Appendix C: Status and Life History of the Eight Assessed Mussels

General information on the habitat requirements, designated critical habitat, food habits, growth and longevity, reproduction, and past and current threats of eight assessed mussels is provided below in Section C.1. Species-specific information for the following eight assessed mussels is provided in Sections C.2 through C.9:

- Pink mucket pearly mussel
- Rough pigtoe mussel
- Shiny pigtoe pearly mussel
- Fine-rayed pigtoe mussel
- Heavy pigtoe mussel
- Ovate clubshell mussel
- Southern clubshell mussel
- Stirrupshell mussel

C.1 General Information

C.1.1 Habitat

Adult mussels are usually found in localized stream patches (beds) 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 (Neves and Widlak, 1987; Leff et al., 1990) and physical qualities of the sediments (e.g., texture, particle size) may be important in allowing the mussels to firmly burrow in the substrate (Lewis and Riebel, 1984). In addition, other aspects of substrate composition, including bulk density (mass/volume), porosity (ratio of void space to volume), sediment sorting, and the percentage of fine sediments, may also influence mussel densities (Brim Box, 1999; Brim Box and Mossa, 1999). According to Huehner (1987), water velocity may be a better predictor than substrate for determining where certain mussel species are found in streams. In general, heavy-shelled species occur in stream channels with stronger currents, while thin-shelled species occur in more backwater areas.

Stream geomorphic and substrate stability is especially crucial for the maintenance of 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. Although several studies have related adult habitat selection with substrate composition, most species tend to be habitat generalists (Tevesz and McCall, 1979; Strayer, 1981; Hove and Neves, 1994; Strayer and Ralley, 1993).

Habitat and stream parameter preferences for juveniles are largely unknown (Neves and Widlak, 1987), although it is likely that juveniles may prefer habitats that have sufficient oxygen, are frequented by fish, and are free of shifting sand and silt accumulation (Isley, 1911). Neves and Widlak (1987) suggest that juveniles inhabit depositional areas with low flow, where they can feed and siphon water from interstitial spaces among substrate particles. Juvenile mussels of certain species stabilize themselves by attaching to rocks and other hard substrates with a byssus (protein threads) (Frierson, 1905; Isley, 1911; Howard, 1922). Strayer (1999) demonstrated in field trials that mussels in streams occur chiefly in flow refuges, or relatively stable areas that display little movement of particles during flood events. Flow refuges allow relatively immobile mussels to remain in the same general location throughout their entire lives. Strayer (1999) also suggested that features commonly used in the past to explain the spatial patchiness of mussels (e.g., water depth, current speed, sediment grain size) are poor predictors of where mussels actually occur in streams.

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 occurring primarily behind boulders, and were significantly correlated with fingernail clam presence. 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, remain in the habitat of the host fish, or exhibit any habitat preference (Neves and Widlak, 1987).

C.1.2 Designated Critical Habitat

Effective August 2, 2004, the U.S. Fish and Wildlife Service (USFWS) designated critical habitat for 11 species of freshwater mussels (USFWS, 2004: 69 FR 40084-40171), two of which are assessed as part of this endangered species assessment. These species, which both occur in the Tombigbee River Basin, include the ovate clubshell and southern clubshell mussels. ‘Critical habitat’ is defined in the Endangered Species Act (ESA) as the geographic area occupied by the species at the time of the listing where the physical and biological features necessary for the conservation of the species exist, and there is a need for special management to protect the listed species. In 1993, the USFWS listed the ovate and southern clubshell mussels as endangered and declared that the assignment of critical habitat was “prudent but not determinable” and therefore, did not compete the critical habitat designation. A lawsuit in 2000, led to a 2001 court order that mandated the USFWS to complete the critical habitat designation for the ovate and southern clubshell mussels.

Critical habitat receives protection under Section 7 of the ESA through prohibition against destruction or adverse modification of critical habitat with regard to actions carried out, funded, or authorized by a Federal Agency. Section 7 requires consultation on Federal actions that are likely to result in the destruction or adverse modification of critical habitat.

To be included in a critical habitat designation, the habitat must first be ‘essential to the conservation of the species.’ Critical habitat designations identify, to the extent known using the best scientific and commercial data available, habitat areas that provide essential life cycle needs of the species (i.e., areas on which the primary constituent elements are found, as defined in 50 CFR 414.12(b)).

Occupied habitat may be included in the critical habitat only if essential features within the habitat may require special management or protection. Therefore, the USFWS does not include areas where existing management is sufficient to conserve the species. Critical habitat is designated outside the geographic area presently occupied by the species only when a designation limited to its present range would be inadequate to ensure the conservation of the species

The designated critical habitat areas for the ovate and southern clubshell mussels are considered to have the primary constituent elements that justify critical habitat designation. These primary constituent elements include the following: 1) geomorphically stable stream and river channels and banks; 2) a flow regime 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 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 predacious nonnative species present (USFWS, 2004).

A summary of designated critical habitat for the ovate clubshell and southern clubshell mussels, including the river/stream reach name and location, critical habitat unit number, and historical and/or current presence of the species within the critical habitat, is provided in Table C-1. Critical habitat for these species includes portions of the Tombigbee River drainage in Mississippi and Alabama; portions of the Black Warrior River drainage in Alabama; portions of the Alabama River drainage in Alabama; portions of the Cahaba River drainage in Alabama; portions of the Tallapoosa River drainage in Alabama and Georgia; and portions of Coosa River drainage in Alabama, Georgia, and Tennessee. No critical habitat has been designated for the other six mussel species included in this assessment.

