Alabama, Kentucky, Tennessee, and Virginia. The species was last

collected at Muscle Shoals, its type locality, prior to 1925 and has not been collected elsewhere in over 50 years. The yellow blossom is believed to have been extirpated throughout its range (USFWS 2001).

HABITAT:
The yellow-blossom prefers riffle and shoal areas with sand and gravel substrates in small to medium-sized streams and rivers (USFWS 1985).

PAST THREATS:
Given the species preference for rivers with high flow velocities, elimination of habitat by impoundments and dredging operations is attributed to its large-scale decline (NatureServe 2003). Other threats that are attributed to population declines are described in the General Mussel Document.

CURRENT THREATS:
Current threats to freshwater mussels are described in the General Mussel Document.

Exposure Scenario Summary Table for the Yellow Blossom

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
yellow blossom	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

TAN RIFFLESHELL
Epioblasma florentina walkeri

STATUS:
On August 23, 1977, the tan riffleshell was designated as endangered throughout its entire range in Kentucky, Tennessee, Virginia (USFWS 1977). A recovery plan for the tan riffleshell was approved in 1984 (USFWS 1984).

SPECIES DESCRIPTION:

The tan riffleshell mussel is a medium-sized freshwater mussel (7 cm) with a brown to yellow colored shell with numerous green rays (NatureServe 2003). Like other freshwater mussels, the tan riffleshell feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of tan riffleshell glochidia, like other freshwater mussels, comprises water (until encysted on a fish host) and fish body fluids (once encysted). This species is similar to the oyster mussel (*Epioblasma capsaeformis*) and is a species complex. The form of this species complex in the Tennessee River is undescribed. The form in the Cumberland River is Atrue@ *E. florentina walkeri*.

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the tan riffleshell is similar to that of other mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. They then detach from their fish host and sink to the stream bottom or other substrate where they continue to develop, provided they land in a suitable substratum with the correct water conditions. Adult mussels of this species are sexually dimorphic. The tan riffleshell is bradytictic and spawning occurs in late spring or early summer (Rogers 1999). Laboratory studies indicate that at least five suitable glochidial host species exist for the tan riffleshell including the fantail darter (*Etheostoma flabellare*), greenside darter (*Etheostoma blennioides*), redline darter (*Etheostoma rufilineatum*), snubnose darter (*Etheostoma simoterum*), and banded sculpin (*Cottus bairdi*) or mottled sculpin (*Cottus carolinae*) (Rogers et al. 2001a).

RANGE AND POPULATION LEVEL:
The tan riffleshell has been reported historically from several streams in the Cumberland and Tennessee River systems. The only extant viable populations are thought to occur in the Big South Fork Cumberland River (in Kentucky and Tennessee) and Indian Creek, Upper Clinch River, Virginia. The Hiwassee River and Middle Fork Holston River populations may be extirpated (USFWS 1984, Parmalee and Hughes 1994, Rogers 1999, Rogers et al. 2001a). In a recent investigation of the remaining population in Indian Creek, the population size was estimated to be approximately 2000 adults (Rogers et al. 2001b).

HABITAT:
The tan riffleshell inhabits sand and gravel substrates and is usually found in headwaters, riffles and shoals (Bogan and Parmalee 1983, NatureServe 2003).

PAST THREATS:
Threats that led to the decline of known populations at the time of the tan riffleshell=s listing included water quality degradation resulting from mine acid and municipal wastes. In the Red River system, low dissolved oxygen levels and untreated wastewater from a meat packing

facility contributed to the species decline. In addition, mercury and lead contamination in the Middle Fork Holston River, low dissolved oxygen levels in the West Fork Stones River, and a history of spills of fly ash and sulfuric acid and heavy metal contamination in the Clinch River are documented pollution concerns for these historic populations. Infestation of tan riffleshell habitat by the Asiatic clam (*Corbicula fluminea*) is also believed to be a principal cause of the species' decline (USFWS 1977).

The species' decline has resulted primarily from habitat and water quality deterioration caused by impoundments and by pollution and siltation resulting from mining, agriculture, and construction activities. Owing to the species' limited distribution, any factor that adversely modifies habitat or water quality in the short river reaches that the species inhabits could threaten its survival (USFWS 1988).

CURRENT THREATS:
The small, but currently viable, population present in Indian Creek is currently threatened by sedimentation and water quality degradation associated with two coal mines in the headwaters of the creek (Rogers et al. 2001b). Other current threats to freshwater mussels are described in the General Mussel Document.

Exposure Scenario Summary Table for the Tan Riffleshell

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
tan riffleshell	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	fantail darter greenside darter redline darter snubnose darter banded sculpin mottled sculpin
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

UPLAND COMBSHELL
Epioblasma metastriata

STATUS:
On March 17, 1993, the upland combshell (*Epioblasma metastriata*) was designated as Endangered throughout its entire range (USFWS 1993). A recovery plan for the upland

combshell was finalized on November 17, 2000 (USFWS 2000). Critical habitat was designated for the upland combshell on July 1, 2004 (69 FR 40083).

SPECIES DESCRIPTION:
The upland combshell is a bivalve mollusk that rarely exceeds 60 millimeters (mm) (2.4 inches) in length. Like other freshwater mussels, adults are filter-feeders, orienting themselves in the substrate to facilitate siphoning of the water column for oxygen and food (Kraemer 1979). Mussels have been reported to consume detritus, diatoms, phytoplankton, zooplankton, and other microorganisms (Coker et al. 1921, Churchill and Lewis 1924, Fuller 1974). Juvenile mussels employ foot (pedal) feeding, and are thus suspension feeders (Yeager et al. 1994). Foods of juvenile freshwater mussels up to two weeks old include bacteria, algae, and diatoms with amounts of detrital and inorganic colloidal particles (Yeager et al. 1994). Specific food habits of the upland combshell are unknown, but are likely similar to those of other freshwater mussels.

REPRODUCTION AND DEVELOPMENT:
The upland combshell likely releases glochidia during late spring or early summer (USFWS 2000). The host fish for this species have not been identified.

RANGE AND POPULATION LEVEL:
The upland combshell was described from the Mulberry Fork of the Black Warrior River near Blount Springs, Alabama. The historical range of the species included portions of the Black Warrior, Cahaba, and Coosa Rivers of the Mobile River Basin and some of their tributaries in Alabama, Georgia, and Tennessee. The most recent records for the upland combshell were from the Conasauga River, Georgia, in 1988, and from the Cahaba River, Alabama, in the early 1970s (USFWS 1993). When listed, the species was believed to be restricted to the Conasauga River in Georgia, and possibly portions of the upper Black Warrior and Cahaba River drainages. Surveys of Coosa River tributaries have been conducted by Service biologists, as well as Bogan and Pierson (1993a), Evans (2001), Feminella and Gangloff (2000), Johnson and Evans 2000, Pierson 1993, pers. comm. 1994), Williams and Hughes (1998), and others. Surveys of the Cahaba River have been conducted by Service biologists, Bogan and Pierson (1993b), McGregor et al. (2000), Shepard et al. (1994), and others. Surveys in the upper Black Warrior drainage have been done by Service biologists, Alabama Malacological Research Center, (in litt. 1996), Sheppard et al. (1993), Vittor and Associates (1993), Warren and Haag (1994), and others. However, these surveys of the Conasauga River and other historic habitat in the Coosa, Cahaba, and Black Warrior River drainages since the mussel was listed have failed to locate any evidence of the upland combshell (Evans 2001, Feminella and Gangloff 2000, Johnson and Evans 2000, McGregor 1992, McGregor et al 2000, Pierson 1991a, Shepard et al. 1994, 1998, Vittor and Associates 1993, Warren and Haag 1994, Williams and Hughes 1998). Not withstanding the results of these surveys, this species= historic range includes thousands of miles of river and stream habitat in the Mobile River Basin, and there are many miles of stream which have not been adequately surveyed. Mussels are cryptic species, living buried in the stream bottom under water, and rare mussels are difficult to locate (USFWS 2003).

HABITAT:

The upland combshell is restricted to shoals in rivers and large streams above the Fall Line with stable sand/gravel/cobble substrate in moderate to swift currents.

CRITICAL HABITAT:
In Jefferson and Blount Counties, Alabama, stream and river channels within the ordinary high water line of the Locust Fork main stem from U.S. Highway 78, Jefferson County, upstream to the confluence of Little Warrior River, Blount County, Alabama; and Little Warrior River from its confluence with the Locust Fork, upstream to the confluence of Calvert Prong and Blackburn Fork, Blount County, Alabama.

In Jefferson, Shelby, and Bibb Counties, Alabama, stream and river channels within the ordinary high water line of the Cahaba River from U.S. Highway 82, Centerville, Bibb County, upstream to Jefferson County Road 143, Jefferson County, Alabama; and the Little Cahaba River from its confluence with the Cahaba River, upstream to the confluence of Mahan and Shoal Creeks, Bibb County, Alabama.

In Cherokee, Calhoun, and Cleburne Counties, Alabama, stream and river channels within the ordinary high water line of the Coosa River main stem from the power line crossing southeast of Maple Grove, Alabama, upstream to Weiss Dam, Cherokee County, Alabama; Terrapin Creek, 53 km (33 mi) extending from its confluence with the Old Coosa River channel, Cherokee County, upstream to Cleburne County Road 49, Cleburne County, Alabama; South Fork Terrapin Creek, 7 km (4 mi), from its confluence with Terrapin Creek, upstream to Cleburne County Road 55, Cleburne County, Alabama.

In Coosa and Clay Counties, Alabama, stream and river channels within the ordinary high water line of the main stem of Hatchet Creek from the confluence of Swamp Creek at Coosa County Road 29, Coosa County, Alabama, upstream to Clay County Road 4, Clay County, Alabama.

In Shelby and St. Clair Counties, Alabama, stream and river channels within the ordinary high water line of the Kelly Creek main stem extending from the confluence with the Coosa River, upstream to the confluence of Shoal Creek, St. Clair County, Alabama;
and the main stem of Shoal Creek from the confluence with Kelly Creek, St. Clair County, Alabama, upstream to the St. Clair/Shelby County Line, St. Clair County, Alabama.

In St. Clair County, Alabama, stream and river channels within the ordinary high water line of the main stem of Big Canoe Creek from its confluence with Little Canoe Creek at the St. Clair/Etowah County line, St. Clair County, upstream to the confluence of Fall Branch.

In Floyd, Gordon, Whitfield, and Murray Counties, Georgia; and Bradley and Polk Counties, Tennessee, stream and river channels within the ordinary high water line of the Oostanaula River main stem from its confluence with the Etowah River, Floyd County, Georgia, upstream to the confluence of the Conasauga and Coosawattee River, Gordon County, Georgia; the Coosawattee River main stem from its confluence with the Conasauga River, upstream to Georgia State Highway 136, Gordon County, Georgia; the Conasauga River main stem from confluence with the Coosawattee River, Gordon County, Georgia, upstream through Bradley and Polk Counties,

Tennessee, to Murray County Road 2, Murray County, Georgia; and the mainstem of Holly Creek from its confluence with the Conasauga River, upstream to its confluence with Rock Creek, Murray County, Georgia.

In Elmore County, Alabama, stream and river channels within the ordinary high water line of the Coosa River main stem from Alabama State Highway 111 bridge, upstream to Jordan Dam.

Primary constituent elements identified at the time of designation included: 1. Geomorphically stable stream and river channels and banks; 2. A flow regime (i.e., the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of mussels and their fish hosts in the river environment; 3. Water quality, including temperature, pH, hardness, turbidity, oxygen content, and other chemical characteristics necessary for normal behavior, growth, and viability of all life stages; 4. Sand, gravel, and/or cobble substrates with low to moderate amounts of fine sediment, low amounts of attached filamentous algae, and other physical and chemical characteristics necessary for normal behavior, growth, and viability of all life stages; 5. Fish hosts with adequate living, foraging, and spawning areas for them; and 6. Few or no competitive or predaceous nonnative species present.

PAST THREATS:
The abundance and distribution of the upland combshell decreased historically from human-induced habitat loss and degradation caused by impoundments, sedimentation and turbidity, channelization and dredging, mining (coal, sand, gravel, or gold) (Jones 1991, USFWS 1993, Leigh 1994, ADEM 1994), and contaminants contained in numerous point (e.g., carpet mills and fabric dying mills) (Hurd 1974) and nonpoint sources (USFWS 2000). Channel modifications and water pollution gradually eliminated these native species that are dependent on a narrow range of flowing water habitat conditions from extensive portions of their former ranges within the Mobile River Basin. These habitat changes have resulted in significant extirpations (localized loss of populations), restricted and fragmented distributions, and poor recruitment of young.

CURRENT THREATS:
Habitat modification, sedimentation, eutrophication, and other forms of water quality degradation are the primary causes of decline of the upland combshell. This species does not tolerate impoundment, and is highly sensitive to water quality degradation. Potential habitat is locally impacted by carpet mill and other industrial discharge, sewage treatment plant discharge, urban and agricultural runoff, and surface mine drainage. Dense filamentous algal growth due to nutrification affects feeding, host fish ineractions, and survival of juveniles.

Due to the extreme rarity of the upland combshell, any adverse impacts to its habitat or an individual could result in the demise of the species. The immediate recovery objective is to prevent the extinction of this species by locating, protecting, and restoring stream drainages with extant populations. Survival of this species may eventually depend on captive propagation if extant populations are located.

Exposure Scenario Summary Table for the Upland Combshell

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
Upland Combshell	glochidia	parasite	contact with water, diet	fish body fluids	unknown host fish(es)
	juvenile/ adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

CATSPAW (PURPLE CAT'S PAW PEARLYMUSSEL)
Epioblasma obliquata obliquata

STATUS:
On July 10 1990, the catspaw (purple cat=s paw pearlymussel) was designated as endangered throughout its entire range in Alabama, Kentucky, Ohio, and Tennessee (USFWS 1990), except where listed as experimental populations (in the free-flowing reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, AL) (USFWS 2001). The species is currently known from two apparently nonreproducing populations (one in Tennessee and one in Kentucky) and one reproducing population in Ohio. A recovery plan for the catspaw was approved March 10, 1992 (USFWS 1992).

SPECIES DESCRIPTION:
The catspaw is a medium-sized freshwater mussel (reaching up to approximately 50 mm in length) with a yellowish tan or brown shell and numerous green rays (INHS 1997, USFWS 2003). Like other freshwater mussels, the catspaw feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of catspaw glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the catspaw is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. They then detach from their fish host and sink to the stream bottom or other substrate where they continue to develop, provided they land in a suitable substratum with the correct water conditions. Adult mussels of this species are sexually

dimorphic. Specific glochidial host species for the catspaw are the blackside darter, logperch, stonecat, mottled sculpin, and rock bass.

RANGE AND POPULATION LEVEL:
This once widespread species historically occurred in the Ohio, Cumberland, and Tennessee River systems in Ohio, Illinois, Indiana, Kentucky, Tennessee, and Alabama (USFWS 1992). The species is currently known from two apparently nonreproducing populations (the Green River in Kentucky and the Cumberland River in Tennessee) and one reproducing population in Killbuck Creek, Muskingum River system, Ohio (USFWS 2001). Fifteen living and 23 dead specimens of the catspaw were collecteed from Killbuck Creek in 1994 (Hoggarth et al. 1995). The species is believed to be extirpated from Indiana and Alabama and it has not been collected in Illinois for over 100 years (USFWS 2003, NatureServe 2003). In addition, the continued existence of the two nonreproducing populations is questionable. Only one individual, an old but freshly dead specimen, has been collected in the Green River since 1971 and only one known individual remains from the Cumberland River (USFWS 1990).

HABITAT:
The catspaw inhabits large rivers with a sand/gravel substrate (Bates and Dennis 1985). The species has also been reported from boulder and sand substrates (USFWS 1992). The catspaw has been found in water of shallow to moderate depth with moderate to swift currents (Bogan and Parmalee 1983, Gordon and Layzer 1989).

PAST THREATS:
Many of the historic populations of the catspaw were apparently lost when the river sections they inhabited were impounded. These impoundments seriously reduced the availability of the species habitat and likely affected the distribution and availability of the mussel=s fish host. The Green River in Kentucky has experienced water quality problems associated with oil and gas production in the watershed and commercial mussel fishing has occurred there in recent years. Individuals still surviving in the Cumberland River are potentially threatened by gravel dredging, channel maintenance, and commercial mussel fishing. Although the catspaw is not commercially valuable, incidental take of the species has occurred in the Cumberland River during commercial mussel fishing for other species. Other threats that are attributed to population declines are described in the General Mussel Document.

CURRENT THREATS:
Current threats to the catspaw population in Killbuck Creek include sedimentation from land clearing, cattle grazing, and agricultural land-use practices as well as muskrat predation (Hoggarth et al. 1995). Other current threats to freshwater mussels are described in the General Mussel Document.

Exposure Scenario Summary Table for the Catspaw

Species	Life Stage	Habitat	Exposure	Diet	Significant

		Type	Route		Interspecies Relationships
catspaw	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	blackside darter, logperch, stonecat, mottled sculpin, rock bass
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

WHITE CATSPAW (PEARLYMUSSEL)
Epioblasma obliquata perobliqua

STATUS:
On June 14, 1976, the white catspaw (pearlymussel) was designated as endangered throughout its entire range in Indiana and Ohio (USFWS 1976). A recovery plan for the catspaw was approved January 25, 1990 (USFWS 1990).

SPECIES DESCRIPTION:
The white catspaw is a small to medium-sized freshwater mussel with a greenish yellow or brown shell and fine green rays. The white catspaw differs from the catspaw (purple catspaw pearlymussel, *Epioblama obliquata obliquata*) by being less ovate and less solid than that subspecies (USFWS 1990). Like other freshwater mussels, the white catspaw feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of white catspaw glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the white catspaw is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. They then detach from their fish host and sink to the stream bottom or other substrate where they continue to develop, provided they land in a suitable substratum with the correct water conditions. Adult mussels of this species are sexually dimorphic. Specific glochidial host species for the white catspaw are not known.

RANGE AND POPULATION LEVEL:

The white catspaw appears to have been distributed only in the Ohio River, Wabash River (IN), White River (IN), Tippecanoe River (IN), Maumee River (IN and OH), St. Joseph River (IN and OH), and Fish Creek (OH) (USFWS 1990). The species is currently known to exist in Fish Creek, a tributary to the St. Joseph=s River (USFWS 1990). According to the recovery plan for the species, the white catspaw is one of the most critically endangered species listed (USFWS 1990). A recent fuel spill in Fish Creek may have eliminated the last remaining population of the white catspaw (NatureServe 2003). A solitary live male approximately 6 years old was documented in Fish Creek in August 1999 (A. Zimmerman pers. comm.).

HABITAT:
Specific habitat requirements for the white catspaw are known, but it has most frequently been reported from riffle-run reaches of small to moderately large rivers. The habitat preference of this subspecies is similar to that of the catspaw which is described below (Stansbery et al. 1982). The catspaw subspecies is known to inhabit large rivers with a sand/gravel substrate (Bates and Dennis 1985). This subspecies has also been reported from boulder and sand substrates (USFWS 1992) and has been found in water of shallow to moderate depth with moderate to swift currents (Bogan and Parmalee 1983, Gordon and Layzer 1989).

PAST THREATS:
Many of the historic populations of the white catspaw were apparently lost when the river sections they inhabited were impounded. These impoundments seriously reduced the availability of the species habitat and likely affected the distribution and availability of the mussel=s fish host. This is perhaps nowhere a more serious problem than in the intensely cultivated Wabash and Maumee River basins. Gravel dredging operations were cited by Clark (1976) as contributing to the abundance of shifting, unstable sand substrate in the lower Wabash River. Instream construction likely destroyed one of the largest mussel beds in the St. Joseph River (USFWS 1990). Furthermore, Hoggarth (1986) noted that stream clearing operations have reduced the amount of stable gravel substrate in the upper St. Joseph River basin. Other threats that are attributed to population declines are similar to those described in the general mussel description.

CURRENT THREATS:
A 1993 fuel spill likely adversely affected (and possibly eliminated) what is believed to be the last remaining population of the species in Fish Creek, Ohio (NatureServe 2003). Sediment toxicity testing (9-day exposures) was conducted at sites upstream and downstream of the spill site in Fish Creek two years after the spill using glochidia and juvenile surrogate unionids (*Villosa villosa* and *Lampsillis siliquoidea*). Low concentrations of heavy metals and detectable (but not quantifiable) levels of organic compounds associated with diesel fuel were found, but toxicity to juveniles of both test species was not indicated. Fish Creek sediments were found to be potentially toxic to *L. siliquoidea* glochidia (Keller et al. 1998). Other current threats to freshwater mussels are described in the General Mussel Document.

Exposure Scenario Summary Table for the White catspaw

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
white catspaw	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

SOUTHERN ACORNSHELL
Epioblasma othcaloogensis

STATUS:
On March 17, 1993, the southern acornshell *(Epioblasma othcaloogensis)* was designated as Endangered throughout its entire range (USFWS 1993). A recovery plan for the southern acornshell was finalized on November 17, 2000 (USFWS 2000). Critical habitat was designated for the southern acornshell on July 1, 2004 (69 FR 40083).

SPECIES DESCRIPTION:
The southern acornshell is a small species that may grow up to 30 mm (1.2 inches) in shell length. Like other freshwater mussels, adults are filter-feeders, orienting themselves in the substrate to facilitate siphoning of the water column for oxygen and food (Kraemer 1979). Mussels have been reported to consume detritus, diatoms, phytoplankton, zooplankton, and other microorganisms (Coker et al. 1921, Churchill and Lewis 1924, Fuller 1974). Juvenile mussels employ foot (pedal) feeding, and are thus suspension feeders (Yeager et al. 1994). Foods of juvenile freshwater mussels up to two weeks old include bacteria, algae, and diatoms with amounts of detrital and inorganic colloidal particles (Yeager et al. 1994). Specific food habits of the southern acornshell are unknown, but are likely similar to those of other freshwater mussels.

REPRODUCTION AND DEVELOPMENT:
The host fish and other aspects of this species life history are unknown. The species life history is presumed to follow that of other, better known, related species.

RANGE AND DEVELOPMENT:
The southern acornshell was described from Othcalooga Creek, Gordon County, Georgia. Historically, the species occurred in the upper Coosa River system and the Cahaba River aabove the fall ine in Alabama, Georgia, and Tennessee. The most recent records for the southern

acornshell were from tributaries of the Coosa River in the early 1970s, and the Cahaba in the 1930s (USFWS 1993). It was our determination at the time of listing, with consensus of the malacological community, that this species was likely to persist in low numbers in the upper Coosa River drainage, and possibly in the Cahaba River. Surveys of the Coosa River tributraries have been conducted by Service biologists, as well as Bogan and Pierson (1993a), Evans (2001), Feminella and Gangloff (2000), Johnson and Evans (2000), Pierson (1993, pers. comm. 1994), Williams and Hughes 1998), and others. Surveys of the Cahaba River have been conducted by Service biologists, Bogan and Pierson (1993b), McGregor et al. (2000), Shepard et al. (1994, 1998), and others. Despite these repeated surveys of historic habitat in the Coosa and Cahaba River drainages, *no living animals or fresh sheels of this species have been located in recent years* (Evans 2001, Feminella and Gangloff 2000, Johnson and Evans 2000, McGregor et al. 2000, Pierson 1993, Shepard et al. 1994, 1998, Williams and Hughes 1998). Not withstanding the results of these surveys, this species= historic range includes thousands of miles of river and stream habitat in the Mobile River Basin, and there are many miles of stream which have not been adequately surveyed. Mussels are cryptic species, living buried in the stream bottom under water, and rare mussels are difficult to locate (USFWS 2003).

HABITAT:
The southern acornshell was historically restricted to shoals in small rivers to small streams above the Fall Line. It was found on stable sand/gravel/cobble substrate in moderate to swift currents.

CRITICAL HABITAT:
In Jefferson, Shelby, and Bibb Counties, Alabama, stream and river channels within the ordinary high water line of the Cahaba River from U.S. Highway 82, Centerville, Bibb County, upstream to Jefferson County Road 143, Jefferson County, Alabama; and the Little Cahaba River from its confluence with the Cahaba River, upstream to the confluence of Mahan and Shoal Creeks, Bibb County, Alabama.

In Cherokee, Calhoun, and Cleburne Counties, Alabama, stream and river channels within the ordinary high water line of the Coosa River main stem from the power line crossing southeast of Maple Grove, Alabama, upstream to Weiss Dam, Cherokee County, Alabama; Terrapin Creek, 53 km (33 mi) extending from its confluence with the Old Coosa River channel, Cherokee County, upstream to Cleburne County Road 49, Cleburne County, Alabama; South Fork Terrapin Creek, 7 km (4 mi), from its confluence with Terrapin Creek, upstream to Cleburne County Road 55, Cleburne County, Alabama.

In Coosa and Clay Counties, Alabama, stream and river channels within the ordinary high water line of the main stem of Hatchet Creek from the confluence of Swamp Creek at Coosa County Road 29, Coosa County, Alabama, upstream to Clay County Road 4, Clay County, Alabama.

In Shelby and St. Clair Counties, Alabama, stream and river channels within the ordinary high water line of the Kelly Creek main stem extending from the confluence with the Coosa River, upstream to the confluence of Shoal Creek, St. Clair County, Alabama; and the main stem of

Shoal Creek from the confluence with Kelly Creek, St. Clair County, Alabama, upstream to the St. Clair/Shelby County Line, St. Clair County, Alabama.

In St. Clair County, Alabama, stream and river channels within the ordinary high water line of the main stem of Big Canoe Creek from its confluence with Little Canoe Creek at the St. Clair/Etowah County line, St. Clair County, upstream to the confluence of Fall Branch.

In Floyd, Gordon, Whitfield, and Murray Counties, Georgia; and Bradley and Polk Counties, Tennessee, stream and river channels within the ordinary high water line of the Oostanaula River main stem from its confluence with the Etowah River, Floyd County, Georgia, upstream to the confluence of the Conasauga and Coosawattee River, Gordon County, Georgia; the Coosawattee River main stem from its confluence with the Conasauga River, upstream to Georgia State Highway 136, Gordon County, Georgia; the Conasauga River main stem from confluence with the Coosawattee River, Gordon County, Georgia, upstream through Bradley and Polk Counties, Tennessee, to Murray County Road 2, Murray County, Georgia; and the mainstem of Holly Creek from its confluence with the Conasauga River, upstream to its confluence with Rock Creek, Murray County, Georgia.

In Elmore County, Alabama, stream and river channels within the ordinary high water line of the Coosa River main stem from Alabama State Highway 111 bridge, upstream to Jordan Dam.

Primary constituent elements identified at the time of designation included: 1. Geomorphically stable stream and river channels and banks; 2. A flow regime (i.e., the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of mussels and their fish hosts in the river environment; 3. Water quality, including temperature, pH, hardness, turbidity, oxygen content, and other chemical characteristics necessary for normal behavior, growth, and viability of all life stages; 4. Sand, gravel, and/or cobble substrates with low to moderate amounts of fine sediment, low amounts of attached filamentous algae, and other physical and chemical characteristics necessary for normal behavior, growth, and viability of all life stages; 5. Fish hosts with adequate living, foraging, and spawning areas for them; and 6. Few or no competitive or predaceous nonnative species present.

PAST THREATS:
The abundance and distribution of the southern acornshell decreased historically from human-induced habitat loss and degradation caused by impoundments, sedimentation and turbidity, channelization and dredging, mining (coal, sand, gravel, or gold) (Jones 1991, USFWS 1993, Leigh 1994, ADEM 1994), and contaminants contained in numerous point (e.g., carpet mills and fabric dying mills) (Hurd 1974) and nonpoint sources (USFWS 2000). Channel modifications and water pollution gradually eliminated these native species that are dependent on a narrow range of flowing water habitat conditions from extensive portions of their former ranges within the Mobile River Basin. These habitat changes have resulted in significant extirpations (localized loss of populations), restricted and fragmented distributions, and poor recruitment of young.

CURRENT THREATS:

Habitat modification, sedimentation, eutrophication, and other forms of water quality degradation are the primary causes of decline of the southern acornshell. This species does not tolerate impoundment, and is highly sensitive to water quality degradation. Potential habitat is locally impacted by carpet mill and other industrial discharge, sewage treatment plant discharge, urban and agricultural runoff, and surface mine drainage.

Due to the extreme rarity of the southern acornshell, any adverse impacts to its habitat or an individual could result in the demise of the species. The immediate recovery objective is to prevent the extinction of this species by locating, protecting, and restoring stream drainages with extant populations.

CONSERVATION MEASURES:
Conservation measures are described in the General Mussel Document.

Exposure Scenario Summary Table for the Southern Acornshell

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
Southern Acornshell	glochidia	parasite	contact with water, diet	fish body fluids	unknown host fish(es)
	juvenile/ adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

SOUTHERN COMBSHELL
Epioblasma penita

STATUS:
On April 7, 1987, the southern combshell mussel was designated as endangered throughout its entire range in Alabama and Mississippi (USFWS 1987). A recovery plan for the southern combshell was approved November 14, 1989 (USFWS 1989).

SPECIES DESCRIPTION:
The southern combshell, which is referred to as the penitent mussel in the species recovery plan (USFWS 1989), is a medium-sized freshwater mussel (reaching up to approximately 55 mm in length) with a yellowish, greenish-yellow, or tawny shell, sometimes with darker dots (USFWS 1989). Like other freshwater mussels, the southern combshell feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile

and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of southern combshell glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the southern combshell is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. This species is sexually dimorphic with the posterior shell of the female expanded (USFWS 1989). Specific glochidial hosts for this species are not known (ESIE 1996).

RANGE AND POPULATION LEVEL:
This species was historically known from the Tombigbee River from the East Fork (downstream to Epes, Alabama), the East Fork Tombigbee River (Mississippi), the Alabama River (at Clairborne and Selma, Alabmama), the Cahaba River (below Centreville, Alabama), and the Coosa River (in Alabama and Georgia). Live specimens were also collected from a Tombigbee River tributary, the Buttahatchie River in Alabama and Mississippi (USFWS 1989, Hartfield and Jones 1989, Jones 1991). The species is believed to be extirpated from the Alabama River drainage and more recent surveys indicate that of the remaining populations in the Buttahatchie River, Sipsey River, and the East Fork Tombigbee River, the only live individual found was in the Buttahatchie River (NatureServe 2003). Miller and Hartfield (1988), however, reported a fresh shell of the southern combshell near the confluence of Bull and Mountain Creek and the East Fork Tombigbee River in Itawamba County, Mississippi.

HABITAT:
The southern combshell, like other Tombigbee River system mussels, inhabits moderate to large rivers with moderate to swift current. Its preferred habitat is riffle-run or shoal areas with stable substrates ranging from sandy gravel to gravel-cobble (Stanbery 1976, 1980, 1983). Unionids collected from the Tombigbee River system have been collected in water up to 0.7 meters deep (USFWS 1987).

PAST THREATS:
The Tombigbee River freshwater mussel fauna once consisted of more than 40 species (Williams 1982). Construction of the Tennessee-Tombigbee Waterway was accomplished in 1984 by dredging portions of the Tombigbee River to form a navigation channel, by cutting off river bends to straighten the channel, by constructing dams and by cutting a canal to the Tennessee River for barge access and to provide water. This resulted in a series of impoundments that inundated much of the known remaining riverine southern combshell habitat or left them in several river bends. The accumulation of sediment in these river bends has eliminated them as potential riverine mussel habitat, except for Gainesville bendway. Recent surveys of this area indicate the lower half of it has heavy sedimentation.

CURRENT THREATS:
The continued existence of the southern combshell appears to depend upon habitat in tributaries of the Tombigbee River and the species ability to complete its life cycle in a small stream environment. The East Fork Tombigbee River is threatened by an 84.8 km (53 mi) clearing and snagging project, sand and gravel mining, the continued diversion of flood flows, and by water removal for municipal use. Headward erosion induced by the Tennessee-Tombigbee Waterway and sand and gravel mining has severely degraded the East Fork Tombigbee and the Buttahatchee River since the species was listed (Patrick and Dueitt 1996). The host species for the southern clubshell is unknown; however, if glochidial host species are large river or migratory species that infrequently enter the tributaries, the future existence of this mussel is very precarious (USFWS 1989).

Exposure Scenario Summary Table for the Southern combshell

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
southern combshell	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

GREEN BLOSSOM (PEARLYMUSSEL)
Epioblasma torulosa gubernaculum

STATUS:
On June 14, 1976, the green blossom was designated as endangered throughout its entire range in Tennessee and Virginia (USFWS 1976). A recovery plan for the green blossom was approved in 1984 (USFWS, 1984).

SPECIES DESCRIPTION:
The green blossom pearlymussel is a medium-sized freshwater mussel with tawny, yellowish green, or straw colored with fine green rays (ESIE 2003). Like other freshwater mussels, the green blossom feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis

1924). The diet of green blossom glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the green blossom is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. They then detach from their fish host and sink to the stream bottom or other substrate where they continue to develop, provided they land in a suitable substratum with the correct water conditions. Adult mussels of this species are sexually dimorphic. Specific glochidial host species for the green blossom are not known.

RANGE AND POPULATION LEVEL:
The green blossom has been reported historically throughout Tennessee and southwestern Virginia in the Tennessee, Nolichucky, Holston, Clinch and Powell Rivers, but is believed to have been extirpated throughout its range (NatureServe 2003).

HABITAT:
The green-blossom is a riffle and run species that occurred in free-flowing, medium-sized streams with moderate flow (USFWS 1983).

PAST THREATS:
Given the abundance of relict shells collected in the Clinch River in Tennessee and Virginia, it appears that the green blossom may have been common in recent decades; however, its rapid decline is attributed to its extreme sensitivity to water quality fluctuations and disturbance (NatureServe 2003). Other threats that are attributed to population declines are similar to those described in the General Mussel document.

CURRENT THREATS:
Current threats to freshwater mussels are described in the General Mussel document.

Exposure Scenario Summary Table for the Green Blossom

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
green blossom	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	

	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)

NORTHERN RIFFLESHELL
Epioblasma turulosa rangiana

STATUS:
On January 22, 1993, the northern riffleshell was designated as endangered throughout its entire range in Indiana, Kentucky, Michigan, Ohio, Pennsylvania, and West Virginia (USFWS 1993). A recovery plan for the northern riffleshell was approved in 1994 (USFWS 1994).

SPECIES DESCRIPTION:
The northern riffleshell can have a shell length up to about 7.6 centimeters (3 inches) long (USFWS 1995). It appears that the northern riffleshell may reach 15 years of age or more based on growth lines from observed specimens (NatureServe 2003). Like other freshwater mussels, the northern riffleshell feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of clubshell glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the clubshell is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. They then detach from their fish host and sink to the stream bottom or other substrate where they continue to develop, provided they land in a suitable substratum with the correct water conditions. Four fish have been identified as glochidial hosts, the banded darter (*Etheostoma zonale*), bluebreast darter (*Etheostoma camurum*), brown trout (*Salmo trutta*), and banded sculpin (*Cottus carolinae*) (Watters, 1996), however the brown trout and banded sculpin are not natural host species.

RANGE AND POPULATION LEVEL:
Historically, the northern riffleshell occurred in the States of Illinois, Indiana, Kentucky, Michigan, Ohio, Pennsylvania, and West Virginia, and the species range also extended into western Ontario, Canada (Stansbery et al. 1982). It existed in the Ohio River basin in the Ohio, Allegheny, Scioto, Kanawha, Little Kanawha, Licking, Kentucky, Wabash, White, Vermillion, Mississinewa, Tippecanoe, Green, and Salt Rivers. It was found in the Maumee River basin and tributaries of western Lake Erie (Huron River and River Raison). The riffleshell also inhabited rivers in southern Michigan and western Ontario in streams such as the St. Clair, Black, Ausable,

and Sydenham Rivers (Stansbery et al. 1982). It is currently extant in seven streams in the United States: the Green River in Kentucky, French and LeBoeuf Creeks and the Allegheny River in Pennsylvania, the Elk River, West Virginia, and Big Darby Creek in Ohio. Recent reproduction has only been documented from French Creek and the Allegheny River. The current distribution represents a range reduction greater than 95 percent (USFWS 1993, 1995) and has been recently discovered in at least one additional river in Ontario (Triannual Unionid Report No. 14 1998).

HABITAT:
This freshwater mussel occurs in a wide variety of streams, large and small, preferring runs with bottoms composed of firmly packed sand and fine to coarse gravel (Stansbery et al. 1982). Preferred habitat appears to require flowing water in mid-size rivers. High dissolved oxygen concentrations in streams may be necessary for survival (NatureServe 2003).

PAST THREATS:
The introduced zebra mussel could also pose a significant threat (USFWS 1993, 1995; NatureServe 2003). The zebra mussel has recently been reported from the Ohio River System, including the Green River in Kentucky. However, the extent of zebra mussel impacts on the basin's freshwater mussels are unknown (USFWS 1995). Other past threats are described in the General Mussel document.

CURRENT THREATS:
Current threats to freshwater mussels are described in the General Mussel document.

Exposure Scenario Summary Table for the Northern Riffleshell

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
northern riffleshell	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	banded darter bluebreast darter brown trout banded sculpin
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

TUBERCLED BLOSSOM (PEARLYMUSSEL)

Epioblasma torulosa torulosa

STATUS:

On June 14, 1976, the tubercled blossom was designated as endangered throughout its entire range in Indiana, Kentucky, Tennessee, and West Virginia (USFWS 1976), except where listed as experimental populations (in the free-flowing reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, AL) (USFWS 1976, 2001). The species is possibly extinct and has not been reported anywhere since 1969; however, any extant populations discovered may be used for experimental reintroduction efforts. A recovery plan for the tubercled blossom was approved in January 1985 (USFWS 1985).

SPECIES DESCRIPTION:

The tubercled blossom pearlymussel is a medium-sized freshwater mussel (reaching up to 90 mm in length) with a yellowish-green shell and numerous fine green rays (ESIE 2003, NatureServe 2003). Like other freshwater mussels, the tubercled blossom feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of tubercled blossom glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:

The reproductive cycle of the tubercled blossom is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. They then detach from their fish host and sink to the stream bottom or other substrate where they continue to develop, provided they land in a suitable substratum with the correct water conditions. Adult mussels of this species are sexually dimorphic. Specific glochidial host species for the tubercled blossom are not known.

RANGE AND POPULATION LEVEL:

The tubercled blossom has been reported historically from nine rivers in the Ohio River System. The species was believed to be common in southern Ontario as well. The last individual was collected freshly dead below Kanawha Falls, WV in 1969 (USFWS 2003). The tubercled blossom is believed to have been extirpated throughout its range (USFWS 2001).

HABITAT:

The tubercled-blossom prefers medium to large large rivers with sand and gravel substrates and high current velocities in riffle areas (USFWS 1985).

PAST THREATS:

Given the species preference for medium to large rivers with high flow velocities, elimination of habitat by impoundments and dredging operations is attributed to its large-scale decline (NatureServe 2003). Other threats that are attributed to population declines are similar to those described in the General Mussel Document.

CURRENT THREATS:
Current threats to freshwater mussels are described in the General Mussel Document.

Exposure Scenario Summary Table for the Tubercled Blossom

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
tubercled blossom	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

TURGID BLOSSOM (PEARLYMUSSEL)
Epioblasma turgidula

STATUS:
On June 14, 1976, the turgid blossom was designated as endangered throughout its entire range in Alabama and Tennessee (USFWS 1976), except where listed as experimental populations (in the free-flowing reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, AL) (USFWS 1976, 2001). The species is possibly extinct and has not been reported anywhere since the early 1960s; however, any extant populations discovered may be used for experimental reintroduction efforts. A recovery plan for the turgid blossom was approved in January 1985 (USFWS 1985).

SPECIES DESCRIPTION:
The turgid blossom pearlymussel is a small Cumberlandian freshwater mussel with a yellowish green shell and numerous green rays (ESIE 1996, NatureServe 2003). Like other freshwater mussels, the turgid blossom feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and

Lewis 1924). The diet of turgid blossom glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the turgid blossom is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. They then detach from their fish host and sink to the stream bottom or other substrate where they continue to develop, provided they land in a suitable substratum with the correct water conditions. Adult mussels of this species are sexually dimorphic. Specific glochidial host species for the turgid blossom are not known.

RANGE AND POPULATION LEVEL:
The turgid blossom has been reported historically from 12 rivers in Arkansas, Missouri, Tennessee, and Alabama. The species was believed to be common in the southern Appalachian Mountains (Tennessee River and tributary streams) with populations occurring in the Cumberland Plateau (Cumberland River and the Ozark Mountains of Arkansas and Missouri. The species was last collected at Muscle Shoals (along with the Cumberland River, TN) prior to 1925 and has not been collected anywhere since the early 1960s (USFWS 1985, AGFC 2003). The turgid blossom is believed to have been extirpated throughout its range (USFWS 1985).

HABITAT:
The turgid-blossom prefers small to medium-sized rivers and can be found in shoal areas with rapid current (USFWS 1985).

PAST THREATS:
Last reported observations of the species were in the Duck River in the mid-1960s. Since that time, the Normandy Dam has been completed and the locations where the turgid blossom was last observed have been either impounded or affected by dam operations (AGFC 2003). Other threats that are attributed to population declines are similar to those described in the General Mussel Document.

CURRENT THREATS:
Current threats to freshwater mussels are described in the General Mussel Document.

Exposure Scenario Summary Table for the Turgid Blossom

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
turgid	glochidia	parasite	contact with	fish body	

blossom			water, diet	fluids (once encysted)
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)

SHINY PIGTOE
Fusconaia cor

STATUS:
On June 14, 1976, the shiny pigtoe mussel was designated as endangered throughout its entire range in Alabama, Tennessee, and Virginia (USFWS 1976), except where listed as experimental populations (in the free-flowing reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, AL) (USFWS 2001). A recovery plan for the shiny pigtoe was approved August 9, 1984 (USFWS 1984).

SPECIES DESCRIPTION:
The shiny pigtoe is a medium-sized freshwater mussel (reaching over 60 mm in length) with a smooth and shiny yellowish-brown shell with prominent dark green to blackish rays (NatureServe 2003, INHS 1997). Like other freshwater mussels, the shiny pigtoe feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of shiny pigtoe glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the shiny pigtoe is similar to that of other mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. The shiny pigtoe is a short term brooder with spawning occurring in May and release of glochidia in June or early July (ESIE 1996, USFWS 1984). Glochidia were found naturally encysted in the North Fork Holston River on the following species: the whitetail shiner (*Cyprinella galactura*), common shiner (*Luxilus cornutus*), warpaint shiner (*Luxilus coccogenis*), and telescope shiner (*Notropis telescopus*) (Kitchel 1983). Laboratory infestation studies confirmed that the whitetail and common shiners are likely host species for the shiny pigtoe (USFWS 1984). The common shiner does not occure in the Tennessee River system; however, and is considered a non-native host species. The life span of shiny pigtoe has been reported to exceed 25 years (Stansbery 1972).

RANGE AND POPULATION LEVEL:

This species was historically widespread in the Tennessee River and 10 of its tributaries. It was last collected from Mussel Shoals, historically an 85 km reach of the Tennessee River in Alabama (that is now reduced to a few kilometers of riverine habitat due to construction of three dams), prior to 1925 (Ortmann 1925) and is presumed to be extirpated from the shoal. It is currently known from four river systems including the Clinch River (from the Virginia-Tennessee border upstream to Nash Ford), Powell River (from the Virginia-Tennessee border upstream to Lee County, Virginia), North Fork Holston River (Virginia), and Paint Rock River (Alabama, where it is exceedingly rare) (USFWS 1984, NatureServe 2003). One fresh dead individual was found in the Paint Rock River in 1997 (Garner 1997). The species is now extirpated form the Elk River in Tennessee (where it was last reported in 1980). The Clinch River and North Fork Holston River populations may be the only viable ones remaining, although a recent die off in the North Fork Holston River has reduced the size of the shiny pigtoe population there.

HABITAT:
The shiny pigtoe is a riffle species and prefers moderate to swiftly flowing streams and rivers with stable substrates (ESIE 1996, USFWS 1984). The species is not found in deep water or impounded areas (USFWS 1984). Substrate preferences include sand, gravel, and cobble (NatureServe 2003, ESIE 1996).

PAST THREATS:
Many of the historic populations of the shiny pigtoe were apparently lost when the river sections they inhabited were impounded (ESIE 1996). Over 50 impoundments in the Tennessee and Cumberland River systems (five mainstem Cumberland River dams, nine mainstem Tennessee River dams, and the rest are located on tributaries) have eliminated the majority of riverine habitat for the species in its historic range (ESIS 1996, USFWS 1984). The Powell River and upper tributaries of the Clinch River, in particular, are also subject to sediment and particulate matter loading from coal mining activities (Stansbery 1973). Water quality degradation has also been attributed to the decline of this species. In particular, the shiny pigtoe has been eliminated from the North Fork Holston River below the town of Saltville, VA as a result of releases of sodium chloride and mercury from a chemical plant (which is no longer operational). Contamination from this facility likely affected over 80 miles of riverine habitat downstream of the plant, and the shiny pigtoe is now only known to survive upstream of this facility. A population in the Holston River above the Cherokee Reservoir was adversely affected by wastewater discharges from industrial and municipal sources. In addition, two chemical spills in the Clinch River in 1967 and 1970 of fly ash slurry and sulfuric acid, respectively, severely reduced the distribution of the shiny pigtoe near Carbo, Virginia (ESIE 1996). In addition, Neves reports that between 1979 and 1986, 28 percent of the shiny pigtoe population at North Holston Ford, North Fork Holston River were eliminated by muskrat predation (Neves 1989). Other threats that are attributed to population declines are similar to those described in the general mussel description.

CURRENT THREATS:
Current threats to freshwater mussels are described in the General Mussel Document.

Exposure Scenario Summary Table for the Shiny pigtoe

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
shiny pigtoe	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	whitetail shiner common shiner warpaint shiner telescope shiner
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

FINE-RAYED PIGTOE
Fusconaia cuneolus

STATUS:
On June 14, 1976, the fine-rayed pigtoe was designated as endangered throughout its entire range in Alabama, Tennessee, and Virginia (USFWS 1976), except where listed as experimental populations (in the free-flowing reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, AL) (USFWS 2001). A recovery plan for the fine-rayed pigtoe was approved September 19, 1984 (USFWS 1984).

SPECIES DESCRIPTION:
The fine-rayed pigtoe is a medium-sized (reaching up to 90 mm in length) freshwater mussel with a yellow to brown shell and fine green rays (NatureServe 2003, Bruenderman and Neves 1993). Like other freshwater mussels, the fine-rayed pigtoe feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of fine-rayed pigtoe glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the fine-rayed pigtoe is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. The fine-rayed pigtoe is a summer brooder, and gravid females have been identified between mid-May and late-July with

peak release of glochidia in mid-June. Recent laboratory studies identified eight species as likely glochidial hosts including the fathead minnow (*Pimephales promelas*), river chub (*Nocomis micropogon*), central stoneroller (*Campostoma anomalum anomalum*), telescope shiner (*Notropis telescopus*), Tennessee shiner (*Notropis leuciodus*), white shiner (*Luxilus albeolus*), whitetail shiner (*Cyprinella galactura*), and mottled sculpin (*Cottus bairdi*) (Bruenderman and Neves 1993). The while shiner, however, is not a natural host as this species does not co-occur with the fine-rayed pigtoe. Through sectioning of valves collected from muskrat middens, the maximum age of the Clinch River population of the species was 35 years and the average annual growth rate was 5 mm per year through age 10 and was reduced to approximately 2 mm per year until senescence (Bruenderman and Neves 1993).