Table C.1. Designated Critical Habitat for the Southern Clubshell and Ovate Clubshell Mussels[1]

River/Stream (Critical Habitat Unit #)	County	Species[2]		Description (Reach Length)
		Southern clubshell	Ovate clubshell	
East Fork Tombigbee River (1)	Monroe, Itawaba (MS)	X (H/C)	X (H)	From MS Highway 278, Monroe County, upstream to the confluence of Mill Creek (16 miles)
Bull Mountain Creek (2)	Itawaba (MS)	X (H/C)	X (H)	From MS Highway 25, upstream to U.S. Highway 78, Itawamba County (21 miles)
Buttahatchee River and tributary (3)	Lowndes, Monroe (MS) Lamar (AL)	X (H/C)	X (H/C)	Buttahatchee River: 54 miles extending from its confluence with impounded waters of Columbus Lake, Lowndes/Monroe County, upstream to confluence of Beaver Creek, Lamar County Sipsey Creek: 14 miles from its confluence with the Buttahatchee River, upstream to the MS/AL State Line, Monroe County (68 total miles)
Luxapalila Creek and tributary (4)	Lowndes (MS) Lamar (AL)	X (H/C)	X (H/C)	Luxapalila Creek: 9 miles extending from Waterworks Rd., Columbus, MS, upstream approximately 0.6 miles above Steens Rd., Lowndes County, MS Yellow Creek: 9 miles extending from its confluence with Luxapalila Creek, upstream to the confluence of Cut Bank Creek, Lamar County, AL (18 total miles)
Coalfire Creek (5)	Pickens (AL)	X (H)	X (H/C)	From confluence with impounded waters of Aliceville Lake, upstream to U.S. Highway 82, Pickens County, AL (18 miles)
Lubbub Creek (6)	Pickens (AL)	X (H/C)	X (H)	From confluence with impounded waters of Gainesville Lake, upstream to the confluence of Little Lubbub Creek, Pickens County, AL (19 miles)
Sipsey River (7)	Greene, Pickens, Tuscaloosa (AL)	X (H/C)	X (H/C)	From confluence with impounded waters of Gainesville Lake, Greene/Pickens County, upstream to AL Highway 171 crossing Tuscaloosa County, AL (56 miles)
Trussels Creek (8)	Greene (AL)	X (H)	X (H)	From confluence with impounded waters of Demopolis Lake, upstream to AL Highway 14, Greene County, AL (13 miles
Sucarnoochee River (9)	Sumter (AL)	X (H)	X (H/C)	From confluence with Tombigbee River, upstream to MS/AL State Line, Sumter County, AL (56 miles)
Sipsey Fork and tributaries (10)	Winston, Lawrence (AL)		X (H)	Sipsey Fork: 19 miles from section 11/12 line, Winston County, upstream to the confluence of Hubbard Creek, Lawrence County, AL Thompson Creek: 5 miles from confluence with Hubbard Creek, upstream to section 2 line, Lawrence County, AL Brushy Creek: 22 miles from confluence of Glover Creek, Winston County, upstream to section 9,

				Lawrence County, AL Capsey Creek: 9 miles from confluence with Bushy Creek, Winston County, upstream to the confluence of Turkey Creek, Lawrence County, AL Rush Creek: 6 miles from confluence with Bushy Creek, upstream to Winston/Lawrence County Line Brown Creek: 2 miles from confluence with Rush Creek, Winston County, upstream to section 24 line, Lawrence County, AL Beech Creek: 2 miles from confluence with Brushy Creek to confluence of East and West Forks, Winston County, AL Caney Creek and North Fork Caney Creek: 8 miles from confluence with Sipsey Fork, upstream to section 14 line, Winston County, AL Borden Creek: 11 miles from confluence with Sipsey Fork, Winston County, upstream to confluence of Montgomery Creek, Lawrence County, AL Flannagin Creek: 6 miles from confluence with Borden Creek, upstream to confluence of Dry Creek, Lawrence County, AL (91 total miles)
North River and tributary (11)	Tuscaloosa, Fayette (AL)	X	(H)	North River: 26 miles from Tuscaloosa County Rd. 38, Tuscaloosa County, upstream to confluence of Ellis Creek, Fayette County, AL Clear Creek: 3 miles from its confluence with the North River to Bays Lake Dam, Fayette County, AL (29 total miles)
Locust Fork and tributary (12)	Jefferson, Blount (AL)	X	(H)	Locust Fork: 58 miles from U.S. Highway 78, Jefferson County, upstream to the confluence of Little Warrior River, Blount County, AL Little Warrior River: 5 miles from confluence with Locust Fork, upstream to the confluence of Calvert Prong and Blackburn Fork, Blount County, AL (63 total miles)
Cahaba River and tributary (13)	Jefferson, Shelby, Bibb (AL)	X (H)	X (H)	Cahaba River: 65 miles from U.S. Highway 82, Centerville, Bibb County, upstream to Jefferson County Rd. 143, Jefferson County, AL Little Cahaba River: 12 miles from confluence with the Cahaba River, upstream to the confluence of Mahan and Shoal Creeks, Bibb County, AL (77 total miles)
Alabama River (14)	Autauga, Lowndes, Dallas (AL)	X (H/C)		From the confluence of the Cahaba River, Dallas County, upstream to the confluence of Big Swamp Creek, Lowndes County, AL (45 miles)
Bogue Chitto Creek (15)	Dallas (AL)	X (H/C)		From its confluence with the Alabama River, Dallas County, upstream to U.S. Highway 80, Dallas County, AL (32 miles)
Uphapee	Macon, Lee	X	X	Uphapee Creek: 18 miles from AL Highway 199, upstream of confluence of Opintlocco and

Complex (17)	(AL)	(H/C)	(H/C)	Chewacla Creeks, Macon County (AL) Choctafaula Creek: 7 miles from confluence of Uphapee, upstream to Macon County Rd. 54, Macon County (AL) Chewacla Creek: 18 miles from confluence with Opintlocco Creek, Macon County, AL, upstream to Lee County RD 159, Lee County (AL) Opintlocco Creek: 10 miles from confluence with Chewacla Creek, upstream to Macon County Rd. 79, Macon County, AL (46 total miles)
Coosa River (18)	Cherokee, Calhoun, Cleburne (AL)	X (H/C)	X (H)	Coosa River: 11 miles from the powerline crossing SE of Maple Grove, AL, upstream to Weiss Dam, Cherokee County, AL Terrapin Creek: 33 miles from its confluence with the Coosa River, Cherokee County, upstream to Cleburne County Rd. 55, Cleburne County, AL South Fork Terrapin Creek: 4 miles from its confluence with Terrapin Creek, upstream to Cleburne County Rd. 55, Cleburne County, AL (48 total miles)
Hatchet Creek (19)	Coosa, Clay (AL)	X (H)	X (H)	From the confluence of Swamp Creek at Coosa County Rd. 29, Coosa County, upstream to Clay County Rd. 4, Clay County, AL (41 miles)
Kelly Creek and tributary (21)	Shelby, St. Clair (AL)	X (H/C)	X (H)	Kelly Creek: 16 miles from the confluence with the Coosa River, upstream to the confluence of Shoal Creek, St. Clair County, AL Shoal Creek: 5 miles from confluence with Kelly Creek, St. Clair County, upstream to St. Clair/Shelby County Line, St. Clair County, AL (21 total miles)
Big Canoe Creek (24)	St. Clair (AL)	X (H/C)	X (H)	From its confluence with Little Canoe Creek at the St. Clair/Etowah County Line, St. Clair County, upstream to the confluence of Fall Branch, St. Clair County, AL (18 miles)
Oostanaula complex (25)	Floyd, Gordon, Whitfield, Murray (GA) Bradley, Polk (TN)	X (H/C)	X (H)	Oostanaula River: 48 miles from its confluence with the Etowah River, Floyd County, upstream to the confluence of the Conasauga and Coosawattee River, Gordon County, GA Coosawattee River: 9 miles from confluence with the Conasauga River, upstream to the GA State Highway 136, Gordon County, GA Conasauga River: 61 miles from confluence with the Coosawattee River, Gordon County, upstream through Bradley and Polk Counties, TN, to the Murray County Rd. 2, Murray County, GA Holly Creek: 10 miles from confluence with Conasauga River, upstream to its confluence with Rock Creek, Murray County, GA (128 total miles)
Lower Coosa River (26)	Elmore (AL)	X (H)	X (H)	From the AL State Highway 111 bridge, upstream to Jordan Dam, Elmore County, AL (8 miles)

[1] USFWS, 2004: 69 FR 40084-40171.

[2] H = Historical habitat (i.e., the species is not currently present within the designated critical habitat, unless denoted by "H/C"). C = Current habitat.

C.1.3 Food Habits

Adult freshwater mussels are filter-feeders, orienting themselves in the substrate to facilitate siphoning of the water column for oxygen and food (Kraemer, 1979). There are no known interspecific differences in feeding among freshwater mussels (Fuller, 1974). Mussels have been reported to consume detritus, diatoms, phytoplankton, zooplankton, and other microorganisms (Coker et al., 1921; Churchill and Lewis, 1924; Fuller 1974). According to Ukeles (1971), phytoplankton is the principal food of bivalves. However, other food sources (e.g., bacteria, organic detritus, assimilated organic material, phagotrophic protozoans) may also play an important role (Neves et al., 1996). Specific percentages of these food items within the mussel's diet are not known, although the available information indicates that adult mussels can clear and assimilate fine particulate organic matter (FPOM) particles ranging in size from 0.9 to 250 µm (Silverman et al., 1997; Wissing, 1997; and Nichols and Garling, 2000). This size range includes bacteria and algal cells, detritus, and soil particles (Allan, 1995). According to Baldwin and Newell (1991), bivalves feed on an entire array of naturally available particles (e.g., heterotrophic bacteria, phagotrophic protozoans, phytoplankton). Based on the findings of Baldwin and Newell (1991) and Neves et al. (1996), an omnivorous opportunistic diet allows mussels to take advantage of whatever food type happens to be abundant.

Juvenile mussels employ foot (pedal) feeding, and are thus suspension feeders (Yeager et al., 1994). Juveniles up to two weeks old feed on bacteria, algae, and diatoms with small amounts of detrital and inorganic colloidal particles (Yeager et al., 1994). The diet of the glochidia comprises water (until encysted on a fish host) and fish body fluids (once encysted).

No studies on the specific food habits of the eight assessed mussel species has been conducted; therefore, required and/or preferred foods of the assessed species are unknown.

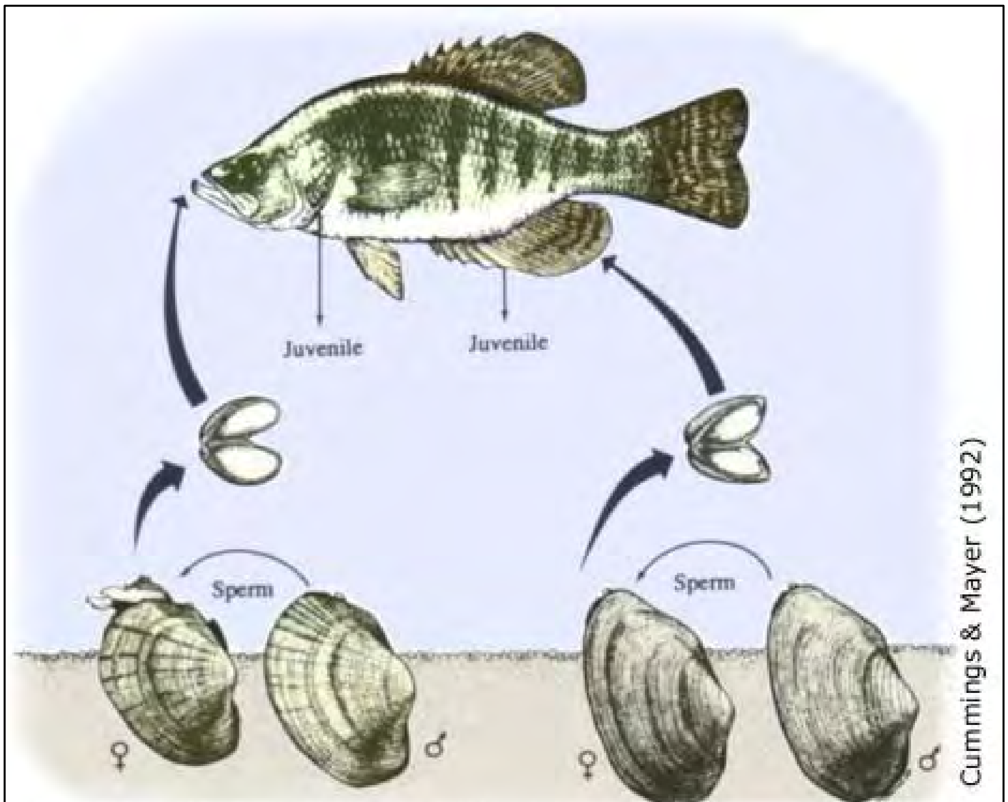
C.1.4 Growth and Longevity

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 due to energies being diverted from growth to gamete production. Growth rates vary among species with heavy-shelled species growing more slowly relative to thin-shelled species (Coon et al., 1977; Hove and Neves, 1994). Under shoal habitat conditions, where high water velocities 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, up to 50 years or more (USFWS, 1985).