RANGE AND POPULATION LEVEL:
This species was historically known from 15 Tennessee River tributaries and is currently known from four rivers (USFWS 1984). It was last collected from Mussel Shoals, historically an 85 km reach of the Tennessee River in Alabama (that is now reduced to a few kilometers of riverine habitat due to construction of three dams), prior to 1925 (Ortmann 1925) and is presumed to be extirpated from the shoal. Recently, it was known to survive only in portions of the Clinch and Powell Rivers, the North Fork of the Holston, and in the Paint Rock River (NatureServe 2003). According to Neves (1991), the largest remaining population is in the Clinch River, which may represent the only viable extant population, although it has declined in recent years. All other populations are small and of questionable viability.

HABITAT:
The fine-rayed pigtoe is found in moderate to high gradient streams with firm cobble or gravel substrates. It appears to prefer riffle areas; however, given the rarity of the species, little is known about specific habitat needs (NatureServe 2003).

PAST THREATS:
Many of the historic populations of the fine-rayed pigtoe were apparently lost when the river sections they inhabited were impounded. Over 50 impoundments in the Tennessee and Cumberland River systems (five mainstem Cumberland River dams, nine mainstem Tennessee River dams, and the rest are located on tributaries) have eliminated the majority of riverine habitat for the species in its historic range (ESIS 1996, USFWS 1984). The Powell River and upper tributaries of the Clinch River, in particular, are also subject to sediment and particulate matter loading from coal mining activities (Stansbery 1973). Other threats that are attributed to population declines are described in the General Mussel Document.

CURRENT THREATS:
Current threats to freshwater mussels are described in the General Mussel Document.

Exposure Scenario Summary Table for the Fine-rayed pigtoe

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies

					Relationships
fine-rayed pigtoe	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	fathead minnow river chub central stoneroller telescope shiner Tennessee shiner whitetail shiner white shiner mottled sculpin
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

CRACKING PEARLYMUSSEL
Hemistena lata

STATUS:
On September 28, 1989, the cracking pearlymussel was designated as endangered throughout its entire range in Alabama, Indiana, Kentucky, Pennsylvania, Tennessee, and Virginia (USFWS 1989), except where listed as experimental populations (in the free-flowing reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, AL) (USFWS 2001). A recovery plan for the cracking pearlymussel was approved in July 9, 1991 (USFWS 1991).

SPECIES DESCRIPTION:
The cracking pearlymussel is a medium-sized freshwater mussel (reaching up to 90 mm in length) with a brownish green to brown shell and broken dark green rays (USFWS 1989, VFWIS 2003). The life span of the species is unknown (USFWS 1989). Like other freshwater mussels, the cracking pearlymussel feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of cracking pearlymussel glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the cracking pearlymussel is similar to that of other mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. Specific glochidial host species for the cracking pearlymussel are not known (USFWS 1989).

RANGE AND POPULATION LEVEL:
The cracking pearlymussel has undergone a substantial range reduction. It was historically distributed in the Ohio, Cumberland, and Tennessee River systems (Bogan and Parmalee 1983, USFWS 1991). The species has been extirpated throughout much of its range. It was last collected from Mussel Shoals, historically an 85 km reach of the Tennessee River in Alabama (that is now reduced to a few kilometers of riverine habitat due to construction of three dams), prior to 1925 (Ortmann 1925) and is presumed to be extirpated from the shoal. It is presently known to survive at only a few shoals in the Clinch River in Tennessee and Virginia (Bogan and Parmalee 1983, Neves 1991, Parmalee and Bogan 1998, USFWS 2001), but appears to be viable (NatureServe 2003). A remnant population survives in the Elk River in Alabama and Tennessee, although this population does not appear to be viable. Populations in the Green River, Kentucky, the Powell River, Tennesee and Virginia, and below Pickwick Landing Dam in the Tennessee River, Tennessee appear to be extirpated.

HABITAT:
The cracking pearlymussel inhabits streams of moderate size on gravel riffles where it is often deeply buried in the substrate (Bogan and Parmalee 1983). Substrate preferences include sand, gravel, and cobble in high velocity areas and mud and sand in slower moving waters (Gordon and Layzer 1989).

PAST THREATS:
The Powell River watershed is mined extensively for coal, and coal mining impacts to mussel habitat are evident in the upper reaches while the lower river reaches still support mussel fauna (USFWS 1991). In 1983, the section of the Powell River inhabited by the cracking pearlymussel experienced a mussel kill that may have resulted in a loss of five percent of the mussel population (Ahlstedt and Jenkinson 1987, USFWS 1991). Clinch River populations have been adversely affected by water quality degradation and impacts from coal mining, and two mussel kills resulting from toxic spills from a riverside coal-fired power plant have occurred (USFWS 1991). Any populations remaining in the Green River were likely impacted by oil and gas exploration and production and by alterations of stream flow from an upstream reservoir. If populations remain below Pickwick Dam, they are likely impacted by gravel dredging, channel maintenance, and dam operations (USFWS 1991). Other threats that are attributed to population declines are described in the General Mussel Document.

CURRENT THREATS:
Other current threats to freshwater mussels are described in the General Mussel Document.

Exposure Scenario Summary Table for the Cracking Pearlymussel

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships

cracking pearlymussel	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)

CRACKING PEARLYMUSSEL
Hemistena lata

STATUS:
On September 28, 1989, the cracking pearlymussel was designated as endangered throughout its entire range in Alabama, Indiana, Kentucky, Pennsylvania, Tennessee, and Virginia (USFWS 1989), except where listed as experimental populations (in the free-flowing reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, AL) (USFWS 2001). A recovery plan for the cracking pearlymussel was approved in July 9, 1991 (USFWS 1991).

SPECIES DESCRIPTION:
The cracking pearlymussel is a medium-sized freshwater mussel (reaching up to 90 mm in length) with a brownish green to brown shell and broken dark green rays (USFWS 1989, VFWIS 2003). The life span of the species is unknown (USFWS 1989). Like other freshwater mussels, the cracking pearlymussel feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of cracking pearlymussel glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the cracking pearlymussel is similar to that of other mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. Specific glochidial host species for the cracking pearlymussel are not known (USFWS 1989).

RANGE AND POPULATION LEVEL:
The cracking pearlymussel has undergone a substantial range reduction. It was historically distributed in the Ohio, Cumberland, and Tennessee River systems (Bogan and Parmalee 1983, USFWS 1991). The species has been extirpated throughout much of its range. It was last collected from Mussel Shoals, historically an 85 km reach of the Tennessee River in Alabama (that is now reduced to a few kilometers of riverine habitat due to construction of three dams),

prior to 1925 (Ortmann 1925) and is presumed to be extirpated from the shoal. It is presently known to survive at only a few shoals in the Clinch River in Tennessee and Virginia (Bogan and Parmalee 1983, Neves 1991, Parmalee and Bogan 1998, USFWS 2001), but appears to be viable (NatureServe 2003). A remnant population survives in the Elk River in Alabama and Tennessee, although this population does not appear to be viable. Populations in the Green River, Kentucky, the Powell River, Tennesee and Virginia, and below Pickwick Landing Dam in the Tennessee River, Tennessee appear to be extirpated.

HABITAT:
The cracking pearlymussel inhabits streams of moderate size on gravel riffles where it is often deeply buried in the substrate (Bogan and Parmalee 1983). Substrate preferences include sand, gravel, and cobble in high velocity areas and mud and sand in slower moving waters (Gordon and Layzer 1989).

PAST THREATS:
The Powell River watershed is mined extensively for coal, and coal mining impacts to mussel habitat are evident in the upper reaches while the lower river reaches still support mussel fauna (USFWS 1991). In 1983, the section of the Powell River inhabited by the cracking pearlymussel experienced a mussel kill that may have resulted in a loss of five percent of the mussel population (Ahlstedt and Jenkinson 1987, USFWS 1991). Clinch River populations have been adversely affected by water quality degradation and impacts from coal mining, and two mussel kills resulting from toxic spills from a riverside coal-fired power plant have occurred (USFWS 1991). Any populations remaining in the Green River were likely impacted by oil and gas exploration and production and by alterations of stream flow from an upstream reservoir. If populations remain below Pickwick Dam, they are likely impacted by gravel dredging, channel maintenance, and dam operations (USFWS 1991). Other threats that are attributed to population declines are described in the General Mussel Document.

CURRENT THREATS:
Other current threats to freshwater mussels are described in the General Mussel Document.

Exposure Scenario Summary Table for the Cracking Pearlymussel

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
cracking pearlymussel	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	
	juvenile / adult	sediment dweller	contact & ingestion of	filter feeder (bacteria,	

			water, diet, sediment	algae, detritus, sediment)

PINK MUCKET (PEARLYMUSSEL)
Lampsilis abrupta

STATUS:
On June 14, 1976, the pink mucket (pearlymussel) was designated as endangered throughout its entire range in Alabama, Arkansas, Illinois, Indiana, Kentucky, Louisiana, Missouri, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia (USFWS 1976). A recovery plan for the pink mucket was approved in January 24, 1985 (USFWS 1985).

SPECIES DESCRIPTION:
The pink mucket is a medium-sized (reaching up to approximately 100 mm in length) freshwater mussel with a smooth, yellow or yellowish green shell and faint green rays (INHS 1997, VFWIS 2003). The life span of the species exceeds 50 years (VFWIS 2003). Like other freshwater mussels, the pink mucket feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of pink mucket glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the pink mucket is similar to that of other mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. Laboratory studies have confirmed that four of nineteen fish tested are suitable hosts for the pink mucket. These include the largemouth bass (*Micropterus salmoides*), spotted bass (*Micropterus punctulatus*), smallmouth bass *(Micropterus dolomieu*), and walleye (*Sander vitreum*) (Barnhart 1997). Other reported glochidial fish host species include the sauger (*Sander canadensis*) and the freshwater drum (*Aplodinotus grunniens*) (USFWS 1985, VFWIS 2003). The pink mucket is unique in that the females possess a spotted mantle flap which may serve to mimic a fish eyespot to attract host fish (USFWS 1985).

RANGE AND POPULATION LEVEL:
The pink mucket has undergone a substantial range reduction. It was historically distributed in 25 rivers and tributaries in the Ohio, Cumberland, Mississippi, and Tennessee River systems. The species is likely extirpated in Ohio, Pennsylvania, and Illinois (NatureServe 2003). Records from 1990 indicate that the species remained in only 16 rivers and tributaries (NatureServe 2003). The population of the species in the lower Tennessee River in Tennessee is viable. Populations in the Green and Barren Rivers in Kentucky remain, but their viability is unknown.

HABITAT:
The pink mucket typically inhabits medium to large rivers with strong currents; however, it has also been able to survive and reproduce in areas of impounded reaches with river/lake conditions without standing water (NatureServe 2003, USFWS 1985). Substrate preferences include sand, gravel, and pockets between rocky ledges in high velocity areas and mud and sand in slower moving waters. Individuals have been found at depths up to one meter in swiftly moving currents and in much deeper waters with slower currents (Gordon and Layzer 1989).

PAST THREATS:
Past threats to the species include habitat modification through impoundments, channelization, and dredging operations as well as water quality degradation and commercial over harvestation (NatureServe 2003). A controlled release of mine water discharge dominated by iron in a tributary to the Ohio River supporting habitat for the pink mucket was evaluated to determine potential toxic effects to surrogate mussel and clam species. Instream monitoring of surrogate mussel populations pre- and post-discharge indicated that there was no significant enzymatic effect response 30 days after the release; however, given the demonstrated recovery ability of mine-water exposed clams in laboratory-based studies, it is believed that Ohio River mussels likely experienced a brief period of impaired physiological function (e.g., enzymatic function, growth, and siphoning activity) that was not apparent at the time of post-release monitoring. Bivalve response thresholds for siphoning and bioconcentration were compared to other standardized test responses, and ultimately, results supported a criteria for the bioavailable form of iron for freshwater mussels at 0.37 mg ferrous iron/liter (Milam and Farris 1998). Other threats are described in the General Mussel Document.

CURRENT THREATS:
Other current threats to freshwater mussels are described in the General Mussel document.

Exposure Scenario Summary Table for the Pink mucket

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
pink mucket	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	largemouth bass potted bass smallmouth bass walleye sauger freshwater drum
	juvenile / adult	sediment dweller	contact & ingestion of water, diet,	filter feeder (bacteria, algae,	

			sediment	detritus, sediment)	

FINE-LINED POCKETBOOK
Lampsilis altilis

STATUS:
On March 17, 1993, fine-lined pocketbook (*Lampsilis altilis)* was designated as Threatened throughout its entire range (USFWS 1993). A recovery plan for the fine-lined pocketbook was finalized on November 17, 2000 (USFWS 2000). Critical habitat was designated for the fine-lined pocketbook on July 1, 2004 (69 FR 40083).

SPECIES DESCRIPTION:
The fine-lined pocketbook is a medium-sized mussel, suboval in shape, and rarely exceeds 100 mm (4 in.) in length. Like other freshwater mussels, adults are filter-feeders, orienting themselves in the substrate to facilitate siphoning of the water column for oxygen and food (Kraemer 1979). Mussels have been reported to consume detritus, diatoms, phytoplankton, zooplankton, and other microorganisms (Coker et al. 1921, Churchill and Lewis 1924, Fuller 1974). Juvenile mussels employ foot (pedal) feeding, and are thus suspension feeders (Yeager et al. 1994). Foods of juvenile freshwater mussels up to two weeks old include bacteria, algae, and diatoms with amounts of detrital and inorganic colloidal particles (Yeager et al. 1994). Specific food habits of the fine-lined pocketbook are unknown, but are likely similar to those of other freshwater mussels.

REPRODUCTION AND DEVELOPMENT:
Gravid females have been observed March through June. They have also been observed releasing glochidia in a single, large conglutinate (Haag et al. 1999), termed a superconglutinate (Haag et al. 1995). Redeye bass *(Micropterus coosa)*, spotted bass *(M. puctulatus)*, largemouth bass (*M. salmoides)*, and green sunfish *(Lepomis cyanellus)* have been identified as suitable hosts (Haag et al. 1999).

RANGE AND POPULATION LEVEL:
The fine-lined pocketbook was described from the Alabama River near Claiborne, Monroe County, Alabama. This species was historically reported from the Tombigbee, Black Warrior, Cahaba, Alabama, Tallapoosa, and Coosa Rivers and many of their tributaries in Alabama, Georgia, Mississippi, and Tennessee. The species has apparently disappeared from the Tombigbee and Alabama River drainages, and possibly from the Black Warrior River drainage (USFWS 2003).

Since publication of the final rule listing the fine-lined pocketbook, this mussel continues to survive in the upper Cahaba River and the Little Cahaba River (Jefferson/Shelby/Bibb Counties, Alabama); Coosa River (Cherokee County, Alabama) and its tributaries, including Duck Creek (Walker County, Georgia), Euharlee Creek (Bartow County, Georgia), Conasauaga River (Murray/Whitfield County, Georgia; Polk County, Tennessee), and Holly Creek (Murray

County, Georgia), Terrapin Creek, and South Fork Terrapin Creek (Cleburne County, Alabama); Yellowleaf Creek and its tributary Muddy Prong (Shelby County, Alabama); Kelly Creek and its tributary Shoal Creek (Shelby/St. Clair County, Alabama), Choccolocco Creek (Calhoun County, Alabama) and its tributaries Cheaha Creek (Talladega/Clay County, Alabama), Shoal Creek (Cleburne County, Alabama), Hatchet Creek (Coosa/Clay County, Alabama), and Tallasahatchee Creek (Talladega County, Alabama); and the Tallapoosa River and tributaries, including Uphapee Creek (Macon County, Alabama), Choctafaula Creek (Macon/Lee County, Alabama), Chewacla Creek (Macon/Lee County, Alabama), Opintlocco Creek (Macon County, Alabama), Cane and Little Cane Creeks (Cleburne County, Alabama), Muscadine Creek (Cleburne County, Alabama), Big Creek (Haralson County, Georgia), and McClendon Creek (Paulding County, Georgia) (USFWS 2003). Populations are small and localized within these streams (USFWS 2003).

HABITAT:
The fine-lined pocketbook was historically found in large river to small creek habitats. Recent collections have been from stable sand/gravel/cobble substrate in moderate to swift currents in small streams above the Fall Line (USFWS 2000).

CRITICAL HABITAT:
In Jefferson, Shelby, and Bibb Counties, Alabama, stream and river channels within the ordinary high water line of the Cahaba River from U.S. Highway 82, Centerville, Bibb County, upstream to Jefferson County Road 143, Jefferson County, Alabama; and the Little Cahaba River from its confluence with the Cahaba River, upstream to the confluence of Mahan and Shoal Creeks, Bibb County, Alabama.

In Cleburne County, Alabama, and Paulding and Haralson Counties, Georgia, stream and river channels within the ordinary high water line of the main stem Tallapoosa River from U.S. Highway 431, Cleburne County, Alabama, upstream to the confluence of McClendon and Mud Creeks, Paulding County, Georgia; and Cane Creek from its confluence with Tallapoosa River, upstream to section 33/4 Line, Cleburne County, Alabama.

In Macon and Lee Counties, Alabama, stream and river channels within the ordinary high water line of the mainstem of Uphapee Creek from Alabama Highway 199, upstream to the confluence of Opintlocco and Chewacla Creeks, Macon County, Alabama; Choctafaula Creek, from confluence with Uphapee Creek, upstream to Macon County Road 54, Macon County, Alabama; Chewacla Creek, from confluence with Opintlocco Creek, Macon County, Alabama, upstream to Lee County Road 159, Lee County, Alabama; Opintlocco Creek, from confluence with Chewacla Creek, upstream to Macon County Road 79, Macon County, Alabama.

In Cherokee, Calhoun, and Cleburne Counties, Alabama, stream and river channels within the ordinary high water line of the Coosa River main stem from the power line crossing southeast of Maple Grove, Alabama, upstream to Weiss Dam, Cherokee County, Alabama; Terrapin Creek, 53 km (33 mi) extending from its confluence with the Old Coosa River channel, Cherokee County, upstream to Cleburne County Road 49, Cleburne County,

Alabama; South Fork Terrapin Creek, 7 km (4 mi), from its confluence with Terrapin Creek, upstream to Cleburne County Road 55, Cleburne County, Alabama.

In Coosa and Clay Counties, Alabama, stream and river channels within the ordinary high water line of the main stem of Hatchet Creek from the confluence of Swamp Creek at Coosa County Road 29, Coosa County, Alabama, upstream to Clay County Road 4, Clay County, Alabama.

In Calhoun and Cleburne Counties, Alabama, stream and river channels within the ordinary high water line of the main stem of Shoal Creek from the headwater of Whitesides Mill Lake, Calhoun County, Alabama, upstream to the tailwater of Coleman Lake Dam, Cleburne County, Alabama.

In Shelby and St. Clair Counties, Alabama, stream and river channels within the ordinary high water line of the Kelly Creek main stem extending from the confluence with the Coosa River, upstream to the confluence of Shoal Creek, St. Clair County, Alabama;
and the main stem of Shoal Creek from the confluence with Kelly Creek, St. Clair County, Alabama, upstream to the St. Clair/Shelby County Line, St. Clair County, Alabama.

In Talladega and Clay Counties, Alabama, stream and river channels within the ordinary high water line of the main stem of Cheaha Creek from its confluence with Choccolocco Creek, Talladega County, Alabama, upstream to the tailwater of Chinnabee Lake Dam, Clay County, Alabama.

In Shelby County, Alabama, stream and river channels within the ordinary high water line of the Yellowleaf Creek main stem from Alabama Highway 25, upstream to Shelby County Road 49; and the Muddy Prong main stem extending from its confluence with Yellowleaf Creek, upstream to U.S. Highway 280.

In St. Clair County, Alabama, stream and river channels within the ordinary high water line of the main stem of Big Canoe Creek from its confluence with Little Canoe Creek at the St. Clair/Etowah County line, St. Clair County, upstream to the confluence of Fall Branch.

In Floyd, Gordon, Whitfield, and Murray Counties, Georgia; and Bradley and Polk Counties, Tennessee, stream and river channels within the ordinary high water line of the Oostanaula River main stem from its confluence with the Etowah River, Floyd County, Georgia, upstream to the confluence of the Conasauga and Coosawattee River, Gordon County, Georgia; the Coosawattee River main stem from its confluence with the Conasauga River, upstream to Georgia State Highway 136, Gordon County, Georgia; the Conasauga River main stem from confluence with the Coosawattee River, Gordon County, Georgia, upstream through Bradley and Polk Counties, Tennessee, to Murray County Road 2, Murray County, Georgia; and the mainstem of Holly Creek from its confluence with the Conasauga River, upstream to its confluence with Rock Creek, Murray County, Georgia.

In Elmore County, Alabama, stream and river channels within the ordinary high water line of the Coosa River main stem from Alabama State Highway 111 bridge, upstream to Jordan Dam.

Primary constituent elements identified at the time of designation included: 1. Geomorphically stable stream and river channels and banks; 2. A flow regime (i.e., the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of mussels and their fish hosts in the river environment; 3. Water quality, including temperature, pH, hardness, turbidity, oxygen content, and other chemical characteristics necessary for normal behavior, growth, and viability of all life stages; 4. Sand, gravel, and/or cobble substrates with low to moderate amounts of fine sediment, low amounts of attached filamentous algae, and other physical and chemical characteristics necessary for normal behavior, growth, and viability of all life stages; 5. Fish hosts with adequate living, foraging, and spawning areas for them; and 6. Few or no competitive or predaceous nonnative species present.

PAST THREATS:
The abundance and distribution of the fine-lined pocketbook decreased historically from human-induced habitat loss and degradation caused by impoundments, sedimentation and turbidity, channelization and dredging, mining (coal, sand, gravel, or gold) (Jones 1991, USFWS 1993, Leigh 1994, ADEM 1994), and contaminants contained in numerous point (e.g., carpet mills and fabric dying mills) (Hurd 1974) and nonpoint sources (USFWS 2000). Channel modifications and water pollution gradually eliminated this native species that is dependent on a narrow range of flowing water habitat conditions from extensive portions of its former range within the Mobile River Basin. These habitat changes have resulted in significant extirpations (localized loss of populations), restricted and fragmented distributions, and poor recruitment of young.

CURRENT THREATS:
Habitat modification, sedimentation, eutrophication, and water quality degradation are the primary causes of decline of the fine-lined pocketbook. This species can not tolerate impoundment. Surviving populations are threatened by urban and agricultural runoff, surface mine drainage, small stream impoundment projects, industrial and sewage treatment plant discharges, and channel degradation caused by sand and gravel mining.

Recovery of the fine-lined pocketbook to the point of delisting is unlikely in the near future. The immediate recovery objective is to prevent the continued decline of this species by locating, protecting, and restoring stream drainages with extant populations. A secondary objective is to work toward restoration of stream habitats to a degree that would allow expansion and/or reintroduction of this species.

Exposure Scenario Summary Table for the Fine-lined Pocketbook

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
Fine-lined Pocketbook	glochidia	parasite	contact with water, diet	fish body fluids	redeye bass, spotted bass,

					largemouth bass, green sunfish
	juvenile/ adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

HIGGINS EYE (PEARLYMUSSEL)

Lampsilis higginsii

STATUS:

On June 14, 1976, the Higgins eye (pearlymussel) was designated as endangered throughout its entire range in Iowa, Illinois, Minnesota, Missouri, and Wisconsin (USFWS 1976). The first recovery plan for the species was approved on July 29, 1983. Revision of the 1983 plan began in 1994 following the Great Flood of 1993. A draft revised recovery plan for the Higgins eye was published in August 15, 2003 (USFWS 2003).

SPECIES DESCRIPTION:

The Higgins eye is a medium-sized (reaching approximately 100 mm in length) freshwater mussel with a smooth, yellow, yellowish green, or brown with green rays that are obscure on some individuals (USFWS 1993). Like other freshwater mussels, the Higgins eye feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of Higgins eye glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:

The reproductive cycle of the Higgins eye is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. Higgins eye is a long-term brooder (bradytictic). Glochidial release has been reported during June and July (Waller and Holland-Bartels 1988) and May and September (Surber 1912). Early studies indicated that the sauger (*Stizostedion canadense*) and freshwater drum (*Aplodinotus grunniens*) were glochidial fish hosts (Surber 1912; Wilson 1916; Coker et al. 1921) based on examination of natural infections; however, field identifications were not robust. In laboratory studies, Waller and Holland-Bartels (1988) indicated that four species of fish were suitable hosts: largemouth bass (*Micropterus salmoides*), smallmouth bass (*M. dolomieu*), walleye (*Stizostedion vitreum*

vitreum) and yellow perch (*Perca flavescens*). There was some transformation of glochidia to juveniles on green sunfish (*Lepomis cyanellus*), whereas two species, bluegill (*Lepomis macrochirus*) and northern pike (*Esox lucius*), were considered marginal hosts. The common carp (*Cyprinus carpio*) and fathead minnow (*Pimephales promelas*) were unsuitable hosts. Hove and Kapuscinski (2002) have confirmed sauger as a suitable host and identified largemouth bass and black crappie (*Pomoxis nigromaculatus*) as additional host species.

RANGE AND POPULATION LEVEL:
In the initial recovery plan for the species (USFWS 1983), the historic distribution of Higgins eye before 1965 was given as the main stem of the Mississippi River from just north of St. Louis, Missouri, to just south of St. Paul, Minnesota; in the Illinois, Sangamon, and Rock Rivers in Illinois; in the Iowa, Cedar, and Wapsipinicon Rivers in Iowa; in the Wisconsin and St. Croix rivers in Wisconsin; and, in the Minnesota River in Minnesota (USFWS 1983). A questionable report of this species in the lower Ohio River was also given (Havlik 1980). Since the 1983 Recovery Plan, a number of studies have provided new information on the distribution and abundance of Higgins eye. Thiel (1981) stated that Pool 10 of the Mississippi River by Prairie du Chien, Wisconsin supported the largest population of the species was considered to be the most productive Higgins eye habitat in the Mississippi River system. Cawley (1996) reviewed Higgins eye distribution from 1980-1996 and noted that 510 specimens had been collected since 1980 corresponding to an additional 98 miles of reported range. Based on Cawley's (1996) review, it appears that there has been recent recruitment of Higgins eye (individuals <30 mm in shell length) in locations surveyed since 1980. The age distribution indicated that there are more middle-age mussels (35-85 mm shell length) than young. Miller and Payne (1988) indicated that some mussel species display infrequent, but fairly strong, recruitment and that there can be substantial variability in recruitment among closely located sites. The actual size distribution of Higgins eye populations is unknown at this time (USFWS 2003).

Clarke and Loter's (1992, 1993, 1994, 1995) monitoring results for Higgins eye at Prairie du Chien, Wisconsin, since 1990 indicate that the flood of 1993 caused no significant change in the number of Higgins eye found. However, due to variability in recruitment among years (Miller and Payne 1991, 1992, 1993, 1994, 1995a,b, 1996a, 1997), a cause-effect relationship cannot necessarily be inferred from Clark and Loter=s (1995) work.

Mussel communities may have been slightly relocated due to the flood of 1993 (USFWS 2003). Sampling conducted by Heath (1995) at the Orion mussel aggregation in the Wisconsin River indicated the presence of suitable habitat, evidence of reproduction within the last decade, and approximately 2,273 individuals at this site. Hornbach et al. (1995) examined Higgins eye populations in the St. Croix River and estimated populations to be approximately 4,000 mussels at Franconia, 4,000 to 10,000 mussels at Prescott, Minnesota, and 238,000 to 260,000 mussels at Hudson, Wisconsin. Recent studies (Doolittle and Heath 1997, Heath 1998, and Heath et al.1999) estimate Higgins eye population densities of approximately 0.01 individuals/m^2 from collections of almost 90 individuals from 1987-1999 in the area of the St. Croix river, extending about three miles upstream of Franconia, MN. In 2000, mean density estimates at Interstate Park and Hudson were 0.01 and 0.09, respectively (Heath et al. 2001); these estimates did not reflect a

statistically significant change in abundance at either site. Miller and Payne (1996b) estimated that there were 40,000 m^2 of suitable habitat at McMillan Island in Pool 10 of the Mississippi River near Guttenberg, Iowa, which contained an estimated 5,320 individuals. A more recent report contained revised estimates of both suitable habitat (860,994 m^2) and potential population size (662,965 individuals), although there was a high level of variability among the data (Miller and Payne 2001). Davis and Hart (1995) examined an area downstream of Lock and Dam No. 6 on the Mississippi River near Trempealeau, Wisconsin, and found two live and two dead Higgins eye. They did not estimate overall population size for the species (USFWS 2003).

HABITAT:
Higgins eye has been characterized as a large river mussel species (USFWS 1983). Heath (1995) found no correlation between overall mussel density and substrate size in the Wisconsin River where Higgins eye was found. Sylvester et al. (1984) found that burrowing times for Higgins eye were similar in clay, silt and sand, but longer in pebble-gravel substrate. The species is not associated with firmly packed clay, flocculent silt, organic material, bedrock, concrete, or unstable moving sand (Wilcox et al. 1993). Cawley (1996) indicated that Higgins eye were most common in sand/gravel substrate. Miller and Payne (1996b) considered substratum that was free of plants and consisted of stable, gravelly sand as suitable. They also noted that immediately downstream of wingdams, mussel diversity was high and new species were found at a more rapid rate on the wingdam than in gravelly sand (Miller and Payne 1996b). The species was found immediately below the wingdam at McMillan Island and has been collected on wingdams near Prairie du Chien. This is likely due to host fish congregating near the wingdams, as they may be fish attractants. Higgins eye may be primarily adapted to large river habitats with moderate current, such as the East channel of the Mississippi River near Prairie du Chien, Wisconsin. Water velocities less than 1 meter per second during periods of low discharge are considered ideal for this species (USFWS 2003).

PAST THREATS:
The major reasons for listing Higgins eye were the decrease in both abundance and range of the species. As stated in the initial recovery plan (USFWS 1983), the Higgins eye pearlymussel was never abundant and Coker (1919) indicated that it was becoming increasingly rare even at the end of the 1800s. Fuller (1978) attributed this decline in part to overfishing of the Higgins eye; however, water quality degradation, sand and gravel mining activities, waterway maintenance, siltation, dam and levee construction, and channelization are all believed to be contributing factors in the decline of the species (NatureServe 2003).

Modifications to the Upper Mississippi River (UMR) for navigation began about 1878 when Congress authorized a 4 2-foot navigation channel. Modifications consisted primarily of clearing and snagging, construction of wing and closing dams, and a canal to bypass the Des Moines rapids at Keokuk, Iowa. In 1907, a six-foot channel was authorized, with construction of more wing and closing dams, dredging, bank revetment, and two locks at the Rock Island rapids, Illinois. In 1930, a nine-foot channel was authorized, including the construction of locks and dams, and was completed by 1940 (Crittenden 1980). These modifications have resulted in profound changes in the nature of the river, primarily replacing a free-flowing alluvial system with a stepped gradient river.

Thiel (1987) reported mid-1980's die-offs of mussels in the Mississippi River that were most noticeable in areas of Higgins eye occurrence. Blodgett and Sparks (1987a) noted a decline in the unionid community near the Sylvan Slough Essential Habitat Area, and Havlik (1987) noted a die-off near Prairie du Chien, Wisconsin, another Essential Habitat Area. Havlik also indicated an Aunusual@ number of fresh-dead Higgins eye at this site in 1985. Few papers presented at a workshop examining die-offs (Neves 1987) gave concrete reasons for the cause of the die-off, however Scholla et al. (1987) indicated that a gram-negative rod bacterium, which forms yellow colonies was associated with Asick@ mussels from the Tennessee River. Research on mussel pathogens (bacterial, viral and protozoan) and their effects on population levels has not been conducted.

Concern that a major flood in 1993 and the infestation of the Mississippi River by the non-native zebra mussel (*Dreissena polymorpha*) may have posed serious threats to the continued existence of Higgins eye prompted reevaluation of recovery efforts for the species by the USFWS (USFWS 2003). Other past threats are described in the General Mussel Document.

CURRENT THREATS:
Since zebra mussels invaded the Mississippi River in the early 1990's, three of the essential habitat areas for Higgins eye (East Channel - Prairie du Chien, Harpers Slough, and Cordova) have become severely infected with zebra mussels and only one essential habitat area (Interstate Park on the St. Croix River) is entirely free of zebra mussels. All current populations of Higgins eye are under the potential threat of being colonized by zebra mussels (USFWS 2003).

Continual maintenance of the nine-foot channel in the Mississippi River requires dredging, wing and closing dam reconstruction, and bank stabilization. The last major modification on the UMRS occurred in 1995 when a second lock at Melvin Price Locks and Dam (Alton, Illinois) became operational, theoretically increasing the capacity of the lock and dam system to pass tow traffic upriver. Although the immediate result of lock and dam construction was an increase in the volume of backwater lakes and sloughs, over time an equilibrium between flow and cross-section was restored by an increase in sedimentation rates in these new navigation pools. These changes in substrate composition are likely to have important impacts on mussel communities (USFWS 2003). Other current threats to freshwater mussels are described in the General Mussel Document.

Exposure Scenario Summary Table for the Higgins= eye

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
Higgins= eye	glochidia	parasite	contact with water, diet	fish body fluids (once	sauger freshwater drum largemouth bass

				encysted)	smallmouth bass walleye yellow perch green sunfish bluegill* northern pike* black crappie
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

* Bluegill and northern pike were reported as marginal glochidial host species (Waller and Holland-Bartels 1988).

ORANGENACRE MUCKET
Lampsilis perovalis

STATUS:
On March 17, 1993, the orangenacre mucket (*Lampsilis perovalis*) was designated as Threatened throughout its entire range (USFWS 1993). A recovery plan for the orangenacre mucket was finalized on November 17, 2000 (USFWS 2000). Critical habitat was designated for the orangenacre mucket on July 1, 2004 (69 FR 40083).

SPECIES DESCRIPTION:
The orangenacre mucket is a medium-sized mussel, 50-90 mm (2-3.6 inches) in length. The shell is oval in shape, moderately thick, and inflated. Like other freshwater mussels, adults are filter-feeders, orienting themselves in the substrate to facilitate siphoning of the water column for oxygen and food (Kraemer 1979). Mussels have been reported to consume detritus, diatoms, phytoplankton, zooplankton, and other microorganisms (Coker et al. 1921, Churchill and Lewis 1924, Fuller 1974). Juvenile mussels employ foot (pedal) feeding, and are thus suspension feeders (Yeager et al. 1994). Foods of juvenile freshwater mussels up to two weeks old include bacteria, algae, and diatoms with amounts of detrital and inorganic colloidal particles (Yeager et al. 1994). Specific food habits of the orangenacre mucket are unknown, but are likely similar to those of other freshwater mussels.

REPRODUCTION AND DEVELOPMENT:
The orangenacre mucket expels mature glochidia in a superconglutinate (Haag et al. 1995). Discharge of superconglutinates by this species has been observed between March and June, with releases concentrated in early April (Hartfield and Butler 1997). Redeye bass *(Micropterus coosa)*, spotted bass *(M. puctulatus)*, largemouth bass *(M. salmoides)*, and chain pickerel *(Esox niger)* have been identified as host fish for the orange-nacre mucket (Haag and Warren 1997; NatureServce 2007).

RANGE AND POPULATION LEVEL:
The orangenacre mucket was described from the Alabama River near Clairborne, Monroe County, Alabama. The orange-nacre mucket was historically known from the Alabama, Tombigbee, Black Warrior, and Cahaba Rivers and their tributaries in Alabama and Mississippi. The species has disappeared from the mainstem Tombigbee, Black Warrior, and Alabama Rivers, but continues to survive in Tombigbee tributaries, including the Buttahatchee River (Lowndes/Monroe County, Mississippi; Lamar County, Alabama), and East Fork Tombigbee River (Itawamba/Monroe County, Mississippi), Luxapalila Creek and tributaries yellow Creek (Monroe County, Mississippi; Lamar County, Alabama) and Cut Bank Creek (Lamar County, Alabama), Sipsey River (Greene/Pickens/Tuscaloos County, Alabama), Coalfire, Lubbub, and Trussels Creeks (Pickens County, Alabama); Black Warrior River tributaries, including North River (Tuscaloosa/Fayette County, Alabama) and its tributary Clear Creek (Fayette County, Alabama), locust and Blackburn Forks of the Black Warrior River (Blount County, Alabama), Sipsey Fork of the Black Warrior (Winston/Lawrence County, Alabama) and tributaries Thompson, Flannagin, and Borden Creeks (Lawrence County, Alabama), and Caney, North Fork Caney, Brushy, Capsey, Rush, Brown, and Beech Creeks (Winston/Lawrence County, Alabama); Cahaba River (Bibb/Jefferson/Shelby County, Alabama) and Little Cahaba River (Bibb/Shelby County, Alabama); and Alabama River tributaries Limestone Creek (Monroe County, Alabama) and Bogue Chitto Creek (Dallas County, Alabama). The orangenacre mucket is locally common in the Sipsey Fork and several of its tributaries. All other populations are small and localized (USFWS 2003).

HABITAT:
The orangenacre mucket is currently restricted to high quality stream and small river habitat. The species is found on stable sand/gravel/cobble substrate in moderate to swift currents.

CRITICAL HABITAT:
In Itawamba County, Mississippi, stream and river channels within the ordinary high water line of the East Fork Tombigbee River main stem from Mississippi Highway 278, Monroe County, upstream to the confluence of Mill Creek.

In Itawamba County, Mississippi, stream and river channels within the ordinary high water line of Bull Mountain Creek from Mississippi Highway 25, upstream to U.S. Highway 78.

In Lowndes/Monroe County, Mississippi and Lamar County, Alabama, stream and river channels within the ordinary high water line of the Buttahatchee River main stem from its confluence with the impounded waters of Columbus Lake, Lowndes/Monroe County, Mississippi, upstream to the confluence of Beaver Creek, Lamar County, Alabama; and Sipsey Creek, from its confluence with the Buttahatchee River, upstream to the Mississippi/Alabama State Line, Monroe County, Mississippi.

In Lowndes County, Mississippi and Lamar County, Alabama, stream and river channels within the ordinary high water line of the Luxapalila Creek main stem from Waterworks Road, Columbus, Mississippi, upstream to approximately 1.0 km (0.6 mi) above Steens Road, Lowndes County, Mississippi; and the Yellow Creek main stem from its confluence with

Luxapalila Creek, Lowndes County, Mississippi, upstream to the confluence of Cut Bank Creek, Lamar County, Alabama.

In Pickens County, Alabama, stream and river channels within the ordinary high water line of the Coalfire Creek main stem from its confluence with the impounded waters of Aliceville Lake, upstream to U.S. Highway 82.

In Pickens County, Alabama, stream and river channels within the ordinary high water line of the main stem of Lubbub Creek from its confluence with the impounded waters of Gainesville Lake, upstream to the confluence of Little Lubbub Creek

In Greene/Pickens and Tuscaloosa Counties, Alabama, stream and river channels within the ordinary high water line of the Sipsey River main stem from its confluence with impounded waters of Gainesville Lake, Greene/Pickens County, upstream to Alabama Highway 171 crossing, Tuscaloosa County, Alabama.

In Greene County, Alabama, stream and river channels within the ordinary high water line of the Trussels Creek main stem from its confluence with the impounded waters of Demopolis Lake, upstream to Alabama Highway 14.

In Sumter County, Alabama, stream and river channels within the ordinary high water line of the Sucarnoochee River main stem from its confluence with the Tombigbee River, upstream to the Mississippi/Alabama State Line.

In Winston and Lawrence Counties, Alabama, stream and river channels within the ordinary high water line of the Sipsey Fork main stem from the section 11/12 line, Winston County, Alabama, upstream to the confluence of Hubbard Creek, Lawrence County, Alabama; Thompson Creek, from its confluence with Hubbard Creek, upstream to section 2 line Lawrence County; Brushy Creek, from the confluence of Glover Creek, Winston County, upstream to section 9, Lawrence County; Capsey Creek, from confluence with Brushy Creek, Winston County, upstream to the confluence of Turkey Creek, Lawrence County; Rush Creek, from confluence with Brushy Creek, upstream to Winston/Lawrence County Line, Winston County; Brown Creek, from confluence with Rush Creek, Winston County, upstream to section 24 line, Lawrence County; Beech Creek, from confluence with Brushy Creek, to confluence of East and West Forks, Winston County; Caney Creek and North Fork Caney Creek, from confluence with Sipsey Fork, upstream to section 14 line, Winston County; Borden Creek, from confluence with Sipsey Fork, Winston County, upstream to the confluence of Montgomery Creek, Lawrence County; and Flannagin Creek, from confluence with Borden Creek, upstream to confluence of Dry Creek, Lawrence County.

In Tuscaloosa and Fayette Counties, Alabama, stream and river channels within the ordinary high water line of the main stem of the North River from Tuscaloosa County Road 38, Tuscaloosa County, upstream to confluence of Ellis Creek, Fayette County, Alabama; and Clear Creek from its confluence with North River to Bays Lake Dam, Fayette County, Alabama.

In Jefferson and Blount Counties, Alabama, stream and river channels within the ordinary high water line of the Locust Fork main stem from U.S. Highway 78, Jefferson County, upstream to the confluence of Little Warrior River, Blount County, Alabama; and Little Warrior River from its confluence with the Locust Fork, upstream to the confluence of Calvert Prong and Blackburn Fork, Blount County, Alabama.

In Jefferson, Shelby, and Bibb Counties, Alabama, stream and river channels within the ordinary high water line of the Cahaba River from U.S. Highway 82, Centerville, Bibb County, upstream to Jefferson County Road 143, Jefferson County, Alabama; and the Little Cahaba River from its confluence with the Cahaba River, upstream to the confluence of Mahan and Shoal Creeks, Bibb County, Alabama.

In Autauga, Lowndes, and Dallas Counties, Alabama, stream and river channels within the ordinary high water line of the Alabama River from the confluence of the Cahaba River, Dallas County, upstream to the confluence of Big Swamp Creek, Lowndes County, Alabama.

In Dallas County, Alabama, stream and river channels within the ordinary high water line of the Bogue Chitto Creek main stem from its confluence with the Alabama River, Dallas County, upstream to U.S. Highway 80.

Primary constituent elements identified at the time of designation included: 1. Geomorphically stable stream and river channels and banks; 2. A flow regime (i.e., the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of mussels and their fish hosts in the river environment; 3. Water quality, including temperature, pH, hardness, turbidity, oxygen content, and other chemical characteristics necessary for normal behavior, growth, and viability of all life stages; 4. Sand, gravel, and/or cobble substrates with low to moderate amounts of fine sediment, low amounts of attached filamentous algae, and other physical and chemical characteristics necessary for normal behavior, growth, and viability of all life stages; 5. Fish hosts with adequate living, foraging, and spawning areas for them; and 6. Few or no competitive or predaceous nonnative species present.

PAST THREATS:
The abundance and distribution of the orangenacre mucket decreased historically from human-induced habitat loss and degradation caused by impoundments, sedimentation and turbidity, channelization and dredging, mining (coal, sand, gravel, or gold) (Jones 1991, USFWS 1993, Leigh 1994, ADEM 1994), and contaminants contained in numerous point (e.g., carpet mills and fabric dying mills) (Hurd 1974) and nonpoint sources (USFWS 2000). Channel modifications and water pollution gradually eliminated this native species that is dependent on a narrow range of flowing water habitat conditions from extensive portions of its former range within the Mobile River Basin. These habitat changes have resulted in significant extirpations (localized loss of populations), restricted and fragmented distributions, and poor recruitment of young.

CURRENT THREATS:
Habitat modification, sedimentation, eutrophication, and water quality degradation are the primary causes of decline of the orangenacre mucket. This species can not tolerate

impoundment or channelization. Surviving populations are threatened by urban and agricultural runoff, surface mine drainage, small stream impoundment projects, industrial and sewage treatment plant discharges, and channel degradation caused by sand and gravel mining. Superconglutinate lures would obviously be most effective in streams and rivers with low turbidity. The current distribution indicates that historic and gradual increases in chronic turbidity levels may be an important factor in the decline of the orange-nacre mucket.

Recovery of the orangenacre mucket to the point of delisting is unlikely in the near future. The immediate recovery objective is to prevent the continued decline of this species by locating, protecting, and restoring stream drainages with extant populations.

Exposure Scenario Summary Table for the Orange-nacre Mucket

Species	**Life Stage**	**Habitat Type**	**Exposure Route**	**Diet**	**Significant Interspecies Relationships**
Orange-nacre Mucket	glochidia	parasite	contact with water, diet	fish body fluids	redeye bass, spotted bass, and largemouth bass
	juvenile/ adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

ARKANSAS FATMUCKET
Lampsilis powelli

STATUS:
On April 5, 1990, the Arkansas fatmucket mussel was designated as threatened throughout its entire range in Arkansas (USFWS 1987). A recovery plan for the Arkansas fatmucket was approved on February 10, 1992 (USFWS 1992).

SPECIES DESCRIPTION:
The Arkansas fatmucket is a medium-sized (sometimes reaching over 100 mm in length) freshwater mussel with a smooth, shiny olive brown to tawny shell without rays (USFWS 1992). Like other freshwater mussels, the Arkansas fatmucket feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and

zooplankton (Churchill and Lewis 1924). The diet of Arkansas fatmucket glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the Arkansas fatmucket is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. Gravid females have been observed in January, February, and April (Harris and Gordon 1990). Members of the genus *Lampsilis* have a distinctive mantle flap with a pigment spot resembling a small minnow to entice fish close enough for the glochidia to attach (USFWS 1992). Adults of this species are sexually dimorphic (Johnson 1980). Two glochidial fish hosts, spotted bass (*Micropterus punctulatus)* and largemouth bass (*Micropterus salmoides*), have been identified (Scott et al., 2004).

RANGE AND POPULATION LEVEL:
The historic range of this species likely included the Caddo River from Norman downstream to the Ouachita River, including at least the lower reach of the South Fork Caddo River; however, collection records on which to base historical distribution information do not exist. The most current information for the species indicates that the Arkansas fatmucket is known to exist in the Ouachita, Saline, and Caddo River systems. In the Ouachita Basin, this species occurs in the Ouachita River (upstream of Lake Ouachita in Montgomery and Polk Counties) and in the South Fork Ouachita River (upstream of Lake Ouachita in Montgomery County). In the Saline River Basin, the species occurs in Alum Fork, the Middle Fork, and the North Fork above their confluence with the Saline River, and in the Saline River from its formation downstream to about the Fall Line. The species does not occur in the South Fork of the Saline River or in Hurricane Creek, a major tributary, but it probably did historically. In the Caddo River, the Arkansas fatmucket is known from three locations, all of which are in the mainstem (USFWS 1992).