C.1.5 Reproduction

The reproductive cycle of freshwater mussels, which is depicted in the figure below, is similar among all species (see Watters [1994] for an annotated bibliography of mussel reproduction). The age of sexual maturity for mussels is variable, usually requiring from three (Zale and Neves, 1982) to nine (Smith, 1979) years, and may be sex dependent (Smith, 1979). During the spawning period, males discharge sperm into the water column, and the sperm are taken in by 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 where they must attach to the gills and fins of appropriate host fishes, which they parasitize for a short time until they develop into juvenile mussels. Once the glochidia metamorphose to the juvenile stage, they drop to the substrate. If the environmental conditions are favorable, the juvenile mussel will survive and develop. All eight listed species are members of the Unionidae family, which exhibit two reproductive cycles based on the length of time glochidia are retained in the gills of females. Mussels are generally categorized as either short-term summer brooders (tachytictic) or longer-term winter brooders (bradytictic) (Neves and Widlak, 1988). Fertilization occurs in the spring in tachytictic mussels (short-term brooders) and glochidia are released during spring and summer. In bradytictic species (long-term brooders), fertilization occurs in mid-summer and fall, and glochidia are released the following spring and summer.



The freshwater mussel life-cycle (Unionidae).

C.1.6 Past and Current Threats

North America harbors the world's greatest diversity of freshwater mussels (Williams and Neves, 1995; Neves, 1999), with about 300 recognized species (Turgeon et al., 1998). Over 90 percent of these species inhabit the southeastern United States (Neves et al., 1997), with the majority of these species endemic to this area. In the last 150 years, there has been a steady decline in the number of freshwater mussels in the U.S. (Williams and Neves, 1993). Although mussel exploitation has proven to be destructive, significant anthropogenic alteration of aquatic habitats is likely to be the major cause of freshwater mussel declines on a grand scale (Lewis, 1868; Kunz, 1898; Kunz and Stevenson, 1908; Ortmann, 1909; and van der Schalie, 1938).

The alteration of aquatic habitats via, dredging, channelization and dam construction has significantly affected riverine ecosystems (Baxter and Glaude, 1980; Williams et al., 1992; Allan and Flecker, 1993; Ligon et al,. 1995; Sparks, 1995; Blalock and Sickel, 1996), and has been a major causal factor in the high extinction rate of freshwater mollusks (Johnson, 1978; Lydeard and Mayden, 1995; Neves et al. 1997). Waterway alteration in the Southeast especially has lead to major mussel population changes and extripation from a large area of many species' historical ranges (USFWS, 1985). These dams and their impounded waters present physical barriers to the natural dispersal of mussels, including emigration (dispersal) of host fishes, and effectively isolate surviving mussel populations in limited portions of the Mobile River Basin's major drainages. Small isolated aquatic populations are subject to natural random events (i.e., droughts, floods) and to changes in human activities and land use practices (i.e., urbanization, industrialization, mining, certain agricultural activities and practices, etc.) that may severely impact aquatic habitats (Neves et al., 1997). Without avenues of emigration to less-affected watersheds, mussel populations gradually disappear where land use activities result in deterioration of aquatic habitats.

Freshwater mussels require fast flowing, silt free streams and rivers in order to survive. Therefore, they are susceptible to adverse effects caused by siltation in waterways. The main causes of siltation are road construction, poor agricultural land management practices, and deforestation. Specific biological impacts on mussels from excessive sediments include reduced feeding and respiratory efficiency from clogged gills, disrupted metabolic processes, reduced growth rates, increased substrata 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; and Waters, 1995). In addition to siltation, freshwater mussels are also threatened by heavy metals, agricultural chemical runoff, and acid mine drainage (Williams and Neves, 1993).

The recent introduction of non-native mussel species poses another serious threat to freshwater mussel survival. In particular, the rapid expanse of the Zebra mussel *Dreissenea polymorpha*) and Asian clam (*Corbicula fluminea*) ranges could pose a direct threat to endangered mussel populations within the United States. These invasive species have the ability to out compete native mussels, and population explosions of these species have been shown to adversely affect native populations (Williams and Neves, 1993).

C.2 Pink Mucket Pearly Mussel (*Lampsilis abrupta*)

C.2.1 Species Listing Status

On June 14, 1976, the pink mucket (pearlymussel) was designated by the USFWS as endangered throughout its entire range in Alabama, Arkansas, Illinois, Indiana, Kentucky, Louisiana, Missouri, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia (USFWS, 1976: 41 FR 24062-24067). A recovery plan addressing the pink mucket was approved on January 24, 1985 (USFWS, 1985).

C.2.2 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 (Virginia Fish and Wildlife Information Service [VFWIS], 2006). The life span of the species exceeds 50 years (USFWS, 1985).

C.2.3 Historic and Current Range

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, 2006). Records from 1990 indicate that the species remains in only 16 rivers and tributaries, with the majority of species occurring in the Tennessee, Cumberland, and Meramec Rivers, a small portion of the Kanawha River below Kanawha Falls (NatureServe, 2006; USFWS, 1985). Recorded observations of the pink mucket have also been observed in the Osage River (MO), Clinch River upstream from Norris Dam and downstream from Melton Hill Dam (TN, VA), the lower Ohio and Green Rivers (KY), the Current River (AR, MO), the Big, Black, and Little Black Rivers (MO), and the French Broad River (TN) (USFWS, 1985). According to James Williams of the USGS (Williams, personal communication, 2006), the only viable populations of pink mucket exist in Guntersville and Wilson Dam tailwaters and in Bear Creek (Colbert County, AL). The current range of the pink pearly mucket mussel is depicted in Figure C-3.

C.2.4 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, 2006; 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). No critical habitat has been designated for the pink mucket.

C.2.5 Reproduction

The reproductive cycle of the pink mucket is similar to that of other native freshwater mussels. The pink mucket is a long-term breeder (bradytictic species) becoming gravid in August. Glochidia are found in females in September and are released the following June (Ortmann, 1912 and 1919). Laboratory studies have confirmed that four fish are suitable hosts for the pink mucket. These include the largemouth bass (*Micropterus salmoides*), spotted bass (*Micropterus punctulatus*), smallmouth bass *(Micropterus dolomieu*), and walleye (*Stizostedion vitreum*) (Barnhart, 1997). Other reported glochidial fish host species include the sauger (*Stizostedion canadense*) and the freshwater drum (*Aplodinotus grunniens*) (USFWS, 1985). 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).

C.2.6 Known Threats

Known threats to the pink mucket include modification of habitat (e.g., dams and dredging), degradation of water quality, and over harvesting by the commercial mussel industry (USFWS, 1985).