HABITAT:
The Arkansas fatmucket prefers deep pools and backwater areas that possess sand, sand-gravel, sand-cobble, or sand-rock with sufficient flow to periodically remove organic detritus, leaves, and other debris. It is not generally found in riffles nor does it occur in impoundments. It is frequently found adjacent to islands of *Justicia americana* (water willow) where substrate is typically depositional and water depth is about 1 meter (3.2 feet) (Harris and Gordon 1988, USFWS 1992).

PAST THREATS:
The range of the Arkansas fatmucket has been curtailed and continues to be threatened by impoundments, channel alteration, gravel dredging, sedimentation, and water quality degradation. In the Ouachita River, the range has been reduced by the construction of Lakes Ouachita, Hamilton, and Catherine and the hypolimnetic water releases from these impoundments. In the Caddo River, the impoundment of DeGray Reservoir and resulting

hypolimnetic water releases have impacted what was probably the uppermost historic habitat for the species in this system (USFWS 1992). A part of the Ouachita River Basin Comprehensive Study by the U.S. Army Corps of Engineers includes a feasibility study for one or more impoundments for flood control and other purposes on the Saline River near Benton (Harris and Gordon 1988). The Natural Resources Conservation Service (NRCS) has constructed two impoundments on a tributaries of the South Fork Ouachita River and plans a third impoundment on the mainstem South Fork Ouachita River (Harris and Gordon 1988). While these NRCS impoundments have not directly inundated known populations of this species, impacts have occurred during the construction and operation of these impoundments that have resulted in population declines. Construction of the third reservoir on the mainstem of the South Fork Ouachita River could cause the loss of the South Fork Ouachita River population (USFWS 1992). In the South Fork Ouachita River, there is evidence of adverse impacts to a population from channel alteration as a result of highway repairs occurring in 1984-1985. In addition, small gravel operations are common within the range of the Arkansas fatmucket and many streams are impacted by the removal of preferred substrate and by the resulting downstream sedimentation. The Saline River downstream of Benton has been severely impacted by gravel dredging (Harris and Gordon 1988).

Water quality degradation apparently is responsible for the absence of the Arkansas fatmucket from a significant area within the species= probable historic range. The South Fork Caddo River receives runoff from a barite mining operation. Prairie Creek, a tributary of the Ouachita River, receives improperly treated municipal waste (Harris and Gordon 1988). Hurricane Creek and Lost Creek of the Saline River drainage receive acid mine runoff from bauxite mines. Additionally, nonpoint source pollution occurs in varying degrees from feedlot runoff, timber harvest, road construction, and fertilization for agriculture in all three river basins where this species is found (USFWS 1990, 1992).

CURRENT THREATS:
Remaining habitat in the Ouachita and Caddo Rivers may be less than satisfactory for this species. Many of the threats described above remain relevant today. Genetic isolation of remaining populations remains a threat to their continued existence. The two populations in the Ouachita River System are isolated from all other populations and each other by Lake Ouachita. The Caddo River population is separated from the Saline River populations by about 200 river miles. If populations still exist in the Caddo River upstream of DeGray Reservoir, they are isolated by that impoundment. The Saline River system populations are not isolated from each other by any apparent barrier; however, if the fish host is not migratory, the exchange of genetic material between these populations would be unlikely given their geographic separation (USFWS 2003). Other current threats to freshwater mussels are described in the General Mussel Document.

Exposure Scenario Summary Table for the Arkansas fatmucket

Species	Life Stage	Habitat	Exposure	Diet	Significant

		Type	Route		Interspecies Relationships
Arkansas fatmucket	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	largemouth bass spotted bass
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

SPECKLED POCKETBOOK
Lampsilis streckeri

STATUS:
On February 28, 1989, the speckled pocketbook was designated as endangered throughout its entire range in Arkansas (USFWS 1989). A recovery plan for the speckled pocketbook was approved January 2, 1992 (USFWS 1992).

SPECIES DESCRIPTION:
The speckled pocketbook is a medium-sized (reaching approximately 80 mm in length) freshwater mussel with a thin, dark-yellow or brown shell with chevron-like spots, and chain-like rays (USFWS 1989). Like other freshwater mussels, the speckled pocketbook feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of speckled pocketbook glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the speckled pocketbook is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. The speckled pocketbook was recently determined to be bradytictic and gravid females were observed in August with release of glochidia in late February through early June (Winterringer et al. 2002). Recent studies of the potential suitability of 22 fish species indicated that glochidia tested on all sunfishes (Centrarchidae) successfully transformed, with greatest success with the green sunfish (*Lepomis cyanellus*) (Winterringer 2003). Other successful transformations occurred on the bluegill (*L. macrochirus*), warmouth (*L. gulosus*), longear sunfish (*L. megalotis*), and spotted

bass (*Micropterus punctulatus*), with marginal transformation on the smallmouth bass (*M. dolomieu*) and shadow bass (*Ambloplites ariommus*).

RANGE AND POPULATION LEVEL:
Historically, populations occurred in Archey, Middle, and South Forks of the Little Red River, Van Buren County, Arkansas (Clarke 1987, USFWS 1991). Within the Little Red River drainage, the only known remaining population is in the Middle Fork. In the Middle Fork, the known range extends from the influence of Greers Ferry Reservoir near Shirley, Arkansas, upstream to Leslie, Arkansas CreekUpstream of Leslie, the Middle Fork is reduced to intermittent flows during dry periods (Winterringer, 2002, Stewart 1988). Clarke (1987) did not find the speckled pocketbook in the Middle Fork downstream of the confluence of Tick Creek; however, live specimens were found there in 1991 (USFWS 1992). Recent surveys indicate that the population remaining in the Middle Fork is stable and the species has been documented in 83 of 124 total river kilometers (Winterringer et al. 2003).

HABITAT:
Clarke (1987) and Harris (1992) found this species in coarse sand and sand/gravel with a constant flow of water. A secondary habitat type was identified by Harris (1992) in pools with substrates that consisted of crevices between large rocks and boulders which had some accumulation of sand/gravel.

PAST THREATS:
The speckled pocketbook once occurred in the stretch of the Little Red River now impounded by Greers Ferry Reservoir, and in the area downstream of the reservoir that is now altered by cold (hypolimnetic) discharges. The lentic conditions imposed by the reservoir and the hypolimnetic discharges undoubtedly eliminated any speckled pocketbook population in this stretch of river. Archey and South Forks have been modified for flood control. The modification of these channels are the likely cause of the species' disappearance from these tributaries. The small population of speckled pocketbooks in the South Fork, below the confluence with Archey Fork, apparently has been extirpated by floods scouring the mussel's habitat (Clarke 1987). This scouring likely results from increased water velocity due to channel modification upstream (USFWS 1992).

CURRENT THREATS:
The Middle Fork population's available habitat is limited upstream by low or non-existent water flows during the dry months of the year. Much of Archey and South Forks have intermittent water flows during dry seasons, which may be partially due to channel modification for flood control and gravel removal. The population is so limited that isolated gene pools are likely and loss of genetic variability increases susceptibility to environmental disturbance. The reduced density of the population decreases the likelihood of successful reproduction (USFWS 1992). Other current threats to freshwater mussels are described in the General Mussel Document.

Exposure Scenario Summary Table for the speckled pocketbook

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
speckled pocketbook	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	Bluegill Green sunfish Warmmouth Longear sunfish Spotted bass Smallmouth bass Shadow bass
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

SHINYRAYED POCKETBOOK

Lampsilis subangulata

STATUS:
On March 16, 1998, the shinyrayed pocketbook was designated as Endangered throughout its range (USFWS 1998). A recovery plan for the shinyrayed pocketbook was finalized on October 1, 2003 (USFWS 2003). A 5-Year Review was approved for the shinyrayed pocketbook on September 17, 2007. Critical habitat was designated for the shinyrayed pocketbook on November 15, 2007 (72 FR 64285).

SPECIES DESCRIPTION:
The shinyrayed pocketbook is a medium-sized mussel that reaches approximately 8.4 cm (3.3 in) in length. . The U.S. Fish and Wildlife Service recognizes *Unio subangulatus* (Lea, 1840), and *Unio kirklandianus* (Wright, 1897), as synonyms of *Lampsilis subangulata.*

Like other freshwater mussels, adults are filter-feeders, orienting themselves in the substrate to facilitate siphoning of the water column for oxygen and food (Kraemer 1979). Mussels have been reported to consume detritus, diatoms, phytoplankton, zooplankton, and other microorganisms (Coker et al. 1921, Churchill and Lewis 1924, Fuller 1974). Juvenile mussels employ foot (pedal) feeding, and are thus suspension feeders (Yeager et al. 1994). Foods of juvenile freshwater mussels up to two weeks old include bacteria, algae, and diatoms with amounts of detrital and inorganic colloidal particles (Yeager et al. 1994). Specific food habits of the shinyrayed pocketbook are unknown, but are likely similar to those of other freshwater mussels.

REPRODUCTION AND DEVELOPMENT:

O'Brien and Brim Box (1999) summarized the reproductive biology of the shinyrayed pocketbook. This species is one of four lampsiline species known to produce a superconglutinate to attract potential fish hosts. Gravid females are found from December through August and superconglutinates are released from late May to early July at water temperatures of 71.6 to 74.3 degrees Fahrenheit. Although apparently mature glochidia are present in the marsupia after the end of the superconglutinate season, they could not get them to transform during a single test trial with largemouth bass (see below). They suggested that nearly an entire year is needed by the incubating glochidia to reach full maturity. This indicates that the shinyrayed pocketbook is a parent overwintering, summer releasing species. Primary host fishes for the shinyrayed pocketbook based on their laboratory infections appear to be largemouth bass (*Micropterus salmoides)* and spotted bass (*Micropterus punctulatus)* (100 percent transformation rates on fishes tested), although transformations also occurred in low percentages on eastern mosquitofish (*Gambusia holbrooki)*, bluegill (*Lepomis macrochirus)*, and the nonindigenous guppy (*Poecilia reticulata)* that were tested. Glochidia metamorphosed in 11 to 16 days on the basses at a temperature of 72.5 $\pm$ 4.5 degrees Fahrenheit.

RANGE AND POPULATION LEVEL:

The shinyrayed pocketbook was described from the Chattahoochee River, Columbus, Muscogee County, Georgia. Historically, this species was widely distributed in streams in the Apalachicola-Chattahoochee-Flint (ACF) River basin and Ochlockonee River systems in Alabama, Florida, and Georgia (Heard 1977, Williams and Butler 1994, Brim Box and Williams 2000). van der Schalie (1940), Clench and Turner (1956), and Burch (1975) erroneously reported it from the Choctawhatchee River system; their records were actually based on the closely related southern sandshell (Williams and Butler 1994).

This species has apparently been extirpated from the Chattahoochee River main stem (although relic specimens were found in 1999) and several of its tributaries, including Mill, Little Uchee, Cowikee, and Kirkland Creeks. Historically, 23 collections were known from this subsystem (Brim Box and Williams 2000). Several streams in the Flint River system have also presumably lost their shinyrayed pocketbook subpopulations, including Patsiliga, Gum, Fowlton, and Dry Creeks. The shinyrayed pocketbook has apparently been extirpated in Mosquito Creek, a tributary to the Apalachicola River. In the Chipola River system, subpopulations are no longer known from Cowarts, Spring (near Marianna), and Rocky Creeks. Although Brim Box and Williams (2000) reported no live specimens from the Chipola River main stem during the early 1990s status survey, USFWS personnel documented living shinyrayed pocketbooks at four Chipola River main stem sites in 2000 (J. Ziewitz, USFWS, pers. obs.). This species is extirpated from the Little River and from the lower Ochlockonee River system below Talquin Dam.

Uchee Creek is one of two remaining subpopulations known from Alabama, while Sawhatchee Creek is the only other shinyrayed pocketbook subpopulation known from the entire Chattahoochee River system. This mussel persists in the uppermost Flint River main stem, and in Line, Whitewater, Swift, Jones, Abrams, Mill, Muckalee, Lanahassee, Kinchafoonee, Ichawaynochaway, Chickasawhatchee, Aycocks, Coolewahee, and Spring Creeks. Small subpopulations are also known from the upper half of the Chipola River main stem and its

tributaries, Big, Waddells Mill, Baker, and Dry Creeks. Ochlockonee River system subpopulations are known from the upper half of the main stem, the Little Ochlockonee River, Barnetts Creek, and West Branch Barnetts Creek. Overall, the shinyrayed pocketbook is thought to persist at 45 sites in seven different watersheds (Table 2, USFWS, 2003).

Relative subpopulation size for shinyrayed pocketbook is generally low (USFWS 2003). An average of 2.9 live specimens of the shinyrayed pocketbook was found at each of 23 sites during the status survey (USFWS 1998). O'Brien and Brim Box (1999) recorded adult densities of the largest known subpopulation of the shinyrayed pocketbook (Cooleewahee Creek) to be 0.02 specimens per square foot in a bed measuring 59 x 26 feet. Densities of shinyrayed pocketbooks at four other sites where quantitative work was conducted in the Flint and Chipola Rivers yielded no more than 0.01 specimens per square foot (J. Brim Box, USGS, unpub. data). At four sites within approximately a two-mile stretch of the Chipola River, 27 shinyrayed pocketbooks were documented in 2000 (J. Ziewitz, USFWS, pers. obs.).

HABITAT:
The shinyrayed pocketbook inhabits small to medium-sized creeks to rivers in clean or silty sand substrates in slow to moderate current (Williams and Butler 1994; Garner, pers. comm. 2003). Specimens are often found in the interface of stream channel and sloping bank habitats, where sediment particle size and current strength are transitional. Clench and Turner (1956) noted it preferred small creeks and spring-fed rivers. During the status survey in the ACF Basin, 45 percent of the specimens were found in a sand/rock substrate, while 38 percent were associated with a predominance of sand/clay or sandy substrates (Brim Box and Williams 2000).

CRITICAL HABITAT:
In Houston County, Alabama, and in Calhoun, Gulf, and Jackson counties, Florida, stream and river channels within the ordinary high water line of the main stem of the Chipola River and seven of its tributaries.

In Russell County, Alabama, stream and river channels within the ordinary high water line of the main stem of Uchee Creek from its confluence with the Chattahoochee River upstream 34.2 km to Island Creek

In Early County, Georgia, stream and river channels within the ordinary high water line of the main stems of Sawhatchee and Kirkland creeks, and one tributary, encompassing a total stream length of 37.8 km.

In Coweta, Crawford, Crisp, Dooly, Fayette, Macon, Meriwether, Peach, Pike, Spalding, Sumter, Talbot, Taylor, Upson, and Worth counties, Georgia, stream and river channels within the ordinary high water line of the Flint River from the State Highway 27 bridge in Dooly and Sumter counties, Georgia, upstream 247.4 km through Macon, Peach, Taylor, Crawford, Talbot, Upson, Pike, Meriwether, and Coweta counties, to Horton Creek in Fayette and Spalding counties, Georgia; Swift Creek from Lake Blackshear upstream 11.3 km to Rattlesnake Branch, Crisp and Worth counties, Georgia; Limestone Creek from Lake Blackshear, Crisp County, Georgia, upstream 8.8 km to County Road 89, Dooly County, Georgia; Turkey Creek from the

Flint River upstream 21.7 km to Rogers Branch, in Dooly County, Georgia; Pennahatchee Creek from Turkey Creek upstream 4.8 km to Little Pennahatchee Creek, Dooly County, Georgia; Little Pennahatchee Creek from Pennahatchee Creek upstream 5.8 km to Rock Hill Creek, Dooly County, Georgia; Hogcrawl Creek from the Flint River upstream 21.6 km to Little Creek, Dooly and Macon counties, Georgia; Red Oak Creek from the Flint River upstream 21.7 km to Brittens Creek, Meriwether County, Georgia; Line Creek from the Flint River upstream 15.8 km to Whitewater Creek, Coweta and Fayette counties, Georgia; and Whitewater Creek from Line Creek upstream 21.5 km to Ginger Cake Creek, Fayette County, Georgia.

In Dougherty, Lee, Marion, Schley, Sumter, Terrell, Webster, and Worth counties, Georgia, stream and river channels within the ordinary high water line of the Flint River from Piney Woods Creek in Dougherty County, Georgia, upstream 39.9 km to the Warwick Dam, Lee and Worth counties, Georgia; Kinchafoonee Creek from its confluence with Lake Worth at the Lee--Dougherty county line, upstream 107.6 km through Terrell and Sumter Counties, Georgia, to Dry Creek, Webster County, Georgia; Lanahassee Creek from Kinchafoonee Creek upstream 9.3 km to West Fork Lanahassee Creek, Webster County, Georgia; Muckalee Creek, from its confluence with Lake Worth at the Lee--Dougherty county line, upstream 104.5 km to County Road 114, Marion County, Georgia; Little Muckalee Creek, from Muckalee Creek in Sumter County, Georgia, upstream 7.2 km to Galey Creek, Schley County, Georgia; Mill Creek from the Flint River upstream 3.2 km to Mercer Millpond Creek, Worth County, Georgia; Mercer Millpond Creek from Mill Creek upstream 0.45 km to Mercer Mill Pond, Worth County, Georgia; Abrams Creek from the Flint River upstream 15.9 km to County Road 123, Worth County, Georgia; Jones Creek from the Flint River upstream 3.8 km to County Road 123, Worth County, Georgia; and Chokee Creek, from the Flint River upstream 10.5 km to Dry Branch Creek, Lee County, Georgia.

In Baker, Calhoun, Decatur, Dougherty, Early, Miller, Mitchell, and Terrell counties, Georgia, stream and river channels within the ordinary high water line of the Flint River from its confluence with Big Slough , Decatur County, Georgia, upstream 116.4 km through Baker and Mitchell Counties, Georgia, to the Flint River Dam, Dougherty County, Georgia; Spring Creek, from its confluence with Lake Seminole at Smith Landing, Decatur County, Georgia, upstream 74.2 km to County Road 35, Early County, Georgia; Aycocks Creek from Spring Creek upstream 15.9 km to Cypress Creek, Miller County, Georgia; Dry Creek from Spring Creek upstream 9.9 km to Wamble Creek , Early County, Georgia; Ichawaynochaway Creek from the Flint River, Baker County, Georgia, upstream 68.6 km to Merrett Creek, Calhoun County, Georgia; Mill Creek from Ichawaynochaway Creek upstream 7.4 km to County Road 163, Baker County, Georgia; Pachitla Creek, from Ichawaynochaway Creek upstream 18.9 km to Little Pachitla Creek, Calhoun County, Georgia; Little Pachitla Creek from Pachitla Creek upstream 5.8 km to Bear Branch, Calhoun County, Georgia; Chickasawhatchee Creek from Ichawaynochaway Creek, Baker County, Georgia, upstream 64.5 km to U.S. Highway 82, Terrell County, Georgia; and Cooleewahee Creek from the Flint River upstream 15.1 km to Piney Woods Branch, Baker County, Georgia.

In Gadsden and Leon counties, Florida, and in Grady and Thomas counties, Georgia, stream and river channels within the ordinary high water line of the main stem of the Ochlockonee River upstream of Lake Talquin and three tributaries.

Primary constituent elements identified at the time of designation included: (1) Space for individual and population growth and for normal behavior; (2) Food, water, air, light, minerals, or other nutritional or physiological requirements; (3) Cover or shelter; (4) Sites for breeding, reproduction, or rearing (or development) of offspring; and (5) Habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species.

PAST THREATS:
The abundance and distribution of the shinyrayed pocketbook decreased historically from habitat loss and degradation (Williams et al. 1993, Neves 1993) caused by impoundments, sedimentation and turbidity, dredging and channelization, gravel mining, and contaminants contained in numerous point and nonpoint sources. A comprehensive review of these past threats is provided elsewhere (USFWS 2003, Brim Box and Williams 2000, Butler 1993, Howard 1997, Frick et al. 1998, Buell and Couch 1995, Richter 1997, Watters 1997, Neves et al. 1997). However, the histories of anthropogenic impacts specifically to the Ochlockonee river drainage have not been summarized. These habitat changes have resulted in significant extirpations (localized loss of populations), restricted and fragmented distributions, and poor recruitment of young.

CURRENT THREATS:
Habitat loss and degradation (Williams et al. 1993, Neves 1993) primarily caused by contaminants contained in point and nonpoint source discharges, gravel mining, sedimentation and erosive land practices, water quantity and withdrawal, construction of new impoundments and alien species are primary threats to the shinyrayed pocketbook.

Sediment samples from various ACF Basin streams tested for heavy metals that are known to be deleterious to mussels had concentrations markedly above background levels (Frick et al. 1998), among those were copper (throughout the Piedmont), and cadmium (large Coastal Plain tributaries of the Flint River). Past episodes of significant heavy metal contamination of ACF Basin streams may continue to impact mussel faunas. An estimated 950 million gallons of chemical-laden rinse, stripping, cleaning, and plating solutions were discharged indirectly into the Flint River (P. Laumeyer, USFWS, pers. comm., 1994) over a several year period. Concentrations of heavy metals (e.g., chromium and cadmium) in Asian clam, *Corbicula fluminea* (Muller 1774), and sediment samples were elevated downstream from two abandoned battery salvage operations on the Chipola River (Winger et al. 1985). Chromium concentrations found in sediments from Dead Lake downstream in the Chipola River (Winger et al. 1985) are known to be toxic to mussels (Havlik and Marking 1987).

Agricultural sources of contaminants in the ACF and Suwannee basins include nutrient enrichment from poultry farms and livestock feedlots, and pesticides and fertilizers from row crop agriculture (Couch et al. 1996, Frick et al. 1998, Berndt et al. 1998). Nitrate concentrations

are particularly high in surface waters downstream of agricultural areas (Mueller et al. 1995; Berndt et al. 1998). A study by the U.S. Soil Conservation Service (USSCS; now the Natural Resources Conservation Service [NRCS]) in the Flint River system determined that between 72 and 75 percent of the nutrients entering Lake Blackshear were derived from agricultural sources (USSCS 1993). Stream ecosystems are impacted when nutrients are added at concentrations that cannot be assimilated (Stansbery 1995). The effects of pesticides on mussels may be particularly profound (Fuller 1974, Havlik and Marking 1987, Moulton et al. 1996, Fleming et al. 1995). Organochlorine pesticides were found at levels in ACF Basin streams that often exceeded chronic exposure criteria for the protection of aquatic life (Buell and Couch 1995, Frick et al. 1998). Once widely used in the ACF Basin (Buell and Couch 1995), these highly toxic compounds are persistent in the environment, and are found in both sediments and the lipid reservoir of organisms (Day 1990, Burton 1992). Commonly used pesticides have been directly implicated in a North Carolina mussel dieoff (Fleming et al. 1995). Cotton is raised extensively in much of the Apalachicolan Region inhabited by these mussels. One of the most important pesticides used in cotton farming, malathion, is known to inhibit physiological activities of mussels (Kabeer et al. 1979) that may decrease the ability of a mussel to respire and obtain food. This chemical may pose a continuing threat to some populations of these mussels. Nutrients from aquaculture ponds may also have an impact on stream water quality. A large catfish farm is located in the floodplain of lower Cooleewahee Creek. Discharges of enriched pond water could negatively affect the largest known population of the shinyrayed pocketbook, which occurs in that stream.

Many pollutants in the ACF Basin originate from urban stormwater runoff, development activities, and municipal waste water facilities, primarily in the Piedmont (Frick et al. 1998). Urban catchments in Piedmont drainages have higher concentrations of nutrients, heavy metals, pesticides, and organic compounds than do agricultural or forested ones (Lenat and Crawford 1994, Frick et al. 1998), and at levels sufficient to significantly affect fish health (Ostrander et al. 1995). Within the Suwannee River basin, nutrient concentrations were greater in agricultural areas and nitrates were found to exceed U.S. Environmental Protection Agency (EPA) drinking water standards in 20 percent of the surficial aquifer groundwater samples (Berndt et al. 1998). Pesticide concentrations were found to exceed criteria for protection of aquatic life mostly in urban areas. Currently, there are discharges from 137 municipal waste water treatment facilities in the ACF River basin alone (Couch et al. 1996). Although effluent quality has improved with modern treatment technologies and a phosphate detergent ban, hundreds of miles of streams in the ACF and Ochlockonee basins in Alabama, Florida, and Georgia, as identified in reports prepared by the water quality agencies of these states under Section 305(b) of the Clean Water Act, do not meet water use classifications.

Since approximately 29 percent of the ACF Basin is in agriculture (Frick et al. 1998), sedimentation from agricultural sources is probably significant. According to USSCS (1993), 89 percent of the sediments entering Lake Blackshear on the Flint River are derived from agricultural sources. The lower Flint River system serves as the heart of numerous mussel species' range (including the shinyrayed pocketbook) and is a major agricultural center. This area has experienced "severe losses of topsoil and nutrient additions to local streams due to agriculture" (Neves et al. 1997), and has profoundly affected the biota of surface and ground

waters there (Patrick 1992). Despite the implications, only a few studies (e.g., Cooper 1987, Stewart and Swinford 1995) have specifically attributed changes in mussel populations to sediments derived from agricultural practices. Within the Suwannee basin, predominant sources of nutrient enrichment were inorganic fertilizers and animal wastes (Crandall 1996). A herd of cattle several score in size was observed to have direct access to a large spring and spring run adjacent the Chipola River just upstream of Florida Caverns State Park during the summer of 2000 (R.S. Butler, USFWS, pers. obs.). Although anecdotal, the shinyrayed pocketbook was found live during mussel sampling in the Chipola River upstream of the mouth of this spring run, but not downstream.

Gravel mining activities continue to threaten the shinyrayed pocketbook subpopulation from the Uchee Creek system (Howard 1997). These activities probably played a significant role in eliminating the Gulf moccasinshell and oval pigtoe from the same creek system.

Many southern streams have increased turbidity levels due to siltation (van der Schalie 1938a). The shinyrayed pocketbook attracts host fishes with visual cues, luring fish into perceiving that their glochidia are prey items. Such a reproductive strategy depends on clear water during the critical time of the year when mussels are releasing their glochidia (Hartfield and Hartfield 1996). Turbidity is a limiting factor impeding sight-feeding fishes (Burkhead and Jenkins 1991). In addition, mussels may be indirectly affected when turbidity levels significantly reduce light available for photosynthesis and the production of unionid food items (Kanehl and Lyons 1992).

Water quantity is becoming more of a concern in maintaining mussel habitat in the Apalachicolan Region. The potential impacts to mussels, their host fishes, and their respective habitats from ground water withdrawal may be profound. Within the Flint River basin, decreases in flow velocity and dissolved oxygen were highly correlated to mussel mortality (Johnson et al. 2001). Maintaining adequate water levels in streams is particularly important during the reproductive season for mussels. Drought-related responses could affect the long-term viability of mussel populations in the lower Flint River basin by decreasing the effectiveness of lures and interrupting the life cycle by hindering the process of glochidial release and attachment. For instance, superconglutinates of the shinyrayed pocketbook have been observed lying on the river bottom due to low flow rates (Johnson et al. 2001). Superconglutinates need to be suspended in current for their erratic “swimming” motions to attract the proper host fish. Approximately 150 specimens of the shinyrayed pocketbook were salvaged live from drought-ravaged segments of Spring Creek, Miller County, Georgia, during the summer 2000 drought (L. Andrews, and R.S. Butler, USFWS, pers. obs.). Large numbers were also found fresh dead in the dried stream bed, in mud holes, and in shrinking pools of water. Low DO conditions in stagnating stream pools due to drought conditions are having a disastrous effect on these mussels. Mussel mortality increases dramatically as DO decreases below 5 mg/L (Johnson et al. 2001). Rare species (e.g., shinyrayed pocketbook, oval pigtoe, and Gulf moccasinshell) were more susceptible to drought-related morality within the Flint River basin and had the highest mortality rates from hypoxic conditions (Johnson et al. 2001).

Exposure Scenario Summary Table for the Shinyrayed Pocketbook

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
Shinyrayed Pocketbook	glochidia	parasite	contact with water, diet	fish body fluids	largemouth bass, spotted bass
	juvenile/ adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

ALABAMA LAMPMUSSEL
Lampsilis virescens

STATUS:
On June 14, 1976, the Alabama lampmussel was designated as endangered throughout its entire range in Alabama and Tennessee (USFWS 1976), except where listed as experimental populations (in the free-flowing reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, AL) (USFWS 2001). A recovery plan for the Alabama lampmussel was approved in July 2, 1985 (USFWS 1985).

SPECIES DESCRIPTION:
The Alabama lampmussel is a medium-sized freshwater mussel (reaching approximately 60 mm in length) with a smooth and shiny greenish to yellow shell, sometimes with rays (USFWS 1985). Like other freshwater mussels, the Alabama lampmussel feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of Alabama lampmussel glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the Alabama lampmussel is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. The life history of this species is largely unknown. The Alabama lampmussel is likely a long-term brooder with spawning occurring in late summer and glochidial release the following spring or summer

(USFWS 1985). Specific glochidial host species for the Alabama lampmussel are not known (ESIE 1996).

RANGE AND POPULATION LEVEL:
The Alabama lampmussel, a Cumberlandian species, was historically known from seven drainages in the Tennessee River system. In Tennessee, the species was found in the Emory River (Roane and Morgan Counties) and Coal Creek (a tributary of the Clinch River). In Alabama, it was known from the Paint Rock River (Jackson County), Bear Creek (Franklin County), and Spring Creek (Lauderdale County) (Ortmann 1918, Bogan and Parmalee 1983, USFWS 1985). The Alabama lampmussel has also been reported from Crow Creek (Jackson County, AL) (Stansbery 1976). It was last collected from Mussel Shoals, an 85 km reach of the Tennessee River in Alabama, prior to 1925 (Ortmann 1925) and is presumed to be extirpated from the shoal. The species is also believed to be extirpated from all historic habitat areas in Tennessee (NatureServe 2003). Currently, the species is known to survive only in the upper Paint Rock River system, Jackson County, Alabama (Service 1985). Recent surveys indicate that the species may still be present in the mainstem of Paint Rock River as well as three major tributaries (Larkin Fork, Estill Fork, and Hurricane Creek) which are all located in Jackson County, Alabama (McGregor and Shelton 1995, Shelton 1997).

HABITAT:
The Alabama lampmussel prefers sand and gravel substrates in small to medium-sized streams (USFWS 1985). This species has also been found in swiftly moving waters in pools or riffles (NatureServe 2003).

PAST THREATS:
Many of the historic populations of the Alabama lampmussel were apparently lost when the river sections they inhabited were impounded. Impoundments on the Tennessee River have eliminated the majority of riverine habitat for the species in its historic range (ESIS 1996, USFWS 1985).

CURRENT THREATS:
The Alabama lampmussel is currently threatened by sedimentation, agricultural runoff, poor silviculture practices, and unrestricted cattle access in remaining habitat areas for this species (Godwin 1995). The Estill Fork area where the species may still be present has recently been affected by instream recreational vehicle use and unpermitted habitat alteration. Crushed Alabama lampmussel shells were found just below this construction site; however, the cause of mortality is undetermined (NatureServe 2003). Given the small size of the remaining Alabama lampmussel populations, any factor that adversely modifies habitat or water quality in the short reaches that the species inhabits could threaten its survival. Other current threats to freshwater mussels are described in the General Mussel document.

Exposure Scenario Summary Table for the Alabama lampmussel

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
Alabama lampmussel	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

CAROLINA HEELSPLITTER
Lasmigona decorata

STATUS:
On June 30, 1993, the Carolina heelsplitter was designated as endangered throughout its entire range in North Carolina and South Carolina (USFWS 1993). A recovery plan for the Carolina heelsplitter was approved on January 17, 1997 (USFWS 1997). Critical habitat was designated for the Carolina heelsplitter on July 2, 2002 (67 FR 44501). A 5-year Review for the Carolina heelsplitter was approved on July 28, 2006 (71 FR 42871).

SPECIES DESCRIPTION:
The Carolina heelsplitter can reach up to 4.6 inches in length, 1.6 inches in width, and 2.7 inches in height (Keferl 1991). Like other freshwater mussels, the Carolina heelsplitter feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of Carolina heelsplitter glochidia, like other freshwater mussels, comprises fish body fluids (once encysted). The Carolina heelsplitter's life span, the fish host species, and many other aspects of its life history are unknown (USFWS 1997).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the Carolina heelsplitter is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. They then detach from their fish host and sink to the stream bottom or other substrate where they continue to develop,

provided they land in a suitable substratum with the correct water conditions. A glochidial fish host species has not yet been identified for the Carolina heelsplitter (USFWS 1997).

RANGE AND POPULATION LEVEL:
The Carolina heelsplitter has been eliminated from the majority of its historical range, and only six populations are presently known to exist. In Union County, NC, one small remnant population occurs in Waxhaw Creek, a tributary to the Catawba River, and another small population occurs in both Goose Creek, a tributary in the Rocky River, and Duck Creek, a tributary to Goose Creek, in the Pee Dee River system. In South Carolina, there are four small surviving populationBone each in the Pee Dee and Catawba River systems and two in the Savannah River system. The population in the Pee Dee River system occurs in a relatively short reach of the Lynches River in Chesterfield, Lancaster, and Kershaw Counties and extends into Flat Creek, a tributary to the Lynches River in Lancaster County. In the Catawba River system, the species survives only in a short reach of Gills Creek in Lancaster County. In the Savannah River system, one population is found in Turkey Creek in Edgefield and McCormick Counties, and two of its tributaries, Mountain Creek and Beaverdam Creek in Edgefield County; another smaller population survives in Cuffytown Creek, in Greenwood and McCormick Counties. Despite extensive surveys in recent years, no evidence of a population has been found in the Saluda River system (Keferl and Shelly 1988; Keferl 1991; Alderman 1998a; USFWS 2002).

HABITAT:
Presently, the species is known to occur in only nine small streams and one small river. It has been recorded from a variety of substrates (including mud, clay, sand, gravel, and cobble/boulder/bedrock) without significant silt accumulations, along stable, well-shaded stream banks (Keferl and Shelly 1988, Keferl 1991). However, individuals have also been found near the center of the stream channel in relatively silt-free substrates comprised primarily of a mixture of sand, gravel, and cobble, with scattered areas of exposed boulders/bedrock (J. Fridell personal observation, 1995). It is conceivable that this is the preferred habitat type for the species and that in other areas scouring and degradation of the gravelly substrate in the center of the channel has restricted the species to the softer substrates found along the portion of the stream banks that receive less scouring (USFWS 1997). The stability of the stream banks and stream bottom appears to be a habitat feature essential to the species. Keferl (1991) noted that in his surveys of Goose, Waxhaw, and Flat Creeks and the Lynches River, he found the highest concentrations of the species in (bank) undercuts and along shaded banks stabilized with extensive tree roots, a buried log, and rocks. The best populations are typically found in areas with significant woodland as a dominant land use. The species appears to exist in creeks or small rivers near or within the transition from Piedmont to Coastal Plain / Sandhills physiographic regions (Alderman 1998a). Past records indicate this mussel may have also inhabited mill ponds (NatureServe 2003).

CRITICAL HABITAT:
In Union County, NC, stream and river channels within the ordinary high water line of the main stem of Goose Creek, from the N.C. Highway 218 Bridge, downstream to its confluence with the Rocky River, and approximately 8.8 km (5.5 mi) of the main stem of Duck Creek, Union County, NC, from the Mecklenburg/Union County line downstream to its

confluence with Goose Creek; stream and river channels within the ordinary high water line of the main stem of Waxhaw Creek, from the N.C. Highway 200 Bridge, downstream to the North Carolina/ South Carolina State line.

In Lancaster County, SC, stream and river channels within the ordinary high water line of the main stem of Gills Creek, from the County Route S–29–875, downstream to the S.C. Route 51 Bridge, east of the city of Lancaster.

In Lancaster, Chesterfield, and Kershaw Counties, SC, stream and river channels within the ordinary high water line of the main stem of Flat Creek, Lancaster County, SC, from the S.C. Route 204 Bridge, downstream to its confluence with the Lynches River, and approximately 23.6 km (14.6 mi) of the main stem of the Lynches River, Lancaster and Chesterfield Counties, SC, from the confluence of Belk Branch, Lancaster County, northeast (upstream) of the U.S. Highway 601 Bridge, downstream to the S.C. Highway 903 Bridge in Kershaw County, SC.

In Edgefield and McCormick Counties, S, stream and river channels within the ordinary high water line of the main stem of Mountain Creek, Edgefield County, SC, from the S.C. Route 36 Bridge, downstream to its confluence with Turkey Creek; approximately 10.8 km (6.7 mi) of Beaverdam Creek, Edgefield County, from the S.C. Route 51 Bridge, downstream to its confluence with Turkey Creek; and approximately 18.4 km (11.4 mi) of Turkey Creek, from the S.C. Route 36 Bridge, Edgefield County, downstream to the S.C. Route 68 Bridge, Edgefield and McCormick Counties, SC.

In Greenwood and McCormick Counties, SC, stream and river channels within the ordinary high water line of the main stem of Cuffytown Creek, from the confluence of Horsepen Creek, northeast (upstream) of the S.C. Route 62 Bridge in Greenwood County, SC, downstream to the U.S. Highway 378 Bridge in McCormick County.

Primary constituent elements identified at the time of designation included: (1) Permanent, flowing, cool, clean water; (2) Geomorphically stable stream and river channels and banks; (3) Pool, riffle, and run sequences within the channel; (4) Stable substrates with no more than low amounts of fine sediment; (5) Moderate stream gradient; (6) Periodic natural flooding; and (7) Fish hosts, with adequate living, foraging, and spawning areas for them.

PAST THREATS:
Available information indicates that several factors have contributed to the decline and loss of populations of the Carolina heelsplitter, and threaten the remaining populations. These factors include pollutants in wastewater discharges (sewage treatment plants and industrial discharges); habitat loss and alteration associated with impoundments, channelization, and dredging operations; channel and streambank scouring associated with increased storm-water runoff; and the runoff of silt, fertilizers, pesticides, and other pollutants from various land disturbance activities with inadequate or poorly maintained erosion and stormwater control (USFWS 1993, 1997). Many of the streams in the area of Charlotte, NC, that are known to have historically supported the Carolina heelsplitter, have been degraded by a combination of the factors listed above and appear to no longer support, or be capable of supporting, any species of native

mussels. Additionally, large reaches of the main stems of the Pee Dee, Catawba, Saluda, and upper Savannah Rivers, that likely once supported the Carolina heelsplitter, have been significantly affected by impoundments, as well as the other factors listed above, and have lost much of their historic freshwater mussel abundance and diversity (Keferl and Shelly 1988; Kerfel 1991; Alderman 1995, 1998a, 1998b; USFWS 2002).

CURRENT THREATS:
The low number of individuals and the restricted range of each of the surviving populations make them extremely vulnerable to extirpation from a single catastrophic event or activity, such as a toxic chemical spill or major channel alteration. Also, the existing and potential future land-uses of the surrounding area threaten the habitat and water quality of all remaining populations with increased discharge or runoff of silt, sediments, and organic and chemical pollutants. Land-clearing and disturbance activities implemented without proper sedimentation control pose a significant threat to the species= continued existence. In particular, the Waxhaw Creek, Lynches River, and Goose Creek populations are threatened by impacts associated with agriculture, logging, highway and residential and commercial construction and development activities. Goose Creek and the Lynches River is also suffering from heavy nutrient and pollutant loads from wastewater treatment plants, as well as from other point and nonpoint sources (USFWS 1993, 2002). Pollutant threats to freshwater mussels are described in the general description for mussels, above.

Exposure Scenario Summary Table for the Carolina heelsplitter

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
Carolina heelsplitter	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

SCALESHELL MUSSEL
Leptodea leptodon

STATUS:

The scaleshell mussel was listed as endangered on October 9, 2001 (66 FR 51322). The Scaleshell Mussel Draft Recovery Plan was completed August 6, 2004. Critical habitat has not been designated for this species.

SPECIES DESCRIPTION:
The scaleshell mussel is a medium-sized freshwater mussel belonging to the family Unionidae and reaches a length of approximately 10 centimeters (4 inches). Its general biology is believed to be similar to other bivalved mollusks. Adults are filter feeders, using their gills to filter out 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).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the scaleshell mussel is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water column, and within a few days they must attach to host fish to complete their life cycle. The scaleshell appears to utilize the freshwater drum (*Aplodinotus grunniens*) exclusively as a host for its larvae. 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. Based on recent collections, it appears that the life expectancy of the scaleshell is less than 10 years.

RANGE AND POPULATION LEVEL:
The scaleshell mussel once occurred in 55 rivers in the Mississippi River Drainage including 13 states. The species has undergone a dramatic reduction in range and currently only 14 rivers support very small populations in Arkansas, Missouri, and Oklahoma. Of the 14 rivers with extant populations, 13 are believed to be declining.

HABITAT:
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. Scaleshell requires good water quality, and is usually found where a diversity of other mussel species are concentrated.

PAST THREATS:
The scaleshell has been eliminated from all streams east of the Mississippi River and the entire upper Mississippi River drainage. Threats that caused the scaleshell's decline continue today.

CURRENT THREATS:
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. The major causes of such alteration are water pollution, sedimentation, channelization, sand and gravel mining, dredging,

and impoundments. The sessile 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 shorter 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.

Exposure Scenario Summary Table for the scaleshell mussel

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
scaleshell mussel	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	freshwater drum
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

LOUISIANA PEARLSHELL
Margaritifera hembeli

STATUS:
On February 5, 1988, the Louisiana pearlshell was designated as endangered in Louisiana (USFWS 1988). On September 24, 1993, the status of this species was reclassified from endangered to threatened based on discovery of new populations of the Louisiana pearlshell and an apparent reduced degree of threat for the species (USFWS 1993). A recovery plan for the Louisiana pearlshell was approved in December 3, 1990 (USFWS 1990).

SPECIES DESCRIPTION:
The Louisiana pearlshell is a medium-sized (reaching approximately 100 mm in length) freshwater mussel with a dark brown shell (USFWS 1990). Like other freshwater mussels, the Louisiana pearlshell feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of Louisiana pearlshell glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:

The reproductive cycle of the Louisiana pearlshell is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. Investigations of gonadal activity in the Louisiana pearlshell indicate that spawning likely occurs in late November and late January (Smith 1988). Hill (1986) identified potential glochidial host species for the Louisiana pearlshell including the striped shiner (*Notropis chrysocephalus*), the redfin shiner (*N. Umbratilis*), and the golden shiner (*Notemigonus crysoleucas*); however, the suitability of these species has not been confirmed (USFWS 1990). The brown madtom (*Noturus phaeus*) has also been identified as a suitable host for this species (Johnson and Brown 1998). Recent studies indicate that the species can reach a maximum age of 75 years (Johnson and Brown 1998).

RANGE AND POPULATION LEVEL:

The Louisiana pearlshell, previously known only from the Bayou Boeuf drainage in Rapides Parish, Louisiana, was recently discovered to also exist in the Red River drainage in Grant Parish (USFWS 1993). The Service conducted surveys of this drainage in 1991 and 1992 in an effort to completely define the range of the species. The 1991 survey located the species at 12 sites in eight streams that are tributary to the Red River. The 1992 survey (Hall 1992) confirmed these findings, extending the range within these streams, and searched more than 50 streams in Grant, Rapides, and Winn Parishes, Louisiana. Hall did not locate any additional populations of the species; however, within the Grant Parish portion of the range there are several streams that are on posted private property that were not surveyed and it is likely that additional populations of the Louisiana pearlshell occur there (USFWS 1993). The currently known range of this species now consists of eight streams in the Red River drainage and 11 streams in the Bayou Boeuf drainage (USFWS 1993). The extent of the known range of the species has increased substantially with the discovery of the Red River drainage populations where the presence of various size classes of the Louisiana pearlshell indicates that most, if not all, populations are successfully reproducing in this area (USFWS 1993).

HABITAT:

The Louisiana pearlshell prefers shallow, flowing waters and sand or gravel substrates (USFWS 1990). Individuals can be found in small creeks with stable substrates (NatureServe 2003), near consolidated grovel outcrops, or along longs or debris in the stream (Shively and Vermillion 1998). A recent habitat suitability analysis for the species indicated that they are rarely found in deep stagnant pools with silt-covered bottoms. The species was found to be most common in small streams with elevated conductivity and water hardness (Johnson and Brown 2000).

PAST THREATS:

The scattered occurrence of the Louisiana pearlshell in headwater streams suggests a historic range including most, if not all, of the Bayou Boeuf headwater systems, and that impoundments have eliminated populations intervening areas (USFWS 1990). Kincaid Reservoir impounds the uppermost headwaters of Bayou Boeuf. Inundation by beaver dams is a significant threat to the species as well and at least one population was eliminated due to beaver dam flooding (Matthews

and Moseley 1990). Habitat within the Kisatchie National Forest has been affected by sedimentation resulting from silviculture practices, road construction and maintenance, and cattle grazing under an open range policy. Sedimentation from gravel pit mining activities have also resulted in impacts to the species' habitat, particularly in the Indian Creek drainage (USFWS 1990). Due to the high visibility of this species in shallow waters where it is often evident protruding from the substrate, it is vulnerable to collection.

CURRENT THREATS:
The remaining threats to the species are similar to those listed above including sedimentation from gravel mining, population fragmentation from impoundments, and collection. Other current threats to freshwater mussels are described in the General Mussel Document.

Exposure Scenario Summary Table for the Louisiana pearlshell

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
Louisiana pearlshell	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	striped shiner* redfin shiner* golden shiner* brown madtom
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

* The striped shiner, redfin shiner, and golden shiner were identified as potential glochidial host species, but their suitability has not been confirmed (Hill 1986).

ALABAMA MOCCASINSHELL
Medionidus acutissimus

STATUS:
On March 17, 1993, the Alabama moccasinshell was designated as Threatened throughout its entire range (USFWS 1993). A recovery plan for the Alabama moccasinshell was finalized on November 17, 2000 (USFWS 2000). Critical habitat was designated for the Alabama moccasinshell on July 1, 2004 (69 FR 40083).

SPECIES DESCRIPTION:

The Alabama moccasinshell is a small, delicate species, approximately 30 mm (1.2 inches) in length. Like other freshwater mussels, adults are filter-feeders, orienting themselves in the substrate to facilitate siphoning of the water column for oxygen and food (Kraemer 1979). Mussels have been reported to consume detritus, diatoms, phytoplankton, zooplankton, and other microorganisms (Coker et al. 1921, Churchill and Lewis 1924, Fuller 1974). Juvenile mussels employ foot (pedal) feeding, and are thus suspension feeders (Yeager et al. 1994). Foods of juvenile freshwater mussels up to two weeks old include bacteria, algae, and diatoms with amounts of detrital and inorganic colloidal particles (Yeager et al. 1994). Specific food habits of the Alabama moccasinshell are unknown, but are likely similar to those of other freshwater mussels.