C.3 Rough Pigtoe Mussel (*Pleurobema plenum)*

C.3.1 Species Listing Status

On June 14, 1976, the rough pigtoe mussel was designated by the USFWS as endangered throughout its entire range in Alabama, Indiana, Kentucky, Pennsylvania, Tennessee, and Virginia (USFWS, 1976: 41 FR 24062-24067). A recovery plan addressing the rough pigtoe was approved August 6, 1984 (USFWS, 1984a).

C.3.2 Description

The rough pigtoe is a medium-sized (reaching up to approximately 100 mm in length) freshwater mussel with a yellowish brown or light brown shell (becoming dark brown in adults) with faint green rays (NatureServe, 2006). Its shell is shaped like an equilateral triangle, with a brown, satinlike appearance (Illinois Natural History Survey, 2006).

C.3.3 Historic and Current Range

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 an undetermined number of miles downstream of three Tennessee

River mainstem dams (Pickwick, Wilson, and Guntersville) and in the Clinch River (between river miles 323 and 154) (NatureServe, 2006). In Alabama, extant populations in the Tennessee River tailwaters of the Wilson and Guntersville Dams are believed to be very rare (Mirarchi et al., 2004). In 1984, the rough pigtoe was also reported in the Green River in Kentucky (below locks 4 and 5) and in the Barren River (below lock and dam 1) (USFWS, 1984a). Parmalee et al. (1980) also reported an undetermined number of freshly dead rough pigtoe specimens from the middle reaches of the Cumberland River, although they are reported to be uncommon to rare in the Cumberland River (USFWS, 1984a). The current range of the rough pigtoe mussel is shown in Figure C-4.

C.3.4 Habitat

The rough pigtoe is found in medium to large rivers with sand, gravel, and cobble substrates (USFWS, 1984a; Endangered Species Information Exchange [ESIE], 1996; NatureServe 2006). The species has also been reported from flats, and muddy sand in shallow waters (NatureServe 2003). It has been collected in muddy sand on Green River and in sand on the Clinch River (Clarke, 1983). This species does not occur in the impounded sections of rivers and is apparently quite sedentary in the substrate (ESIE, 1996). The rough pigtoe has been collected in water depths ranging from 0.8 m in the Green River to roughly 1 m in the Clinch River (Clarke, 1983). No critical habitat has been designated for the rough pigtoe.

C.3.5 Reproduction

The reproductive cycle of the rough pigtoe is similar to that of other freshwater 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, 1984a). Specific glochidial hosts for this species are not known (ESIE, 1996).

C.3.6 Known 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, has ultimately led to the loss of the rough pigtoe population within 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 similar to those described in the general mussel description in Section C.1.6.

C.4 Shiny Pigtoe Pearly Mussel (*Fusconaia edgariana*)

C.4.1 Species Listing Status

On June 14, 1976, the shiny pigtoe mussel was designated by the USFWS as endangered throughout its entire range in Alabama, Tennessee, and Virginia (USFWS, 1976: 41 FR 24062-24067), except where listed as experimental populations (in the free-flowing reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties in Alabama) (USFWS, 2001). A recovery plan addressing the shiny pigtoe was approved on July 9, 1984 (USFWS, 1984b).

C.4.2 Description

The shiny pigtoe is a medium-sized (reaching over 60 mm in length) freshwater mussel with a smooth and shiny yellowish-brown shell with prominent dark green to blackish rays (NatureServe, 2006; INHS, 2006).

C.4.3 Historic and Current Range

This species was historically widespread in the Tennessee River and 10 of its tributaries. It was last collected from Mussel Shoals, an 85 km reach of the Tennessee River in Alabama (this reach 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. The shiny pigtoe is currently known to exist in four river systems including the Clinch River and its tributary Copper Creek (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, 1984b; NatureServe, 2006). One fresh dead individual was found in the Paint Rock River in Alabama in 1997 (Garner, 1997). The species is now extirpated from the Elk River in Tennessee, where it was last reported in 1980 (USFWS, 1984b). It is thought that the Tennessee side of the Clinch River has the largest population of shiny pigtoe mussels (NatureServe, 2006). The current range of the shiny pigtoe mussel is shown in Figure C-5.

C.4.4 Habitat

The shiny pigtoe is a riffle species and prefers moderate to swiftly flowing streams and rivers with stable substrates (ESIE, 1996; USFWS, 1984b). The species is not found in deep pools, impounded water, or other lentic habitats (USFWS, 1984b). The species is usually observed well buried in the sand and gravel substrate during most of the year, and is more readily visible in early summer (ESIE, 1996). The shiny pigtoe appears to be able to tolerate small amounts of silt over the substrate (2 mm or less), but requires ample water flow and a stable sand or gravel substrate (USFWS, 1984b; Ortmann, 1925; Ahlstedt, 1980). No critical habitat has been designated for the shiny pigtoe.

C.4.5 Reproduction

The shiny pigtoe is likely a short term brooder with spawning occurring in May and release of glochidia in June or early July (ESIE, 1996; USFWS 1984b). Glochidia have been found naturally encysted in the North Fork Holston River on the following species: the whitetail shiner (*Notropis galacturus*), common shiner (*Notropis cornutus*), warpaint shiner (*Notropis coccogenis*) and telescope shiner (*Notropis telescopus*) (Kitchel, 1983). Laboratory infestation studies have confirmed that the whitetail and common shiners are likely host species for the shiny pigtoe (USFWS, 1984b). The life span of shiny pigtoe mussels has been reported to exceed 25 years (Stansbery, 1972).

C.4.6 Known 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 on the Tennessee and Cumberland Rivers have eliminated the majority of riverine habitat for the species in its historic range (ESIS, 1996; USFWS, 1984b). 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 (USFWS, 1984b). A population in the Holston River above the Cherokee Reservoir was adversely affected by wastewater discharges from industrial and municipal sources (USFWS, 1984b). 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). Between 1979 and 1986, 28 percent of the shiny pigtoe population at North Holston Ford, North Fork Holston River was eliminated by muskrat predation (ESIE, 1996). Other threats that are attributed to population declines are similar to those described in the general mussel description in Section C.1.6.

C.5 Fine-rayed Pigtoe Mussel (*Fusconaia cuneolus*)

C.5.1 Species Listing Status

On June 14, 1976, the fine-rayed pigtoe was designated by the USFWS as endangered throughout its entire range in Alabama, Tennessee, and Virginia (USFWS, 1976: 41 FR 24062-24067), 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, 1984c).