REPRODUCTION AND DEVELOPMENT:
Alabama moccasinshell females are gravid from October to June. This species lives completely embedded in stream bottoms for most of the year. Gravid females migrate to the surface of the stream bottom between March and June, anchor themselves to gravel by a bysal thread and lie exposed, displaying a black mantle lure apparently to attract potential host fish (P. Hartfield, USFWS, pers. obs. 1994; Haag and Warren 2001). Blackspotted topminnows *(Fundulus olivaceus)*, Tuskaloosa darter *(Etheostoma douglasi)*, redfin darter *(E. whipplei)*, blackbanded darter *(Percina nigrofaciata)*, Roanoke darter (*P. roanoka*), naked sand darter *(Ammocrypta beani)*, southern sand darter *(A. meridiana)*, johnny darter *(E. nigrum)*, speckled darter *(E. stigmaeum)*, rock darter *(E. rupestre)*, Gulf darter *(E. swaini)*, redspot darter *(E. artesiae)*, saddleback darter *(Percina vigil)*, and logperch *(P. caprodes)* have been identified as host fish (Haag and Warren 1997, 2001, 2003; Jones et al. 2004).

RANGE AND POPULATION LEVEL:
The Alabama moccasinshell was described from the Alabama River, Alabama. The Alabama moccasinshell was historically known from the Alabama, Tombigbee, Black Warrior, Cahaba, and Coosa Rivers and their tributaries in Alabama, Mississippi, Georgia, and Tennessee. The species has disappeared from the mainstems of all of these rivers, but continues to survive in Tombigbee River tributaries, including Bull Mountain Creek (Itawamba County, Mississippi), Luxapalila Creek (Lowndes County, Mississippi) and tributary Yellow Creek (Lowndes County, Mississippi; Lamar County, Alabama), Buttahatchee River (Lowndes/Monroe County, Mississippi, Lamar County, Alabama), and tributary Sipsey Creek (Monroe County, Mississippi), Lubbub Creek (Pickens County, Alabama) and Sipsey River (Greene/Pickens County, Alabama); Black Warrior River tributaries, including the Sipsey Fork and tributaries (Winston/Lawrence County, Alabama); and Holly Creek (Murray County, Georgia) in the Coosa River drainage (USFWS 2003). Except for the Sipsey Fork, populations are small and localized. Highest densities observed during field surveys have been from the Sipsey Fork and its headwater tributaries in Bankhead National Forest, where quantitative samples from selected sites estimated Alabama moccasinshells densities from 0 to 2.8/10 m^2 (Warren and Haag 1994).

HABITAT:
The species inhabits sand/gravel/cobble shoals with moderate to strong currents in streams and small rivers (USFWS 2000).

CRITICAL HABITAT:
In Itawamba County, Mississippi, stream and river channels within the ordinary high water line of the East Fork Tombigbee River main stem from Mississippi Highway 278, Monroe County, upstream to the confluence of Mill Creek.

In Itawamba County, Mississippi, stream and river channels within the ordinary high water line of Bull Mountain Creek from Mississippi Highway 25, upstream to U.S. Highway 78.

In Lowndes/Monroe County, Mississippi and Lamar County, Alabama, stream and river channels within the ordinary high water line of the Buttahatchee River main stem from its confluence with the impounded waters of Columbus Lake, Lowndes/Monroe County, Mississippi, upstream to the confluence of Beaver Creek, Lamar County, Alabama; and Sipsey Creek, from its confluence with the Buttahatchee River, upstream to the Mississippi/Alabama State Line, Monroe County, Mississippi.

In Lowndes County, Mississippi and Lamar County, Alabama, stream and river channels within the ordinary high water line of the Luxapalila Creek main stem from Waterworks Road, Columbus, Mississippi, upstream to approximately 1.0 km (0.6 mi) above Steens Road, Lowndes County, Mississippi; and the Yellow Creek main stem from its confluence with Luxapalila Creek, Lowndes County, Mississippi, upstream to the confluence of Cut Bank Creek, Lamar County, Alabama.

In Pickens County, Alabama, stream and river channels within the ordinary high water line of the Coalfire Creek main stem from its confluence with the impounded waters of Aliceville Lake, upstream to U.S. Highway 82.

In Pickens County, Alabama, stream and river channels within the ordinary high water line of the main stem of Lubbub Creek from its confluence with the impounded waters of Gainesville Lake, upstream to the confluence of Little Lubbub Creek

In Greene/Pickens and Tuscaloosa Counties, Alabama, stream and river channels within the ordinary high water line of the Sipsey River main stem from its confluence with impounded waters of Gainesville Lake, Greene/Pickens County, upstream to Alabama Highway 171 crossing, Tuscaloosa County, Alabama.

In Greene County, Alabama, stream and river channels within the ordinary high water line of the Trussels Creek main stem from its confluence with the impounded waters of Demopolis Lake, upstream to Alabama Highway 14.

In Sumter County, Alabama, stream and river channels within the ordinary high water line of the Sucarnoochee River main stem from its confluence with the Tombigbee River, upstream to the Mississippi/Alabama State Line.

In Winston and Lawrence Counties, Alabama, stream and river channels within the ordinary high water line of the Sipsey Fork main stem from the section 11/12 line, Winston County, Alabama,

upstream to the confluence of Hubbard Creek, Lawrence County, Alabama; Thompson Creek, from its confluence with Hubbard Creek, upstream to section 2 line Lawrence County; Brushy Creek, from the confluence of Glover Creek, Winston County, upstream to section 9, Lawrence County; Capsey Creek, from confluence with Brushy Creek, Winston County, upstream to the confluence of Turkey Creek, Lawrence County; Rush Creek, from confluence with Brushy Creek, upstream to Winston/Lawrence County Line, Winston County; Brown Creek, from confluence with Rush Creek, Winston County, upstream to section 24 line, Lawrence County; Beech Creek, from confluence with Brushy Creek, to confluence of East and West Forks, Winston County; Caney Creek and North Fork Caney Creek, from confluence with Sipsey Fork, upstream to section 14 line, Winston County; Borden Creek, from confluence with Sipsey Fork, Winston County, upstream to the confluence of Montgomery Creek, Lawrence County; and Flannagin Creek, from confluence with Borden Creek, upstream to confluence of Dry Creek, Lawrence County.

In Tuscaloosa and Fayette Counties, Alabama, stream and river channels within the ordinary high water line of the main stem of the North River from Tuscaloosa County Road 38, Tuscaloosa County, upstream to confluence of Ellis Creek, Fayette County, Alabama; and Clear Creek from its confluence with North River to Bays Lake Dam, Fayette County, Alabama.

In Jefferson and Blount Counties, Alabama, stream and river channels within the ordinary high water line of the Locust Fork main stem from U.S. Highway 78, Jefferson County, upstream to the confluence of Little Warrior River, Blount County, Alabama; and Little Warrior River from its confluence with the Locust Fork, upstream to the confluence of Calvert Prong and Blackburn Fork, Blount County, Alabama.

In Jefferson, Shelby, and Bibb Counties, Alabama, stream and river channels within the ordinary high water line of the Cahaba River from U.S. Highway 82, Centerville, Bibb County, upstream to Jefferson County Road 143, Jefferson County, Alabama; and the Little Cahaba River from its confluence with the Cahaba River, upstream to the confluence of Mahan and Shoal Creeks, Bibb County, Alabama.

In Dallas County, Alabama, stream and river channels within the ordinary high water line of the Bogue Chitto Creek main stem from its confluence with the Alabama River, Dallas County, upstream to U.S. Highway 80.

In Floyd, Gordon, Whitfield, and Murray Counties, Georgia; and Bradley and Polk Counties, Tennessee, stream and river channels within the ordinary high water line of the Oostanaula River main stem from its confluence with the Etowah River, Floyd County, Georgia, upstream to the confluence of the Conasauga and Coosawattee River, Gordon County, Georgia; the Coosawattee River main stem from its confluence with the Conasauga River, upstream to Georgia State Highway 136, Gordon County, Georgia; the Conasauga River main stem from confluence with the Coosawattee River, Gordon County, Georgia, upstream through Bradley and Polk Counties, Tennessee, to Murray County Road 2, Murray County, Georgia; and the mainstem of Holly Creek from its confluence with the Conasauga River, upstream to its confluence with Rock Creek, Murray County, Georgia.

In Elmore County, Alabama, stream and river channels within the ordinary high water line of the Coosa River main stem from Alabama State Highway 111 bridge, upstream to Jordan Dam.

Primary constituent elements identified at the time of designation included: 1. Geomorphically stable stream and river channels and banks; 2. A flow regime (i.e., the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of mussels and their fish hosts in the river environment; 3. Water quality, including temperature, pH, hardness, turbidity, oxygen content, and other chemical characteristics necessary for normal behavior, growth, and viability of all life stages; 4. Sand, gravel, and/or cobble substrates with low to moderate amounts of fine sediment, low amounts of attached filamentous algae, and other physical and chemical characteristics necessary for normal behavior, growth, and viability of all life stages; 5. Fish hosts with adequate living, foraging, and spawning areas for them; and 6. Few or no competitive or predaceous nonnative species present.

PAST THREATS: The abundance and distribution of the Alabama moccasinshell decreased historically from human-induced habitat loss and degradation caused by impoundments, sedimentation and turbidity, channelization and dredging, mining (coal, sand, gravel, or gold) (Jones 1991, USFWS 1993, Leigh 1994, ADEM 1994), and contaminants contained in numerous point (e.g., carpet mills and fabric dying mills) (Hurd 1974) and nonpoint sources (USFWS 2000). Channel modifications and water pollution gradually eliminated this native species that is dependent on a narrow range of flowing water habitat conditions from extensive portions of its former range within the Mobile River Basin. These habitat changes have resulted in significant extirpations (localized loss of populations), restricted and fragmented distributions, and poor recruitment of young.

CURRENT THREATS:
Habitat modification, sedimentation, eutrophication, and water quality degradation are the primary causes of decline of the Alabama moccasinshell. This species does not tolerate impoundment or channelization. The Alabama moccasinshell, one of the smallest unionid species, inhabits the interstices of gravel and cobble substrates, and is very sensitive to sedimentation and erosion. Surviving populations are threatened by urban and agricultural runoff, surface mine drainage, small stream impoundment projects, industrial and sewage treatment plant discharges, and channel degradation caused by sand and gravel mining.

Exposure Scenario Summary Table for the Alabama Moccasinshell

Species	**Life Stage**	**Habitat Type**	**Exposure Route**	**Diet**	**Significant Interspecies Relationships**
Alabama Moccasinshell	glochidia	parasite	contact with water, diet	fish body fluids	blackspotted topminnows, Tuskaloosa

					darter, redfin darter, blackbanded darter, naked sand darter, southern sand darter, johnny darter, speckled darter, saddleback darter, and logperch
	juvenile/ adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

COOSA MOCCASINSHELL
Medionidus parvulus

STATUS:
On March 17, 1993, the Coosa moccasinshell (*Medionidus parvulus)* was designated as Endangered throughout its entire range (USFWS 1993). A recovery plan for the Coosa moccasinshell was finalized on November 17, 2000 (USFWS 2000). Critical habitat was designated for the Coosa moccasinshell on July 1, 2004 (69 FR 40083).

SPECIES DESCRIPTION:
The Coosa moccasinshell is a small species occasionally exceeding 40 mm (1.6 inches) in length. The shell is thin and fragile, elongate and elliptical to rhomboidal in outline. Like other freshwater mussels, adults are filter-feeders, orienting themselves in the substrate to facilitate siphoning of the water column for oxygen and food (Kraemer 1979). Mussels have been reported to consume detritus, diatoms, phytoplankton, zooplankton, and other microorganisms (Coker et al. 1921, Churchill and Lewis 1924, Fuller 1974). Juvenile mussels employ foot (pedal) feeding, and are thus suspension feeders (Yeager et al. 1994). Foods of juvenile freshwater mussels up to two weeks old include bacteria, algae, and diatoms with amounts of detrital and inorganic colloidal particles (Yeager et al. 1994). Specific food habits of the Coosa moccasinshell are unknown, but are likely similar to those of other freshwater mussels.

REPRODUCTION AND DEVELOPMENT:

Coosa moccasinshells are usually completely buried in the stream bottom. Because this species is apparently closely related to the Alabama moccasinshell, gravid females of this species likely migrate to the surface of the stream bottom during spring glochidial release periods, as do gravid Alabama moccasinshell females. Coosa moccasinshell glochidia are known to use blackbanded darters *(Percina nigrofaciata)* as hosts; however, other species of darters are also likely to be used (P. Johnson, Tennessee Aquarium Research Institute, pers. comm., 2002).

RANGE AND POPULATION LEVEL:
The Coosa moccasinshell was described from the Coosa River, Alabama, and the Chatooga River, Georgia. This species has been historically reported from the Cahaba River, the Sipsey Fork of the Black Warrior River, and the Coosa River, and their tributaries, in Alabama, Georgia, and Tennessee. Since the species was listed, its presence has been confirmed only in the Conasauga River (Murray/Whitfield County, Georgia; Bradley County, Tennessee), and its tributary, Holly Creek (Murray County, Georgia) (Johnson and Evans 2000, Williams and Hughes 1998). It has apparently been eliminated from the Cahaba and Black Warrior River drainages, as well as from the Coosa River and many of its tributaries (USFWS 2003).

HABITAT:
The Coosa moccasinshell inhabits sand/gravel/cobble shoals with moderate to strong currents in streams and small rivers.

CRITICAL HABITAT:
In Macon and Lee Counties, Alabama, stream and river channels within the ordinary high water line of the mainstem of Uphapee Creek from Alabama Highway 199, upstream to the confluence of Opintlocco and Chewacla Creeks, Macon County, Alabama; Choctafaula Creek, from confluence with Uphapee Creek, upstream to Macon County Road 54, Macon County, Alabama; Chewacla Creek, from confluence with Opintlocco Creek, Macon County, Alabama, upstream to Lee County Road 159, Lee County, Alabama; Opintlocco Creek, from confluence with Chewacla Creek, upstream to Macon County Road 79, Macon County, Alabama.

In Cherokee, Calhoun, and Cleburne Counties, Alabama, stream and river channels within the ordinary high water line of the Coosa River main stem from the power line crossing southeast of Maple Grove, Alabama, upstream to Weiss Dam, Cherokee County, Alabama; Terrapin Creek, 53 km (33 mi) extending from its confluence with the Old Coosa River channel, Cherokee County, upstream to Cleburne County Road 49, Cleburne County, Alabama; South Fork Terrapin Creek, 7 km (4 mi), from its confluence with Terrapin Creek, upstream to Cleburne County Road 55, Cleburne County, Alabama.

In Coosa and Clay Counties, Alabama, stream and river channels within the ordinary high water line of the main stem of Hatchet Creek from the confluence of Swamp Creek at Coosa County Road 29, Coosa County, Alabama, upstream to Clay County Road 4, Clay County, Alabama.

In Calhoun and Cleburne Counties, Alabama, stream and river channels within the ordinary high water line of the main stem of Shoal Creek from the headwater of Whitesides Mill Lake,

Calhoun County, Alabama, upstream to the tailwater of Coleman Lake Dam, Cleburne County, Alabama.

In Shelby and St. Clair Counties, Alabama, stream and river channels within the ordinary high water line of the Kelly Creek main stem extending from the confluence with the Coosa River, upstream to the confluence of Shoal Creek, St. Clair County, Alabama;
and the main stem of Shoal Creek from the confluence with Kelly Creek, St. Clair County, Alabama, upstream to the St. Clair/Shelby County Line, St. Clair County, Alabama.

In Talladega and Clay Counties, Alabama, stream and river channels within the ordinary high water line of the main stem of Cheaha Creek from its confluence with Choccolocco Creek, Talladega County, Alabama, upstream to the tailwater of Chinnabee Lake Dam, Clay County, Alabama.

In Shelby County, Alabama, stream and river channels within the ordinary high water line of the Yellowleaf Creek main stem from Alabama Highway 25, upstream to Shelby County Road 49; and the Muddy Prong main stem extending from its confluence with Yellowleaf Creek, upstream to U.S. Highway 280.

In St. Clair County, Alabama, stream and river channels within the ordinary high water line of the main stem of Big Canoe Creek from its confluence with Little Canoe Creek at the St. Clair/Etowah County line, St. Clair County, upstream to the confluence of Fall Branch.

In Floyd, Gordon, Whitfield, and Murray Counties, Georgia; and Bradley and Polk Counties, Tennessee, stream and river channels within the ordinary high water line of the Oostanaula River main stem from its confluence with the Etowah River, Floyd County, Georgia, upstream to the confluence of the Conasauga and Coosawattee River, Gordon County, Georgia; the Coosawattee River main stem from its confluence with the Conasauga River, upstream to Georgia State Highway 136, Gordon County, Georgia; the Conasauga River main stem from confluence with the Coosawattee River, Gordon County, Georgia, upstream through Bradley and Polk Counties, Tennessee, to Murray County Road 2, Murray County, Georgia; and the mainstem of Holly Creek from its confluence with the Conasauga River, upstream to its confluence with Rock Creek, Murray County, Georgia.

In Elmore County, Alabama, stream and river channels within the ordinary high water line of the Coosa River main stem from Alabama State Highway 111 bridge, upstream to Jordan Dam.

Primary constituent elements identified at the time of designation included: 1. Geomorphically stable stream and river channels and banks; 2. A flow regime (i.e., the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of mussels and their fish hosts in the river environment; 3. Water quality, including temperature, pH, hardness, turbidity, oxygen content, and other chemical characteristics necessary for normal behavior, growth, and viability of all life stages; 4. Sand, gravel, and/or cobble substrates with low to moderate amounts of fine sediment, low amounts of attached filamentous algae, and other physical and chemical characteristics necessary for normal

behavior, growth, and viability of all life stages; 5. Fish hosts with adequate living, foraging, and spawning areas for them; and 6. Few or no competitive or predaceous nonnative species present.

PAST THREATS:
The abundance and distribution of the Coosa moccasinshell decreased historically from human-induced habitat loss and degradation caused by impoundments, sedimentation and turbidity, channelization and dredging, mining (coal, sand, gravel, or gold) (Jones 1991, USFWS 1993, Leigh 1994, ADEM 1994), and contaminants contained in numerous point (e.g., carpet mills and fabric dying mills) (Hurd 1974) and nonpoint sources (USFWS 2000). Channel modifications and water pollution gradually eliminated this native species that is dependent on a narrow range of flowing water habitat conditions from extensive portions of its former ranges within the Mobile River Basin. These habitat changes have resulted in significant extirpations (localized loss of populations), restricted and fragmented distributions, and poor recruitment of young.

CURRENT THREATS:
Habitat modification, sedimentation, eutrophication, and water quality degradation are the primary causes of decline of the Coosa moccasinshell. This species does not tolerate impoundment or channelization. The Coosa moccasinshell is a small mussel that inhabits the interstices of gravel and cobble substrates, and is very sensitive to sedimentation and erosion. Surviving populations are threatened by household and agricultural runoff, surface mine drainage, and small stream impoundment projects.

Due to the extreme rarity of the Coosa moccasinshell, any adverse impacts to its habitat or an individual could result in the demise of the species. The immediate recovery objective is to prevent the continued decline of this species by locating, protecting, and restoring stream drainages with extant populations.

Exposure Scenario Summary Table for the Coosa Moccasinshell

Species	**Life Stage**	**Habitat Type**	**Exposure Route**	**Diet**	**Significant Interspecies Relationships**
Coosa Moccasinshell	glochidia	parasite	contact with water, diet	fish body fluids	blackbanded darters, potentially other species of darters
	juvenile/ adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

GULF MOCCASINSHELL
Medionidus penicillatus

STATUS:
On March 16, 1998, the Gulf moccasinshell was designated as Endangered throughout its range (USFWS 1998). A recovery plan for the Gulf moccasinshell was finalized on October 1, 2003 (USFWS 2003). A 5-Year Review was approved for the Gulf moccasinshell on September 17, 2007. Critical habitat was designated for the Gulf moccasinshell on November 15, 2007 (72 FR 64285).

SPECIES DESCRIPTION:
The Gulf moccasinshell is a small mussel that reaches a length of about 5.6 cm (2.2 in), is elongate-elliptical or rhomboidal in outline, fairly inflated, and has relatively thin valves. Much confusion has clouded the taxonomy of *Medionidus* species in the Apalachicolan Region (Brim Box and Williams 2000, USFWS 2003). The Service recognizes *Unio kingii* Wright, 1900, as a synonym of *Medionidus penicillatus* (USFWS 2003).

Like other freshwater mussels, adults are filter-feeders, orienting themselves in the substrate to facilitate siphoning of the water column for oxygen and food (Kraemer 1979). Mussels have been reported to consume detritus, phytoplankton, zooplankton, and other microorganisms (Coker et al. 1921, Churchill and Lewis 1924, Fuller 1974). Juvenile mussels employ foot (pedal) feeding, and are thus suspension feeders (Yeager et al. 1994). Foods of juvenile freshwater mussels up to two weeks old include bacteria, algae, and diatoms with amounts of detrital and inorganic colloidal particles (Yeager et al. 1994). Specific food habits of the Gulf moccasinshell are unknown, but are likely similar to those of other freshwater mussels.

REPRODUCTION AND DEVELOPMENT:
Gulf moccasinshell glochidia are released in early to late spring, while gravid females were found in March, April, September, and November (O'Brien and Williams 2002). The presence of gravid specimens of this lampsiline species in the late summer and fall months suggests that the Gulf moccasinshell is a parent overwintering, summer releasing species. Gravid specimens were observed lying upside down (i.e., umbos down) on top of gravel and sand substrates in mid-March and flapping their mantle margins (Brim Box and Williams 2000). This host-attractant behavior has been noted in the Alabama moccasinshell (*M. acutissimus* Lea, 1831) during the spring in northern Alabama (W.R. Haag, U.S. Forest Service [USFS], pers. comm., 1995). Glochidial morphology was described and figured first by Lea (1858), and then by O'Brien and Williams (2002).

Primary fish hosts for the Gulf moccasinshell in the Apalachicola-Chattahoochee-Flint (ACF) Basin appear to include the blackbanded darter *(Percina nigrofasciata)* and the brown darter (*Etheostoma edwini)*(O'Brien and Williams 2002). Laboratory tests reveal that 100 percent of the fish of these two species transformed the glochidia that were exposed to them. Glochidia metamorphosed in 29 to 33 days for the blackbanded darter and 30 to 37 days for the brown

darter. Two other fishes, the eastern mosquitofish and guppy, also transformed glochidia, but at lower percentage rates. All tests were conducted at 70.7 ± 2.7 degrees Fahrenheit (O'Brien and Williams 2002).

RANGE AND POPULATION LEVEL:
The type locality for the Gulf moccasinshell was originally recorded as three sites in the ACF Basin in Georgia - the Chattahoochee River near Columbus and near Atlanta, and the Flint River near Albany (Table, 3, USFWS, 2003). Historically, the Gulf moccasinshell was known in Alabama, Georgia, and Florida from the main stems and tributaries throughout the ACF Basin and Econfina Creek (Johnson 1977, Butler 1989, Williams and Butler 1994, Brim Box and Williams 2000). The Service adheres to the position of Brim Box and Williams (2000) concerning the present taxonomy and distribution of the Gulf moccasinshell (USFWS 2003).

Subpopulation losses have been substantial for the Gulf moccasinshell. The species is no longer found in the Chattahoochee River main stem (Brim Box and Williams 2000). ACF Basin streams where the Gulf moccasinshell has apparently been extirpated include Mulberry, Uchee, and Little Uchee Creeks in the Chattahoochee River system; Line, Patsiliga, Turkey, Sandy Mount, Gum, Cedar, Jones, Abrams, Mill, Ichawaynochaway, and Spring Creeks, all tributaries to the Flint River; the Apalachicola River main stem; and Marshall, Cowarts, Dry, Rocky, and both Spring Creeks in the Chipola River system. This species has also been eliminated from most of the Flint and Chipola River main stems.

Generally small subpopulations of the Gulf moccasinshell persist in ACF Basin streams. These include Sawhatchee and Kirkland Creeks (Chattahoochee River system); Whitewater, Little Pennahatchee, Swift, Muckalee, Kinchafoonee, and Chickasawhatchee Creeks (Flint River system); single main stem localities in the Flint and Chipola Rivers; and Big, Baker and Waddells Mill Creeks in the latter system. The Gulf moccasinshell also persists in Econfina Creek. This mussel, overall, is found in 24 subpopulations in 6 different watersheds.

During the status surveys, an average of 1.4 Gulf moccasinshell specimens was found per site of occurrence (eight sites), although new and larger subpopulations were subsequently discovered (USFWS 1998). The subpopulation in Waddells Mill Creek, where dozens of specimens can be found, is thought to be the largest remaining (D.N. Shelton, Alabama Malacological Research Center, pers. comm., 1998). Recent quantitative sampling using sieves from 50 quadrat samples (2.7 square feet each) in Chickasawhatchee Creek recorded a density of 0.044 specimens per square foot of substrate (R.S. Butler, USFWS, unpub. data).

HABITAT:
The Gulf moccasinshell inhabits the channels of small to medium-sized creeks to large rivers with sand and gravel or silty sand substrates in slow to moderate currents (Williams and Butler 1994; Garner, pers. comm., 2003). Approximately 46 percent of the ACF basin specimens located during the Basin's status survey were in a substrate of sand/rock (Brim Box and Williams 2000).

CRITICAL HABITAT:

In Bay and Washington Counties, Florida, stream and river channels within the ordinary high water line of the main stem of Econfina Creek and one of its tributaries, Moccasin Creek.

In Houston County, Alabama, and in Calhoun, Gulf, and Jackson counties, Florida, stream and river channels within the ordinary high water line of the main stem of the Chipola River and seven of its tributaries.

In Early County, Georgia, stream and river channels within the ordinary high water line of the main stems of Sawhatchee and Kirkland creeks, and one tributary, encompassing a total stream length of 37.8 km.

In Coweta, Crawford, Crisp, Dooly, Fayette, Macon, Meriwether, Peach, Pike, Spalding, Sumter, Talbot, Taylor, Upson, and Worth counties, Georgia, stream and river channels within the ordinary high water line of the Flint River from the State Highway 27 bridge in Dooly and Sumter counties, Georgia, upstream 247.4 km through Macon, Peach, Taylor, Crawford, Talbot, Upson, Pike, Meriwether, and Coweta counties, to Horton Creek in Fayette and Spalding counties, Georgia; Swift Creek from Lake Blackshear upstream 11.3 km to Rattlesnake Branch, Crisp and Worth counties, Georgia; Limestone Creek from Lake Blackshear, Crisp County, Georgia, upstream 8.8 km to County Road 89, Dooly County, Georgia; Turkey Creek from the Flint River upstream 21.7 km to Rogers Branch, in Dooly County, Georgia; Pennahatchee Creek from Turkey Creek upstream 4.8 km to Little Pennahatchee Creek, Dooly County, Georgia; Little Pennahatchee Creek from Pennahatchee Creek upstream 5.8 km to Rock Hill Creek, Dooly County, Georgia; Hogcrawl Creek from the Flint River upstream 21.6 km to Little Creek, Dooly and Macon counties, Georgia; Red Oak Creek from the Flint River upstream 21.7 km to Brittens Creek, Meriwether County, Georgia; Line Creek from the Flint River upstream 15.8 km to Whitewater Creek, Coweta and Fayette counties, Georgia; and Whitewater Creek from Line Creek upstream 21.5 km to Ginger Cake Creek, Fayette County, Georgia.

In Dougherty, Lee, Marion, Schley, Sumter, Terrell, Webster, and Worth counties, Georgia, stream and river channels within the ordinary high water line of the Flint River from Piney Woods Creek in Dougherty County, Georgia, upstream 39.9 km to the Warwick Dam, Lee and Worth counties, Georgia; Kinchafoonee Creek from its confluence with Lake Worth at the Lee--Dougherty county line, upstream 107.6 km through Terrell and Sumter Counties, Georgia, to Dry Creek, Webster County, Georgia; Lanahassee Creek from Kinchafoonee Creek upstream 9.3 km to West Fork Lanahassee Creek, Webster County, Georgia; Muckalee Creek, from its confluence with Lake Worth at the Lee--Dougherty county line, upstream 104.5 km to County Road 114, Marion County, Georgia; Little Muckalee Creek, from Muckalee Creek in Sumter County, Georgia, upstream 7.2 km to Galey Creek, Schley County, Georgia; Mill Creek from the Flint River upstream 3.2 km to Mercer Millpond Creek, Worth County, Georgia; Mercer Millpond Creek from Mill Creek upstream 0.45 km to Mercer Mill Pond, Worth County, Georgia; Abrams Creek from the Flint River upstream 15.9 km to County Road 123, Worth County, Georgia; Jones Creek from the Flint River upstream 3.8 km to County Road 123, Worth County, Georgia; and Chokee Creek, from the Flint River upstream 10.5 km to Dry Branch Creek, Lee County, Georgia.

In Baker, Calhoun, Decatur, Dougherty, Early, Miller, Mitchell, and Terrell counties, Georgia, stream and river channels within the ordinary high water line of the Flint River from its confluence with Big Slough , Decatur County, Georgia, upstream 116.4 km through Baker and Mitchell Counties, Georgia, to the Flint River Dam, Dougherty County, Georgia; Spring Creek, from its confluence with Lake Seminole at Smith Landing, Decatur County, Georgia, upstream 74.2 km to County Road 35, Early County, Georgia; Aycocks Creek from Spring Creek upstream 15.9 km to Cypress Creek, Miller County, Georgia; Dry Creek from Spring Creek upstream 9.9 km to Wamble Creek , Early County, Georgia; Ichawaynochaway Creek from the Flint River, Baker County, Georgia, upstream 68.6 km to Merrett Creek, Calhoun County, Georgia; Mill Creek from Ichawaynochaway Creek upstream 7.4 km to County Road 163, Baker County, Georgia; Pachitla Creek, from Ichawaynochaway Creek upstream 18.9 km to Little Pachitla Creek, Calhoun County, Georgia; Little Pachitla Creek from Pachitla Creek upstream 5.8 km to Bear Branch, Calhoun County, Georgia; Chickasawhatchee Creek from Ichawaynochaway Creek, Baker County, Georgia, upstream 64.5 km to U.S. Highway 82, Terrell County, Georgia; and Cooleewahee Creek from the Flint River upstream 15.1 km to Piney Woods Branch, Baker County, Georgia.

Primary constituent elements identified at the time of designation included: (1) Space for individual and population growth and for normal behavior; (2) Food, water, air, light, minerals, or other nutritional or physiological requirements; (3) Cover or shelter; (4) Sites for breeding, reproduction, or rearing (or development) of offspring; and (5) Habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species.

PAST THREATS:
The abundance and distribution of the Gulf moccasinshell decreased historically from habitat loss and degradation (Williams et al. 1993, Neves 1993) caused by impoundments, gravel mining (e.g., Uchee Creek system, a tributary of the Chattahoochee River in Alabama), sedimentation and turbidity, dredging and channelization, and contaminants contained in numerous point and nonpoint sources. A comprehensive review of these past threats is provided elsewhere (USFWS 2003, Brim Box and Williams 2000, Butler 1993, Howard 1997, Frick et al. 1998, Buell and Couch 1995, Richter 1997, Watters 1997, Neves et al. 1997). These habitat changes have resulted in significant extirpations (localized loss of populations), restricted and fragmented distributions, and poor recruitment of young.

CURRENT THREATS:
Habitat loss and degradation (Williams et al. 1993, Neves 1993) primarily caused by contaminants contained in point and nonpoint source discharges, sedimentation and erosive land practices, water quantity and withdrawal, construction of new impoundments, and alien species are primary threats to the Gulf moccasinshell (USFWS 2003). Low population levels and restricted ranges now render these mussels extremely vulnerable to toxic chemical spills and other catastrophic events, and the deleterious effects of genetic isolation.

Sediment samples from various ACF Basin streams tested for heavy metals that are known to be deleterious to mussels had concentrations markedly above background levels (Frick et al. 1998),

among those were copper (throughout the Piedmont), and cadmium (large Coastal Plain tributaries of the Flint River). Past episodes of significant heavy metal contamination of ACF Basin streams may continue to impact mussel faunas. An estimated 950 million gallons of chemical-laden rinse, stripping, cleaning, and plating solutions were discharged indirectly into the Flint River (P. Laumeyer, USFWS, pers. comm., 1994) over a several year period. Concentrations of heavy metals (e.g., chromium and cadmium) in Asian clam, *Corbicula fluminea* (Muller 1774), and sediment samples were elevated downstream from two abandoned battery salvage operations on the Chipola River (Winger et al. 1985). Chromium concentrations found in sediments from Dead Lake downstream in the Chipola River (Winger et al. 1985) are known to be toxic to mussels (Havlik and Marking 1987).

Agricultural sources of contaminants in the ACF and Suwannee basins include nutrient enrichment from poultry farms and livestock feedlots, and pesticides and fertilizers from row crop agriculture (Couch et al. 1996, Frick et al. 1998, Berndt et al. 1998). Nitrate concentrations are particularly high in surface waters downstream of agricultural areas (Mueller et al. 1995; Berndt et al. 1998). A study by the U.S. Soil Conservation Service (USSCS; now the Natural Resources Conservation Service [NRCS]) in the Flint River system determined that between 72 and 75 percent of the nutrients entering Lake Blackshear were derived from agricultural sources (USSCS 1993). Stream ecosystems are impacted when nutrients are added at concentrations that cannot be assimilated (Stansbery 1995). The effects of pesticides on mussels may be particularly profound (Fuller 1974, Havlik and Marking 1987, Moulton et al. 1996, Fleming et al. 1995). Organochlorine pesticides were found at levels in ACF Basin streams that often exceeded chronic exposure criteria for the protection of aquatic life (Buell and Couch 1995, Frick et al. 1998). Once widely used in the ACF Basin (Buell and Couch 1995), these highly toxic compounds are persistent in the environment, and are found in both sediments and the lipid reservoir of organisms (Day 1990, Burton 1992). Commonly used pesticides have been directly implicated in a North Carolina mussel dieoff (Fleming et al. 1995). Cotton is raised extensively in much of the Apalachicolan Region inhabited by these mussels. One of the most important pesticides used in cotton farming, malathion, is known to inhibit physiological activities of mussels (Kabeer et al. 1979) that may decrease the ability of a mussel to respire and obtain food. This chemical may pose a continuing threat to some populations of these mussels.

Many pollutants in the ACF Basin originate from urban stormwater runoff, development activities, and municipal waste water facilities, primarily in the Piedmont (Frick et al. 1998). Urban catchments in Piedmont drainages have higher concentrations of nutrients, heavy metals, pesticides, and organic compounds than do agricultural or forested ones (Lenat and Crawford 1994, Frick et al. 1998), and at levels sufficient to significantly affect fish health (Ostrander et al. 1995). Within the Suwannee River basin, nutrient concentrations were greater in agricultural areas and nitrates were found to exceed U.S. Environmental Protection Agency (EPA) drinking water standards in 20 percent of the surficial aquifer groundwater samples (Berndt et al. 1998). Pesticide concentrations were found to exceed criteria for protection of aquatic life mostly in urban areas. Currently, there are discharges from 137 municipal waste water treatment facilities in the ACF River basin alone (Couch et al. 1996). Although effluent quality has improved with modern treatment technologies and a phosphate detergent ban, hundreds of miles of streams in the ACF and Ochlockonee basins in Alabama, Florida, and Georgia, as identified in reports

prepared by the water quality agencies of these states under Section 305(b) of the Clean Water Act, do not meet water use classifications.

Since approximately 29 percent of the ACF Basin is in agriculture (Frick et al. 1998), sedimentation from agricultural sources is probably significant. According to USSCS (1993), 89 percent of the sediments entering Lake Blackshear on the Flint River are derived from agricultural sources. The lower Flint River system serves as the heart of numerous mussel species' range (including the Gulf moccasinshell) and is a major agricultural center. This area has experienced "severe losses of topsoil and nutrient additions to local streams due to agriculture" (Neves et al. 1997), and has profoundly affected the biota of surface and ground waters there (Patrick 1992). Despite the implications, only a few studies (e.g., Cooper 1987, Stewart and Swinford 1995) have specifically attributed changes in mussel populations to sediments derived from agricultural practices.

Many southern streams have increased turbidity levels due to siltation (van der Schalie 1938a). The Gulf moccasinshell attracts host fishes with visual cues, luring fish into perceiving that their glochidia are prey items. Such a reproductive strategy depends on clear water during the critical time of the year when mussels are releasing their glochidia (Hartfield and Hartfield 1996). Turbidity is a limiting factor impeding sight-feeding fishes (Burkhead and Jenkins 1991). In addition, mussels may be indirectly affected when turbidity levels significantly reduce light available for photosynthesis and the production of unionid food items (Kanehl and Lyons 1992).

Water quantity is becoming more of a concern in maintaining mussel habitat in the Apalachicolan Region. The potential impacts to mussels, their host fishes, and their respective habitats from ground water withdrawal may be profound. Within the Flint River basin, decreases in flow velocity and dissolved oxygen were highly correlated to mussel mortality (Johnson et al. 2001). Low DO conditions in stagnating stream pools due to drought conditions are having a disastrous effect on these mussels. Mussel mortality increases dramatically as DO decreases below 5 mg/L (Johnson et al. 2001). Rare species (e.g., oval pigtoe, shinyrayed pocketbook, and Gulf moccasinshell) were more susceptible to drought-related morality within the Flint River basin and had the highest mortality rates from hypoxic conditions (Johnson et al. 2001).

Maintaining vegetated riparian buffer zones adjacent to stream banks is a well-known method of reducing stream sedimentation and other runoff (Allan and Flecker 1993, Lenat and Crawford 1994). Buffers reduce impacts to fish and other aquatic faunas (Armour et al. 1991, Naiman et al. 1988, Osborne and Kovacic 1993, Belt and O'Laughlin 1994, Penczak 1995, Rabeni and Smale 1995), and are particularly crucial for mussels (Neves et al. 1997). Riparian forest removal in southeastern streams and subsequent sedimentation has been shown to be detrimental to fish communities (Burkhead et al. 1997, Jones et al. 1999). Particularly affected in the study by Jones et al. (1999) were benthic-dependent species (e.g., darters, benthic minnows, sculpins), which were found to decrease in abundance with longer deforested patches of riparian area. Benthic-dependent fishes, themselves disproportionately imperiled (Burkhead et al. 1997), commonly serve as hosts for numerous imperiled mussel species (Watters 1994), including Gulf moccasinshell.

Exposure Scenario Summary Table for the Gulf Moccasinshell

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
Gulf Moccasinshell	glochidia	parasite	contact with water, diet	fish body fluids	blackbanded darter, brown darter
	juvenile/ adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

OCHLOCKONEE MOCCASINSHELL
Medionidus simpsonianus

STATUS:
On March 16, 1998, the Ochlockonee moccasinshell was designated as Endangered throughout its entire range (USFWS 1998). A recovery plan for the Ochlockonee moccasinshell was finalized on October 1, 2003 (USFWS 2003). A 5-Year Review was approved for the Ochlockonee moccasinshell on September 17, 2007. Critical habitat was designated for the Ochlockonee moccasinshell on November 15, 2007 (72 FR 64285).

SPECIES DESCRIPTION:
The Ochlockonee moccasinshell is a small species, generally under 5.6 cm (2.2 in) in length. The taxonomic confusion that has surrounded the genus *Medionidus* is summarized elsewhere (USFWS 2003). Like other freshwater mussels, adults are filter-feeders, orienting themselves in the substrate to facilitate siphoning of the water column for oxygen and food (Kraemer 1979). Mussels have been reported to consume detritus, diatoms, phytoplankton, zooplankton, and other microorganisms (Coker et al. 1921, Churchill and Lewis 1924, Fuller 1974). Juvenile mussels employ foot (pedal) feeding, and are thus suspension feeders (Yeager et al. 1994). Food of juvenile freshwater mussels up to two weeks old includes bacteria, algae, and diatoms with amounts of detrital and inorganic colloidal particles (Yeager et al. 1994). Specific food habits of the Ochlockonee moccasinshell are unknown, but are likely similar to those of other freshwater mussels.

REPRODUCTION AND DEVELOPMENT:
The extreme rarity of the lampsiline Ochlockonee moccasinshell has precluded any opportunities to explore its life history. It can only be assumed that this species has similar reproductive biology traits of its congener, the Gulf moccasinshell. Therefore, it may be a parent

overwintering, summer releasing species that probably utilizes darters as hosts, as does the Gulf moccasinshell, Alabama moccasinshell (Haag and Warren 1997), and Cumberland moccasinshell (Lea, 1834) (Zale and Neves 1982).

RANGE AND POPULATION LEVEL:
The Ochlockonee moccasinshell was described from the Ochlockonee River, Calvary, Grady County, Georgia. This Ochlockonee River system endemic mussel was known historically from the main stem in Georgia and Florida, and the Little River (Johnson 1977, Butler 1993, Williams and Butler 1994). The Service has provided a table of occurrences of Ochlockonee moccasinshell (Table 4, USFWS 2003).

Museum records for the Ochlockonee moccasinshell indicate that it was historically common, including two Ochlockonee River sites (21 and 24 specimens collected twice from a single site in the early 1930s, 19 from another collected in 1969) (J.D. Williams, USGS, unpub. data). Even as late as the early 1970s this species was found in some numbers above Talquin Reservoir, Florida (W.H. Heard, Florida State University, pers. comm., 1994). This species may now be the rarest mussel currently inhabiting the Apalachicolan Region and is one of the rarest mussels nationwide (USFWS 2003). Only three live specimens are known to have been collected since 1974 despite concerted efforts by numerous investigators (J.D. Williams, USGS, unpub. data). The most recent live specimen was collected during the status survey in 1 of 4 hand-picked 97-square foot quadrats (J. Brim Box, USGS, unpub. data). Currently, this species persists in only a relatively short reach of Ochlockonee River above Talquin Reservoir (Table 4, USFWS 2003).

HABITAT:
The Ochlockonee moccasinshell inhabits large creeks and the Ochlockonee River main stem in areas with current. Typical substrates are sand with some gravel (Williams and Butler 1994).

CRITICAL HABITAT:
In Gadsden and Leon counties, Florida, and in Grady and Thomas counties, Georgia, stream and river channels within the ordinary high water line of the main stem of the Ochlockonee River upstream of Lake Talquin and three tributaries.

Primary constituent elements identified at the time of designation included: (1) Space for individual and population growth and for normal behavior; (2) Food, water, air, light, minerals, or other nutritional or physiological requirements; (3) Cover or shelter; (4) Sites for breeding, reproduction, or rearing (or development) of offspring; and (5) Habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species.

PAST THREATS:
The abundance and distribution of the Ochlockonee moccasinshell decreased historically from habitat loss and degradation (Williams et al. 1993, Neves 1993) caused by impoundments (Talquin Reservoir), sedimentation and turbidity, dredging and channelization, and contaminants contained in numerous point and nonpoint sources. A comprehensive review of these past threats is provided elsewhere (USFWS 2003, Brim Box and Williams 2000, Butler 1993, Richter

et al. 1997, Watters 1997, Neves et al. 1997). However, the histories of anthropogenic impacts specifically to the Ochlockonee river drainage have not been summarized. These habitat changes have resulted in significant extirpations (localized loss of populations), restricted and fragmented distributions, and poor recruitment of young.

CURRENT THREATS:
Habitat loss and degradation (Williams et al. 1993, Neves 1993) primarily caused by contaminants contained in point and nonpoint source discharges, sedimentation and erosive land practices, water quantity and withdrawal, construction of new impoundments and alien species are primary threats to the Ochlockonee moccasinshell (USFWS 2003). Low populations levels and restricted ranges now render these mussels extremely vulnerable to toxic chemical spills and other catastrophic events, and the deleterious effects of genetic isolation.

Although effluent quality has improved with modern treatment technologies and a phosphate detergent ban, hundreds of miles of streams in the Ochlockonee basin in Georgia and Florida, as identified in reports prepared by the water quality agency of the states under Section 305(b) of the Clean Water Act, do not meet water use classifications.

Many southern streams have increased turbidity levels due to siltation (van der Schalie 1938a). The Ochlockonee moccasinshell attracts host fishes with visual cues, luring fish into perceiving that their glochidia are prey items. Such a reproductive strategy depends on clear water during the critical time of the year when mussels are releasing their glochidia (Hartfield and Hartfield 1996). Turbidity is a limiting factor impeding sight-feeding fishes (Burkhead and Jenkins 1991). In addition, mussels may be indirectly affected when turbidity levels significantly reduce light available for photosynthesis and the production of unionid food items (Kanehl and Lyons 1992).

Maintaining vegetated riparian buffer zones adjacent to stream banks is a well-known method of reducing stream sedimentation and other runoff (Allan and Flecker 1993, Lenat and Crawford 1994). Buffers reduce impacts to fish and other aquatic faunas (Armour et al. 1991, Naiman et al. 1988, Osborne and Kovacic 1993, Belt and O'Laughlin 1994, Penczak 1995, Rabeni and Smale 1995), and are particularly crucial for mussels (Neves et al. 1997). Riparian forest removal in southeastern streams and subsequent sedimentation has been shown to be detrimental to fish communities (Burkhead et al. 1997, Jones et al. 1999). Particularly affected in the study by Jones et al. (1999) were benthic-dependent species (e.g., darters, benthic minnows, sculpins), which were found to decrease in abundance with longer deforested patches of riparian area. Benthic-dependent fishes, themselves disproportionately imperiled (Burkhead et al. 1997), commonly serve as hosts for numerous imperiled mussel species (Watters 1994), probably including the Ochlockonee moccasinshell.

Water quantity is becoming more of a concern in maintaining mussel habitat in the Apalachicolan Region. The potential impacts to mussels, their host fishes, and their respective habitats from ground water withdrawal may be profound. Low DO conditions in stagnating stream pools due to drought conditions are having a disastrous effect on these mussels. Mussel mortality increases dramatically as DO decreases below 5 mg/L (Johnson et al. 2001).

Due to the extreme rarity of the Ochlockonee moccasinshell, any adverse impacts to its habitat or an individual could result in the potential demise of the species.

Exposure Scenario Summary Table for the Ochlockonee Moccasinshell

Species	**Life Stage**	**Habitat Type**	**Exposure Route**	**Diet**	**Significant Interspecies Relationships**
Ochlockonee Moccasinshell	glochidia	parasite	contact with water, diet	fish body fluids	host fish(es) unknown
	juvenile/ adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

RING PINK (MUSSEL)

Obovaria retusa

STATUS:

On September 29, 1989 the ring pink mussel was designated as endangered throughout its entire range in Alabama, Indiana, Kentucky, Pennsylvania, and Tennessee (USFWS 1989). A recovery plan for the ring pink was approved in March 25, 1991 (USFWS 1991).

SPECIES DESCRIPTION:

The ring pink, also known as the golf stick pearly mussel, is a medium to large freshwater mussel with a round shell that is yellow-green to brown in color and lacks rays (USFWS 2003). Like other freshwater mussels, the ring pink feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of ring pink glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:

The reproductive cycle of the ring pink is similar to that of other mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. Gravid ring pink mussels have been observed in late August (Ortmann 1909 and 1912). Specific glochidial hosts for the ring pink mussel are not known (USFWS 1989, 1991, NatureServe 2003).

RANGE AND POPULATION LEVEL:

Historically, the ring pink mussel was widely distributed in the Ohio, Cumberland, and Tennessee River systems in Pennsylvania, West Virginia, Ohio, Illinois, Indiana, Kentucky, Tennessee, and Alabama (Gordon and Layzer 1989, Bogan and Parmalee 1983, Kentucky State Nature Preserves Commission 1980, Parmalee and Klippel 1982, Lauritsen 1987, Stansbery 1970).

In Kentucky waters, the ring pink mussel has been taken in recent years only from the Tennessee River (two live specimens) in McCracken, Livingston, and Marshall Counties, and from the Green River (two fresh-dead specimens) in Hart and Edmonson Counties. In Tennessee, the ring pink apparently still survives (based on collections by commercial mussel fishermen) in the Cumberland River in Wilson, Trousdale, and Smith Counties, and in the Tennessee River in Hardin County. One live specimen was taken in West Virginia's Kanawha River, Fayette County, in 1990 (USFWS 1989, 1991). Only two specimens have been recorded in the past 10 years from the Green River in Kentucky. Populations in other river reaches are likely extirpated (USFWS 2003).

HABITAT:
A large river species (Bates and Dennis 1985; Bogan and Parmalee 1983, Parmalee and Bogan 1998), the ring pink mussel inhabits relatively shallow waters (2 feet deep) with gravel and sandy substrates (Neel and Allen 1964, Hickman 1937).

PAST THREATS:
Most of the historically known ring pink populations were apparently lost due to conversion of many sections of these big rivers to a series of large impoundments. This seriously reduced the availability of its preferred riverine gravel and sand habitat and likely affected the distribution and availability of the ring pink mussel=s fish host. As a result, the species' distribution has been substantially reduced (USFWS 1991, NatureServe 2003). Individuals in the remaining five populations are threatened by many factors. Kentucky's Green River has experienced water quality problems related to impacts from oil and gas production and reservoir releases upstream in the watershed. The Kanawha River population may be threatened by a barge terminal that is proposed just downstream from the area where one specimen was collected. The individuals surviving in the Tennessee and Cumberland Rivers are potentially threatened by gravel dredging, channel maintenance, and commercial mussel fishing. Although the species is not commercially valuable, incidental take of the species does sometimes occur during commercial mussel fishing for other species (USFWS 1991).

CURRENT THREATS:
As mentioned, none of the five extant populations is known to be reproducing. Therefore, unless reproducing populations are found or methods are developed to maintain these or create new populations, the species will be lost in the foreseeable future. In fact, three of the populations (Cumberland and Tennessee River populations) may contain only old individuals that have passed their reproductive age (USFWS 1991). Other current threats to freshwater mussels are well documented in the general mussel description.

Exposure Scenario Summary Table for the Ring pink

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
ring pink	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	
	juvenile / adult	sediment dweller	contact & ingestion of water, diet,	filter feeder (bacteria, algae,	

			sediment	detritus, sediment)

LITTLEWING PEARLYMUSSEL
Pegias fabula

STATUS:
On November 14, 1988, the littlewing pearlymussel was designated as endangered throughout its entire range (USFWS 1988). A recovery plan for the littlewing pearlymussel was approved on September 22, 1989 (USFWS 1989).

SPECIES DESCRIPTION:
The littlewing pearly mussel is small, not exceeding 3.8 cm in length and 1.3 cm in width. Like other freshwater mussels, the littlewing pearlymussel feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of littlewing pearlymussel glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the littlewing pearlymussel is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. They then detach from their fish host and sink to the stream bottom or other substrate where they continue to develop, provided they land in a suitable substratum with the correct water conditions. Ahlstedt (1986) suggests that the species is a winter or long-term brooder, holding glochidia from midsummer until the following spring. Ahlstedt (1986) reports that the banded sculpin (*Cottus carolinae*) and redline darter (*Etheostoma rufilineatum*) are found in the same habitat as this mussel in parts of its range and may be prime candidates as host species. The greenside darter (*Etheostoma blennioides*) and emerald darter (*Etheostoma baileyi*) have also been identified as glochidial hosts (NCNHP 2003).

RANGE AND POPULATION LEVEL:
This freshwater mussel has been reported historically from 27 river reaches in Alabama, North Carolina, Kentucky, Tennessee, and Virginia. Only a few small populations are known to survive in Horse Lick Creek (Jackson and Rockcastle Counties, KY), Big South Fork Cumberland River (McCreary and Wayne Counties, KY), Cane Creek (Van Buren County, TN), North Fork Holston River (Smyth and Washington Counties, VA), Clinch River (Tazewell County, VA), and Little Tennessee River (Swain and Macon Counties, NC) (USFWS 1989, 2003). The Big South Fork Cumberland River harbors the only population considered healthy and viable. It has declined dramatically in Horselick Creek in recent years and is exceedingly rare elsewhere and may have become extirpated in some streams.

HABITAT:
The littlewing pearly mussel inhabits small to medium, low turbidity, cool-water, high to moderate gradient streams in the Cumberland and Tennessee River basins (Bogan and Parmalee 1983, Ahlstedt 1986). The species is commonly found near riffles on sand and gravel substrates with scattered cobbles or in sand pockets between rocks, cobbles and boulders (Gordon and Layzer 1989, NatureServe 2003). Individuals have been found lying on top of the substratum, buried in or on top of the substratum in the transition zone between a long pool and riffle, or buried in gravel or beneath boulders and slabrock (Blankenship 1971, Starnes and Starnes 1980, DiStefano 1984).

PAST THREATS:
The species' decline has resulted primarily from habitat and water quality deterioration caused by impoundments and by pollution and siltation resulting from mining, agriculture, and construction activities. Owing to the species= limited distribution, any factor that adversely modifies habitat or water quality in the short river reaches that the species inhabits could threaten its survival (USFWS 1988).

CURRENT THREATS:
Current threats to freshwater mussels are described in the General Mussel Document.

Exposure Scenario Summary Table for the Littlewing Pearlymussel

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
littlewing pearlymussel	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	greenside darter emerald darter
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

WHITE WARTYBACK (PEARLYMUSSEL)
Plethobasus cicatricosus

STATUS:
On June 14, 1976, the white wartyback (pearlymussel) was designated as endangered throughout its entire range in Alabama, Indiana, Kentucky, and Tennessee (USFWS 1976). A recovery plan

for the white wartyback was approved in September 19, 1984 (USFWS 1984). A 5-Tear Review for the white wartyback was approved on September 21, 2007 (72 FR 54057).

SPECIES DESCRIPTION:
The white wartyback is a medium-sized freshwater mussel (reaching up to approximately 130 mm in length) with a light brown to greenish-yellow shell with a row of large tear-shaped tubercles along its side (ESIE 1996, INHS 1997, NatureServe 2003). Like other freshwater mussels, the white wartyback feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of white wartyback glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the white wartyback is similar to that of other mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. The species is likely a short-term brooder with spawning occurring in the spring and release of glochidia in the summer (USFWS 1984). Specific glochidial host species for the white wartyback are not known.

RANGE AND POPULATION LEVEL:
The white wartyback has undergone a substantial range reduction and is considered to be critically imperiled. It was historically distributed in the Wabash, Ohio, Kanawha, Cumberland, Holston, and Tennesse Rivers of the Ohio, Cumberland, and Tennessee River systems; however, no live specimens have been recovered from these drainages since the early 1900s (NatureServe 2003). According to Ahlstedt (1984), the white wartyback may still exist in a short reach of the Tennessee River below Pickwick Dam. The viability of remaining populations is extremely threatened (NatureServe 2003). An extant population of this species remains in the Tennessee River below Pickwick Landing Dam where juveniles have been found in the last four years.

HABITAT:
The white wartyback is a riffle species that is typically found in large rivers in gravel substrates (NatureServe 2003, INHS 1997).

PAST THREATS:
Past threats to the species include habitat modification through impoundments, channelization, and dredging operations as well as water quality degradation and incidental take associated with commercial harvesting (NatureServe 2003). Other threats are described in the General Mussel Document.

CURRENT THREATS:

The low number of individuals and the restricted range makes them extremely vulnerable to extirpation from a single catastrophic event or activity, such as a toxic chemical spill or major channel alteration. Pollutant threats to freshwater mussels are described in the General Mussel Document.

Exposure Scenario Summary Table for the White wartyback

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
white wartyback	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

ORANGEFOOT PIMPLEBACK (PEARLYMUSSEL)

Plethobasus cooperianus

STATUS:

On June 14, 1976, the orangefoot pimpleback (pearlymussel) was designated as endangered throughout its entire range in Alabama, Illinois, Indiana, Kentucky, Pennsylvania, and Tennessee (USFWS 1976). A recovery plan for the orangefoot pimpleback was approved September 30, 1984 (USFWS 1984).

SPECIES DESCRIPTION:

The orangefoot pimpleback is a medium-sized (reaching up to approximately 100 mm in length) freshwater mussel with a rayless, light brown shell which becomes more chestnut or dark brown as the animal matures (NatureServe 2003, INHS 1997). Like other freshwater mussels, the orangefoot pimpleback feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of orangefoot pimpleback glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:

The reproductive cycle of the orangefoot pimpleback is similar to that of other mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. The orangefoot pimpleback is likely a short term brooder with spawning occurring in the spring and release of glochidia during summer months (ESIE 1996, USFWS 1984). Specific glochidial hosts for this species are not known (ESIE 1996).

RANGE AND POPULATION LEVEL:
This species was historically known from the Ohio River (from western Pennsylvania to southern Illinois), the Wabash River (below Mt. Carmel, Illinois), the Cumberland River (from Cumberland County, Kentucky to near Nashville, Tennessee), the lower Clinch River (Anderson County, Tennessee) and the Tennessee River (near Knoxville to Benton County, Tennessee) and has also been reported from the Caney Fork, Holston, and French Broad Rivers in Tennessee and the Green and Rough Rivers in Kentucky (NatureServe 2003). The species is believed to survive only in the lower Ohio River in Illinois, the middle reaches of the Cumberland River, and the lower reaches of the Tennessee River in northern Alabama and western Tennessee with the largest known population likely remaining in a short reach of the Tennessee River below Pickwick Landing Dam (Ahlstedt 1984, Miller et al. 1986). Though considered rare, live individuals have been regularly documented in the Ohio River in the vicinity of Metropolis, Illinois (Cummings and Mayer 1995) and the lower Tennessee River. The Cumberland River population may be extirpated.

HABITAT:
The orangefoot pimpleback is found in medium to large rivers with sand and gravel substrates (USFWS 1984). Although it has typically been reported in deep waters with steady currents, it has also been found in shallower shoals and riffles (ESIE 1996, USFWS 1984).

PAST THREATS:
Many of the historic populations of the orangefoot pimpleback were apparently lost when the river sections they inhabited were impounded (ESIE 1996). In addition, the dominance of zebra mussels in this species= habitat has been attributed to its decline. Collection and consumption of this species was evident over a three-year period in the early 1980's when large numbers of fresh dead orangefoot pimpleback shells were found adjacent to a camp cookout area below Pickwick Dam (NatureServe 2003). Other threats that are attributed to population declines are described in the General Mussel Document.

CURRENT THREATS:
Current threats to freshwater mussels are described in the General Mussel Document.

Exposure Scenario Summary Table for the Orangefoot pimpleback

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
orangefoot pimpleback	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

CLUBSHELL
Pleurobema clava

STATUS:
On January 22, 1993, the clubshell was designated as endangered throughout its entire range in Indiana, Kentucky, Michigan, Ohio, Pennsylvania, and West Virginia (USFWS 1993). A recovery plan for the clubshell was approved in 1994 (USFWS 1994).

SPECIES DESCRIPTION:
The clubshell, which was described by Lamark (1819), can have a shell length up to about 7.6 centimeters (3 inches) long (USFWS 1995). It appears that the clubshell may reach 30 years of age or more based on growth lines from observed specimens (NatureServe 2003). Like other freshwater mussels, the clubshell feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of clubshell glochidia, like other freshwater mussels, entails fish body fluids once encysted.

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the clubshell is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. They then detach from their fish host and sink to the stream bottom or other substrate where they continue to develop, provided they land in a suitable substratum with the correct water conditions. The striped shiner (*Notropis chrysocephalus*), central stoneroller (*Campostoma anomalum*), blackside darter (*Percina*

maculata), and logperch (*Percina caprodes*) are capable of serving as hosts for the clubshell under laboratory conditions (Watters 1996, Watters and O=Dee, 1997, O=Dee and Watters, 2000). It is likely that additional untested fish species can be used by clubshell glochidia in the wild.

RANGE AND POPULATION LEVEL:
Historically, the species ranged widely and was abundant in the States of Alabama, Illinois, Indiana, Kentucky, Michigan, Ohio, Pennsylvania, Tennessee, and West Virginia (Stansbery et al. 1982). It existed in the Ohio River basin in the Ohio, Allegheny, Scioto, Kanawha, Little Kanawha, Licking, Kentucky, Wabash, White, Vermillion, Mississinewa, Tippecanoe, Tennessee, Green, and Salt Rivers. It was found in the Maumee River basin and tributaries of western Lake Erie (Huron River and River Raison) (Stansbery et al. 1982). It is currently known from 12 streams in six states: Tippecanoe River in Indiana; Fish Creek in Ohio and Indiana; West Branch of the St. Josephs River in Ohio and Michigan; Walhonding River in Ohio; East Fork of the West Branch of the St. Josephs River in Michigan; Little Darby Creek in Ohio; French Creek in Pennsylvania and the Elk River in West Virginia. The clubshell has also been recently documented in the Allegheny River in Pennsylvania near West Hickory (Smith et al. 2001). It is believed to be extirpated from Alabama, Illinois, Tennessee (USFWS 1993, Cummings et al. 1998), Eagle Creek, a tributary to the Kentucky River, (Taylor 1981), and possibly New York (Strayer and Jirka 1997).

HABITAT:
This freshwater mussel occurs in small to medium rivers and streams in clean sweep sand and gravel (Stansbery et al. 1982). The species has been found buried in clean, loose sand to a depth of 2 to 4 inches (USFWS 1993) and apparently relies on water that has percolated through sediment particles (Watters 1990). As a result, the clubshell is very susceptible to siltation and resulting suffocation (USFWS 1994). While the literature found in Natureserve, 2003 states that the clubshell appears to prefer shallow (less than one and a half feet) waters with riffles and runs, this may be a researh bias since clubshells, like most mussels, are easier to find in shallow water. Clubshell sites in Pennsylvania have been identified in water depths of between 10 and 15 deep (B. Anderson, personal communication)

PAST THREATS:
Domestic and industrial waste and navigation developments in the upper Ohio and Wabash river watersheds are documented concerns for this species. According to NatureServe, it was believed that pesticides were at least partially responsible for the overall decrease in the fauna of areas in which the clubshell was present. Proposed coal mining in the Elk River watershed also may have threatened that population. The introduced zebra mussel could also pose a significant threat (USFWS 1993, NatureServe 2003).

CURRENT THREATS:
Current threats to freshwater mussels are described in the General Mussel Document.

Exposure Scenario Summary Table for the Clubshell

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
clubshell	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

JAMES SPINYMUSSEL
Pleurobema collina

STATUS:
On July 22, 1988, the James spinymussel was designated as endangered throughout its entire range (USFWS 1988). A recovery plan for the James spinymussel was approved on September 24, 1990 (USFWS 1990).

SPECIES DESCRIPTION:
The James spinymussel is a small freshwater mussel slightly less than three inches in length. Adults have a dark to yellowish brown shell with prominent growth rings and occasionally, short spines on each valve (USFWS 1990, 2003). Like other freshwater mussels, the James spinymussel feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of James spinymussel glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the James spinymussel is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. They then detach from their fish host and sink to the stream bottom or other substrate where they continue to develop, provided they land in a suitable substratum with the correct water conditions. The James

spinymussel is a tachytictic (short-term) brooder; its eggs are fertilized in the spring and glochidia are released in spring and summer (Hove 1990). Glochidia are released in a formation known as a conglutinate (USFWS 1990). Laboratory studies have identified eight glochidial host species: the bluehead chub (*Nocomis leptocephalus*), rosyside dace (*Clinostomus funduloides*), satinfin shiner (*Cyprinella analostana*), rosefin shiner (*Lythrurus ardens*), central stoneroller (*Campostoma anomalum*), blacknose dace (*Rhinichthys atratulus*), moutain redbelly dace (*Phoxinus oreas*), and the swallowtail shiner (*Notropis procne*) (Hove and Neves 1994, USFWS 2002).

RANGE AND POPULATION LEVEL:
The species has declined rapidly during the past three decades and now exists only in small, headwater tributaries of the upper James River basin in Virginia and West Virginia and the upper Roanoke River drainage of Virginia and North Carolina (USFWS 2003; VEGIF, VAFWIS, BOVA Database, 2004). The Recovery Plan for the species indicates that populations occur in the Rivanna River drainage in Rocky Run, Mechums River and Moormans River (Albemarle County, VA)), the Craig Creek drainage (Craig and Botetourt Counties, VA), Johns Creek (Craig County, VA), Dicks Creek (Craig County, VA), and Patterson Creek (Botetourt County, VA), the Jackson River drainage in South Fork Potts Creek (Monroe County, WV), Potts Creek (Craig and Alleghany Counties, VA), and in Catawba Creek (Botetourt County, VA) and Pedlar River (Amherst County, VA) (USFWS 1990). Survey efforts conducted cooperatively by the Virginia Department of Game and Inland Fisheries, USFWS, US Forest Service, Virginia Polytechnic Institute and State University and non-governmental agency volunteers working with the VDGIF in 2003 and 2004 indicate the species occurs in limited numbers in the Rivanna and upper James River watersheds. Two new populations were found in the Cowpasture River and Hardware River. A population of significant numbers (80 plus individuals) was found in one location in the upper reaches of Johns Creek ((Craig County, VA). No other populations of significant numbers have been found recently; although individuals of various size classes have been found in rivers within the species range. In addition, the species has also been documented to occur in the mainstem of the Dan River (Stokes County, NC) and in the Mayo River (Rockingham County, NC) (Fridell, pers. com. 2002).

HABITAT:
This species lives in stream sites that vary in width from 10-75 feet and depth of 1/2 to 3 feet. It requires a slow to moderate water current with clean sand and cobble bottom sediments but also has been found in unstable sand covered with silt. The James spinymussel is limited to areas of unpolluted water, and may be more susceptible to competition from exotic clam species when its habitat is disturbed (Clark and Neves 1984; USFWS 1990).

PAST THREATS:
Habitat modification has been a major factor in the James spinymussel=s abrupt decline. Adverse habitat changes including dam construction, industrial pollution, chemical spills, channelization, and sewage discharges have occurred at various locations within the species= historic range in the James River drainage.

CURRENT THREATS:
Degraded water quality and habitat is the number one threat to the species. Current threats include: direct loss of habitat due to creation of impoundments and reservoirs and the associated changes in water quality and habitat downstream of impoundments due to quantity and quality of releases from the reservoirs; water withdrawals and increasing impervious surfaces that impact hydrology: siltation from land clearing for development and silviculture; degraded water quality due to fertilizers, pesticides, metals, and PAHs in stormwater runoff; and pollutants that pass through standard secondary wastewater treatment plants, such as endocrine disruptors; toxic chemical spills; and channelization (USFWS, 1988). The Nature Conservancy (draft 2004) has identified stressors to aquatic biota in the Rivanna watershed, such as sedimentation that causes constantly shifting substrate/habitat for mussels, and degraded habitat for host fishes. In addition, competition from non-native species such as Asiatic clam (*Corbicula fluminea*) may also contribute to the species decline (Clarke and Neves 1984; USFWS 19988, 1990)

CONSERVATION MEASURES:
Conservation measures can include implementation of streambank restortation with riparian buffers; best management measures in new developments to provide increased stormwater treatment; balanced flow regimes; and prevention of the introduction of new, non-native aquatic species. Other conservation measures are described in the General Mussel document.

Exposure Scenario Summary Table for the James spinymussel

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
James spinymussel	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	bluehead chub rosyside dace satinfin shiner rosefin shiner central stoneroller blacknose dace mountain redbelly dace swallowtail shiner
	juvenile / adult	sediment dweller	contact & ingestion of water, diet,	filter feeder (bacteria, algae,	

			sediment	detritus, sediment)

BLACK CLUBSHELL
Pleurobema curtum

STATUS:
On April 7, 1987 the black clubshell, also known as Curtus= mussel, was designated as endangered throughout its entire range in Mississippi (USFWS 1987). Although habitat remains in Mississippi, no populations have been found in recent years and the species is possibly extinct. A recovery plan for the black clubshell was approved November 14, 1989 (USFWS 1989).

SPECIES DESCRIPTION:
The black clubshell is a medium-sized freshwater mussel (reaching up to approximately 50 mm in length) with a shell varying from green in juveniles to dark greenish-black in older individuals (USFWS 1989). Like other freshwater mussels, the black clubshell feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of black clubshell glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the black clubshell is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. They then detach from their fish host and sink to the stream bottom or other substrate where they continue to develop, provided they land in a suitable substratum with the correct water conditions. Adult mussels of this species are sexually dimorphic. Specific glochidial host species for the black clubshell are not known.

RANGE AND POPULATION LEVEL:
The black clubshell is historically known from the Tombigbee River near Pickensville, Alabama, and the East Fork Tombigbee River downstream of its confluence with Bull Mountain Creek (Stansbery 1983). A single record of the species from the Big Black River in Mississippi (Hinkley 1906) is believed to be erroneous (USFWS 1989). The species has been collected from only five locations and only two living specimens are known to have been collected. Several fresh dead shells have been collected since 1990 from a single location in the East Fork Tombigbee River, Mississippi (Paul Hartfield, USFWS, Jackson, MS, pers. comm.), which contains the only remaining viable habitat (USFWS 1987, NatureServe 2003).

HABITAT:

The black clubshell, like other Tombigbee River system mussels, inhabits moderate to large rivers with moderate to swift current. Its preferred habitat is riffle-run or shoal areas with stable substrates ranging from sandy gravel to gravel-cobble (Stanbery 1976, 1980, 1983). Unionids collected from the Tombigbee River system have been collected in water up to 0.7 meters deep (USFWS 1987).

PAST THREATS:
The Tombigbee River freshwater mussel fauna once consisted of more than 40 species (Williams 1982). Construction of the Tennessee-Tombigbee Waterway was accomplished in 1984 by dredging portions of the Tombigbee River to form a navigation channel, by cutting off river bends to straighten the channel, by constructing dams and by cutting a canal to the Tennessee River for barge access and to provide water. This resulted in a series of impoundments that inundated much of the known remaining riverine black clubshell habitat or left them in several river bends. The accumulation of sediment in these river bends has eliminated them as potential riverine mussel habitat, except for Gainesville bendway. Recent surveys indicate heavy sedimentation in the lower half of the area.

CURRENT THREATS:
The continued existence of the black clubshell appears to depend upon habitat in tributaries of the Tombigbee River and the species ability to complete its life cycle in a small stream environment. The East Fork Tombigbee River is threatened by an 84.8 km (53 mi) clearing and snagging project, sand and gravel mining, the continued diversion of flood flows, and by water removal for municipal use. Headward erosion induced by the Tennessee-Tombigbee Waterway and sand and gravel mining has severely degraded the East Fork Tombigbee since the species was listed (Patrick and Dueitt 1996). The host species for the black clubshell is unknown; however, if glochidial host species are large river or migratory species that infrequently enter the tributaries, the future existence of this mussel is very precarious (USFWS 1989). Other current threats to freshwater mussels are described in the General Mussel Document.

Exposure Scenario Summary Table for the Black clubshell

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
black clubshell	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus,	

				sediment)

SOUTHERN CLUBSHELL
Pleurobema decisum

STATUS:
On March 17, 1993, the southern clubshell (*Pleurobema decisum)* was designated as Endangered throughout its entire range (USFWS 1993). A recovery plan for the southern clubshell was finalized on November 17, 2000 (USFWS 2000). Critical habitat was designated for the southern clubshell on July 1, 2004 (69 FR 40083).

SPECIES DESCRIPTION:
The southern clubshell is a medium sized mussel about 70 mm (2.8 inches) long, with a thick shell, and heavy hinge plate and teeth. Like other freshwater mussels, adults are filter-feeders, orienting themselves in the substrate to facilitate siphoning of the water column for oxygen and food (Kraemer 1979). Mussels have been reported to consume detritus, diatoms, phytoplankton, zooplankton, and other microorganisms (Coker et al. 1921, Churchill and Lewis 1924, Fuller 1974). Juvenile mussels employ foot (pedal) feeding, and are thus suspension feeders (Yeager et al. 1994). Foods of juvenile freshwater mussels up to two weeks old include bacteria, algae, and diatoms with amounts of detrital and inorganic colloidal particles (Yeager et al. 1994). Specific food habits of the southern clubshell are unknown, but are likely similar to those of other freshwater mussels.

REPRODUCTION AND DEVELOPMENT:
Gravid southern clubshell females with mature glochidia have been collected in June and July. Glochidia are released in well formed conglutinates orange or white in coloration (Haag and Warren 2001). Blacktail shiner *(Cyprinella venusta)*, Alabama shiner *(C. callistia)*, and tricolor shiner *(C. trichroistia)* have been identified as fish host (Haag and Warren 2001, P. Johnson, pers. comm., 2002).

RANGE AND POPULATION LEVEL:
The southern clubshell was described from the Alabama River, Alabama. With the exception of the Tensas/Mobile River, the southern clubshell was formerly known from every major river system in the Mobil River Basin, including the Alabama, Tombigbee, Black Warrior, Cahaba, Tallapoosa, and Coosa Rivers and many of their tributaries in Mississippi, Alabama, Georgia, and Tennessee. This species has disappeared from the Cahaba River drainage, the main channels of the Tombigbee and Black Warrior Rivers, and from a number of tributaries in all of the drainages (USFWS 2003).

Southern clubshell continues to inhabit the East For Tombigbee River (Itawamba/Monroe County, Mississippi), Bull Mountain Creek (Itawamba County, Mississippi), Buttahatchee River (Monroe/Lowndes County, Mississippi), Luxapalila and Yellow Creeks (Lowndes County, Mississippi), Lubbub Creek (Pickens County, Alabama), and Sipsey River (Greene/Pickens/Tuscaloos County, Alabama) in the Tombigbee drainage; a short reach of the

Alabama River and Bogue Chitto Creek (Dallas County, Alabama); Chewacla Creek (Macon County, Alabama) in the Tallapoosa drainage; Coosa River (Dead River) below Weiss Dam (Cherokee County, Alabama) and tributaries Kelly Creek (Shelby County, Alabama), Big Canoe Creek (St. Clair County, Alabama), Terrapin Creek (Cherokee County, Alabama), and Conassauga River (Murray/Whitfield County, Georgia) (USFWS 2003). The southern clubshell is relatively common in localized reaches of the Buttahatchee and Sipsey Rivers. Average density at four sites in the Coosa River below Weiss Dam was 0.19/square meter (Herod et al. 2001). It is rare to uncommon in other occupied streams.

HABITAT:
The southern clubshell inhabits sand/gravel/cobble substrate in shoals and runs of small rivers and large streams.

CRITICAL HABITAT:
In Itawamba County, Mississippi, stream and river channels within the ordinary high water line of the East Fork Tombigbee River main stem from Mississippi Highway 278, Monroe County, upstream to the confluence of Mill Creek.

In Itawamba County, Mississippi, stream and river channels within the ordinary high water line of Bull Mountain Creek from Mississippi Highway 25, upstream to U.S. Highway 78.

In Lowndes/Monroe County, Mississippi and Lamar County, Alabama, stream and river channels within the ordinary high water line of the Buttahatchee River main stem from its confluence with the impounded waters of Columbus Lake, Lowndes/Monroe County, Mississippi, upstream to the confluence of Beaver Creek, Lamar County, Alabama; and Sipsey Creek, from its confluence with the Buttahatchee River, upstream to the Mississippi/Alabama State Line, Monroe County, Mississippi.

In Lowndes County, Mississippi and Lamar County, Alabama, stream and river channels within the ordinary high water line of the Luxapalila Creek main stem from Waterworks Road, Columbus, Mississippi, upstream to approximately 1.0 km (0.6 mi) above Steens Road, Lowndes County, Mississippi; and the Yellow Creek main stem from its confluence with Luxapalila Creek, Lowndes County, Mississippi, upstream to the confluence of Cut Bank Creek, Lamar County, Alabama.

In Pickens County, Alabama, stream and river channels within the ordinary high water line of the Coalfire Creek main stem from its confluence with the impounded waters of Aliceville Lake, upstream to U.S. Highway 82.

In Pickens County, Alabama, stream and river channels within the ordinary high water line of the main stem of Lubbub Creek from its confluence with the impounded waters of Gainesville Lake, upstream to the confluence of Little Lubbub Creek

In Greene/Pickens and Tuscaloosa Counties, Alabama, stream and river channels within the ordinary high water line of the Sipsey River main stem from its confluence

with impounded waters of Gainesville Lake, Greene/Pickens County, upstream to Alabama Highway 171 crossing, Tuscaloosa County, Alabama.

In Greene County, Alabama, stream and river channels within the ordinary high water line of the Trussels Creek main stem from its confluence with the impounded waters of Demopolis Lake, upstream to Alabama Highway 14.

In Sumter County, Alabama, stream and river channels within the ordinary high water line of the Sucarnoochee River main stem from its confluence with the Tombigbee River, upstream to the Mississippi/Alabama State Line.

In Jefferson, Shelby, and Bibb Counties, Alabama, stream and river channels within the ordinary high water line of the Cahaba River from U.S. Highway 82, Centerville, Bibb County, upstream to Jefferson County Road 143, Jefferson County, Alabama; and the Little Cahaba River from its confluence with the Cahaba River, upstream to the confluence of Mahan and Shoal Creeks, Bibb County, Alabama.

In Autauga, Lowndes, and Dallas Counties, Alabama, stream and river channels within the ordinary high water line of the Alabama River from the confluence of the Cahaba River, Dallas County, upstream to the confluence of Big Swamp Creek, Lowndes County, Alabama.

In Dallas County, Alabama, stream and river channels within the ordinary high water line of the Bogue Chitto Creek main stem from its confluence with the Alabama River, Dallas County, upstream to U.S. Highway 80.

In Macon and Lee Counties, Alabama, stream and river channels within the ordinary high water line of the mainstem of Uphapee Creek from Alabama Highway 199, upstream to the confluence of Opintlocco and Chewacla Creeks, Macon County, Alabama; Choctafaula Creek, from confluence with Uphapee Creek, upstream to Macon County Road 54, Macon County, Alabama; Chewacla Creek, from confluence with Opintlocco Creek, Macon County, Alabama, upstream to Lee County Road 159, Lee County, Alabama; Opintlocco Creek, from confluence with Chewacla Creek, upstream to Macon County Road 79, Macon County, Alabama.

In Cherokee, Calhoun, and Cleburne Counties, Alabama, stream and river channels within the ordinary high water line of the Coosa River main stem from the power line crossing southeast of Maple Grove, Alabama, upstream to Weiss Dam, Cherokee County, Alabama; Terrapin Creek, 53 km (33 mi) extending from its confluence with the Old Coosa River channel, Cherokee County, upstream to Cleburne County Road 49, Cleburne County, Alabama; South Fork Terrapin Creek, 7 km (4 mi), from its confluence with Terrapin Creek, upstream to Cleburne County Road 55, Cleburne County, Alabama.

In Coosa and Clay Counties, Alabama, stream and river channels within the ordinary high water line of the main stem of Hatchet Creek from the confluence of Swamp Creek at Coosa County Road 29, Coosa County, Alabama, upstream to Clay County Road 4, Clay County, Alabama.

In Shelby and St. Clair Counties, Alabama, stream and river channels within the ordinary high water line of the Kelly Creek main stem extending from the confluence with the Coosa River, upstream to the confluence of Shoal Creek, St. Clair County, Alabama;
and the main stem of Shoal Creek from the confluence with Kelly Creek, St. Clair County, Alabama, upstream to the St. Clair/Shelby County Line, St. Clair County, Alabama.

In St. Clair County, Alabama, stream and river channels within the ordinary high water line of the main stem of Big Canoe Creek from its confluence with Little Canoe Creek at the St. Clair/Etowah County line, St. Clair County, upstream to the confluence of Fall Branch.

In Floyd, Gordon, Whitfield, and Murray Counties, Georgia; and Bradley and Polk Counties, Tennessee, stream and river channels within the ordinary high water line of the Oostanaula River main stem from its confluence with the Etowah River, Floyd County, Georgia, upstream to the confluence of the Conasauga and Coosawattee River, Gordon County, Georgia; the Coosawattee River main stem from its confluence with the Conasauga River, upstream to Georgia State Highway 136, Gordon County, Georgia; the Conasauga River main stem from confluence with the Coosawattee River, Gordon County, Georgia, upstream through Bradley and Polk Counties, Tennessee, to Murray County Road 2, Murray County, Georgia; and the mainstem of Holly Creek from its confluence with the Conasauga River, upstream to its confluence with Rock Creek, Murray County, Georgia.

In Elmore County, Alabama, stream and river channels within the ordinary high water line of the Coosa River main stem from Alabama State Highway 111 bridge, upstream to Jordan Dam.

Primary constituent elements identified at the time of designation included: 1. Geomorphically stable stream and river channels and banks; 2. A flow regime (i.e., the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of mussels and their fish hosts in the river environment; 3. Water quality, including temperature, pH, hardness, turbidity, oxygen content, and other chemical characteristics necessary for normal behavior, growth, and viability of all life stages; 4. Sand, gravel, and/or cobble substrates with low to moderate amounts of fine sediment, low amounts of attached filamentous algae, and other physical and chemical characteristics necessary for normal behavior, growth, and viability of all life stages; 5. Fish hosts with adequate living, foraging, and spawning areas for them; and 6. Few or no competitive or predaceous nonnative species present.

PAST THREATS:
The abundance and distribution of the southern clubshell decreased historically from human-induced habitat loss and degradation caused by impoundments, sedimentation and turbidity, channelization and dredging, mining (coal, sand, gravel, or gold) (Jones 1991, USFWS 1993, Leigh 1994, ADEM 1994), and contaminants contained in numerous point (e.g., carpet mills and fabric dying mills) (Hurd 1974) and nonpoint sources (USFWS 2000). Channel modifications and water pollution gradually eliminated this native species that is dependent on a narrow range of flowing water habitat conditions from extensive portions of its former range within the Mobile River Basin. These habitat changes have resulted in significant extirpations (localized loss of populations), restricted and fragmented distributions, and poor recruitment of young.

CURRENT THREATS:
Habitat modification, sedimentation, and water quality degradation are the primary causes of decline of the southern clubshell. This species does not tolerate impoundment or channelization. Surviving populations are threatened by channelization projects, urban and agricultural runoff, and channel degradation caused by sand and gravel mining and/or channel maintenance projects.

Due to the extreme rarity of the southern clubshell, any adverse impacts to its habitat or an individual could result in the demise of the species. The immediate recovery objective is to prevent extinction of this species by locating, protecting, and restoring stream drainages with extant populations.

Exposure Scenario Summary Table for the Southern Clubshell

Species	**Life Stage**	**Habitat Type**	**Exposure Route**	**Diet**	**Significant Interspecies Relationships**
Southern Clubshell	glochidia	parasite	contact with water, diet	fish body fluids	Blacktail shiner, Alabama shiner, and tricolor shiner
	juvenile/ adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

DARK PIGTOE
Pleurobema furvum

STATUS:
On March 17, 1993, the dark pigtoe (*Pleurobema furvum*) was designated as Endangered throughout its entire range (USFWS 1993). A recovery plan for the dark pigtoe was finalized on.November 17, 2000 (USFWS 2000).

SPECIES DESCRIPTION:
The dark pigtoe is a small- to medium-sized mussle, occasionally reaching 60 mm (2.4 inches) in length. The shell is oval in outline, and moderately inflated. Beaks ar located in the anterior portion of the shell. Like other freshwater mussels, adults are filter-feeders, orienting themselves in the substrate to facilitate siphoning of the water column for oxygen and food (Kraemer 1979). Mussels have been reported to consume detritus, diatoms, phytoplankton, zooplankton, and other

microorganisms (Coker et al. 1921, Churchill and Lewis 1924, Fuller 1974). Juvenile mussels employ foot (pedal) feeding, and are thus suspension feeders (Yeager et al. 1994). Foods of juvenile freshwater mussels up to two weeks old include bacteria, algae, and diatoms with amounts of detrital and inorganic colloidal particles (Yeager et al. 1994). Specific food habits of the dark pigtoe are unknown, but are likely similar to those of other freshwater mussels.

REPRODUCTION AND DEVELOPMENT:
The life history of the dark pigtoe is unknown. However, the largescale stoneroller, Alabama shiner, blacktail shiner, creek chub, and blackspotted topminnow have been confirmed as hosts.

RANGE AND POPULATION LEVEL:
The dark pigtoe was described from the Black Warrior River, Alabama. The historic distribution of the dark pigtoe was probably restricted to the Black Warrior River above the fall line. Dodd et al. (1986) collected this species, misidentified as Pleurobema rubellum (Hartfield pers. Obs., February 1990), from the headwaters of the Sipsey Fork in 1985. Shells from this popoulation were collected by a Service biologist in 1990 (Hartfield 1991). Badly weathered speciemsn were also found in the Locust Fork of the Black Warrior River near the Jefferson-Blount County line. Butler (in litt. 1992) found two live specimens in the Sipsey Fork tributary Rush Creek in 1992. Fresh dead shells of the species have also been recently collected from the North River above lake Tuscaloosa (Stuart McGregor, Geological Survey of Alabama, pers. Comm., 1991; Pierson, pers. Comm. 1992).

HABITAT:
The dark pigtoe inhabits sand/gravel/cobble shoals and rapids in small rivers and large streams.

CRITICAL HABITAT:
In Winston and Lawrence Counties, Alabama, stream and river channels within the ordinary high water line of the Sipsey Fork main stem from the section 11/12 line, Winston County, Alabama, upstream to the confluence of Hubbard Creek, Lawrence County, Alabama; Thompson Creek, from its confluence with Hubbard Creek, upstream to section 2 line Lawrence County; Brushy Creek, from the confluence of Glover Creek, Winston County, upstream to section 9, Lawrence County; Capsey Creek, from confluence with Brushy Creek, Winston County, upstream to the confluence of Turkey Creek, Lawrence County; Rush Creek, from confluence with Brushy Creek, upstream to Winston/Lawrence County Line, Winston County; Brown Creek, from confluence with Rush Creek, Winston County, upstream to section 24 line, Lawrence County; Beech Creek, from confluence with Brushy Creek, to confluence of East and West Forks, Winston County; Caney Creek and North Fork Caney Creek, from confluence with Sipsey Fork, upstream to section 14 line, Winston County; Borden Creek, from confluence with Sipsey Fork, Winston County, upstream to the confluence of Montgomery Creek, Lawrence County; and Flannagin Creek, from confluence with Borden Creek, upstream to confluence of Dry Creek, Lawrence County.

In Tuscaloosa and Fayette Counties, Alabama, stream and river channels within the ordinary high water line of the main stem of the North River from Tuscaloosa County Road 38,

Tuscaloosa County, upstream to confluence of Ellis Creek, Fayette County, Alabama; and Clear Creek from its confluence with North River to Bays Lake Dam, Fayette County, Alabama.

In Jefferson and Blount Counties, Alabama, stream and river channels within the ordinary high water line of the Locust Fork main stem from U.S. Highway 78, Jefferson County, upstream to the confluence of Little Warrior River, Blount County, Alabama; and Little Warrior River from its confluence with the Locust Fork, upstream to the confluence of Calvert Prong and Blackburn Fork, Blount County, Alabama.

Primary constituent elements identified at the time of designation included: 1.Geomorphically stable stream and river channels and banks; 2. A flow regime (i.e., the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of mussels and their fish hosts in the river environment; 3. Water quality, including temperature, pH, hardness, turbidity, oxygen content, and other chemical characteristics necessary for normal behavior, growth, and viability of all life stages; 4. Sand, gravel, and/or cobble substrates with low to moderate amounts of fine sediment, low amounts of attached filamentous algae, and other physical and chemical characteristics necessary for normal behavior, growth, and viability of all life stages; 5. Fish hosts with adequate living, foraging, and spawning areas for them; and 6. Few or no competitive or predaceous nonnative species present.

PAST THREATS:
Habitat modification, sedimentation, and degradation of water quality are reasons for the decline of the dark pigtoe (USFWS 1993). Other past threats are described in the General Mussel Document.

CURRENT THREATS:
As in the past, habitat modification, sedimentation, eutrophication, and other forms of water quality degradation are the primary causes of decline of the dark pigtoe. This species does not tolerate impoundment. Surviving populations are threatened by impoundment projects, surface mine runoff, and household and agricultural runoff.

Due to the extreme rarity of the dark pigtoe, any adverse impacts to its habitat or an individual could result in the demise of the species. The immeidate recovery objective is to prevent the continued decline of this species by locating, protecting, and restoring stream drainages with extant populations.

Exposure Scenario Summary Table for the Dark Pigtoe

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
Dark Pigtoe	glochidia	parasite	contact with water, diet	fish body fluids	Largescale stoneroller,

					Alabama shiner, blacktail shiner, creek chub, blackspotted topminnow
	juvenile/ adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

SOUTHERN PIGTOE
Pleurobema georgianum

STATUS:
On March 17, 1993, the southern pigtoe (*Pleurobema georgianum)* was designated as Endangered throughout its entire range (USFWS 1993). A recovery plan for the southern pigtoe was finalized on November 17, 2000 (USFWS 2000). Critical habitat was designated for the southern pigtoe on July 1, 2004 (69 FR 40083).

SPECIES DESCRIPTION:
The southern pigtoe is a small to medium-sized mussel occasionally exceeding 60 mm (2.4 inches) in length. Like other freshwater mussels, adults are filter-feeders, orienting themselves in the substrate to facilitate siphoning of the water column for oxygen and food (Kraemer 1979). Mussels have been reported to consume detritus, diatoms, phytoplankton, zooplankton, and other microorganisms (Coker et al. 1921, Churchill and Lewis 1924, Fuller 1974). Juvenile mussels employ foot (pedal) feeding, and are thus suspension feeders (Yeager et al. 1994). Foods of juvenile freshwater mussels up to two weeks old include bacteria, algae, and diatoms with amounts of detrital and inorganic colloidal particles (Yeager et al. 1994). Specific food habits of the southern pigtoe are unknown, but are likely similar to those of other freshwater mussels.

REPRODUCTION AND DEVELOPMENT:
Known host fish are the Alabama shiner *(Cyprinella callistia)*, blacktail shiner *(C. venusta)*, and tricolor shiner *(C. trichroistia)* (P. Johnson, pers. comm., 2002). Otherwise, the life history of the southern pigtoe is unknown.

RANGE AND POPULATION LEVEL:
The southern pigtoe was described from the upper Coosa River drainage in Georgia. The historical range of the southern pigtoe included the Coosa River and its tributaries in Alabama, Georgia, and Tennessee. The species is currently known to survive in the Conasauga River (Murray/Whitfield County, Georgia; Bradley County, Tennessee), Holly Creek (Murray County,

Georgia), Shoal Creek (Cleburne County, Alabama), Big Canoe Creek (St. Clair County, Alabama), and Cheaha Creek (Talladega County, Alabama) (USFWS 2003). Populations are small and localized.

HABITAT:
The southern pigtoe inhabits sand/gravel/cobble shoals and runs in small rivers and large streams.

CRITICAL HABITAT:
In Cherokee, Calhoun, and Cleburne Counties, Alabama, stream and river channels within the ordinary high water line of the Coosa River main stem from the power line crossing southeast of Maple Grove, Alabama, upstream to Weiss Dam, Cherokee County, Alabama; Terrapin Creek, 53 km (33 mi) extending from its confluence with the Old Coosa River channel, Cherokee County, upstream to Cleburne County Road 49, Cleburne County, Alabama; South Fork Terrapin Creek, 7 km (4 mi), from its confluence with Terrapin Creek, upstream to Cleburne County Road 55, Cleburne County, Alabama.

In Coosa and Clay Counties, Alabama, stream and river channels within the ordinary high water line of the main stem of Hatchet Creek from the confluence of Swamp Creek at Coosa County Road 29, Coosa County, Alabama, upstream to Clay County Road 4, Clay County, Alabama.

In Calhoun and Cleburne Counties, Alabama, stream and river channels within the ordinary high water line of the main stem of Shoal Creek from the headwater of Whitesides Mill Lake, Calhoun County, Alabama, upstream to the tailwater of Coleman Lake Dam, Cleburne County, Alabama.

In Shelby and St. Clair Counties, Alabama, stream and river channels within the ordinary high water line of the Kelly Creek main stem extending from the confluence with the Coosa River, upstream to the confluence of Shoal Creek, St. Clair County, Alabama;
and the main stem of Shoal Creek from the confluence with Kelly Creek, St. Clair County, Alabama, upstream to the St. Clair/Shelby County Line, St. Clair County, Alabama.

In Talladega and Clay Counties, Alabama, stream and river channels within the ordinary high water line of the main stem of Cheaha Creek from its confluence with Choccolocco Creek, Talladega County, Alabama, upstream to the tailwater of Chinnabee Lake Dam, Clay County, Alabama.

In Shelby County, Alabama, stream and river channels within the ordinary high water line of the Yellowleaf Creek main stem from Alabama Highway 25, upstream to Shelby County Road 49; and the Muddy Prong main stem extending from its confluence with Yellowleaf Creek, upstream to U.S. Highway 280.

In St. Clair County, Alabama, stream and river channels within the ordinary high water line of the main stem of Big Canoe Creek from its confluence with Little Canoe Creek at the St. Clair/Etowah County line, St. Clair County, upstream to the confluence of Fall Branch.

In Floyd, Gordon, Whitfield, and Murray Counties, Georgia; and Bradley and Polk Counties, Tennessee, stream and river channels within the ordinary high water line of the Oostanaula River main stem from its confluence with the Etowah River, Floyd County, Georgia, upstream to the confluence of the Conasauga and Coosawattee River, Gordon County, Georgia; the Coosawattee River main stem from its confluence with the Conasauga River, upstream to Georgia State Highway 136, Gordon County, Georgia; the Conasauga River main stem from confluence with the Coosawattee River, Gordon County, Georgia, upstream through Bradley and Polk Counties, Tennessee, to Murray County Road 2, Murray County, Georgia; and the mainstem of Holly Creek from its confluence with the Conasauga River, upstream to its confluence with Rock Creek, Murray County, Georgia.

In Elmore County, Alabama, stream and river channels within the ordinary high water line of the Coosa River main stem from Alabama State Highway 111 bridge, upstream to Jordan Dam.

Primary constituent elements identified at the time of designation included: 1. Geomorphically stable stream and river channels and banks; 2. A flow regime (i.e., the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of mussels and their fish hosts in the river environment; 3. Water quality, including temperature, pH, hardness, turbidity, oxygen content, and other chemical characteristics necessary for normal behavior, growth, and viability of all life stages; 4. Sand, gravel, and/or cobble substrates with low to moderate amounts of fine sediment, low amounts of attached filamentous algae, and other physical and chemical characteristics necessary for normal behavior, growth, and viability of all life stages; 5. Fish hosts with adequate living, foraging, and spawning areas for them; and 6. Few or no competitive or predaceous nonnative species present.