C.5.2 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, 2006; Bruenderman and Neves, 1993).

C.5.3 Historic and Current Range

This species was historically widespread in tributaries of the Tennessee River in Tennessee (above the Mussel Shoals area), Virginia, and Alabama (USFWS, 1984c). It currently persists in portions of the Clinch and Powell rivers, the North Fork of the Holston, and in the Paint Rock River (NatureServe, 2006). The largest population of fine-rayed pigtoe mussels resides in the Clinch River, but is reproductively isolated from the Powell River population (Neves, 1991). In addition, the shiny pigtoe has also been observed in the Elk River, Little River, and Sequatchie River, based on surveys conducted by the Tennessee Valley Authority (TVA) in the 1980s (USFWS, 1984c). However, according to NatureServe (2006), populations outside of the Clinch River are either extirpated or have poor or no viability. The current range of the fine-rayed pigtoe mussel is shown in Figure C-6.

C.5.4 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, 2006). This species is apparently intolerant of lentic conditions and has been extirpated from many river sections of its historic range that were impounded (USFWS, 1984c). No critical habitat has been designated for the fine-rayed pigtoe.

C.5.5 Reproduction

The fine-rayed pigtoe is a short-term summer brooder, and gravid females have been identified between mid-May and late-July with peak release of glochidia in mid-June (USFWS, 1984c). Laboratory studies have identified eight species as likely glochidial hosts for the fine-rayed pigtoe including the fathead minnow (*Pimephales promelas*), river chub (*Notropis micropogon*), stoneroller (*Campostoma anomalum*), telescope chub (*Notropis telescopus*), Tennessee shiner (*Notropis leuciodus*), white shiner (*Luxilus albeolus*), whitetail shiner (*Cyprinella galactura*), and mottled sculpin (*Cottus bairdi*) (Bruenderman and Neves, 1993). Based on information from Bruenderman and Neves (1993), the maximum age of the Clinch River fine-rayed pigtoe population is approximately 35 years with an average annual growth rate of 5 mm per year through age 10 and 2 mm per year until senescence.

C.5.6 Known 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 on the Tennessee and Cumberland Rivers have eliminated the majority of riverine habitat for the fine-rayed pigtoe in its historic range (ESIE, 1996; USFWS, 1984c). The Powell River and upper tributaries of the Clinch River, in particular, are also subject to sediment and particulate matter loading from coal mining and oil and gas activities (Stansbery, 1973; Neves, 1991). The Clinch River population was reduced by toxic discharges and spills prior to 1972, and the invasion of the Asian clam, and the possible invasion of the zebra mussel, also threaten remaining populations (NatureServe, 2006). Other threats that are attributed to population declines are similar to those described in the general mussel description in Section C.1.6.

C.6 Heavy Pigtoe Mussel (Judge Tait's mussel) (*Pleurobema taitianum*)

C.6.1 Species Listing Status

On April 7, 1987, the heavy pigtoe, also known as Judge Tait's mussel, was designated by the USFWS as endangered throughout its entire range in Alabama (USFWS, 1987: 52 FR 11162-11168). A recovery plan addressing the heavy pigtoe was approved on November 14, 1989 (USFWS, 1989). In addition, a second recovery plan was approved by the USFWS on November 17, 2000 as part of a larger plan for endangered aquatic species within the Mobile River Basin (USFWS, 2000). The Mobile River Basin Recovery Plan was developed to complement the existing recovery plan for the heavy pigtoe mussel.

C.6.2 Description

The heavy pigtoe is a small (reaching approximately 50 mm in length) freshwater mussel; the shell is obliquely triangular in shape, and yellowish, greenish-yellow, or tawny, sometimes with darker dots (USFWS, 1989 and 2000; NatureServe, 2006).

C.6.3 Historic and Current Range

The heavy pigtoe mussel was historically found in the Tombigbee River from the mouth of Tibbee Creek near Columbus, 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 dead shells were recently found at one location on the Buttahatchie River, a tributary of the Tombigbee, in Mississippi (Schultz ,1981). This species has also been reported from the East Fork Tombigbee River (Schultz, 1981) and from the Sipsey River, Alabama. Only four 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, 1989). 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 (NatureServe, 2006). This species has not been found alive at any other site since 1987 (USFWS, 2000). The current range of the heavy pigtoe mussel is shown in Figure C-7.

C.6.4 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, and 1983). Unionids collected from the Tombigbee River system have been collected in water up to 0.7 meters deep (USFWS, 1989). No critical habitat has been designated for the heavy pigtoe.

C.6.5 Reproduction

The type of reproductive cycle and specific glochidal host species for the heavy pigtoe are not known (ESIE, 1996; USFWS, 2000).

C.6.6 Known Threats

The primary cause of population decline for the heavy pigtoe is habitat modification via construction of the Tennessee-Tombigbee waterway for navigation (USFWS, 1989). As previously discussed, this species cannot tolerate impoundment. Construction of the waterway has adversely impacted the species by physical destruction during dredging, increasing sedimentation, reducing water flow, and suffocating juveniles with sediment (USFWS, 1989). Its continued existence in the Tombigbee River drainage is dependent upon habitat in the tributaries of the Tombigbee River and the species' ability to complete its life cycle in smaller streams. The Sipsey River is threatened by proposed channel improvement including clearing and snagging. The Buttahatchie River is threatened by a channel improvement project, and the East Fork Tombigbee River is threatened by a clearing and snagging project, sand and gravel mining, the continued diversion of flood flows, and water removal for municipal use. In addition, agricultural runoff within and adjacent to river channels, and low population levels also threaten the species (USFWS, 2000). 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 of this mussel is precarious (USFWS, 1989). Other current threats to freshwater mussels are described in Section C.1.6.

C.7 Ovate Clubshell Mussel (*Pleurobema perovatum*)

C.7.1 Species Listing Status

The ovate clubshell was listed as endangered by the USFWS on March 17, 1993 (USFWS, 1993: 58 FR 14339). A recovery plan for the ovate clubshell was approved by the USFWS as part of the Mobile River Basin Recovery Plan on November 17, 2000 (USFWS, 2000). A draft five year review was recently conducted (U.S. FWS, 2006).

C.7.2 Description

The ovate clubshell is a small to medium-sized freshwater mussel that rarely exceeds 50 mm (2.0 in) in length. The shell is oval to elliptical in shape, varies from yellow to dark brown, and occasionally has broad green rays that may cover most of the umbro (beak) and the posterior ridge (USFWS, 2000).