PAST THREATS:
The abundance and distribution of the southern pigtoe decreased historically due to human-induced habitat loss and degradation caused by impoundments, sedimentation and turbidity, channelization and dredging, mining (coal, sand, gravel, or gold) (Jones 1991, USFWS 1993, Leigh 1994, ADEM 1994), and contaminants contained in numerous point (e.g., carpet mills and fabric dying mills) (Hurd 1974) and nonpoint sources (USFWS 2000). Channel modifications and water pollution gradually eliminated this native species that is dependent on a narrow range of flowing water habitat conditions from extensive portions of its former range within the Mobile River Basin. These habitat changes have resulted in significant extirpations (localized loss of populations), restricted and fragmented distributions, and poor recruitment of young.

CURRENT THREATS:
Habitat modification, sedimentation, eutrophication, and other forms of water quality degradation are the primary causes of decline of the southern pigtoe. This species can not tolerate impoundments. Surviving populations are threatened by household and agricultural runoff on private lands, and to a lesser degree, by recreational activities on public lands. Dense filamentous algal growth due to nutrification affects feeding, host fish interactions, and survival of juveniles.

Due to the rarity of the southern pigtoe, any adverse impacts to its habitat or an individual could result in the extirpation of a localized population. Recovery of the southern pigtoe to the point of downlisting to threatened is unlikely in the near future. The immediate recovery objective is to prevent the extinction of this species by locating, protecting, and restoring stream drainages with extant populations.

Exposure Scenario Summary Table for the Southern Pigtoe

Species	**Life Stage**	**Habitat Type**	**Exposure Route**	**Diet**	**Significant Interspecies Relationships**
Southern Pigtoe	glochidia	parasite	contact with water, diet	fish body fluids	Alabama shiner, blacktail shiner, and tricolor shiner
	juvenile/ adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

CUMBERLAND PIGTOE
Pleurobema gibberum

STATUS:
On May 7, 1991 the Cumberland pigtoe was designated as endangered throughout its entire range in Tennessee (USFWS 1991). A recovery plan for the Cumberland pigtoe was approved in August 13, 1992 (USFWS 1992).

SPECIES DESCRIPTION:
The Cumberland pigtoe is a small freshwater mussel (rarely exceeding 60 mm in length) with a yellowish-brown shell in juveniles and a dark mahogany brown coloration in adults (USFWS 1991). Like other freshwater mussels, the Cumberland pigtoe feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of Cumberland pigtoe glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the Cumberland pigtoe is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females

through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. In a recent study, Layzer et al. (2003) observed and collected gravid Cumberland pigtoe individuals from late June through August. Anderson (1990) also observed gravid females (with bright red marsupial gills) in mid-July. In laboratory infestation tests, metamorphosis of Cumberland pigtoe glochidia occurred on the telescope shiner (*Notropis telescopus*) and the striped shiner (*Luxilus chrysocephalus*) (Layzer et al. 2003). The telescope shiner is believed to be the primary host for the Cumberland pigtoe given 1) the high frequency of occurrence of glochidia found on this host in the Collins River and 2) observed successful metamorphosis of glochidia from naturally infested telescope shiners collected from the Collins River under laboratory conditions (Layzer et al. 2003).

RANGE AND POPULATION LEVEL:
Based on historic mussel collection records from the Cumberland River system (Anderson 1990, Gordon and Layzer 1989), the Cumberland pigtoe is restricted to the Caney Fork River basin above Great Falls. Within this isolated river basin, the species has been reported from only five Caney Fork River tributaries. However, historic mussel collection records from the upper Caney Fork system are very limited. The species once likely occurred in the main stem of the Caney Fork River, and it was historically collected from Hickory Creek and the Collins River. Anderson (1990) surveyed both areas and found the species in the Collins River but did not collect any specimens at his four sampling stations in the lower Hickory Creek system. However, a population was located in 1992 in the upper portion of Hickory Creek above the area previously searched. Anderson (1990) did not find the species in any unimpounded reaches of the Caney Fork River. It is believed that the species has now been extirpated from the Caney Fork River and lower Hickory Creek.

Presently, the species is restricted to isolated populations in short reaches of five Caney Fork tributariesBBarren Fork (Warren County), Calfkiller River (White County), Cane Creek (Van Buren County), Hickory Creek (Warren County), and Collins River (Warren and Grundy Counties) (Anderson 1990, Widlak 1992). Anderson (1990) also surveyed other Caney Fork tributaries, and he did not find the mussel in Big Creek, Big Hickory Creek (Widlak [1992] later reported a population from this creek), Charles Creek, Dry Branch Barren River, Falling Water River, Firescald Creek, Fultz Creek, Little Hickory Creek, Mountain Creek, Pine Creek, Rocky River, Sink Creek, Smith Fork, Smith Fork Creek, and West Fork Hickory Creek (USFWS 1992).

HABITAT:
The Cumberland pigtoe inhabits small to medium-sized rivers in riffle areas (Gordon and Layzer 1989, NatureServe 2003). This mussel=s preferred habitat is riffle areas with sand and gravel with occasional mud and cobble substratum (Anderson 1990, Gordon and Layzer 1989). Anderson (1990) found it inhabiting fast-flowing water in areas with predominately gravel, sand, and cobble substratum. Some sites where the species was collected had beds of macrophitic plants, but the mussel was usually found between, not within, these beds. Water depth ranged

from about 10 centimeters to one meter. Anderson (1990) did not find any living specimens in pools or heavily silted areas (USFWS 1992).

PAST THREATS:
The five extant populations are impacted by such factors as impoundments and the general deterioration of water quality resulting from domestic and industrial waste outfalls. Prior to the construction of Rock Island Reservoir in the 1910s, this the preferred habitat for this species was more common. Nonpoint pollution sources have limited the distribution of mussels, including the Cumberland pigtoe, in the Caney Fork system. Runoff from surface and deep coal mining operations affects areas of the Collins River, Caney Fork River, Rocky River, and their headwater tributaries. Poor agricultural practices have resulted in soil loss and nutrient enrichment that impact scattered stream reaches throughout the species= range. Construction of bridges, roads, and buildings without adequate siltation control appears to have reduced habitat in sections of the Calfkiller and Collins Rivers. Recent gravel removal operations have destroyed habitat and increased siltation in the upper Caney Fork River and some tributaries. The population in lower Hickory Creek appears to have been lost due to nutrient enrichment and siltation resulting from domestic animal waste (from cows and hogs), as well as from physical habitat alteration caused by allowing animals to have free access to the stream (USFWS 1992).

CURRENT THREATS:
Given the small size of remaining Cumberland pigtoe populations, any factor that adversely modifies habitat or water quality in the limited reaches where the species is found could threaten its survival in these areas. Also, because the populated reaches are physically isolated from each other by impoundments and unsuitable habitat, recolonization of any extirpated population would be unlikely without human intervention. Additionally, because natural gene flow among populations is no longer possible, the long-term genetic viability of these remaining isolated populations is questionable (USFWS 1992).

Exposure Scenario Summary Table for the Cumberland pigtoe

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
Cumberland pigtoe	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	telescope shiner striped shiner
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus,	

sediment)

FLAT PIGTOE
Pleurobema marshalli

STATUS:
On April 7, 1987 the flat pigtoe, also known as Marshall=s mussel, was designated as endangered throughout its entire range in Alabama and Mississippi (USFWS 1987). A recovery plan for the flat pigtoe was approved November 14, 1989 (USFWS 1989).

SPECIES DESCRIPTION:
The flat pigtoe is a small freshwater mussel (rarely exceeding 60 mm in length) with a reddish-brown shell (USFWS 1987, NatureServe 2003). Like other freshwater mussels, the flat pigtoe feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of flat pigtoe glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the flat pigtoe is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. The life history of this species is largely unknown. Specific glochidial host species for the flat pigtoe are not known (ESIE 1996).

RANGE AND POPULATION LEVEL:
The flat pigtoe was historically known from the mainstem of the Tombigbee River from just above Tibbee Creek near Columbus, Mississippi, down to Epes, Alabama (Stansbery 1983). Studies of clams of the Gulf Coast rivers from the Escambia River to the Suwannee River (Clench and Turner 1956) and of the Mississippi streams (Grantham 1969) did not reveal the presence of this species in those areas. The flat pigtoe was not found after extensive surveys of the Cahaba River (van der Schalie 1938b) and the Coosa River (Hurd 1974) as well. Yokley (1978), Hartfield and Jones (1990), or Jones (1991) did not find the flat pigtoe in surveys of the Buttahatchie River. This complete lack of specimens from anywhere except the Tombigbee River suggests that the historic range of the species was restricted to this river reach. An extensive survey of the Tombigbee River in 1971-1976 recorded the flat pigtoe in the lower half of the river from Tibbee Creek downstream to just above the mouth of the Noxubee River. The only remaining viable habitat for this species in the Tombigbee River is a gravel bar in a bendway in Sumter County, Alabama (USFWS 1987); however, surveys of this area have failed to locate the flat pigtoe (Hartfield and Jones 1989). No live specimens of the flat pigtoe have

been collected since the completion of the Tennessee-Tombigbee River Waterway (NatureServe 2003).

HABITAT:
The flat pigtoe, like other Tombigbee River system mussels, inhabits moderate to large rivers with moderate to swift current. Its preferred habitat is riffle-run or shoal areas with stable substrates ranging from sandy gravel to gravel-cobble (Stanbery 1976, 1980, 1983). Unionids collected from the Tombigbee River system have been collected in water up to 0.7 meters deep (USFWS 1987).

PAST THREATS:
The Tombigbee River freshwater mussel fauna once consisted of more than 40 species (Williams 1982). Construction of the Tennessee-Tombigbee Waterway was accomplished in 1984 by dredging portions of the Tombigbee River to form a navigation channel, by cutting off river bends to straighten the channel, by constructing dams and by cutting a canal to the Tennessee River for barge access and to provide water. This resulted in a series of impoundments that inundated much of the known remaining riverine flat pigtoe habitat or left them in several river bends. The accumulation of sediment in these river bends has eliminated them as potential riverine mussel habitat, except for Gainesville bendway. Recent surveys of this area indicate the lower half of it has heavy sedimentation (USFWS 1989).

CURRENT THREATS:
Given the small size of remaining flat pigtoe populations, any factor that adversely modifies habitat or water quality in the limited remaining habitat for the species could threaten its survival in these areas. The continued existence of the flat pigtoe appears to depend upon habitat in tributaries of the Tombigbee River and the species ability to complete its life cycle in a small stream environment. The East Fork Tombigbee River is threatened by an 84.8 km (53 mi) clearing and snagging project, sand and gravel mining, the continued diversion of flood flows, and by water removal for municipal use. The host species for the flat pigtoe is unknown; however, if glochidial host species are large river or migratory species that infrequently enter the tributaries, the future existence of this mussel is very precarious (USFWS 1989). Other current threats to freshwater mussels are described in the General Mussel document.

Exposure Scenario Summary Table for the Flat pigtoe

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
flat pigtoe	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	

	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)

FLAT PIGTOE
Pleurobema marshalli

STATUS:
On April 7, 1987 the flat pigtoe, also known as Marshall=s mussel, was designated as endangered throughout its entire range in Alabama and Mississippi (USFWS 1987). A recovery plan for the flat pigtoe was approved November 14, 1989 (USFWS 1989).

SPECIES DESCRIPTION:
The flat pigtoe is a small freshwater mussel (rarely exceeding 60 mm in length) with a reddish-brown shell (USFWS 1987, NatureServe 2003). Like other freshwater mussels, the flat pigtoe feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of flat pigtoe glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the flat pigtoe is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. The life history of this species is largely unknown. Specific glochidial host species for the flat pigtoe are not known (ESIE 1996).

RANGE AND POPULATION LEVEL:
The flat pigtoe was historically known from the mainstem of the Tombigbee River from just above Tibbee Creek near Columbus, Mississippi, down to Epes, Alabama (Stansbery 1983). Studies of clams of the Gulf Coast rivers from the Escambia River to the Suwannee River (Clench and Turner 1956) and of the Mississippi streams (Grantham 1969) did not reveal the presence of this species in those areas. The flat pigtoe was not found after extensive surveys of the Cahaba River (van der Schalie 1938b) and the Coosa River (Hurd 1974) as well. Yokley (1978), Hartfield and Jones (1990), or Jones (1991) did not find the flat pigtoe in surveys of the Buttahatchie River. This complete lack of specimens from anywhere except the Tombigbee River suggests that the historic range of the species was restricted to this river reach. An extensive survey of the Tombigbee River in 1971-1976 recorded the flat pigtoe in the lower half of the river from Tibbee Creek downstream to just above the mouth of the Noxubee River. The

only remaining viable habitat for this species in the Tombigbee River is a gravel bar in a bendway in Sumter County, Alabama (USFWS 1987); however, surveys of this area have failed to locate the flat pigtoe (Hartfield and Jones 1989). No live specimens of the flat pigtoe have been collected since the completion of the Tennessee-Tombigbee River Waterway (NatureServe 2003).

HABITAT:
The flat pigtoe, like other Tombigbee River system mussels, inhabits moderate to large rivers with moderate to swift current. Its preferred habitat is riffle-run or shoal areas with stable substrates ranging from sandy gravel to gravel-cobble (Stanbery 1976, 1980, 1983). Unionids collected from the Tombigbee River system have been collected in water up to 0.7 meters deep (USFWS 1987).

PAST THREATS:
The Tombigbee River freshwater mussel fauna once consisted of more than 40 species (Williams 1982). Construction of the Tennessee-Tombigbee Waterway was accomplished in 1984 by dredging portions of the Tombigbee River to form a navigation channel, by cutting off river bends to straighten the channel, by constructing dams and by cutting a canal to the Tennessee River for barge access and to provide water. This resulted in a series of impoundments that inundated much of the known remaining riverine flat pigtoe habitat or left them in several river bends. The accumulation of sediment in these river bends has eliminated them as potential riverine mussel habitat, except for Gainesville bendway. Recent surveys of this area indicate the lower half of it has heavy sedimentation (USFWS 1989).

CURRENT THREATS:
Given the small size of remaining flat pigtoe populations, any factor that adversely modifies habitat or water quality in the limited remaining habitat for the species could threaten its survival in these areas. The continued existence of the flat pigtoe appears to depend upon habitat in tributaries of the Tombigbee River and the species ability to complete its life cycle in a small stream environment. The East Fork Tombigbee River is threatened by an 84.8 km (53 mi) clearing and snagging project, sand and gravel mining, the continued diversion of flood flows, and by water removal for municipal use. The host species for the flat pigtoe is unknown; however, if glochidial host species are large river or migratory species that infrequently enter the tributaries, the future existence of this mussel is very precarious (USFWS 1989). Other current threats to freshwater mussels are described in the General Mussel document.

Exposure Scenario Summary Table for the Flat pigtoe

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
flat pigtoe	glochidia	parasite	contact with water, diet	fish body fluids (once	

				encysted)
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)

OVATE CLUBSHELL
Pleurobema perovatum

STATUS:
On March 17, 1993, the ovate clubshell (*Pleurobema perovatum)* was designated as Endangered throughout its entire range (USFWS 1993). A recovery plan for the ovate clubshell was finalized on November 17, 2000 (USFWS 2000). Critical habitat was designated for the ovate clubshell on July 1, 2004 (69 FR 40083).

SPECIES DESCRIPTION:
The ovate clubshell is a small to medium-sized mussel that rarely exceeds 50 mm (2.0 inches) in length. Like other freshwater mussels, adults are filter-feeders, orienting themselves in the substrate to facilitate siphoning of the water column for oxygen and food (Kraemer 1979). Mussels have been reported to consume detritus, diatoms, phytoplankton, zooplankton, and other microorganisms (Coker et al. 1921, Churchill and Lewis 1924, Fuller 1974). Juvenile mussels employ foot (pedal) feeding, and are thus suspension feeders (Yeager et al. 1994). Foods of juvenile freshwater mussels up to two weeks old include bacteria, algae, and diatoms with amounts of detrital and inorganic colloidal particles (Yeager et al. 1994). Specific food habits of the ovate clubshell are unknown, but are likely similar to those of other freshwater mussels.

REPRODUCTION AND DEVELOPMENT:
Gravid females of this species have been observed in June and July. Glochidia are released in well formed, white conglutinates (W.R. Haag, unpublished data). Host fishes for this species are unknown.

RANGE AND POPULATION LEVEL:
The ovate clubshell was described from small streams in Greene County, Alabama. The species was historically distributed in the Tombigbee, Black Warrior, Alabama, Cahaba, and Coosa Rivers and their tributaries in Mississippi, Alabama, Georgia, and Tennessee; and In Chewacla, Uphapee and Opintlocco Creeks in the Tallapoosa River drainage, Alabama. It has disappeared from the Black Warrior, Cahaba, and Alabama River drainages, as well as the mainstem Tombigbee River and Uphapee and Opintlocco Creeks. Currently, the species is known to survive in several Tombigbee River tributaries, including Buttahatchee River (Lowndes/Monroe County, Mississippi), Luxapalila Creek and its tributary Yellow Creek (Lowndes County, Mississippi), Sipsey River (Greene/Pickens/Tuscaloosa County, Alabama), Sucarnoochee River (Sumter County, Alabama), and Coalfire Creek (Pickens County, Alabama); and Chewacla

Creek (Macon County, Alabama) in the Tallapoosa River drainage; and a short reach of the Coosa River below the mouth of Terrapin Creek (Cherokee County, Alabama) (USFWS 2003). Populations are small and localized.

HABITAT:
The ovate clubshell inhabits sand/gravel shoals and runs of small rivers and large streams.

CRITICAL HABITAT:
In Itawamba County, Mississippi, stream and river channels within the ordinary high water line of the East Fork Tombigbee River main stem from Mississippi Highway 278, Monroe County, upstream to the confluence of Mill Creek.

In Itawamba County, Mississippi, stream and river channels within the ordinary high water line of Bull Mountain Creek from Mississippi Highway 25, upstream to U.S. Highway 78.

In Lowndes/Monroe County, Mississippi and Lamar County, Alabama, stream and river channels within the ordinary high water line of the Buttahatchee River main stem from its confluence with the impounded waters of Columbus Lake, Lowndes/Monroe County, Mississippi, upstream to the confluence of Beaver Creek, Lamar County, Alabama; and Sipsey Creek, from its confluence with the Buttahatchee River, upstream to the Mississippi/Alabama State Line, Monroe County, Mississippi.

In Lowndes County, Mississippi and Lamar County, Alabama, stream and river channels within the ordinary high water line of the Luxapalila Creek main stem from Waterworks Road, Columbus, Mississippi, upstream to approximately 1.0 km (0.6 mi) above Steens Road, Lowndes County, Mississippi; and the Yellow Creek main stem from its confluence with Luxapalila Creek, Lowndes County, Mississippi, upstream to the confluence of Cut Bank Creek, Lamar County, Alabama.

In Pickens County, Alabama, stream and river channels within the ordinary high water line of the Coalfire Creek main stem from its confluence with the impounded waters of Aliceville Lake, upstream to U.S. Highway 82.

In Pickens County, Alabama, stream and river channels within the ordinary high water line of the main stem of Lubbub Creek from its confluence with the impounded waters of Gainesville Lake, upstream to the confluence of Little Lubbub Creek

In Greene/Pickens and Tuscaloosa Counties, Alabama, stream and river channels within the ordinary high water line of the Sipsey River main stem from its confluence with impounded waters of Gainesville Lake, Greene/Pickens County, upstream to Alabama Highway 171 crossing, Tuscaloosa County, Alabama.

In Greene County, Alabama, stream and river channels within the ordinary high water line of the Trussels Creek main stem from its confluence with the impounded waters of Demopolis Lake, upstream to Alabama Highway 14.

In Sumter County, Alabama, stream and river channels within the ordinary high water line of the Sucarnoochee River main stem from its confluence with the Tombigbee River, upstream to the Mississippi/Alabama State Line.

In Winston and Lawrence Counties, Alabama, stream and river channels within the ordinary high water line of the Sipsey Fork main stem from the section 11/12 line, Winston County, Alabama, upstream to the confluence of Hubbard Creek, Lawrence County, Alabama; Thompson Creek, from its confluence with Hubbard Creek, upstream to section 2 line Lawrence County; Brushy Creek, from the confluence of Glover Creek, Winston County, upstream to section 9, Lawrence County; Capsey Creek, from confluence with Brushy Creek, Winston County, upstream to the confluence of Turkey Creek, Lawrence County; Rush Creek, from confluence with Brushy Creek, upstream to Winston/Lawrence County Line, Winston County; Brown Creek, from confluence with Rush Creek, Winston County, upstream to section 24 line, Lawrence County; Beech Creek, from confluence with Brushy Creek, to confluence of East and West Forks, Winston County; Caney Creek and North Fork Caney Creek, from confluence with Sipsey Fork, upstream to section 14 line, Winston County; Borden Creek, from confluence with Sipsey Fork, Winston County, upstream to the confluence of Montgomery Creek, Lawrence County; and Flannagin Creek, from confluence with Borden Creek, upstream to confluence of Dry Creek, Lawrence County.

In Tuscaloosa and Fayette Counties, Alabama, stream and river channels within the ordinary high water line of the main stem of the North River from Tuscaloosa County Road 38, Tuscaloosa County, upstream to confluence of Ellis Creek, Fayette County, Alabama; and Clear Creek from its confluence with North River to Bays Lake Dam, Fayette County, Alabama.

In Jefferson and Blount Counties, Alabama, stream and river channels within the ordinary high water line of the Locust Fork main stem from U.S. Highway 78, Jefferson County, upstream to the confluence of Little Warrior River, Blount County, Alabama; and Little Warrior River from its confluence with the Locust Fork, upstream to the confluence of Calvert Prong and Blackburn Fork, Blount County, Alabama.

In Jefferson, Shelby, and Bibb Counties, Alabama, stream and river channels within the ordinary high water line of the Cahaba River from U.S. Highway 82, Centerville, Bibb County, upstream to Jefferson County Road 143, Jefferson County, Alabama; and the Little Cahaba River from its confluence with the Cahaba River, upstream to the confluence of Mahan and Shoal Creeks, Bibb County, Alabama.

In Macon and Lee Counties, Alabama, stream and river channels within the ordinary high water line of the mainstem of Uphapee Creek from Alabama Highway 199, upstream to the confluence of Opintlocco and Chewacla Creeks, Macon County, Alabama; Choctafaula Creek, from confluence with Uphapee Creek, upstream to Macon County Road 54, Macon County, Alabama; Chewacla Creek, from confluence with Opintlocco Creek, Macon County, Alabama, upstream to Lee County Road 159, Lee County, Alabama; Opintlocco Creek, from confluence with Chewacla Creek, upstream to Macon County Road 79, Macon County, Alabama.

In Cherokee, Calhoun, and Cleburne Counties, Alabama, stream and river channels within the ordinary high water line of the Coosa River main stem from the power line crossing southeast of Maple Grove, Alabama, upstream to Weiss Dam, Cherokee County, Alabama; Terrapin Creek, 53 km (33 mi) extending from its confluence with the Old Coosa River channel, Cherokee County, upstream to Cleburne County Road 49, Cleburne County, Alabama; South Fork Terrapin Creek, 7 km (4 mi), from its confluence with Terrapin Creek, upstream to Cleburne County Road 55, Cleburne County, Alabama.

In Coosa and Clay Counties, Alabama, stream and river channels within the ordinary high water line of the main stem of Hatchet Creek from the confluence of Swamp Creek at Coosa County Road 29, Coosa County, Alabama, upstream to Clay County Road 4, Clay County, Alabama.

In Shelby and St. Clair Counties, Alabama, stream and river channels within the ordinary high water line of the Kelly Creek main stem extending from the confluence with the Coosa River, upstream to the confluence of Shoal Creek, St. Clair County, Alabama; and the main stem of Shoal Creek from the confluence with Kelly Creek, St. Clair County, Alabama, upstream to the St. Clair/Shelby County Line, St. Clair County, Alabama.

In St. Clair County, Alabama, stream and river channels within the ordinary high water line of the main stem of Big Canoe Creek from its confluence with Little Canoe Creek at the St. Clair/Etowah County line, St. Clair County, upstream to the confluence of Fall Branch.

In Floyd, Gordon, Whitfield, and Murray Counties, Georgia; and Bradley and Polk Counties, Tennessee, stream and river channels within the ordinary high water line of the Oostanaula River main stem from its confluence with the Etowah River, Floyd County, Georgia, upstream to the confluence of the Conasauga and Coosawattee River, Gordon County, Georgia; the Coosawattee River main stem from its confluence with the Conasauga River, upstream to Georgia State Highway 136, Gordon County, Georgia; the Conasauga River main stem from confluence with the Coosawattee River, Gordon County, Georgia, upstream through Bradley and Polk Counties, Tennessee, to Murray County Road 2, Murray County, Georgia; and the mainstem of Holly Creek from its confluence with the Conasauga River, upstream to its confluence with Rock Creek, Murray County, Georgia.

In Elmore County, Alabama, stream and river channels within the ordinary high water line of the Coosa River main stem from Alabama State Highway 111 bridge, upstream to Jordan Dam.

Primary constituent elements identified at the time of designation included: 1. Geomorphically stable stream and river channels and banks; 2. A flow regime (i.e., the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of mussels and their fish hosts in the river environment; 3. Water quality, including temperature, pH, hardness, turbidity, oxygen content, and other chemical characteristics necessary for normal behavior, growth, and viability of all life stages; 4. Sand, gravel, and/or cobble substrates with low to moderate amounts of fine sediment, low amounts of attached filamentous algae, and other physical and chemical characteristics necessary for normal

behavior, growth, and viability of all life stages; 5. Fish hosts with adequate living, foraging, and spawning areas for them; and 6. Few or no competitive or predaceous nonnative species present.

PAST THREATS:
The abundance and distribution of the ovate clubshell decreased historically from human-induced habitat loss and degradation caused by impoundments, sedimentation and turbidity, channelization and dredging, mining (coal, sand, gravel, or gold) (Jones 1991, USFWS 1993, Leigh 1994, ADEM 1994), and contaminants contained in numerous point (e.g., carpet mills and fabric dying mills) (Hurd 1974) and nonpoint sources (USFWS 2000). Channel modifications and water pollution gradually eliminated this native species that is dependent on a narrow range of flowing water habitat conditions from extensive portions of its former range within the Mobile River Basin. These habitat changes have resulted in significant extirpations (localized loss of populations), restricted and fragmented distributions, and poor recruitment of young.

CURRENT THREATS:
Habitat modification, sedimentation, eutrophication, and other forms of water quality degradation are the primary causes of decline of the ovate clubshell. This species can not tolerate impoundments or channelization. Surviving populations are threatened by channelization, household and agricultural runoff, and channel erosion.

Due to the extreme rarity of the ovate clubshell, any adverse impacts to its habitat or an individual could result in the demise of the species. The immediate recovery objective is to prevent the extinction of this species by locating, protecting, and restoring stream drainages with extant populations.

Exposure Scenario Summary Table for the Ovate Clubshell

Species	**Life Stage**	**Habitat Type**	**Exposure Route**	**Diet**	**Significant Interspecies Relationships**
Ovate Clubshell	glochidia	parasite	contact with water, diet	fish body fluids	Unknown fish(es) hosts
	juvenile/ adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

ROUGH PIGTOE
Pleurobema plenum

STATUS:

On June 14, 1976, the rough pigtoe mussel was designated as endangered throughout its entire range in Alabama, Indiana, Kentucky, Pennsylvania, Tennessee, and Virginia (USFWS 1976). A recovery plan for the rough pigtoe was approved August 6, 1984 (USFWS 1984).

SPECIES DESCRIPTION:
The rough pigtoe is a medium-sized freshwater mussel (reaching up to approximately 100 mm in length) with a yellowish brown or light brown shell (becoming dark brown in adults) with faint green rays (NatureServe 2003, INHS 1997). Like other freshwater mussels, the rough pigtoe feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of rough pigtoe glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the rough pigtoe is similar to that of other mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. The rough pigtoe is likely a short term brooder with spawning occurring in the spring and release of glochidia during summer months (ESIE 1996, USFWS 1984). Specific glochidial hosts for this species are not known (ESIE 1996).

RANGE AND POPULATION LEVEL:
This species was historically known from the Ohio, Cumberland and Tennessee River drainages in Alabama, Illinois, Indiana, Kentucky, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia; however, the species is now believed to be extirpated from Pennsylvania, Ohio, West Virginia, Virginia, and Illinois. The species currently is known to survive downstream of three Tennessee River mainstem dams (Pickwick Landing, Wilson, and Guntersville) and in the Clinch River (upstream of Norris Reservoir) (NatureServe 2003). The best remaining populations exist in the Green River in Kentucky (below locks 4 and 5) and in the Barren River (below lock and dam 1).

HABITAT:
The rough pigtoe is found in medium to large rivers with sand, gravel, and cobble substrates (USFWS 1984, ESIE 1996, NatureServe 2003). The species has also been reported from flats, and muddy sand in shallow waters (NatureServe 2003).

PAST THREATS:
Many of the historic populations of the rough pigtoe were apparently lost when the river sections they inhabited were impounded (ESIE 1996). It is believed that establishment of the Green River dam, which was completed in 1969, may ultimately lead to the loss of the rough pigtoe population on that river (if it still exists). In addition, acidic drainage from mines on tributaries to the Cumberland and Tennessee Rivers is believed to be responsible for declines in the mussel

populations inhabiting those waters. A portion of the Green River below Greensburg, KY has been affected by oil brine pollution which has eliminated nearly the entire mussel population that was once located there (ESIE 1996). Other threats that are attributed to population declines are described in the General Mussel Document.

CURRENT THREATS:
Current threats to freshwater mussels are described in the General Mussel Document.

Exposure Scenario Summary Table for the Rough pigtoe

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
rough pigtoe	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

OVAL PIGTOE
Pleurobema pyriforme

STATUS:
On March 16, 1998, the oval pigtoe was designated as Endangered throughout its range (USFWS 1998). A recovery plan for the oval pigtoe was finalized on October 1, 2003 (USFWS 2003). A 5-Year Review was approved for the oval pigtoe on September 17, 2007. Critical habitat was designated for the oval pigtoe on November 15, 2007 (72 FR 64285).

SPECIES DESCRIPTION:
The oval pigtoe is a small to medium-sized mussel that attains a length of about 6.1 cm (2.4 in). The Service currently recognizes *Unio modicus* Lea, 1857, *Unio bulbosus* Lea 1857, *Unio amabilis* Lea, 1865, *Unio harperi* Wright, 1899, *Unio reclusus* Wright, 1898, and *Pleurobema simpsoni* Vanatta, 1915, as synonyms of *Pleurobema pyriforme* (USFWS 2003).

Like other freshwater mussels, adults are filter-feeders, orienting themselves in the substrate to facilitate siphoning of the water column for oxygen and food (Kraemer 1979). Mussels have

been reported to consume detritus, diatoms, phytoplankton, zooplankton, and other microorganisms (Coker et al. 1921, Churchill and Lewis 1924, Fuller 1974). Juvenile mussels employ foot (pedal) feeding, and are thus suspension feeders (Yeager et al. 1994). Foods of juvenile freshwater mussels up to two weeks old include bacteria, algae, and diatoms with amounts of detrital and inorganic colloidal particles (Yeager et al. 1994). Specific food habits of the oval pigtoe are unknown, but are likely similar to those of other freshwater mussels.

REPRODUCTION AND DEVELOPMENT:
Ortmann (1909) considered *Pleurobema* species to have a short, summer breeding season (tachytictic). Gravid oval pigtoe were collected from the Apalachicola-Chattahoochee-Flint (ACF) Basin from March through July at water temperatures of 55.4 to 77.0 degrees Fahrenheit (O'Brien and Williams 2002). This indicates that this unionine is a summer releasing, but not necessarily a parent overwintering species, as fertilization may take place in late winter or early spring. Females readily aborted their conglutinates in the laboratory, which contained both ova and glochidia in several stages of development. The structures are elongate, white to pinkish, approximately 0.5 cm (0.2 in) long, and one layer thick (O'Brien and Williams 2002). Once released, the glochidia remained viable for three days. The morphology of the glochidia was described and figured by O'Brien and Williams (2002). Based on laboratory infections, juvenile specimens transformed on the gills of the sailfin shiner *(Pteronotrophis hypselopterus)*, eastern mosquitofish (*Gambusia holbrooki)*, and guppy *(Poecilia reticulata)* (O'Brien and Williams 2002). Only the sailfin shiner was considered to be a primary host as it was the only species upon which the glochidial transformation rate exceeded 50 percent. Glochidia metamorphosed in 20 to 25 days at a temperature of 70.7 $\pm$ 2.7 degrees Fahrenheit (O'Brien and Williams 2002).

RANGE AND POPULATION LEVEL:
The oval pigtoe was described from the Chattahoochee River, near Columbus, Muscogee County, Georgia. This species historically occurred in four major stream systems in Alabama, Georgia, and Florida: Econfina, ACF, Ochlockonee and Suwannee (Brim Box and Williams 2000). All four stream systems still harbor the oval pigtoe, but numerous subpopulations have been lost. Stream extirpations in the ACF Basin are thought to include the Chattahoochee River main stem and three tributaries, Randall, Uchee, and Little Uchee Creeks; most of the Flint River main stem and its tributaries Patsiliga, Little Patsiliga, Sandy Mount, Gum, Cedar, Chokee, Abrams, Mill, Little Pachitla, Dry, and Spring Creeks; the Apalachicola River main stem; and several Chipola River tributaries including both Spring, Rocky (Houston County, Alabama), Marshall, and Cowarts Creeks. The oval pigtoe was recently found extant at only three sites within Suwannee River drainage, two in the New River, and one in the Santa Fe River (Blalock-Herod and Williams 2001). This species is no longer known from the Suwannee River main stem and the Sampson River and its range is greatly reduced in the Santa Fe River (Blalock-Herod and Williams 2001).

The oval pigtoe is currently known from Econfina Creek; Sawhatchee Creek (the only Chattahoochee River system locality remaining); Flint River, Decatur County, Georgia; the upper-most main stem of the Flint River and its tributaries Line, Red Oak, tributary to Walnut Creek, Hogcraw, Little Pennahatchee, Turkey, Swift, Jones, Muckalee, Lanahassee, Kinchafoonee, Cooleewahee, Chickasawhatchee, and Spring Creeks; the upper Chipola River

main stem, and Big, Baker, Waddells Mill, Dry, and Rocky (Jackson County, Florida) Creeks; the upper Ochlockonee River main stem, Little Ochlockonee River, and Barnetts Creek; and the New and Santa Fe Rivers in the Suwannee River system. This relatively wide ranging mussel presently persists in 43 subpopulations, overall (see Table 5, USFWS 2003).

Nearly all known subpopulations are presently comprised of relatively small numbers of oval pigtoes, with the exceptions of sites on the Chipola River and Chickasawhatchee Creek (Brim Box and Williams 2000). Rangewide, an average of 5.2 specimens per site of occurrence (24 sites) were recorded during the status survey (USFWS 1998). More recent quantitative sampling using sieves at two sites (Chickasawhatchee Creek, 50 samples 2.7-square feet each; and New River, 75 samples 2.7-square feet each) found 8 specimens in Chickasawhatchee Creek and 3 in new River for densities of 0.059 and 0.015 per square feet of substrate, respectively (R.S. Butler, USFWS, unpub. data). Blalock-Herod (2000) reported an overall density of 0.003 per square foot (15 specimens in 2,000 samples 2.7-square feet each) in sieved samples and found no recruitment at a study site on the New River (Suwannee River drainage). Only one specimen was detected after searching for two hours at another site on the New River (Blalock-Herod and Williams 2001).

HABITAT:
The oval pigtoe occurs in small to medium-sized creeks to small rivers where it inhabits silty sand to sand and gravel substrates, usually in slow to moderate current (Willliams and Butler 1994; Garner, pers. comm., 2003). Stream channels appear to offer the best habitat for this species. The ACF Basin status survey located 85 percent of the specimens in sandy substrates associated with either detritus, clay, silt, or cobble (Brim Box and Williams 2000). In the Suwannee River drainage, specimens of the oval pigtoe were associated with sandy mud and coarse sand sediments with little or no detritus (Blalock-Herod 2000).

CRITICAL HABITAT: In Bay and Washington Counties, Florida, stream and river channels within the ordinary high water line of the main stem of Econfina Creek and one of its tributaries, Moccasin Creek.

In Houston County, Alabama, and in Calhoun, Gulf, and Jackson counties, Florida, stream and river channels within the ordinary high water line of the main stem of the Chipola River and seven of its tributaries.

In Early County, Georgia, stream and river channels within the ordinary high water line of the main stems of Sawhatchee and Kirkland creeks, and one tributary, encompassing a total stream length of 37.8 km.

In Coweta, Crawford, Crisp, Dooly, Fayette, Macon, Meriwether, Peach, Pike, Spalding, Sumter, Talbot, Taylor, Upson, and Worth counties, Georgia, stream and river channels within the ordinary high water line of the Flint River from the State Highway 27 bridge in Dooly and Sumter counties, Georgia, upstream 247.4 km through Macon, Peach, Taylor, Crawford, Talbot, Upson, Pike, Meriwether, and Coweta counties, to Horton Creek in Fayette and Spalding counties, Georgia; Swift Creek from Lake Blackshear upstream 11.3 km to

Rattlesnake Branch, Crisp and Worth counties, Georgia; Limestone Creek from Lake Blackshear, Crisp County, Georgia, upstream 8.8 km to County Road 89, Dooly County, Georgia; Turkey Creek from the Flint River upstream 21.7 km to Rogers Branch, in Dooly County, Georgia; Pennahatchee Creek from Turkey Creek upstream 4.8 km to Little Pennahatchee Creek, Dooly County, Georgia; Little Pennahatchee Creek from Pennahatchee Creek upstream 5.8 km to Rock Hill Creek, Dooly County, Georgia; Hogcrawl Creek from the Flint River upstream 21.6 km to Little Creek, Dooly and Macon counties, Georgia; Red Oak Creek from the Flint River upstream 21.7 km to Brittens Creek, Meriwether County, Georgia; Line Creek from the Flint River upstream 15.8 km to Whitewater Creek, Coweta and Fayette counties, Georgia; and Whitewater Creek from Line Creek upstream 21.5 km to Ginger Cake Creek, Fayette County, Georgia.

In Dougherty, Lee, Marion, Schley, Sumter, Terrell, Webster, and Worth counties, Georgia, stream and river channels within the ordinary high water line of the Flint River from Piney Woods Creek in Dougherty County, Georgia, upstream 39.9 km to the Warwick Dam, Lee and Worth counties, Georgia; Kinchafoonee Creek from its confluence with Lake Worth at the Lee--Dougherty county line, upstream 107.6 km through Terrell and Sumter Counties, Georgia, to Dry Creek, Webster County, Georgia; Lanahassee Creek from Kinchafoonee Creek upstream 9.3 km to West Fork Lanahassee Creek, Webster County, Georgia; Muckalee Creek, from its confluence with Lake Worth at the Lee--Dougherty county line, upstream 104.5 km to County Road 114, Marion County, Georgia; Little Muckalee Creek, from Muckalee Creek in Sumter County, Georgia, upstream 7.2 km to Galey Creek, Schley County, Georgia; Mill Creek from the Flint River upstream 3.2 km to Mercer Millpond Creek, Worth County, Georgia; Mercer Millpond Creek from Mill Creek upstream 0.45 km to Mercer Mill Pond, Worth County, Georgia; Abrams Creek from the Flint River upstream 15.9 km to County Road 123, Worth County, Georgia; Jones Creek from the Flint River upstream 3.8 km to County Road 123, Worth County, Georgia; and Chokee Creek, from the Flint River upstream 10.5 km to Dry Branch Creek, Lee County, Georgia.

In Baker, Calhoun, Decatur, Dougherty, Early, Miller, Mitchell, and Terrell counties, Georgia, stream and river channels within the ordinary high water line of the Flint River from its confluence with Big Slough , Decatur County, Georgia, upstream 116.4 km through Baker and Mitchell Counties, Georgia, to the Flint River Dam, Dougherty County, Georgia; Spring Creek, from its confluence with Lake Seminole at Smith Landing, Decatur County, Georgia, upstream 74.2 km to County Road 35, Early County, Georgia; Aycocks Creek from Spring Creek upstream 15.9 km to Cypress Creek, Miller County, Georgia; Dry Creek from Spring Creek upstream 9.9 km to Wamble Creek , Early County, Georgia; Ichawaynochaway Creek from the Flint River, Baker County, Georgia, upstream 68.6 km to Merrett Creek, Calhoun County, Georgia; Mill Creek from Ichawaynochaway Creek upstream 7.4 km to County Road 163, Baker County, Georgia; Pachitla Creek, from Ichawaynochaway Creek upstream 18.9 km to Little Pachitla Creek, Calhoun County, Georgia; Little Pachitla Creek from Pachitla Creek upstream 5.8 km to Bear Branch, Calhoun County, Georgia; Chickasawhatchee Creek from Ichawaynochaway Creek, Baker County, Georgia, upstream 64.5 km to U.S. Highway 82, Terrell County, Georgia; and Cooleewahee Creek from the Flint River upstream 15.1 km to Piney Woods Branch, Baker County, Georgia.

In Gadsden and Leon counties, Florida, and in Grady and Thomas counties, Georgia, stream and river channels within the ordinary high water line of the main stem of the Ochlockonee River upstream of Lake Talquin and three tributaries.

In Alachua, Bradford, Columbia, and Union counties, Florida, stream and river channels within the ordinary high water line of the main stem of the Santa Fe River and its tributary the New River.

Primary constituent elements identified at the time of designation included: (1) Space for individual and population growth and for normal behavior; (2) Food, water, air, light, minerals, or other nutritional or physiological requirements; (3) Cover or shelter; (4) Sites for breeding, reproduction, or rearing (or development) of offspring; and (5) Habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species.

PAST THREATS:
The abundance and distribution of the oval pigtoe decreased historically from habitat loss and degradation (Williams et al. 1993, Neves 1993) caused by impoundments, sedimentation and turbidity, dredging and channelization, gravel mining, and contaminants contained in numerous point and nonpoint sources. A comprehensive review of these past threats is provided elsewhere (USFWS 2003, Brim Box and Williams 2000, Butler 1993, Howard 1997, Frick et al. 1998, Buell and Couch 1995, Richter 1997, Watters 1997, Neves et al. 1997). These habitat changes have resulted in significant extirpations (localized loss of populations), restricted and fragmented distributions, and poor recruitment of young.

CURRENT THREATS:
Habitat loss and degradation (Williams et al. 1993, Neves 1993) primarily caused by contaminants contained in point and nonpoint source discharges, sedimentation and erosive land practices, water quantity and withdrawal, construction of new impoundments and alien species are primary threats to the oval pigtoe (USFWS 2003).

Sediment samples from various ACF Basin streams tested for heavy metals that are known to be deleterious to mussels had concentrations markedly above background levels (Frick et al. 1998), among those were copper (throughout the Piedmont), and cadmium (large Coastal Plain tributaries of the Flint River). Past episodes of significant heavy metal contamination of ACF Basin streams may continue to impact mussel faunas. An estimated 950 million gallons of chemical-laden rinse, stripping, cleaning, and plating solutions were discharged indirectly into the Flint River (P. Laumeyer, USFWS, pers. comm., 1994) over a several year period. Concentrations of heavy metals (e.g., chromium and cadmium) in Asian clam, *Corbicula fluminea* (Muller 1774), and sediment samples were elevated downstream from two abandoned battery salvage operations on the Chipola River (Winger et al. 1985). Chromium concentrations found in sediments from Dead Lake downstream in the Chipola River (Winger et al. 1985) are known to be toxic to mussels (Havlik and Marking 1987).

Agricultural sources of contaminants in the ACF and Suwannee basins include nutrient enrichment from poultry farms and livestock feedlots, and pesticides and fertilizers from row crop agriculture (Couch et al. 1996, Frick et al. 1998, Berndt et al. 1998). Nitrate concentrations are particularly high in surface waters downstream of agricultural areas (Mueller et al. 1995; Berndt et al. 1998). A study by the U.S. Soil Conservation Service (USSCS; now the Natural Resources Conservation Service [NRCS]) in the Flint River system determined that between 72 and 75 percent of the nutrients entering Lake Blackshear were derived from agricultural sources (USSCS 1993). Stream ecosystems are impacted when nutrients are added at concentrations that cannot be assimilated (Stansbery 1995). The effects of pesticides on mussels may be particularly profound (Fuller 1974, Havlik and Marking 1987, Moulton et al. 1996, Fleming et al. 1995). Organochlorine pesticides were found at levels in ACF Basin streams that often exceeded chronic exposure criteria for the protection of aquatic life (Buell and Couch 1995, Frick et al. 1998). Once widely used in the ACF Basin (Buell and Couch 1995), these highly toxic compounds are persistent in the environment, and are found in both sediments and the lipid reservoir of organisms (Day 1990, Burton 1992). Commonly used pesticides have been directly implicated in a North Carolina mussel dieoff (Fleming et al. 1995). Cotton is raised extensively in much of the Apalachicolan Region inhabited by these mussels. One of the most important pesticides used in cotton farming, malathion, is known to inhibit physiological activities of mussels (Kabeer et al. 1979) that may decrease the ability of a mussel to respire and obtain food. This chemical may pose a continuing threat to some populations of these mussels. Nutrients from aquaculture ponds may also have an impact on stream water quality. A large catfish farm is located in the floodplain of lower Cooleewahee Creek. Discharges of enriched pond water could negatively affect an oval pigtoe population which occurs in that stream.

Many pollutants in the ACF Basin originate from urban stormwater runoff, development activities, and municipal waste water facilities, primarily in the Piedmont (Frick et al. 1998). Urban catchments in Piedmont drainages have higher concentrations of nutrients, heavy metals, pesticides, and organic compounds than do agricultural or forested ones (Lenat and Crawford 1994, Frick et al. 1998), and at levels sufficient to significantly affect fish health (Ostrander et al. 1995). Within the Suwannee River basin, nutrient concentrations were greater in agricultural areas and nitrates were found to exceed U.S. Environmental Protection Agency (EPA) drinking water standards in 20 percent of the surficial aquifer groundwater samples (Berndt et al. 1998). Pesticide concentrations were found to exceed criteria for protection of aquatic life mostly in urban areas. Currently, there are discharges from 137 municipal waste water treatment facilities in the ACF River basin alone (Couch et al. 1996). Although effluent quality has improved with modern treatment technologies and a phosphate detergent ban, hundreds of miles of streams in the ACF and Ochlockonee basins in Alabama, Florida, and Georgia, as identified in reports prepared by the water quality agencies of these states under Section 305(b) of the Clean Water Act, do not meet water use classifications.

Since approximately 29 percent of the ACF Basin is in agriculture (Frick et al. 1998), sedimentation from agricultural sources is probably significant. According to USSCS (1993), 89 percent of the sediments entering Lake Blackshear on the Flint River are derived from agricultural sources. The lower Flint River system serves as the heart of numerous mussel species' range (including the oval pigtoe) and is a major agricultural center. This area has

experienced “severe losses of topsoil and nutrient additions to local streams due to agriculture” (Neves et al. 1997), and has profoundly affected the biota of surface and ground waters there (Patrick 1992). Despite the implications, only a few studies (e.g., Cooper 1987, Stewart and Swinford 1995) have specifically attributed changes in mussel populations to sediments derived from agricultural practices.

Within the Suwannee basin, predominant sources of nutrient enrichment were inorganic fertilizers and animal wastes (Crandall 1996). A herd of cattle several score in size was observed to have direct access to a large spring and spring run adjacent the Chipola River just upstream of Florida Caverns State Park during the summer of 2000 (R.S. Butler, USFWS, pers. obs.). Although anecdotal, the oval pigtoe was found live during mussel sampling in the Chipola River upstream of the mouth of this spring run, but not downstream.

Many southern streams have increased turbidity levels due to siltation (van der Schalie 1938a). The oval pigtoe attracts host fishes with visual cues, luring fish into perceiving that their glochidia are prey items. Such a reproductive strategy depends on clear water during the critical time of the year when mussels are releasing their glochidia (Hartfield and Hartfield 1996). Turbidity is a limiting factor impeding sight-feeding fishes (Burkhead and Jenkins 1991). In addition, mussels may be indirectly affected when turbidity levels significantly reduce light available for photosynthesis and the production of unionid food items (Kanehl and Lyons 1992).

Water quantity is becoming more of a concern in maintaining mussel habitat in the Apalachicolan Region. The potential impacts to mussels, their host fishes, and their respective habitats from ground water withdrawal may be profound. Within the Flint River basin, decreases in flow velocity and dissolved oxygen were highly correlated to mussel mortality (Johnson et al. 2001). Approximately 90 specimens of the oval pigtoe were salvaged live from drought-ravaged segments of Spring Creek, Miller County, Georgia, during the summer 2000 drought (L. Andrews, and R.S. Butler, USFWS, pers. obs.). Large numbers were also found dead in the dried stream bed, in mud holes, and in shrinking pools of water. Low DO conditions in stagnating stream pools due to drought conditions are having a disastrous effect on these mussels. Mussel mortality increases dramatically as DO decreases below 5 mg/L (Johnson et al. 2001). Rare species (e.g., oval pigtoe, shinyrayed pocketbook, and Gulf moccasinshell) were more susceptible to drought-related morality within the Flint River basin and had the highest mortality rates from hypoxic conditions (Johnson et al. 2001).

Nonnative aquatic species invasions may also impact the oval pigtoe. For example, the nonindigenous Asian clam (*Corbicula fluminea*) has invaded all of the rivers where the oval pigtoe occurs. This species has been implicated as a competitor with native mussels for resources such as food, nutrients, and space (Heard 1977, Kraemer 1979, Clarke 1986), particularly as juveniles (Neves and Widlak 1987). Densities of Asian clams are sometimes high in Apalachicolan Region streams (Stringfellow and Stanton 1998), with estimates from approximately 9 per square foot (Flint River, Sickel 1973) to over 195 per square foot (Santa Fe River, Bass and Hitt 1974). In the New River (Suwannee River drainage), Blalock and Herod (1999) found an overall density of 8 Asian clams per square foot in the same study area where oval pigtoe density was 0.003 per square foot (Blalock-Herod 2000).

Exposure Scenario Summary Table for the Oval Pigtoe					
Species	**Life Stage**	**Habitat Type**	**Exposure Route**	**Diet**	**Significant Interspecies Relationships**
Oval Pigtoe	glochidia	parasite	contact with water, diet	fish body fluids	sailfin shiner
	juvenile/ adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

HEAVY PIGTOE
Pleurobema taitianum

STATUS:
On April 7, 1987 the heavy pigtoe, also known as Judge Tait=s mussel, was designated as endangered throughout its entire range in Alabama and Mississippi (USFWS 1987). A recovery plan for the heavy pigtoe was approved November 14, 1989 (USFWS 1989).

SPECIES DESCRIPTION:
The heavy pigtoe is a small (reaching approximately 50 mm in length) freshwater mussel with a brown to brownish-black shell (USFWS 1987, NatureServe 2003). Like other freshwater mussels, the heavy pigtoe feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of heavy pigtoe glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the heavy pigtoe is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. The life history of this species is largely unknown. Specific glochidial host species for the heavy pigtoe are not known (ESIE 1996).

RANGE AND POPULATION LEVEL:
The heavy pigtoe mussel was historically found in the Tombigbee River from the mouth of Bull Mountain Creek in northeast, Mississippi, to Demopolis, Alabama; the Alabama River at Claiborne and Selma, Alabama; the lower Cahaba River, Alabama; and possibly the Coosa River, Alabama (Stansbery 1983, Williams 1982). Several shells from recently dead specimens were found at one location on the Buttahatchie River, a tributary of the Tombigbee, in Mississippi (Schultz 1981, Hartfield and Jones 1990). This species has also been reported from the East Fork Tombigbee River (Schultz 1981) and from the Sipsey River, Alabama. Only five sites with suitable habitat remain: these consist of localities in a bendway of the Tombigbee River (Sumter County, Alabama), the East Fork Tombigbee River (Mississippi), the Buttahatchie River (Mississippi), ~~and~~ the Sipsey River (Pickens and Greene Counties, Alabama) (USFWS 1987), and the Alabama River near Selma (Dallas County, Alabama) (Hartfield and Garner 1998). It was believed that there were few individuals, if any, of this species remaining until recently when three live specimens were found in the Alabama River near Selma (Dallas and Lowndes Counties, Alabama) in 1997 (Hartfield and Garner 1998, NatureServe 2003).

HABITAT:
The heavy pigtoe, like other Tombigbee River system mussels, inhabits moderate to large rivers with moderate to swift current. Its preferred habitat is riffle-run or shoal areas with stable substrates ranging from sandy gravel to gravel-cobble (Stanbery 1976, 1980, 1983). The heavy pigtoe has been collected at depths of 9.0 meters.

PAST THREATS:
The Tombigbee River freshwater mussel fauna once consisted of more than 40 species (Williams 1982). Construction of the Tennessee-Tombigbee Waterway was accomplished in 1984 by dredging portions of the Tombigbee River to form a navigation channel, by cutting off river bends to straighten the channel, by constructing dams and by cutting a canal to the Tennessee River for barge access and to provide water. This resulted in a series of impoundments that inundated much of the known remaining riverine heavy pigtoe habitat or left them in several river bends. The accumulation of sediment in these river bends has eliminated them as potential riverine mussel habitat, except for Gainesville bendway. Recent surveys of this area indicate the lower half of it has heavy sedimentation (USFWS 1989).

CURRENT THREATS:
Given the small size of remaining heavy pigtoe populations, any factor that adversely modifies habitat or water quality in the limited remaining habitat for the species could threaten its survival in these areas. The continued existence of the heavy pigtoe appears to depend upon habitat in tributaries of the Tombigbee River and the species ability to complete its life cycle in a small stream environment. The East Fork Tombigbee River is threatened by an 84.8 km (53 mi) clearing and snagging project, sand and gravel mining, the continued diversion of flood flows, and by water removal for municipal use. Headward erosion induced by the Tennessee-Tombigbee Waterway and sand and gravel mining has severely degraded the East Fork Tombigbee and the Buttahatchee River since the species was listed (Patrick and Dueitt 1996). The host species for the heavy pigtoe is unknown; however, if glochidial host species are large river or migratory species that infrequently enter the tributaries, the future existence of this

mussel is very precarious (USFWS 1989). Other current threats to freshwater mussels are described in the General Mussel Document.

Exposure Scenario Summary Table for the Heavy pigtoe

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
heavy pigtoe	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

FAT POCKETBOOK
Potamilus capax

STATUS:

On June 14, 1976, the fat pocketbook was designated as endangered throughout its entire range in Arkansas, Illinois, Indiana, Kentucky, Missouri, and Mississippi (USFWS 1976). A recovery plan for the fat pocketbook was approved November 14, 1989 (USFWS 1989).

SPECIES DESCRIPTION:

The fat pocketbook is a large (reaching approximately 130 mm in length) freshwater mussel with a shiny, tan or light brown shell without rays (USFWS 1989, INHS 1997). Like other freshwater mussels, the fat pocketbook feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of fat pocketbook glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:

The reproductive cycle of the fat pocketbook is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a

short time while they develop into juvenile mussels. Recent laboratory studies indicate that the freshwater drum (*Aplodinotus grunniens*) was the only suitable glochidial host of 28 fish species tested (Barnhart 1997). Since that time, drum have been used to propagate thousands of fat pocketbook juveniles.

RANGE AND POPULATION LEVEL:
The fat pocketbook was once widely distributed in the Mississippi River drainage from the confluence of the Minnesota and St. Croix rivers downstream to the White River system and was known in Minnesota, Wisconsin, Iowa, Illinois, Indiana, Missouri, Kentucky, and Arkansas (NatureServe 2003). Most historic records for this species are from the upper Mississippi River (above St. Louis), the Wabash River in Indiana, and the St. Francis River in Arkansas (USFWS 1989). The fat pocketbook is currently known to exist in approximately 200 miles of the St. Francis River system, including the Floodway and associated drainage ditches; the lower Wabash River, Indiana; the mouth of the Cumberland River, Kentucky; and the Mississippi River, Missouri (USFWS 1989). The species also remains in the Ohio and White Rivers (NatureServe 2003). Over 2,000 individuals were transplanted from the St. Francis Floodway to the Mississippi River by the Missouri Department of Conservation in 1989 to augment that population in an effort to restore viability. Fresh dead shells have been collected from the Ohio River in Kentucky (USFWS 1989). Populations appear to be viable in the lower Wabash and Ohio Rivers and the St. Francis River drainages as well as portions of the bootheel region in Missouri (NatureServe 2003).

HABITAT:
The fat pocketbook is a large river species which requires flowing water and stable substrate (USFWS 1989). There are population-level differences in the fat pocketbook=s habitat preference (e.g., it appears that they prefer different substrate types in different locales). Parmalee (1967) reported the fat pocketbook from sand and mud bottoms, in flowing water a few inches to more than eight feet in depth. Individuals have also been found in sand, mud, and fine gravel substrates in the St. Francis River, Arkansas (Bates and Dennis 1983). Clarke (1985) reported this species primarily from sand substrates in the St. Francis River, Arkansas. Jenkinson and Ahlstedt (1988) reported this species from the full range of habitat types, including shifting sand and flocculent mud, to hard clay and gravel. According to their findings, the most likely habitat is a mixture of sand, silt and clay (USFWS 1989).

PAST THREATS:
The greatest impact on the habitat of the fat pocketbook throughout its historic range has been from activities related to navigation and flood control. Channel maintenance dredging has been particularly destructive. The upper Mississippi River has been impounded for navigation and is dredged routinely to maintain a nine-foot navigation channel. This species, once widespread in this river, has disappeared in recent years even from areas where other species (including the endangered species *Lampsilis higginsii*) continue to exist. The presence of the fat pocketbook in dredged portions of the St. Francis Floodway indicates a recolonization of the channelized river reaches. Dredging in the St. Francis basin has been primarily for the purpose of irrigation and flood control. Drastic changes in the watershed have resulted in loss of much of the original river channel and its associated mussel fauna. The occurrence of the fat pocketbook in the St. Francis

River below the Marked Tree siphon is likely dependent upon the population in the St. Francis Floodway and the passage of glochidia-infested fish through the siphons. Bates and Dennis (1983) reported that much of the substrate of the White River, Arkansas, now consists of shifting sand bars. The only stable substrate left in these areas is found along the bank where some undredged mud ledges remain. In addition, suspended silt, due primarily to erosion, appears to be increasing as mussel resources decline. This has been observed throughout the Mississippi River drainage (Ellis 1936, Thiel 1981).

CURRENT THREATS:
Channel maintenance activities and impoundments remain the greatest threats to the continued existence of this species (NatureServe 2003, USFWS 1989). Other current threats to freshwater mussels are described in the General Mussel Docuement.

The fat pocketbook is unique in that it persists in agricultural drainage ditches. An important consideration for conservation is that the fat pocketbook can be prolific in some ditches and completely absent in others in identical habitats. Since the ditches are nearly 100% ag runoff, determining tolerances to different chemicals is very valuable in attempts to restore this species to areas in its range. (Personnel communication from Susan Rogers, 2004)

Exposure Scenario Summary Table for the Fat pocketbook

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
fat pocketbook	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	freshwater drum
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

ALABAMA HEELSPLITTER
Potamilus inflatus

STATUS:
On September 28, 1990, the Alabama heelsplitter mussel was designated as threatened throughout its entire range in Alabama and Louisiana (USFWS 1990). A recovery plan for the Alabama heelsplitter was approved April 13, 1993 (USFWS 1993).

SPECIES DESCRIPTION:
The Alabama heelsplitter, which is referred to as the inflated heelsplitter in the species recovery plan (USFWS 1993), is a large (sometimes reaching over 140 mm in length) freshwater mussel with a brown to black shell with green rays in young individuals (USFWS 1993). Like other freshwater mussels, the Alabama heelsplitter feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of Alabama heelsplitter glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the Alabama heelsplitter is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. The life history of this species is largely unknown. Gravid females have been collected from the Amite River, Louisiana, during October (Hartfield 1988). At that time, they were observed to extend a mantle margin just above the substratum surface in shallow, clear water (USFWS 1993). Recent investigations indicate that the freshwater drum (*Aplodinotus grunniens*) is a suitable glochidial host for the Alabama heelsplitter (Roe et al. 1997).

RANGE AND POPULATION LEVEL:
The Alabama heelsplitter was known historically from the Amite and Tangipahoa Rivers, Louisiana; the Pearl River, Mississippi; and the Tombigbee, Black Warrior, Alabama, and Coosa Rivers, Alabama (Hurd 1974; Stern 1976; Hartfield 1988.). The presently known distribution is limited to the Amite River, Louisiana, and five sites in the Tombigbee and Black Warrior Rivers, Alabama (Stern 1976; Hartfield 1988, NatureServe 2003). The collection of this species from the Pearl River by Hinckley was reported by Frierson (1911) and a single valve collected by Parker is curated in the U.S. National Museum (USFWS 1993). Fresh dead shells of the Alabama heelsplitter were recently collected in the lower Pearl River (George *et al*. 1996) A single specimen was collected from the Tangipahoa River, Louisiana in 1964 by Stein and Stansbery (USFWS 1993). Hartfield (1988.) did not find the species in the Tangipahoa River during his survey. A single fresh dead shell was collected from the lower Alabama River in 1998 (Hartfield and Garner 1998). The species has not been reported from the Coosa in over 20 years (Hurd 1974; Hartfield 1988). This species is not abundant within any known habitat.

It is believed that more than 50 miles of available habitat remains for the species (NatureServe 2003); however, exact population numbers are unknown (USFWS 1993, 2003). The U.S. Army Corps of Engineers recently discovered 63 live animals during their surveys of the Tombigbee and Black Warrior Rivers (Miller 1995). In addition, George et al. (1996) report that two fresh dead specimens were found in two separate locations in the West Pearl River drainage, the first such records since 1911. Recent surveys indicated that the species remains in the lower Amite

River where some small individuals were collected indicating successful recruitment (Brown and Banks 2001).

HABITAT:
The preferred habitat of this species is soft, stable substrata in slow to moderate currents (Stern 1976). It has been found in sand, mud, silt and sandy-gravel, but not in large or armored gravel (Hartfield 1988). It is usually collected on the protected side of bars and may occur in depths over six meters (20 feet). The occurrence of this species in silt does not necessarily indicate that the species can be successful in that substratum (Hartfield 1988). Adult mussels may survive limited amounts of silt, whereas juveniles would suffocate. In addition, it is possible that the species was established in an area prior to deposition of the silt (USFWS 1993).

PAST THREATS:
Historic habitat for the Alabama heelsplitter has been impacted by channel modification for navigation and flood control, impoundment, pollution, and gravel dredging. Impoundments for navigation and sedimentation from surface mining have impacted the Black Warrior River. Most of the Tombigbee River was modified by construction of the Tennessee-Tombigbee Waterway. This resulted in the loss of river habitat by impoundment, channelization, and flow diversion. Habitat that should continue to support mussel populations has been destroyed by heavy accumulations of sediment. The entire Tombigbee River has been modified for navigation by impoundment; channelization and frequent dredging are required to maintain the navigation channel. Navigation dredging threatens this species by the deposition of spoil on bars along the sides of the river channel (Hartfield 1988). In addition, Hartfield (1989) concluded that 30 percent of the range of this species in the Amite River had been lost since 1976, primarily due to gravel mining.

CURRENT THREATS:
In the Amite River, there is a continued and serious threat from gravel mining that is largely unregulated. The impact of the proposed Darlington Reservoir as a flood control measure will likely be determined by the type and method of water releases incorporated. An alternative flood control measure under consideration is the widening and channelization of the Amite River. This potential action would likely eliminate the Alabama heelsplitter from the Amite River, leaving the only population in the Tombigbee and Black Warrior system (USFWS 2003). In addition, the population below Coffeeville Lock and Dam is not very abundant. The population in Gainesville Bendway may be adversely affected by the regulation of water flows from Gainesville Dam. During low flows, there is little, if any, water released over Gainesville Dam spillway for varying periods of time. This could result in very low dissolved oxygen conditions on the river bottom in Gainesville Bendway and adversely impact the Alabama heelsplitter (USFWS 1990, 1993). Chanel maintenance remains a threat in the Tombigbee and Black Warrior Rivers (USFWS 1993). The known populations are both geographically and genetically isolated from each other and apparently are limited in extent making them more susceptible to environmental disturbance due to loss of adaptability (USFWS 2003). Other current threats to freshwater mussels are described in the General Mussel document.

Exposure Scenario Summary Table for the Alabama heelsplitter

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
Alabama heelsplitter	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	freshwater drum
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

TRIANGULAR KIDNEYSHELL
Ptychobranchus greeni

STATUS:
On March 17, 1993, the triangular kidneyshell (*Ptychobranchus greeni)* was designated as Endangered throughout its entire range (USFWS 1993). A recovery plan for the triangular kidneyshell was finalized on November 17, 2000 (USFWS 2000). Critical habitat was designated for the triangular kidneyshell on July 1, 2004 (69 FR 40083).

SPECIES DESCRIPTION:
The triangular kidneyshell is oval to elliptical in outline, and may approach 100 mm (4.0 inches) in length. Like other freshwater mussels, adults are filter-feeders, orienting themselves in the substrate to facilitate siphoning of the water column for oxygen and food (Kraemer 1979). Mussels have been reported to consume detritus, diatoms, phytoplankton, zooplankton, and other microorganisms (Coker et al. 1921, Churchill and Lewis 1924, Fuller 1974). Juvenile mussels employ foot (pedal) feeding, and are thus suspension feeders (Yeager et al. 1994). Foods of juvenile freshwater mussels up to two weeks old include bacteria, algae, and diatoms with amounts of detrital and inorganic colloidal particles (Yeager et al. 1994). Specific food habits of the triangular kidneyshell are unknown, but are likely similar to those of other freshwater mussels.

REPRODUCTION AND DEVELOPMENT:
Gravid triangular kidneyshell females were observed in March 1994 and April 1996. Glochidia are packaged into conglutinates that mimic small aquatic fly larvae (Hartfield and Hartfield 1996) or fish eggs (Haag and Warren 1997). Suitable fish hosts have been identified as Warrior darter *(Etheostoma bellator)*, Tuskaloosa darter *(E. douglasi)*, blackbanded darter *(Percina nigrofaciata)* and logperch *(P. caprodes)* (Haag and Warren 1997).

RANGE AND POPULATION LEVEL:
The triangular kidneyshell was described from the headwaters of the Black Warrior River, Alabama. The historical range of the triangular kidneyshell included the Black Warrior, Cahaba, Alabama, and Coosa Rivers and tributaries in Alabama, Georgia, and Tennessee. The species has disappeared from the Alabama River, and from the primary channels of the Black Warrior and Coosa Rivers. The triangular kidneyshell is currently known to inhabit the Sipsey Fork and tributaries (Winston/Lawrence County, Alabama) and Locust Fork (Blount County, Alabama) of the Black Warrior; Cahaba River (Bibb County, Alabama); and Coosa tributaries Shoal Creek (Cleburne County, Alabama), Kelly Creek (Shelby County, Alabama), Big Canoe Creek (St. Clair County, Alabama), Conasauga River (Murray/Whitfield County, Georgia; Bradley County, Tennessee), Holly Creek (Murray County, Georgia), Coosawattee River (Gordon County, Georgia), and Oostanaula River (Floyd/Gordon County, Georgia). Populations are small and localized (USFWS 2003).

HABITAT:
The triangular kidneyshell inhabits sand/gravel/cobble substrate in shoals and runs of small rivers and large streams.

CRITICAL HABITAT:
In Winston and Lawrence Counties, Alabama, stream and river channels within the ordinary high water line of the Sipsey Fork main stem from the section 11/12 line, Winston County, Alabama, upstream to the confluence of Hubbard Creek, Lawrence County, Alabama; Thompson Creek, from its confluence with Hubbard Creek, upstream
to section 2 line Lawrence County; Brushy Creek, from the confluence of Glover Creek, Winston County, upstream to section 9, Lawrence County; Capsey Creek, from confluence with Brushy Creek, Winston County, upstream to the confluence of Turkey Creek, Lawrence County; Rush Creek, from confluence with Brushy Creek, upstream to Winston/Lawrence County Line, Winston County; Brown Creek, from confluence with Rush Creek, Winston County, upstream to section 24 line, Lawrence County; Beech Creek, from confluence with Brushy Creek, to confluence of East and West Forks, Winston County; Caney Creek and North Fork Caney Creek, from confluence with Sipsey Fork, upstream to section 14 line, Winston County; Borden Creek, from confluence with Sipsey Fork, Winston County, upstream to the confluence of Montgomery Creek, Lawrence County; and Flannagin Creek, from confluence with Borden Creek, upstream to confluence of Dry Creek, Lawrence County.

In Tuscaloosa and Fayette Counties, Alabama, stream and river channels within the ordinary high water line of the main stem of the North River from Tuscaloosa County Road 38, Tuscaloosa County, upstream to confluence of Ellis Creek, Fayette County, Alabama; and Clear Creek from its confluence with North River to Bays Lake Dam, Fayette County, Alabama.

In Jefferson and Blount Counties, Alabama, stream and river channels within the ordinary high water line of the Locust Fork main stem from U.S. Highway 78, Jefferson County, upstream to the confluence of Little Warrior River, Blount County, Alabama; and Little Warrior River from

its confluence with the Locust Fork, upstream to the confluence of Calvert Prong and Blackburn Fork, Blount County, Alabama.

In Jefferson, Shelby, and Bibb Counties, Alabama, stream and river channels within the ordinary high water line of the Cahaba River from U.S. Highway 82, Centerville, Bibb County, upstream to Jefferson County Road 143, Jefferson County, Alabama; and the Little Cahaba River from its confluence with the Cahaba River, upstream to the confluence of Mahan and Shoal Creeks, Bibb County, Alabama.

In Cherokee, Calhoun, and Cleburne Counties, Alabama, stream and river channels within the ordinary high water line of the Coosa River main stem from the power line crossing southeast of Maple Grove, Alabama, upstream to Weiss Dam, Cherokee County, Alabama; Terrapin Creek, 53 km (33 mi) extending from its confluence with the Old Coosa River channel, Cherokee County, upstream to Cleburne County Road 49, Cleburne County, Alabama; South Fork Terrapin Creek, 7 km (4 mi), from its confluence with Terrapin Creek, upstream to Cleburne County Road 55, Cleburne County, Alabama.

In Coosa and Clay Counties, Alabama, stream and river channels within the ordinary high water line of the main stem of Hatchet Creek from the confluence of Swamp Creek at Coosa County Road 29, Coosa County, Alabama, upstream to Clay County Road 4, Clay County, Alabama.

In Calhoun and Cleburne Counties, Alabama, stream and river channels within the ordinary high water line of the main stem of Shoal Creek from the headwater of Whitesides Mill Lake, Calhoun County, Alabama, upstream to the tailwater of Coleman Lake Dam, Cleburne County, Alabama.

In Shelby and St. Clair Counties, Alabama, stream and river channels within the ordinary high water line of the Kelly Creek main stem extending from the confluence with the Coosa River, upstream to the confluence of Shoal Creek, St. Clair County, Alabama;
and the main stem of Shoal Creek from the confluence with Kelly Creek, St. Clair County, Alabama, upstream to the St. Clair/Shelby County Line, St. Clair County, Alabama.

In Talladega and Clay Counties, Alabama, stream and river channels within the ordinary high water line of the main stem of Cheaha Creek from its confluence with Choccolocco Creek, Talladega County, Alabama, upstream to the tailwater of Chinnabee Lake Dam, Clay County, Alabama.

In Shelby County, Alabama, stream and river channels within the ordinary high water line of the Yellowleaf Creek main stem from Alabama Highway 25, upstream to Shelby County Road 49; and the Muddy Prong main stem extending from its confluence with Yellowleaf Creek, upstream to U.S. Highway 280.

In St. Clair County, Alabama, stream and river channels within the ordinary high water line of the main stem of Big Canoe Creek from its confluence with Little Canoe Creek at the St. Clair/Etowah County line, St. Clair County, upstream to the confluence of Fall Branch.

In Floyd, Gordon, Whitfield, and Murray Counties, Georgia; and Bradley and Polk Counties, Tennessee, stream and river channels within the ordinary high water line of the Oostanaula River main stem from its confluence with the Etowah River, Floyd County, Georgia, upstream to the confluence of the Conasauga and Coosawattee River, Gordon County, Georgia; the Coosawattee River main stem from its confluence with the Conasauga River, upstream to Georgia State Highway 136, Gordon County, Georgia; the Conasauga River main stem from confluence with the Coosawattee River, Gordon County, Georgia, upstream through Bradley and Polk Counties, Tennessee, to Murray County Road 2, Murray County, Georgia; and the mainstem of Holly Creek from its confluence with the Conasauga River, upstream to its confluence with Rock Creek, Murray County, Georgia.

In Elmore County, Alabama, stream and river channels within the ordinary high water line of the Coosa River main stem from Alabama State Highway 111 bridge, upstream to Jordan Dam.

Primary constituent elements identified at the time of designation included: 1. Geomorphically stable stream and river channels and banks; 2. A flow regime (i.e., the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of mussels and their fish hosts in the river environment; 3. Water quality, including temperature, pH, hardness, turbidity, oxygen content, and other chemical characteristics necessary for normal behavior, growth, and viability of all life stages; 4. Sand, gravel, and/or cobble substrates with low to moderate amounts of fine sediment, low amounts of attached filamentous algae, and other physical and chemical characteristics necessary for normal behavior, growth, and viability of all life stages; 5. Fish hosts with adequate living, foraging, and spawning areas for them; and 6. Few or no competitive or predaceous nonnative species present.

PAST THREATS:
The abundance and distribution of the triangular kidneyshell decreased historically due to human-induced habitat loss and degradation caused by impoundments, sedimentation and turbidity, channelization and dredging, mining (coal, sand, gravel, or gold) (Jones 1991, USFWS 1993, Leigh 1994, ADEM 1994), and contaminants contained in numerous point (e.g., carpet mills and fabric dying mills) (Hurd 1974) and nonpoint sources (USFWS 2000). Channel modifications and water pollution gradually eliminated these native species that are dependent on a narrow range of flowing water habitat conditions from extensive portions of their former ranges within the Mobile River Basin. These habitat changes have resulted in significant extirpations (localized loss of populations), restricted and fragmented distributions, and poor recruitment of young.

CURRENT THREATS:
Habitat modification, sedimentation, eutrophication, and other forms of water quality degradation represent the major threats to the triangular kidneyshell. This species does not tolerate impoundment. Surviving populations are threatened by urban and agricultural runoff, surface mine drainage, industrial and sewage treatment plant discharges, and localized household discharges. Dense filamentous algal growth due to nutrification affects feeding, host fish interactions, and survival of juveniles.

Due to the rarity of the triangular kidneyshell, any adverse impacts to its habitat or an individual could result in the extirpation of a localized population. Recovery of the triangular kidneyshell to the point of downlisting to threatened is unlikely in the near future. The immediate recovery objective is to prevent the extinction of this species by locating, protecting, and restoring stream drainages with extant populations.

Exposure Scenario Summary Table for the Triangular Kidneyshell

Species	**Life Stage**	**Habitat Type**	**Exposure Route**	**Diet**	**Significant Interspecies Relationships**
Triangular Kidneyshell	glochidia	parasite	contact with water, diet	fish body fluids	Warrior darter, Tuskaloosa darter, blackbanded darter, and logperch
	juvenile/ adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

ROUGH RABBITSFOOT

Quadrula cylindrica strigillata

STATUS:

On January 10, 1997, the rough rabbitsfoot (*Quadrula cylindrica strigillata*), was designated as Endangered throughout its entire range (USFWS 1997). The *Recovery Plan for the Cumberland Elktoe, Oyster Mussel, Cumberlandian Combshell, Purple Bean, and Rough Rabbitsfoot* was approved on May 4, 2004 (69 FR 29569). Critical habitat was designated for the Rough Rabbitsfoot on August 31, 2004 (69 FR 53135). A 5-Year Review was initiated for the Rough Rabbitsfoot on January 23, 2008.

SPECIES DESCRIPTION:

The rough rabbitsfoot has an elongated, heavy, highly pustulate (bumpy) shell with iridescence in the posterior area of the shell. .

REPRODUCTION AND DEVELOPMENT:

Yeager and Neves (1986) summarized the reproductive biology and identified fish hosts of the unionine rough rabbitsfoot. Spawning occurred from May through June (water temperature 68.0° to 71.6°F). Fertilization success was high (>95 percent) through late June, but by July only unfertilized ova were found. Unlike most unionines, 65 percent of 82 gravid females examined utilized only the outer demibranchs as marsupia. They estimated gravidity rates (30 to 60 percent) peaked in late May then gradually declined. Females release lanceolate-shaped whitish to reddish brown conglutinates (0.4 inch long) that contain 375 to 505 semicircular-shaped glochidia. Fecundity was estimated at 115,000 embryos per female. The age of gravid females was qualitatively estimated to be 10 to 22 years. Three cyprinid host fish species have been identified--the whitetail shiner, spotfin shiner (*C. spiloptera*), and bigeye chub (*Hybopsis amblops*). Infestation rates ranged from as few as five to ten glochidia on individual fishes. Transformation took from 13 to 23 days, at 68.9° to 71.4°F.

RANGE AND POPULATION LEVEL:

The rough rabbitsfoot is considered a subspecies of the wide-ranging rabbitsfoot (Turgeon et al. 1998). The type locality is the Clinch River in Virginia (erroneously given as Lee Co., VA.; Ortmann 1918). The historical distribution of this taxon is generally considered to be above the Norris Reservoir (Powell and Clinch Rivers) and in the North Fork and South Fork of the Holston River in northeastern Tennessee and southwestern Virginia (Ortmann 1918). Downstream (main stem of the Tennessee River and larger tributaries), the typical form (*Quadrula c. cylindrica*) is presumed to have occurred. The rough rabbitsfoot is restricted to the upland-most portion of the Ridge and Valley Physiographic Province, making it one of the more narrowly distributed species endemic to the Cumberlandian Region (Table 5, USFWS 2003).

Ortmann (1924) stated that the range of the rough rabbitsfoot was the headwaters of the Powell, Clinch, and Holston Rivers. Today, the entire Holston River system population of the rough rabbitsfoot has been extirpated (e.g., North Fork Holston River, South Fork Holston River, Big Moccasin Creek, Possum Creek) (Table 5, USFWS 2003). Populations of this species remain in the Clinch River in Russell, Scott, and (possibly) Tazewell Counties (but see Table 5, Footnote 1, USFWS 2003), Virginia, and Hancock County, Tennessee; Indian Creek, Tazewell County, Virginia; and the Powell River, Lee County, Virginia, and Hancock and Claiborne Counties, Tennessee (Table 5, USFWS 2003). Ahlstedt (1981) reported it live from Copper Creek in 1980, but only relic shells were reported in 1998 by Fraley and Ahlstedt (2000). They indicated that it “may be extirpated” from the stream, which is the viewpoint taken by the Service (USFWS 2003). The rough rabbitsfoot persists, however, in the Clinch River in areas adjacent to the mouth of Copper Creek (Jones, pers. comm., 2003). It is therefore possible that it will be discovered to persist in the lower portions of Copper Creek.

Recent quantitative population density information is available for the rough rabbitsfoot in the Powell and Clinch Rivers in Tennessee and Virginia. Sampling revealed “extremely low densities” of the rough rabbitsfoot in the Powell, and a decline in the Clinch, over the course of the 20-year study (Ahlstedt and Tuberville 1997; Ahlstedt, unpub. data). Taking from 432 (1979) to 542 (1999) quadrats (2.7 square feet) at 14 to 18 sites per year in the Powell, they found it at densities of 0.01 per square foot at 1 of 15 sites in both 1979 and 1988 but none

during 1983, 1994, and 1999 sampling. Similar sampling of from 345 (1979) to 428 (1994 and 1999) quadrats from 11 to 14 sites in the Clinch River revealed average densities of 0.05 per square foot at 3 of 11 sites in 1979, 0.02 per square foot at 2 of 14 sites in 1994, and 0.02 per square foot at 1 of 14 sites in 1999. Limited quantitative sampling in the Powell River in Virginia by Wolcott and Neves (1990, 1994) during 1988 and 1989 revealed no specimens of the rough rabbitsfoot. According to Ahlstedt and Tuberville (1997), a prolonged drought between 1983 and 1988 at least partially accounted for the low numbers detected during 1988 sampling efforts, although stream degradation also contributed to its decline (see comments on below on coal mining).

Preimpoundment historical abundance of this species was not recorded by Ortmann (1918) or any other investigator. Until relatively recently, the rough rabbitsfoot in the Scott County, Virginia, portion of the Clinch was locally abundant, particularly at Pendleton Island (Yeager and Neves 1986, Ahlstedt 1991a). Currently, it has suffered a marked decline in Virginia but is recruiting and viable in the Tennessee portion of the river (Ahlstedt, pers. comm., 2003). Its population status elsewhere appears to be much more tenuous. The Powell River population is probably not currently viable (Ahlstedt, pers. comm., 2003). Efforts by the TVA to transplant specimens into the North Fork Holston River during the mid-1970s (Ahlstedt 1980) have apparently failed (Ahlstedt, pers. comm., 1997). Restoration efforts are planned to reestablish the recently viable upper Clinch River population decimated by the 1998 chemical spill at Cedar Bluff ®. J. Neves, USGS, letter dated June 11, 2003; J. Schmerfeld, Service, pers. comm., 2003). This population is contiguous with those specimens in Indian Creek, forming a metapopulation. The Indian Creek population is very small and probably dependent on the main-stem population for long-term survival (Neves, letter dated June 11, 2003).

HABITAT:
This species inhabits medium-sized to large rivers in moderate to swift current but often exists in areas close to, but not in, the swiftest current (Gordon 1991). It is reported to live in silt, sand, gravel, or cobble in eddies at the edge of midstream currents and may be associated with macrophyte beds (Yeager and Neves 1986, Gordon 1991). The rough rabbitsfoot seldom burrows; it generally lies on its side on the stream bottom (Neves, pers. comm., 2003).

CRITICAL HABITAT:
In Claiborne and Hancock Counties, Tennessee, and Lee County, Virginia, all stream and river channels within the ordinary high-water line of the Powell River from the U.S. 25E Bridge in Claiborne County, Tennessee, upstream to rkm 256 (rmi 159) (upstream of Rock Island in the vicinity of Pughs), Lee County, Virginia. In Hancock County, Tennessee, and Scott, Russell, and Tazewell Counties, Virginia, all stream and river channels within the ordinary high-water line of the Clinch River from rkm 255 (rmi 159) immediately below Grissom Island, Hancock County, Tennessee, upstream to its confluence with Indian Creek in Cedar Bluff, Tazewell County, Virginia; 4 rkm (2.5 rmi) of Indian Creek from its confluence with the Clinch River upstream to the fourth Norfolk Southern Railroad crossing at Van Dyke, Tazewell County, Virginia; and 21 rkm (13 rmi) of Copper Creek from its confluence with the Clinch River upstream to Virginia State Route 72, Scott County, Virginia.

Primary constituent elements identified at the time of designation included: 1. Permanent, flowing stream reaches with a flow regime (i.e, the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of the mussel and its host fish; 2. Geomorphically stable stream and river channels and banks (structurally stable stream cross section); 3. Stable substrates, consisting of mud, sand, gravel, and/or cobble/boulder, with low amounts of fine sediments or attached filamentous algae; 4. Water quality (including temperature, turbidity, oxygen content, and other characteristics) necessary for the normal behavior, growth, and survival of all life stages of the five mussels and their host fish; and 5. Fish hosts with adequate living, foraging, and spawning areas for them.

PAST THREATS:
The abundance and distribution of the rough rabbitsfoot decreased historically from human-induced habitat loss and degradation (Williams et al. 1993, Neves 1993) caused by impoundments, sedimentation and turbidity, channelization, and contaminants contained in numerous point and nonpoint sources. A comprehensive review of these past threats is provided elsewhere (USFWS 2003, Williams et al. 1993, Neves 1993, Neves 1991, Neves et al. 1997, Watters 2000, Richter et al. 1997). These habitat changes have resulted in significant extirpations (localized loss of populations), restricted and fragmented distributions, and poor recruitment of young.

Numerous Cumberlandian Region streams have experienced mussel kills from toxic chemical spills and other causes (Cairns et al. 1971, Crossman et al. 1973, Neves 1986, Wolcott and Neves 1994). The high number of jeopardized species in the upper Tennessee River system makes accidental spills a particular concern to conservationists and resource managers (Hampson et al. 2000). The dramatic impact the chlor-alkali chemical plant in Saltville, Virginia, has had on the aquatic fauna in the North Fork Holston River is well documented (Adams 1915; Cairns et al. 1971; Stansbery and Clench 1974; Hill et al. 1975; Ahlstedt 1980, 1991c; Neves and Zale 1982; Sheehan et al. 1989; Hampson et al. 2000). Although it is considered a chronic episode, and not an “event” like most other toxic spills, it is discussed in this section simply because of the tremendous impact it has had on the river.

Since the plant’s opening in 1893, mercury and various salts (e.g., calcium chloride, sodium chloride) from this site have polluted the North Fork Holston River and decimated the entire molluscan fauna all the way to the mouth of the river, a distance of 80 miles (Ahlstedt 1991b). Occurring in this river reach were populations of the rough rabbitsfoot, Cumberlandian combshell, oyster mussel, purple bean, and 34 other mussel species (Neves and Zale 1982). From 1950 to 1971, an estimated 75 pounds of mercury per day were discharged from this facility directly into the North Fork or into unlined floodplain holding ponds (Hampson et al. 2000). The long-term kill was so thorough that only one mussel species was reported in the early 1970s by Hill et al. (1975).

The closing of the plant in 1972 brought about the possible opportunity for natural mussel recolonization in the North Fork Holston River (Stansbery and Clench 1974). Efforts were soon made to help speed up the recovery of mussels in the North Fork. However, the lingering effects of mercury, extremely low numbers of mussels, and possibly low numbers of fish hosts may be

responsible for the general lack of mussels observed at sites within 20 miles downstream of Saltville (Henley and Neves 1995).

An alkaline fly ash pond spill in 1967 and a sulfuric acid spill in 1970 on the Clinch River at the power plant at Carbo, Virginia, caused a massive mussel kill for up to 12 miles downstream from the power plant site (Cairns et al. 1971, Crossman et al. 1973, Stansbery 1986, Sheehan et al. 1989, Wilcove and Bean 1994). Populations of the rough rabbitsfoot, Cumberlandian combshell, oyster mussel, and purple bean that may have resided in the affected river reach were undoubtedly impacted by these spill events. Natural recolonization has not occurred in the impacted river reach (Stansbery 1986, Ahlstedt 1991a, Hampson et al. 2000), possibly due to copper contamination from the power plant at Carbo (Wilcove and Bean 1994). An experimental reintroduction of nonlisted mussels in 1981 and 1984 has largely failed (Sheehan et al. 1989).

An overturned tanker truck resulted in a chemical spill in the upper Clinch River on August 27, 1998, killing more than 7,000 mussel specimens of 16 species. Approximately 250 specimens of three federally listed species were found dead over a 5.5-mile reach, including at least 52 purple bean specimens and 20 rough rabbitsfoot specimens (Jones et al. 2001). According to Ahlstedt (1983), "hundreds of dead shells were observed buried in the substratum" during a 1980 Elk River survey. He attributed this kill to an unknown chemical spill.

CURRENT THREATS:

The rough rabbitsfoot and its habitat is currently being impacted by excessive sediment bed loads of smaller sediment particles, changes in turbidity, increased suspended solids (primarily resulting from nonpoint-source loading from poor land-use practices and lack of, or maintenance of, best management practices [BMPs], and pesticides (USFWS 2003, Williams et al. 1993, Neves 1993, Neves 1991, Neves et al. 1997, Watters 2000, Richter et al. 1997)). Other primarily localized impacts include coal mining, gravel mining, reduced water quality below dams, developmental activities, water withdrawal, impoundments, and alien species. Their restricted ranges and low population levels also increase their vulnerability to toxic chemical spills and the deleterious effects of genetic isolation.

Coal mining activities occur in portions of the upper Powell and Clinch River systems, primarily in Virginia. Scores of active and inactive mines are known from these drainages (Hampson et al. 2000). The role that coal mining has played in the decline of mussel fauna in the Powell River in Virginia was prophesied by Ortmann (1918) and has been briefly summarized by Wolcott and Neves (1990, 1994). Five mine tailings pond spills were reported from 1995 to 1999 in the upper Clinch and Powell River systems (Hampson et al. 2000), at least one of which resulted in a major fish kill (Koch, pers. comm., 1996). Research by Kitchel et al. (1981) indicates that Powell River mussel populations were inversely correlated with coal fines in the substrate. When coal fines were present, decreased filtration times and increased movements were noted in laboratory-held mussels (Kitchel et al. 1981).

Polycyclic aromatic compounds (PAHs) are indicative of coal fines in the bottom sediments of streams. Known to be toxic to mussels and fishes, PAHs have been found at relatively high

levels in the upper portions of the Clinch and Powell Rivers in Virginia (Hampson et al. 2000). In fact, Hampson et al. (2000) detected 29 different PAHs in stream sediment samples in the two watersheds. The Clinch River at Pendleton Island had concentrations of two measured PAHs, naphthalene and phenanthrene, at 400 micrograms per kilogram (µg/kg) and 570 µg/kg, respectively, both of which are above the protection guidelines for aquatic life. The Canadian probable-effect levels of 391 µg/kg and 515 µg/kg, respectively, have been established for these compounds. The probable-effect levels define concentrations above which adverse effects to aquatic organisms can be expected. Pendleton Island was once a stronghold for the rough rabbitsfoot and home to the Cumberlandian combshell, oyster mussel, and purple bean as well in the early 1980s (Ahlstedt 1991a). However, the fauna there was in marked decline less than a decade later. Three other sites in the Clinch River system (i.e., lower Clinch River, Guest River, Copper Creek) had concentrations of these two compounds below the probable-effect levels. A site on the Powell River near Arthur, Tennessee, had much higher levels of naphthalene and phenanthrene (1,600 µg/kg and 1,300 µg/kg, respectively) than at Pendleton Island.

In a quantitative study in the Powell River, Ahlstedt and Tuberville (1997) attributed a 15-year decline of the rough rabbitsfoot, Cumberlandian combshell, and oyster mussel and the long-term decrease in species diversity (from 30 in 1979 to 21 in 1994) to general stream degradation due primarily to coal mining activities in the headwaters. Iron and phosphate mining in the Duck River watershed was thought to have caused mussel declines in the early 1900s (Ortmann 1924).

Wastewater is discharged at sites throughout the country with permits (and some without permits) issued by the National Pollution Discharge Elimination System (NPDES). Elimination sites are ubiquitous in watersheds containing rough rabbitsfoot populations, providing ample opportunities for some pollutants to enter streams. Collectively, pollutants from these sources may cause decreased dissolved oxygen levels, increased acidity, and other water chemistry changes that may be lethal to mussels (Horne and McIntosh 1979, Rand and Petrocelli 1985, Sheehan et al. 1989, Keller and Zam 1991, Dimock and Wright 1993, Goudreau et al. 1993, Jacobson et al. 1993, Keller 1993).

Sediment from the upper Clinch River, where several of these species occur, was found to be toxic to juvenile mussels (Robison et al. 1996). Ahlstedt and Tuberville (1997) speculated that the presence of toxins in the Clinch River may explain the decline and lack of mussel recruitment at some sites in the Virginia portion of that stream. Wilcove and Bean (1994) reported that studies indicated that mussel reproduction below the site of the Appalachian Power Company's (APCO) electric generating station in Carbo, Virginia, was being inhibited by copper discharges. In addition, copper was shown to be toxic to mussels at levels below the U.S. Environmental Protection Agency (EPA) criteria established in Virginia. The Virginia State Water Control Board began proceedings to impose a special water quality standard for copper below the plant. In 1992, the State and APCO agreed on a lower standard for copper for this specific stretch of the Clinch. APCO is spending several million dollars to control copper discharge from its facility to meet the new standard (Wilcove and Bean 1994).

Although the Clean Water Act (CWA), administered by the EPA, has helped eliminate many point-source effluents, "straight pipes" (pipelines conveying untreated household effluents; e.g.,

chlorine, detergents, household chemicals, human waste, etc., from rural homes directly into streams) continue to discharge wastes. Fraley and Ahlstedt (2000) thought that effluents from straight pipes were partially to blame for the documented decline of the native mussel fauna in Copper Creek from 19 species in 1980 to 11 species in 1998. Included in the historical Copper Creek fauna were the rough rabbitsfoot, oyster mussel, and purple bean, although only the latter species was found live in 1998. Numerous other streams in the Cumberlandian Region doubtless also have straight pipes discharging pollutants into mussel habitat.

Armour et al. (1991) reviewed the effects of livestock grazing on riparian and stream ecosystems. Unrestricted access by livestock is a significant threat to streams (Trimble and Mendel 1995) and their mussel populations throughout much of the Cumberlandian Region (Anonymous 1999, Fraley and Ahlstedt 2000). Grazing may reduce infiltration rates and increase runoff and erosion (Brim Box and Mossa 1999). Trampling causes or accelerates stream-bank erosion, and grazing reduces a bank's resistance to erosion (Armour et al. 1991, Trimble and Mendel 1995). In addition, livestock may add nutrients to streams at levels that are not easily assimilated, particularly during low-flow conditions, resulting in overenrichment. Fraley and Ahlstedt (2000) attributed the decline of the Copper Creek mussel fauna between 1980 and 1998, among other factors, to an increase in cattle grazing and loss of riparian vegetation in the stream. They considered the rough rabbitsfoot and oyster mussel as possibly being extirpated from Copper Creek.