C.7.3 Historic and Current Range

The species is currently extant at five sites compared with 23 historic sites. It is known to survive in several Tombigbee River tributaries (Buttahatchee River, Luxapalila Creek and Yellow Creek, Sipsey River, Sucarnoochee River, and Coalfire Creek) (NatureServe, 2006). It was also recently discovered in Cahaba River (above and below the fall line), in tributaries of the Alabama River (Sturdivant and McCalls Creek), and in the Tallapoosa River drainage (Uphapee Creek). The South Carolina specimen is a likely misidentification of *Fusconaia masoni* (NatureServe, 2006). The current range of the ovate clubshell mussel is shown in Figure C-8.

C.7.4 Habitat

The habitat of the ovate clubshell includes sand and gravel shoals and runs of small rivers and large streams with moderate to high flow (USFWS, 2000; NatureServe, 2006). This species cannot tolerate impoundments or channelization (USFWS, 2000). Designated critical habitat for the ovate clubshell is discussed in Section C.1.2 and summarized in Table C.1.

C.7.5 Reproduction

Gravid females have been observed in June and July; however host fishes for the ovate clubshell mussel are unknown (NatureServe, 2006).

C.7.6 Known Threats

Habitat modification, sedimentation, eutrophication, and other forms of water quality degradation are the primary causes of decline of the ovate clubshell. In addition, this species may also be threatened by overutilization for commercial, recreational, scientific, and educational purposes (USFWS, 1993). In Chewacla Creek, the ovate clubshell is affected by recent impacts including clear cutting for road improvement projects which did not use best management practices (i.e. lack of silt fences, etc.) (NatureServe, 2006). Disappearance from significant portions of its range are primarily due to changes in river and stream channels due to dams, dredging, or mining, and historic or episodic pollution events. As previously discussed, this species cannot tolerate impoundment or channelization; however, more than 1700 km of large and small river habitat in the Mobile River Basin have been impounded by dams for navigation, flood control, water supply, and/or hydroelectric production purposes (USFWS, 1993).

Limited habitat and small population size also render the ovate clubshell species vulnerable to competition or predation from nonnative species (Neves et al., 1997). The Asian clam, *Corbicula fluminea*, has invaded all major drainages of the Mobile River Basin; however, little is known of the effects of competitive interaction between Asian clams and native species.

Distribution and status of the ovate clubshell mussel was recently reviewed by USFW in a 5-year review (USFWS, 2006) and reported the following:

> Status has improved slightly regarding numbers of known populations. However, host fish and reproductive behavior remain unknown, the range remains highly fragmented, and all populations are small, isolated, and vulnerable to nonpoint source pollution, drought, or other stochastic events. Population trends and viability of all populations is unknown. The ovate clubshell remains vulnerable to extinction due to extreme curtailment of range and habitat, low numbers, and vulnerability to nonpoint source pollution and stochastic events.

C.8 Southern Clubshell Mussel (*Pleurobema decisum*)

C.8.1 Species Listing Status

On March 17, 1993, the southern clubshell (*Pleurobema decisum)* was designated as by the USFWS as endangered throughout its entire range (USFWS, 1993: 58 FR 14339). A recovery plan for the southern clubshell was finalized as part of the Mobile River Basin Recovery Plan on November 17, 2000 (USFWS, 2000).

C.8.2 Description

The southern clubshell is a medium-sized mussel about 70 mm (2.8 in.) long, with a thick shell that is yellow to yellowish-brown with occasional green rays or spots on young specimens (USFWS, 1993).

C.8.3 Historic and Current Range

With the exception of the Mobile Delta, the southern clubshell was formerly known from every major river system in the Mobile 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, 2004).

The southern clubshell continues to inhabit the East Fork 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/Tuscaloosa 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 and Logan Martin Dam (Cherokee/ St. Clair/Talladega County, Alabama) and tributaries Yellowleaf Creek

(Shelby County, Alabama), Big Canoe Creek (St. Clair County, Alabama), Terrapin Creek (Cherokee County, Alabama), and Conassauga River (Murray/Whitfield County, Georgia) (USFWS, 2004). The southern clubshell is relatively common in localized reaches of the Buttahatchee and Sipsey Rivers; however, it is rare to uncommon in other occupied streams (USFWS, 2004). It has recently been reported to inhabit the Uphapee Creek (Macon County, AL) and the Oakmulgee Creek (Cahaba River Drainage, Dallas County, AL) (USFWS, 2006). According to Mirarchi et al. (2004), this species may be extirpated from the Black Warrior and Chahaba Rivers. The current range of the southern clubshell mussel is shown in Figure C-9.

C.8.4 Habitat

The southern clubshell inhabits sand/gravel/cobble substrate in shoals and runs of small rivers and large streams. This species is usually found in highly oxygenated streams with sand and gravel substrates, although it may also be found in sand and gravel in the center of the stream or in sand along the margins of the stream (NatureServe, 2006). This species does not tolerate impoundment or channelization. Designated critical habitat for the southern clubshell is discussed in Section C.1.2 and summarized in Table C.1.

C.8.5 Reproduction

Gravid southern clubshell females with mature glochidia have been collected in June and July. Blacktail shiner *(Cyprinella venusta),* Alabama shiner *(C. callistia),* and tricolor shiner *(C. trichroistia)* have been identified as fish host for the southern clubshell (Haag and Warren, 2001).

C.8.6 Known Threats

Habitat modification, sedimentation, and water quality degradation are the primary causes of decline of the southern clubshell (USFWS, 2004). 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. 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. Due to the extreme rarity of the southern clubshell, any adverse impacts to its habitat or an individual, including further habitat degradation and/or competition or predation from nonnative species, could result in the demise of the species (USFWS, 2004).

Distribution and status of the Southern clubshell mussel was recently reviewed by USFW in a 5-year review (USFWS, 2006) and reported the following:

Status has improved regarding numbers of known populations. Host fish have been identified, fecundity has been estimated, and population growth models have been developed for the species. The range remains highly fragmented and all populations are small, isolated, and vulnerable to nonpoint source pollution, drought, or other stochastic events. Population trends and viability of most populations is poorly known. Although the vulnerability of the southern clubshell to extinction due to stochastic threats has been reduced by the increased number of relict populations now known, the species has experienced extreme curtailment and fragmentation of range and habitat. The restricted extent and low population numbers of extant populations remain vulnerable to nonpoint source pollution and stochastic threats. However, downlisting to threatened status may become foreseeable in the near future if population trends are determined to be stable or increasing.