Exposure Scenario Summary Table for the Rough Rabbitsfoot

Species	**Life Stage**	**Habitat Type**	**Exposure Route**	**Diet**	**Significant Interspecies Relationships**
Rough Rabbitsfoot	glochidia	parasite	contact with water, diet	fish body fluids	whitetail shiner, spotfin shiner, bigeye chub
	juvenile/ adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

WINGED MAPLELEAF (MUSSEL)

Quadrula fragosa

STATUS:

On June 20, 1991 the winged mapleleaf mussel was designated as endangered throughout its entire range in Arkansas, Kentucky, Minnesota, Tennessee, Wisconsin (USFWS 1991), except where listed as experimental populations (in the free-flowing reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, AL) (USFWS 2001). A recovery plan for the winged mapleleaf was approved June 25, 1997 (USFWS 1997).

SPECIES DESCRIPTION:
The winged mapleleaf, is a medium-sized (reaching up to 100 mm in length) freshwater mussel with a dull brown shell with broad, broken green rays and two prominent, heavily tuberculated, radial ridges (USFWS 1997). Like other freshwater mussels, the winged mapleleaf feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of winged mapleleaf glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the winged mapleleaf is similar to that of other mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. The brooding season is not known for *Q. fragosa*, although the presumed brooding period is late May to the middle of July (Baker 1928, Heath and Rasmussen 1990). Wilson and Clark (1914) reported two gravid individuals from the Cumberland River on May 17 and 29, and noted they brood glochidia on all four gills. Heath et al. (1999), however, reported a short brooding period in September and October. Studies using 28 fish species indicated that the channel catfish (*Ictalurus punctatus*) may be a suitable host species for the winged mapleleaf (Hove et al. 2000). Recent studies have confirmed the channel catfish as a host and identified the blue catfish (*Ictalurus furcatus*) as an even more prolific host than the channel catfish (Steingraeber et al., 2007). The maximum age of the winged mapleleaf is not known, but the oldest known individual in the St. Croix population was aged at 22 years (USFWS 1997).

RANGE AND POPULATION LEVEL:
This species was historically reported from 34 rivers in 12 states, all from tributaries of the upper Mississippi River of from the Mississippi River mainstem (USFWS 1997). Due to misidentifications, its relative similarity of appearance to *Quadrula quadrula*, and the rarity of the winged mapleleaf relative to that species, population declines of this mussel went largely undetected until more recently (NatureServe 2003). It is now believed to be extirpated from nearly its entire historic range. A remnant population exists in the St. Croix River between Minnesota and Wisconsin. All known specimens from this population have been found within a 20-km reach of the river, but the full distribution and size of the winged mapleleaf population in the St. Croix River are not defined (USFWS 1997, 2001). Another viable population has been reported from the Ouachita River in Arkansas (NatureServe 2003). Recently a singe winged

mapleleaf was collected from the Ohio River; however, the condition of the shell and the status of the population, if it exists, is unknown (NatureServe 2003).

HABITAT:
Historical descriptions characterized winged mapleleaf as a Alarge-stream@ species (Wilson and Clark 1914, Baker 1928) found on mud (Baker 1928), mud-covered gravel (Ortmann 1924), and gravel (Ortmann 1925) substrates. Wilson and Clark (1914) reported winged mapleleaf from 21 different beds in the Cumberland River system and these beds varied considerably in their habitat from impounded water to fast flowing water and from muddy to sandy to clear gravel substrates. They found mussels in 1.5 m to 6.5 m depth. Ortmann (1924) reported the species from a spillway just below a dam. There is substantial information on the habitat of the remnant population in the St. Croix River. The species has also been found in riffles with clean gravel, sand, or rubble substrates and in clear water of high water quality. Winged mapleleaf was most abundant in shallow areas with fast current (USFWS 1997).

PAST THREATS:
Habitat modification including land use changes, river channel modifications, and pollution are the primary factors threatening the continued existence of the winged mapleleaf. The species was usually found in well-preserved large to medium-sized clear-water streams in riffles or on gravel bars. These areas have been lost due to the development of impoundments, channelization, soil erosion, and sediment accumulation originating from land use practices.

Minnesota and Wisconsin Departments of Natural Resources agree that the peaking operation of Northern States Power Company power plant located upstream from the mussel bed is posing a possible threat to the mussel population. The normal winter operation of Northern States Power Company is a twice daily peaking mode (once a day during droughts) with only 800 cfs being discharged between peaking operations. It appears that this is not enough water to cover the beds so mussels are exposed to freezing, abrasion, and predation. In fact, in 1989, the peaking operation completely exposed the beds during the night. In 1991, the Wisconsin Department of Natural Resources surveyed the bed and found that a layer of ice 13 inches deep was laid directly on the gravel of the bed with each lowering of flow. The ice layer adhered to and abraded the bottom exposing the mussels. A Minnesota Department of Natural Resources study for this portion of the river concluded that the dam must release 1980 cfs to adequately protect the mussel beds (USFWS 1991).

CURRENT THREATS:
Additional threats to the small, remaining populations include expanded agriculture or modified land use practices in the watershed, toxic substance spills, point discharges of harmful chemicals, low water levels, and large recreational boat traffic. The small size of the population makes it particularly vulnerable to single catastrophic events and genetic deterioration. These factors may affect the host fish which is necessary for the reproduction of the winged mapleleaf in addition to affecting the remaining mussel population. In addition, it is likely that many of the remaining populations are now small enough that their long-term genetic viability is in question (USFWS 1991). Other current threats to freshwater mussels are described in the General Mussel Document.

Exposure Scenario Summary Table for the Winged mapleleaf

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
winged mapleleaf	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	channel catfish blue catfish
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

CUMBERLAND MONKEYFACE (PEARLYMUSSEL)

Quadrula intermedia

STATUS:

On June 14, 1976, the Cumberland monkeyface (pearlymussel) was designated as endangered throughout its entire range in Alabama, Tennessee, and Virginia (USFWS 1976), except where listed as experimental populations (in the free-flowing reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, AL) (USFWS 2001). A recovery plan for the Cumberland monkeyface was approved in 1984 (USFWS 1984).

SPECIES DESCRIPTION:

The Cumberland monkeyface is a medium-sized freshwater mussel (reaching up to 80 mm in length) with a yellow-green shell characterized by numerous green spots, chevrons, or zig-zag patterns and is similar in appearance to the Appalachian monkeyface pearlymussel (*Quadrula sparsa*) (VFWIS 2003). Like other freshwater mussels, the Cumberland monkeyface feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of Cumberland monkeyface glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:

The reproductive cycle of the Cumberland monkeyface is similar to that of other mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until

the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. They then detach from their fish host and sink to the stream bottom or other substrate where they continue to develop, provided they land in a suitable substratum with the correct water conditions. Adult mussels of this species are sexually dimorphic. Recent studies have identified two cyprinids, the streamline chub (*Erimystax dissimilis*) and blotched chub (*Erimystax insignis*) as glochidial host species for the Cumberland monkeyface. Both fish hosts are known to occupy similar riffle habitats as the mussel (Yeager and Saylor 1995).

RANGE AND POPULATION LEVEL:
The Cumberland monkeyface was historically known from 11 rivers in the Tennessee River system (USFWS 1984). It was last collected from Mussel Shoals, Mussel Shoals, historically an 85 km reach of the Tennessee River in Alabama (that is now reduced to a few kilometers of riverine habitat due to construction of three dams), around 1900 (Ortmann 1925) and is presumed to be extirpated from the shoal. Currently, the species survives only at a few shoals in the Powell River in Tennessee and Virginia and the Duck River in Tennessee (USFWS 1984). Both populations appear to be viable, but the Powell River population is declining. The Elk River population in Tennessee is now extirpated.

HABITAT:
The Cumberland monkeyface typically occurs in shallow shoal and riffle areas in free-flowing streams of high to moderate gradient. Substrate preferences include firm rubble, gravel and sand and the species most often remains buried with only siphons visible (USFWS 1984, ESIS 1996, VFWIS 2003). The Cumberland monkeyface has been found in waters ranging from six inches to two feet in depth (Bogan and Parmalee 1983, Parmalee and Bogan 1998). The species has never been found in small streams (VFWIS 2003). The habitat preference of this species is similar to that of the closely related Appalachian monkeyface (ESIS 1996).

PAST THREATS:
Many of the historic populations of the Cumberland monkeyface were apparently lost when the upper Tennesse River drainage was impacted by dam constuction, channelization, siltation and water pollution (USFWS 1984). The Powell River and upper tributaries of the Clinch River, in particular, are also subject to sediment and particulate matter loading from coal mining activities (Stansbery 1973). Other threats that are attributed to population declines are similar to those described in the general mussel description.

CURRENT THREATS:
In addition to the factors listed above, current threats include the low gene pool for remaining populations, collection, invasion of the Asiatic clam (*Corbicula fluminea*), and the Columbia Dam project on the Duck River in Tennessee. Other current threats to freshwater mussels are described in the General Mussel document.

Exposure Scenario Summary Table for the Cumberland monkeyface

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
Cumberland monkeyface	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	streamline chub blotched chub
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

CUMBERLAND MONKEYFACE (PEARLYMUSSEL)
Quadrula intermedia

STATUS:
On June 14, 1976, the Cumberland monkeyface (pearlymussel) was designated as endangered throughout its entire range in Alabama, Tennessee, and Virginia (USFWS 1976), except where listed as experimental populations (in the free-flowing reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, AL) (USFWS 2001). A recovery plan for the Cumberland monkeyface was approved in 1984 (USFWS 1984).

SPECIES DESCRIPTION:
The Cumberland monkeyface is a medium-sized freshwater mussel (reaching up to 80 mm in length) with a yellow-green shell characterized by numerous green spots, chevrons, or zig-zag patterns and is similar in appearance to the Appalachian monkeyface pearlymussel (*Quadrula sparsa*) (VFWIS 2003). Like other freshwater mussels, the Cumberland monkeyface feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of Cumberland monkeyface glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the Cumberland monkeyface is similar to that of other mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. They then detach from their fish host and sink to

the stream bottom or other substrate where they continue to develop, provided they land in a suitable substratum with the correct water conditions. Adult mussels of this species are sexually dimorphic. Recent studies have identified two cyprinids, the streamline chub (*Erimystax dissimilis*) and blotched chub (*Erimystax insignis*) as glochidial host species for the Cumberland monkeyface. Both fish hosts are known to occupy similar riffle habitats as the mussel (Yeager and Saylor 1995).

RANGE AND POPULATION LEVEL:
The Cumberland monkeyface was historically known from 11 rivers in the Tennessee River system (USFWS 1984). It was last collected from Mussel Shoals, Mussel Shoals, historically an 85 km reach of the Tennessee River in Alabama (that is now reduced to a few kilometers of riverine habitat due to construction of three dams), around 1900 (Ortmann 1925) and is presumed to be extirpated from the shoal. Currently, the species survives only at a few shoals in the Powell River in Tennessee and Virginia and the Duck River in Tennessee (USFWS 1984). Both populations appear to be viable, but the Powell River population is declining. The Elk River population in Tennessee is now extirpated.

HABITAT:
The Cumberland monkeyface typically occurs in shallow shoal and riffle areas in free-flowing streams of high to moderate gradient. Substrate preferences include firm rubble, gravel and sand and the species most often remains buried with only siphons visible (USFWS 1984, ESIS 1996, VFWIS 2003). The Cumberland monkeyface has been found in waters ranging from six inches to two feet in depth (Bogan and Parmalee 1983, Parmalee and Bogan 1998). The species has never been found in small streams (VFWIS 2003). The habitat preference of this species is similar to that of the closely related Appalachian monkeyface (ESIS 1996).

PAST THREATS:
Many of the historic populations of the Cumberland monkeyface were apparently lost when the upper Tennesse River drainage was impacted by dam constuction, channelization, siltation and water pollution (USFWS 1984). The Powell River and upper tributaries of the Clinch River, in particular, are also subject to sediment and particulate matter loading from coal mining activities (Stansbery 1973). Other threats that are attributed to population declines are similar to those described in the general mussel description.

CURRENT THREATS:
In addition to the factors listed above, current threats include the low gene pool for remaining populations, collection, invasion of the Asiatic clam (*Corbicula fluminea*), and the Columbia Dam project on the Duck River in Tennessee. Other current threats to freshwater mussels are described in the General Mussel document.

Exposure Scenario Summary Table for the Cumberland monkeyface

Species	Life Stage	Habitat	Exposure	Diet	Significant

		Type	Route		Interspecies Relationships
Cumberland monkeyface	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	streamline chub blotched chub
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

APPALACHIAN MONKEYFACE (PEARLYMUSSEL)

Quadrula sparsa

STATUS:
On June 14, 1976, the Appalachian monkeyface (pearlymussel) was designated as endangered throughout its entire range in Tennessee and Virginia (USFWS 1976). A recovery plan for the Appalachian monkeyface was approved in 1984 (USFWS 1984).

SPECIES DESCRIPTION:
The Appalachian monkeyface is a medium-sized freshwater mussel (reaching up to 70 mm in length) with a yellow-green or brown shell and small greenish triangles. Like other freshwater mussels, the Appalachian monkeyface feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of Appalachian monkeyface glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the Appalachian monkeyface is similar to that of other mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. They then detach from their fish host and sink to the stream bottom or other substrate where they continue to develop, provided they land in a suitable substratum with the correct water conditions. Adult mussels of this species are sexually dimorphic. Specific glochidial host species for the Appalachian monkeyface are not known.

RANGE AND POPULATION LEVEL:

The Appalachian monkeyface historically was widespread in the upper Tennessee and Cumberland River systems; however, it is currently found only in the free-flowing reaches of the of the Powell and Clinch Rivers above Norris Reservoir in Tennessee and Virginia (USFWS 1984, Neves 1991, NatureServe 2003). The long-term viability of both populations is doubtful. The Powell River population is declining, and the species was only recently rediscovered in the Clinch River after an approximately 20-year hiatus.

HABITAT:
The Appalachian monkeyface typically occurs in shallow shoal and riffle areas in free-flowing streams of moderate gradient. Substrate preferences include firm rubble, gravel and sand and the species most often remains buried with only siphons visible (USFWS 1984, ESIS 1996, VFWIS 2003).

PAST THREATS:
Many of the historic populations of the Appalachian monkeyface were apparently lost when the river sections they inhabited were impounded. Over 50 impoundments in the Tennessee and Cumberland River systems (five mainstem Cumberland River dams, nine mainstem Tennessee River dams, and the rest are located on tributaries) have eliminated the majority of riverine habitat for the species in its historic range (ESIS 1996, USFWS 1984). The Powell River and upper tributaries of the Clinch River, in particular, are also subject to sediment and particulate matter loading from coal mining activities (Stansbery 1973). Other threats that are attributed to population declines are described in the General Mussel document.

CURRENT THREATS:
Current threats to freshwater mussels are described in the General Mussel Document.

Exposure Scenario Summary Table for the Appalachian monkeyface

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
Appalachian monkeyface	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

STIRRUPSHELL
Quadrula stapes

STATUS:
On April 7, 1987 the stirrupshell was designated as endangered throughout its entire range in Alabama and Mississippi (USFWS 1987). No populations have been found in recent years and the species is possibly extinct. A recovery plan for the stirrupshell was approved November 14, 1989 (USFWS 1989). A Mobile River Basin Aquatic Ecosystem Recovery Plan was approved November 17, 2000.

SPECIES DESCRIPTION:
The stirrupshell is a small freshwater mussel (reaching approximately 50 mm in length) with a yellowish-green shell with green, zigzag markings in juveniles with the shell becoming brown with age (USFWS 1987). Like other freshwater mussels, the stirrupshell feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of stirrupshell glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the stirrupshell is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. The life history of this species is largely unknown. Specific glochidial host species for the stirrupshell are not known (ESIE 1996).

RANGE AND POPULATION LEVEL:
The stirrupshell was found historically in the Tombigbee River from the mouth of Tibbee Creek (near Columbus, Mississippi, downstream to Epes, Alabama), the Black Warrior River (Alabama), and in the Alabama River (Stansbery 1981, Williams 1962). One specimen was also found in the Sipsey River (Pickens and Greene Counties, Alabama), a tributary to the Tombigbee River (USFWS 1987). Only two small areas of viable habitat remain: one in the Sipsey River and the other in a bendway of the Tombigbee River in Sumter County, Alabama. Surveys conducted in the late 1980s found only fresh dead specimens near the mouth of the Sipsey River (USFWS 1989). No live individuals have been found in recent years and it is possible that this species is extinct (NatureServe 2003).

HABITAT:
The stirrupshell, like other Tombigbee River system mussels, inhabits moderate to large rivers with moderate to swift current. Its preferred habitat is riffle-run or shoal areas with stable substrates ranging from sandy gravel to gravel-cobble (Stanbery 1976, 1980, 1983). Unionids

collected from the Tombigbee River system have been collected in water up to 0.7 meters deep (USFWS 1987).

PAST THREATS:
The Tombigbee River freshwater mussel fauna once consisted of more than 40 species (Williams 1982). Construction of the Tennessee-Tombigbee Waterway was accomplished in 1984 by dredging portions of the Tombigbee River to form a navigation channel, by cutting off river bends to straighten the channel, by constructing dams and by cutting a canal to the Tennessee River for barge access and to provide water. This resulted in a series of impoundments that inundated much of the known remaining riverine stirrupshell habitat or left them in several river bends. The accumulation of sediment in these river bends has eliminated them as potential riverine mussel habitat, except for Gainesville bendway. Recent surveys of this area indicate the lower half of it has heavy sedimentation (USFWS 1989).

CURRENT THREATS:
Given the small size of remaining stirrupshell populations, any factor that adversely modifies habitat or water quality in the limited remaining habitat for the species could threaten its survival in these areas. The continued existence of the stirrupshell appears to depend upon habitat in tributaries of the Tombigbee River and the species ability to complete its life cycle in a small stream environment. The East Fork Tombigbee River is threatened by an 84.8 km (53 mi) clearing and snagging project, sand and gravel mining, the continued diversion of flood flows, and by water removal for municipal use. The host species for the stirrupshell is unknown; however, if glochidial host species are large river or migratory species that infrequently enter the tributaries, the future existence of this mussel is very precarious (USFWS 1989). Other current threats to freshwater mussels are described in the General Mussel Document.

Exposure Scenario Summary Table for the Stirrupshell

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
stirrupshell	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

PALE LILLIPUT (PEARLYMUSSEL)

Toxolasma cylindrellus

STATUS:

On June 14, 1976, the pale lilliput was designated as endangered throughout its entire range in Alabama and Tennessee (USFWS 1976). A recovery plan for the pale lilliput was approved August 22, 1984 (USFWS 1984).

SPECIES DESCRIPTION:

The pale lilliput is a small freshwater mussel (reaching approximately 45 mm in length) with a tawny or yellowish-green shell (USFWS 1985). Like other freshwater mussels, the pale lilliput feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of pale lilliput glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:

The reproductive cycle of the pale lilliput is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. The life history of this species is largely unknown. The pale lilliput is likely a long-term brooder with spawning occurring in late summer and glochidial release the following spring or summer (USFWS 1985). Specific glochidial host species for the pale lilliput are not known, but glochidia of a related species, *T. moesta*, transformed on two sunfish species (*Lepomis cyanellus* and *L. megalotis*) (ESIE 1996, USFWS 1984).

RANGE AND POPULATION LEVEL:

The pale lilliput, a Cumberlandian species, was historically widespread throughout the Tennessee River system with the exception of a single record from Swamp Creek in Georgia (NatureServe 2003). This species has been recorded in the Little Pigeon River, Tennessee (Ortmann 1925), the Sequatchie and Little Sequatchie Rivers in Marion County, Tennessee (Bogan and Parmalee 1983). In Alabama, there are historic records for the species in the Flint River and Indian Creek in Madison County, Alabama. The pale lilliput has also been documented in the Elk River in Franklin County and in the Duck River from Hickman County upstream to Bedford County in Tennessee (NatureServe 2003). Currently, the species is known to survive only in the upper Paint Rock River system (Bogan and Parmalee 1983, Service 1984). Recent surveys indicate that the species remains in the mainstem of Paint Rock River as well as three major tributaries (Larkin Fork, Estill Fork, and Hurricane Creek) which are all located in Jackson County, Alabama (McGregor and Shelton 1995). According to Shelton (1997), the largest remaining population is found in the Estill Fork from the Tennessee state line extending downstream for approximately one mile.

HABITAT:
The pale lilliput is found in shallow areas of small streams and rivers with swift currents and riffles and stable substrate (USFWS 1984). It has been observed in stable rubble, gravel, and sand substrates and may sometimes be found in sand between aquatic vegetation along the shoreline (NatureServe 2003).

PAST THREATS:
Many of the historic populations of the pale lilliput were apparently lost when the river sections they inhabited were impounded. Impoundments on the Tennessee River have eliminated the majority of riverine habitat for the species in its historic range (ESIS 1996, USFWS 1985).

CURRENT THREATS:
Biologists conducting surveys for the species have noted that frequent instream recreational vehicle use is the greatest threat to the largest remaining population of this species (NatureServe 2003). The pale lilliput is also threatened by sedimentation, agricultural runoff, and poor silviculture practices in remaining habitat areas for this species (NatureServe 2003). Given the small size of the remaining pale lilliput populations, any factor that adversely modifies habitat or water quality in the short reaches that the species inhabits could threaten its survival. Other current threats to freshwater mussels are described in the General Mussel Document.

CONSERVATION MEASURES:
Conservation measures are described in the General Mussel Document.

Exposure Scenario Summary Table for the Pale lilliput

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
Pale lilliput	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

CUMBERLAND BEAN
Villosa trabalis

STATUS:

On June 14, 1976, the Cumberland bean was designated as endangered throughout its entire range, except where listed as experimental populations (USFWS 1976). Within the area covered by this listing, this species is known to occur in Kentucky and Tennessee. On June 14, 2001, the Cumerland bean pearlymussel was designated as experimental population, non-essential in Alabama (the free-flowing reach of the Tennessee River from the base of the Wilson Dam downstream to the backwaters of Pickwick Reservoir and the lower five reach miles of all tributaries to this reach in Colbert and Lauderdale Counties (USFWS 2001). A recovery plan for the species was approved August 22, 1984 (USFWS 1984).

SPECIES DESCRIPTION:
The Cumberland bean is a small to medium-sized freshwater mussel with relatively thick, elongated, oval shells. The shells of the females are somewhat more rounded and slightly larger (maximum about 5.5 cm long) (Parmalee and Bogan 1998; USFWS 1984). Like other freshwater mussels, the Cumberland bean feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of Cumberland bean glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:
The reproductive cycle of the Cumberland bean is similar to that of other mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. They then detach from their fish host and sink to the stream bottom or other substrate where they continue to develop, provided they land in a suitable substratum with the correct water conditions. Spawning likely occur in late summer through early fall; the glochidia are likely released in late spring and early summer (Schultz 1996). Two fish have been identified as glochidial hosts, the fantail darter (*Etheostoma flabellare*) and striped darter (*Etheostoma virgatum*) (Layzer and Madison 1995).

RANGE AND POPULATION LEVEL:
The Cumberland bean was historically known from ten river systems in the Cumberland and Tennessee River basins in Alabama, Georgia, Kentucky, Tennessee, and Virginia (USFWS 1984). The Cumberland bean currently survives only in the Hiwassee River in Tennessee and in Buck Creek, the Big South Fork Cumberland River (in Kentucky and Tennessee), and the Rockcastle River system in Kentucky (USFWS 2001). The species is apparently extirpated from the Little South Fork Cumberland River. A relatively strong population still exists in a short reach of the Hiwassee River downstream of the North Carolina/Tennessee State line in Polk County, Tennessee (Parmalee and Bogan 1998). Although no specimens have been collected in North Carolina, habitat appears suitable, and it is possible that the species occurs in the North Carolina portion of the Hiwassee River below Appalachia Dam, Cherokee County.

HABITAT:
The Cumberland bean inhabits small rivers and streams in fast riffles with gravel or sand and gravel substrate. Individuals have been found in riffle and run habitat areas with shallow water depths (less than one meter) and clean, stable substrate. Individuals can often be found in transitional zones between sand and gravel substrates (USFWS 1984; Clark 1981; NatureServe 2003).

PAST THREATS:
The Cumberland bean has been directly impacted by impoundments, siltation, channelization, and water pollution. Reservoir construction is the most obvious cause of the loss of mussel diversity in the basin's larger rivers. Most of the main stem of both the Tennessee and Cumberland River and many of their tributaries are impounded. For example, over 2,300 river miles or about 20 percent of the Tennessee River and its tributaries with drainage areas of 25 square miles or greater are impounded (Tennessee Valley Authority 1971). In addition to the loss of riverine habitat within impoundments, most impoundments also seriously alter downstream aquatic habitat; and mussel populations upstream of reservoirs may be adversely affected by changes in the fish fauna essential to a mussel's reproductive cycle (USFWS 2003). Coal mining related siltation and associated toxic runoff have adversely impacted many stream reaches. Numerous streams have experienced mussel and fish kills from toxic chemical spills, and poor land use practices have fouled many waters with silt. Runoff from urban areas has degraded water and substrate quality. Because of the extent of habitat destruction, the overall aquatic faunal diversity in many of the basins' rivers has declined significantly (USFWS 1984).

CURRENT THREATS:
The low number of individuals and the restricted range of each of the surviving populations make them extremely vulnerable to extirpation from a single catastrophic event or activity, such as a toxic chemical spill or major channel alteration. Pollutant threats to freshwater mussels are described in the General Mussel Document.

CONSERVATION MEASURES:
Objectives in the recovery plan call for: (1) restoring the viability of its populations in Buck Creek, the Rockcastle River, and the Little South Fork River in Kentucky (at the time the recovery plan was written, it was know that a population still existed in the Hiwassee River); (2) reestablishing or discovering viable populations in two additional rivers; and (3) ensuring that there are no foreseeable threats to the continued existence of any of the populations. Currently, artificial propagation and reintroduction technologies for this and other federally listed mussels are being developed. Other potential conservation measures include reintroducing the Cumberland bean into historic habitats in two reaches in the Tennessee River basin (USFWS 1984).

Exposure Scenario Summary Table for the Cumberland bean

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies

					Relationships
Cumberland bean	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	fantail darter striped darter
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

CUMBERLAND BEAN
Villosa trabalis

STATUS:

On June 14, 1976, the Cumberland bean was designated as endangered throughout its entire range, except where listed as experimental populations (USFWS 1976). Within the area covered by this listing, this species is known to occur in Kentucky and Tennessee. On June 14, 2001, the Cumerland bean pearlymussel was designated as experimental population, non-essential in Alabama (the free-flowing reach of the Tennessee River from the base of the Wilson Dam downstream to the backwaters of Pickwick Reservoir and the lower five reach miles of all tributaries to this reach in Colbert and Lauderdale Counties (USFWS 2001). A recovery plan for the species was approved August 22, 1984 (USFWS 1984).

SPECIES DESCRIPTION:

The Cumberland bean is a small to medium-sized freshwater mussel with relatively thick, elongated, oval shells. The shells of the females are somewhat more rounded and slightly larger (maximum about 5.5 cm long) (Parmalee and Bogan 1998; USFWS 1984). Like other freshwater mussels, the Cumberland bean feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of Cumberland bean glochidia, like other freshwater mussels, comprises fish body fluids (once encysted).

REPRODUCTION AND DEVELOPMENT:

The reproductive cycle of the Cumberland bean is similar to that of other mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. They then detach from their fish host and sink to the stream bottom or other substrate where they continue to develop, provided they land in a suitable substratum with the correct water conditions. Spawning likely occur in late summer

through early fall; the glochidia are likely released in late spring and early summer (Schultz 1996). Two fish have been identified as glochidial hosts, the fantail darter (*Etheostoma flabellare*) and striped darter (*Etheostoma virgatum*) (Layzer and Madison 1995).

RANGE AND POPULATION LEVEL:
The Cumberland bean was historically known from ten river systems in the Cumberland and Tennessee River basins in Alabama, Georgia, Kentucky, Tennessee, and Virginia (USFWS 1984). The Cumberland bean currently survives only in the Hiwassee River in Tennessee and in Buck Creek, the Big South Fork Cumberland River (in Kentucky and Tennessee), and the Rockcastle River system in Kentucky (USFWS 2001). The species is apparently extirpated from the Little South Fork Cumberland River. A relatively strong population still exists in a short reach of the Hiwassee River downstream of the North Carolina/Tennessee State line in Polk County, Tennessee (Parmalee and Bogan 1998). Although no specimens have been collected in North Carolina, habitat appears suitable, and it is possible that the species occurs in the North Carolina portion of the Hiwassee River below Appalachia Dam, Cherokee County.

HABITAT:
The Cumberland bean inhabits small rivers and streams in fast riffles with gravel or sand and gravel substrate. Individuals have been found in riffle and run habitat areas with shallow water depths (less than one meter) and clean, stable substrate. Individuals can often be found in transitional zones between sand and gravel substrates (USFWS 1984; Clark 1981; NatureServe 2003).

PAST THREATS:
The Cumberland bean has been directly impacted by impoundments, siltation, channelization, and water pollution. Reservoir construction is the most obvious cause of the loss of mussel diversity in the basin's larger rivers. Most of the main stem of both the Tennessee and Cumberland River and many of their tributaries are impounded. For example, over 2,300 river miles or about 20 percent of the Tennessee River and its tributaries with drainage areas of 25 square miles or greater are impounded (Tennessee Valley Authority 1971). In addition to the loss of riverine habitat within impoundments, most impoundments also seriously alter downstream aquatic habitat; and mussel populations upstream of reservoirs may be adversely affected by changes in the fish fauna essential to a mussel's reproductive cycle (USFWS 2003). Coal mining related siltation and associated toxic runoff have adversely impacted many stream reaches. Numerous streams have experienced mussel and fish kills from toxic chemical spills, and poor land use practices have fouled many waters with silt. Runoff from urban areas has degraded water and substrate quality. Because of the extent of habitat destruction, the overall aquatic faunal diversity in many of the basins' rivers has declined significantly (USFWS 1984).

CURRENT THREATS:
The low number of individuals and the restricted range of each of the surviving populations make them extremely vulnerable to extirpation from a single catastrophic event or activity, such as a toxic chemical spill or major channel alteration. Pollutant threats to freshwater mussels are described in the General Mussel Document.

CONSERVATION MEASURES:
Objectives in the recovery plan call for: (1) restoring the viability of its populations in Buck Creek, the Rockcastle River, and the Little South Fork River in Kentucky (at the time the recovery plan was written, it was know that a population still existed in the Hiwassee River); (2) reestablishing or discovering viable populations in two additional rivers; and (3) ensuring that there are no foreseeable threats to the continued existence of any of the populations. Currently, artificial propagation and reintroduction technologies for this and other federally listed mussels are being developed. Other potential conservation measures include reintroducing the Cumberland bean into historic habitats in two reaches in the Tennessee River basin (USFWS 1984).

Exposure Scenario Summary Table for the Cumberland bean

Species	Life Stage	Habitat Type	Exposure Route	Diet	Significant Interspecies Relationships
Cumberland bean	glochidia	parasite	contact with water, diet	fish body fluids (once encysted)	fantail darter striped darter
	juvenile / adult	sediment dweller	contact & ingestion of water, diet, sediment	filter feeder (bacteria, algae, detritus, sediment)	

PURPLE BEAN
Villosa perpurpurea

STATUS:
On January 10, 1997, the purple bean was designated as Endangered throughout its entire range (USFWS 1997). The *Recovery Plan for the Cumberland Elktoe, Oyster Mussel, Cumberlandian Combshell, Purple Bean, and Rough Rabbitsfoot* was approved on May 4, 2004 (69 FR 29569). Critical habitat was designated for the Purple Bean on August 31, 2004 (69 FR 53135). A 5-Year Review for the Purple Bean was approved on October 24, 2006.

SPECIES DESCRIPTION:
The purple bean has a small to medium-sized shell. See Bogan and Parmalee (1983) and Parmalee and Bogan (1998) for a more complete description of the species and Parmalee and Bogan (1998) for a synonymy of the species. Gordon (1991) provided diagnostic characters.

Freshwater mussel adults are filter-feeders, positioning themselves in substrates to facilitate siphoning of the water column for oxygen and food (Kraemer 1979). Their food includes primarily detritus, plankton, and other microorganisms (Fuller 1974). Juvenile mussels employ foot (pedal) feeding, and are thus suspension feeders (Yeager et al. 1994). Foods of juvenile freshwater mussels up to two weeks old include bacteria, algae, and diatoms with amounts of detrital and inorganic colloidal particles (Yeager et al. 1994). Specific food habits of the purple bean are unknown, but are likely similar to those of other freshwater mussels.

REPRODUCTION AND DEVELOPMENT:

Gravid females of the lampsiline purple bean have been observed in January and February (Ahlstedt 1991a; Butler, pers. obs., 2001), and they release their glochidia in May and June (Watson 1999). The smallest gravid individual found in a study in Indian Creek was 1.5 inches (Watson 1999). The length of the glochidia is 0.005 inch, and the width is 0.007 inch (Watson 1999). At least four host fish species have been identified: the fantail darter (*Etheostoma flabellare*), greenside darter, black sculpin, and mottled sculpin and/or banded sculpin (Watson and Neves 1996, Watson 1999; Jones, letter dated June 9, 2003). Transformation took from 11 to 25 days, at 70.7° to 76.1°F.

RANGE AND POPULATION LEVEL: The purple bean is endemic to the upper Tennessee River system above its confluence with the Clinch River (Table 4, USFWS 2003). (Its type locality was stated simply as "Tennessee" therefore, the type locality is not included in Table 4.) Primarily a species of the Ridge and Valley Physiographic Province, it also occurs at the eastern edge of the Cumberland Plateau. The entire range of the purple bean occurs in northeastern Tennessee and southwestern Virginia.

The purple bean has apparently been extirpated from the Powell River, North Fork Holston River, Emory River, Daddys Creek, and North Fork Beech Creek (Table 4, USFWS 2003). Extant populations are located in isolated portions of the Clinch River, Tazewell, Russell, and Scott Counties, Virginia; Indian Creek, Tazewell County, Virginia; Copper Creek, Scott County, Virginia; Obed River, Cumberland County, Tennessee; and Beech Creek, Hawkins County, Tennessee (Table 4, USFWS 2003). A recent quantitative study by Ahlstedt and Tuberville (1997) in the Clinch River in Tennessee and Virginia revealed this species to be "rare" over the 15-year sampling period. Periodic sampling (approximately 5-year intervals) of at least 345 quadrats from 11 to 14 sites in the Clinch revealed densities of 0.11 per square foot in both 1979 and 1988, but no specimens were taken during 1994.

Currently, the largest population may have occurred in the upper Clinch River and Indian Creek metapopulation (Ahlstedt, pers. comm., 1997), prior to a Clinch River chemical spill in late 1998 that resulted in the death of at least 52 specimens. Watters (1999) found 26 live purple bean specimens in Indian Creek in 1996-97, which represented 2 percent of the entire mussel fauna. The population probably numbers in the hundreds and is probably viable, as evidenced by the presence of individuals that were probably juveniles (0.9 inch in length). Neves (1991) considered the Copper Creek population to be the largest, but that population has been decimated in recent years. Fraley and Ahlstedt (2000) found only two live specimens and a single fresh dead shell during their 1998 qualitative resurvey of Copper Creek (see Ahlstedt 1981a). The status of the Emory River system population is tenuous. It remains at six sites in the Obed River but in very low numbers (Ahlstedt et al. 2001). Its viability status is questionable (Ahlstedt, pers. comm., 2003). The Beech Creek population, the only extant purple bean population in the Holston River system, was sampled in February 2001. A total of 74 live specimens were found; most were exposed on the substrate while apparently attracting host fish (S. J. Fraley, TVA, unpub. data [currently with the North Carolina Wildlife Resources Commission]). Live individuals were located at 9 of 12 Beech Creek sites sampled, and evidence of recent recruitment was observed. Beech Creek probably harbors the largest

and healthiest remaining purple bean population rangewide. However, it appears tenuous, because riparian development and agricultural impacts are prevalent in the watershed (R. S. Butler, pers. obs., 2001). This purple bean population is also thought to be declining (Ahlstedt, pers. comm., 2001).

HABITAT:
This species inhabits small headwater streams (Neves 1991) to medium-sized rivers (Gordon 1991). It is found in moderate to fast-flowing riffles with sand, gravel, and cobble substrates (Neves 1991) and rarely occurs in deep pools or slack water (Ahlstedt 1991a). It is sometimes found out of the main current adjacent to water-willow beds and under flat rocks (Ahlstedt 1991a, Gordon 1991).

CRITICAL HABITAT:
In Cumberland and Morgan Counties, Tennessee, all stream and river channels within the ordinary high-water line at the confluence of the Obed River with the Emory River, Morgan County, Tennessee, and continues upstream to Adams Bridge, Cumberland County, Tennessee. In Claiborne and Hancock Counties, Tennessee, and Lee County, Virginia, all stream and river channels within the ordinary high-water line of the Powell River from the U.S. 25E Bridge in Claiborne County, Tennessee, upstream to rkm 256 (rmi 159) (upstream of Rock Island in the vicinity of Pughs), Lee County, Virginia. In Hancock County, Tennessee, and Scott, Russell, and Tazewell Counties, Virginia, all stream and river channels within the ordinary high-water line of the Clinch River from rkm 255 (rmi 159) immediately below Grissom Island, Hancock County, Tennessee, upstream to its confluence with Indian Creek in Cedar Bluff, Tazewell County, Virginia; 4 rkm (2.5 rmi) of Indian Creek from its confluence with the Clinch River upstream to the fourth Norfolk Southern Railroad crossing at Van Dyke, Tazewell County, Virginia; and 21 rkm (13 rmi) of Copper Creek from its confluence with the Clinch River upstream to Virginia State Route 72, Scott County, Virginia. In Hawkins County, Tennessee, all stream and river channels within the ordinary high-water line of Beech Creek in the vicinity of Slide, Hawkins County, Tennessee, upstream to the dismantled railroad bridge at rkm 27 (rmi 16).

Primary constituent elements identified at the time of designation included: 1. Permanent, flowing stream reaches with a flow regime (i.e, the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of the mussel and its host fish; 2. Geomorphically stable stream and river channels and banks (structurally stable stream cross section); 3. Stable substrates, consisting of mud, sand, gravel, and/or cobble/boulder, with low amounts of fine sediments or attached filamentous algae; 4. Water quality (including temperature, turbidity, oxygen content, and other characteristics) necessary for the normal behavior, growth, and survival of all life stages of the five mussels and their host fish; and 5. Fish hosts with adequate living, foraging, and spawning areas for them.

PAST THREATS:
The abundance and distribution of the purple bean decreased historically from human-induced habitat loss and degradation (Williams et al. 1993, Neves 1993) caused by

impoundments, sedimentation and turbidity, channelization, and contaminants contained in numerous point and nonpoint sources. A comprehensive review of these past threats is provided elsewhere (USFWS 2003, Williams et al. 1993, Neves 1993, Neves 1991, Neves et al. 1997, Watters 2000, Richter et al. 1997). These habitat changes have resulted in significant extirpations (localized loss of populations), restricted and fragmented distributions, and poor recruitment of young.Numerous Cumberlandian Region streams have experienced mussel kills from toxic chemical spills and other causes (Cairns et al. 1971, Crossman et al. 1973, Neves 1986, Wolcott and Neves 1994). The high number of jeopardized species in the upper Tennessee River system make accidental spills a particular concern to conservationists and resource managers (Hampson et al. 2000). The dramatic impact the chlor-alkali chemical plant in Saltville, Virginia, has had on the aquatic fauna in the North Fork Holston River is well documented (Adams 1915; Cairns et al. 1971; Stansbery and Clench 1974; Hill et al. 1975; Ahlstedt 1980, 1991c; Neves and Zale 1982; Sheehan et al. 1989; Hampson et al. 2000). Although it is considered a chronic episode, and not an "event" like most other toxic spills, it is discussed in this section simply because of the tremendous impact it has had on the river.

Since the plant's opening in 1893, mercury and various salts (e.g., calcium chloride, sodium chloride) from this site have polluted the North Fork Holston River and decimated the entire molluscan fauna all the way to the mouth of the river, a distance of 80 miles (Ahlstedt 1991b). Occurring in this river reach were populations of the purple bean, rough rabbitsfoot, Cumberlandian combshell, oyster mussel, and 34 other mussel species (Neves and Zale 1982). From 1950 to 1971, an estimated 75 pounds of mercury per day were discharged from this facility directly into the North Fork or into unlined floodplain holding ponds (Hampson et al. 2000). The long-term kill was so thorough that only one mussel species was reported in the early 1970s by Hill et al. (1975).

The closing of the plant in 1972 brought about the possible opportunity for natural mussel recolonization in the North Fork Holston River (Stansbery and Clench 1974). Efforts were soon made to help speed up the recovery of mussels in the North Fork. However, the lingering effects of mercury, extremely low numbers of mussels, and possibly low numbers of fish hosts may be responsible for the general lack of mussels observed at sites within 20 miles downstream of Saltville (Henley and Neves 1995).

An alkaline fly ash pond spill in 1967 and a sulfuric acid spill in 1970 on the Clinch River at the power plant at Carbo, Virginia, caused a massive mussel kill for up to 12 miles downstream from the power plant site (Cairns et al. 1971, Crossman et al. 1973, Stansbery 1986, Sheehan et al. 1989, Wilcove and Bean 1994). Populations of the purple bean, rough rabbitsfoot, Cumberlandian combshell, and oyster mussel that may have resided in the affected river reach were undoubtedly impacted by these spill events. Natural recolonization has not occurred in the impacted river reach (Stansbery 1986, Ahlstedt 1991a, Hampson et al. 2000), possibly due to copper contamination from the power plant at Carbo (Wilcove and Bean 1994). An experimental reintroduction of nonlisted mussels in 1981 and 1984 has largely failed (Sheehan et al. 1989).

An overturned tanker truck resulted in a chemical spill in the upper Clinch River on August 27, 1998, killing more than 7,000 mussel specimens of 16 species. Approximately 250 specimens of three federally listed species were found dead over a 5.5-mile reach, including at least 52 purple bean specimens and 20 rough rabbitsfoot specimens (Jones et al. 2001). According to Ahlstedt (1983), "hundreds of dead shells were observed buried in the substratum" during a 1980 Elk River survey. He attributed this kill to an unknown chemical spill.

CURRENT THREATS:
The purple bean and its habitat is currently being impacted by excessive sediment bed loads of smaller sediment particles, changes in turbidity, increased suspended solids (primarily resulting from nonpoint-source loading from poor land-use practices, lack of best management practices [BMPs], and maintenance of existing BMPs), and pesticides. Other primarily localized impacts include coal mining, gravel mining, reduced water quality below dams, developmental activities, water withdrawal, impoundments, and alien species. Their restricted ranges and low population levels also increase their vulnerability to toxic chemical spills and the deleterious effects of genetic isolation.

Coal mining activities occur in portions of the upper Powell and Clinch River systems, primarily in Virginia. Scores of active and inactive mines are known from these drainages (Hampson et al. 2000). The role that coal mining has played in the decline of mussel fauna in the Powell River in Virginia was prophesied by Ortmann (1918) and has been briefly summarized by Wolcott and Neves (1990, 1994). Five mine tailings pond spills were reported from 1995 to 1999 in the upper Clinch and Powell River systems (Hampson et al. 2000), at least one of which resulted in a major fish kill (Koch, pers. comm., 1996). Research by Kitchel et al. (1981) indicates that Powell River mussel populations were inversely correlated with coal fines in the substrate. When coal fines were present, decreased filtration times and increased movements were noted in laboratory-held mussels (Kitchel et al. 1981).

Polycyclic aromatic compounds (PAHs) are indicative of coal fines in the bottom sediments of streams. Known to be toxic to mussels and fishes, PAHs have been found at relatively high levels in the upper portions of the Clinch and Powell Rivers in Virginia (Hampson et al. 2000). In fact, Hampson et al. (2000) detected 29 different PAHs in stream sediment samples in the two watersheds. The Clinch River at Pendleton Island had concentrations of two measured PAHs, naphthalene and phenanthrene, at 400 micrograms per kilogram (µg/kg) and 570 µg/kg, respectively, both of which are above the protection guidelines for aquatic life. The Canadian probable-effect levels of 391 µg/kg and 515 µg/kg, respectively, have been established for these compounds. The probable-effect levels define concentrations above which adverse effects to aquatic organisms can be expected. Pendleton Island was once a stronghold for the rough rabbitsfoot and home to the purple bean, Cumberlandian combshell, and oyster mussel as well in the early 1980s (Ahlstedt 1991a). However, the fauna there was in marked decline less than a decade later. Three other sites in the Clinch River system (i.e., lower Clinch River, Guest River, Copper Creek) had concentrations of these two compounds below the probable-effect levels. A site on the Powell River near Arthur, Tennessee, had

much higher levels of naphthalene and phenanthrene (1,600 µg/kg and 1,300 µg/kg, respectively) than at Pendleton Island. In the Emory River, downstream of a population of the purple bean in the Obed River, excessive napthalene levels were detected (610 ug/kg). Mining activities also likely contributed to the extirpation of the purple bean from the Powell River several decades ago.

Sediment from the upper Clinch River, where this species occurs, was found to be toxic to juvenile mussels (Robison et al. 1996). Ahlstedt and Tuberville (1997) speculated that the presence of toxins in the Clinch River may explain the decline and lack of mussel recruitment at some sites in the Virginia portion of that stream. Wilcove and Bean (1994) reported that studies indicated that mussel reproduction below the site of the Appalachian Power Company's (APCO) electric generating station in Carbo, Virginia, was being inhibited by copper discharges. In addition, copper was shown to be toxic to mussels at levels below the U.S. Environmental Protection Agency (EPA) criteria established in Virginia. The Virginia State Water Control Board began proceedings to impose a special water quality standard for copper below the plant. In 1992, the State and APCO agreed on a lower standard for copper for this specific stretch of the Clinch. APCO is spending several million dollars to control copper discharge from its facility to meet the new standard (Wilcove and Bean 1994).

Although the Clean Water Act (CWA), administered by the EPA, has helped eliminate many point-source effluents, "straight pipes" (pipelines conveying untreated household effluents; e.g., chlorine, detergents, household chemicals, human waste, etc., from rural homes directly into streams) continue to discharge wastes. Fraley and Ahlstedt (2000) thought that effluents from straight pipes were partially to blame for the documented decline of the native mussel fauna in Copper Creek from 19 species in 1980 to 11 species in 1998. Included in the historical Copper Creek fauna were the purple bean, rough rabbitsfoot, and oyster mussel, although only a few of these species were found live in 1998. Numerous other streams in the Cumberlandian Region doubtless also have straight pipes discharging pollutants into mussel habitat.

Exposure Scenario Summary Table for the Purple Bean

Species	**Life Stage**	**Habitat Type**	**Exposure Route**	**Diet**	**Significant Interspecies Relationships**
Purple Bean	glochidia	parasite	contact with water, diet	fish body fluids	fantail darter, greenside darter, black sculpin, mottled sculpin and/or banded sculpin
	juvenile/	sediment	contact &	filter feeder	

	adult	dweller	ingestion of water, diet, sediment	(bacteria, algae, detritus, sediment)	

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