C.9 Stirrup Shell (*Quadrula stapes)*

C.9.1 Species Listing Status

On April 7, 1987 the stirrupshell was designated as endangered by the USFWS throughout its entire range in Alabama and Mississippi (USFWS, 1987: 52 FR 11162-11168). A recovery plan addressing the stirrupshell was approved November 14, 1989 (USFWS 1989). In addition, a second recovery plan was approved by the USFWS on November 17, 2000 as part of a larger plan for endangered aquatic species within the Mobile River Basin (USFWS, 2000).

It should be noted that the stirrupshell is presumed extinct as no observations of this species have been recorded in over 20 years. (personal communications with Paul Hartfield [USFWS], James Williams [U.S.Geological Survey], and Paul Johnson [Alabama Aquatic Biodiversity Center], 2006).

C.9.2 Description

The stirrupshell is a small (reaching approximately 50 mm in length) freshwater mussel with a yellowish-green shell; juveniles show green, zigzag markings with the shell becoming brown with age (USFWS, 1987).

C.9.3 Historic and Current Range

The stirrup shell 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, 1980; Williams, 1982). 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. The last observed record of this species was from the lower Sipsey River in 1986, where a fresh dead shell was observed (USFWS, 1989). No live individuals have been found in recent years and, according to several freshwater mussel experts, this species is likely to be extinct (personal communications with Paul Hartfield [USFWS], James Williams [USGS], and Paul Johnson [Alabama Aquatic Biodiversity Center], 2006).

C.9.4 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, and1983). Unionids collected from the Tombigbee River system have been collected in water up to 0.7 meters deep (USFWS, 1987). No critical habitat has been designated for the stirrupshell.

C.9.5 Reproduction

The type of reproductive cycle and specific glochidal host species for the stirrupshell are not known (ESIE, 1996).

C.9.6 Known Threats

Habitat modification is the major cause of decline of the stirrupshell (USFWS, 2000). It is believed that the U.S. Army Corp of Engineer's construction of the Tenneseee-Tombigbee Waterway in the 1970s led to the extinction of the stirrupshell mussel (personal communication with Williams, USGS, 2006). In fact, Stansbery (1976) warned that the construction of this waterway might cause the extinction of the species.

Any factor that adversely modifies habitat or water quality in the limited remaining habitat for the species could threaten its survival in these areas, if it still exists. 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 uncertain (USFWS, 1989).

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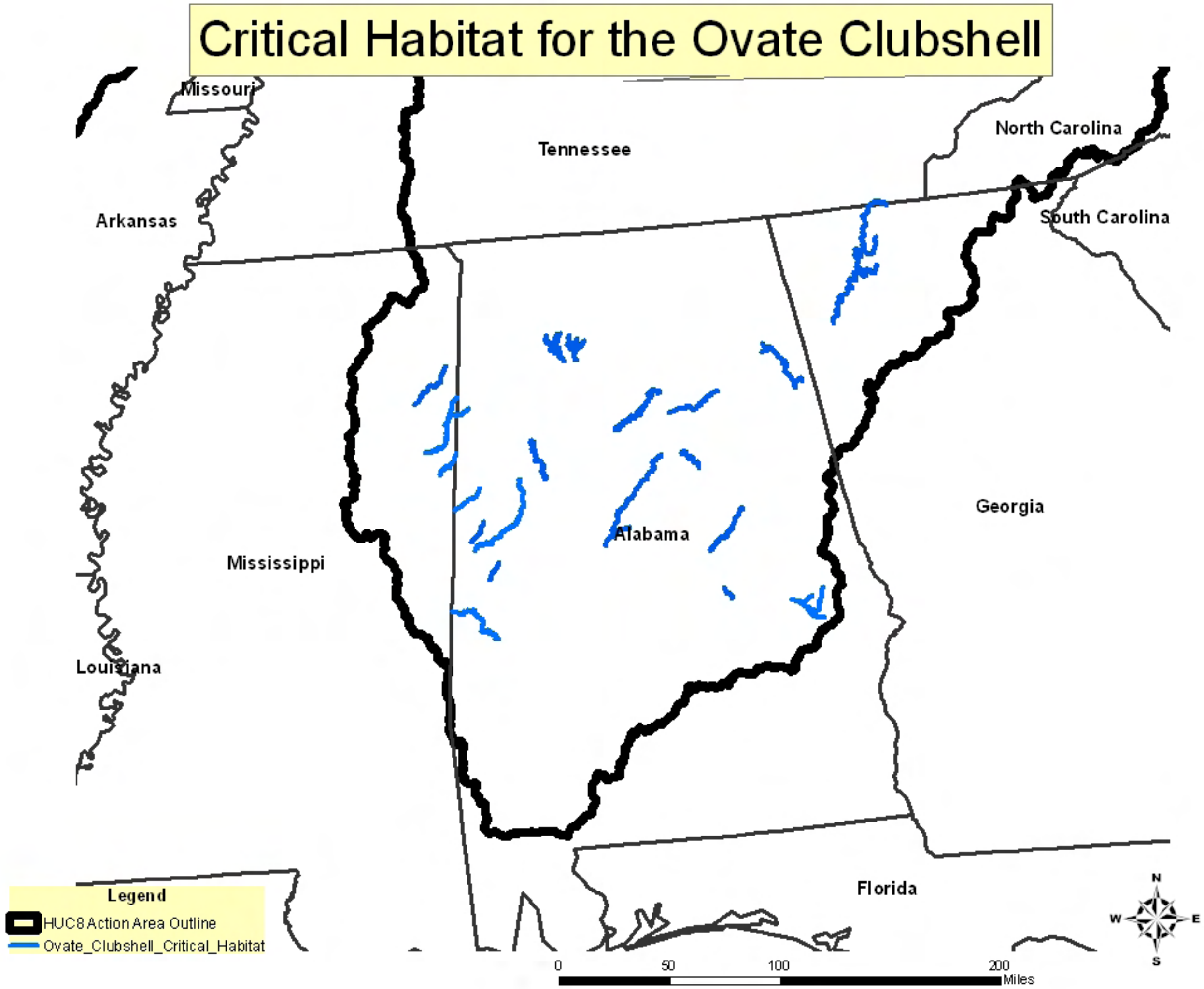

Figure C-1: Designated Critical Habitat for the Ovate Clubshell Mussel

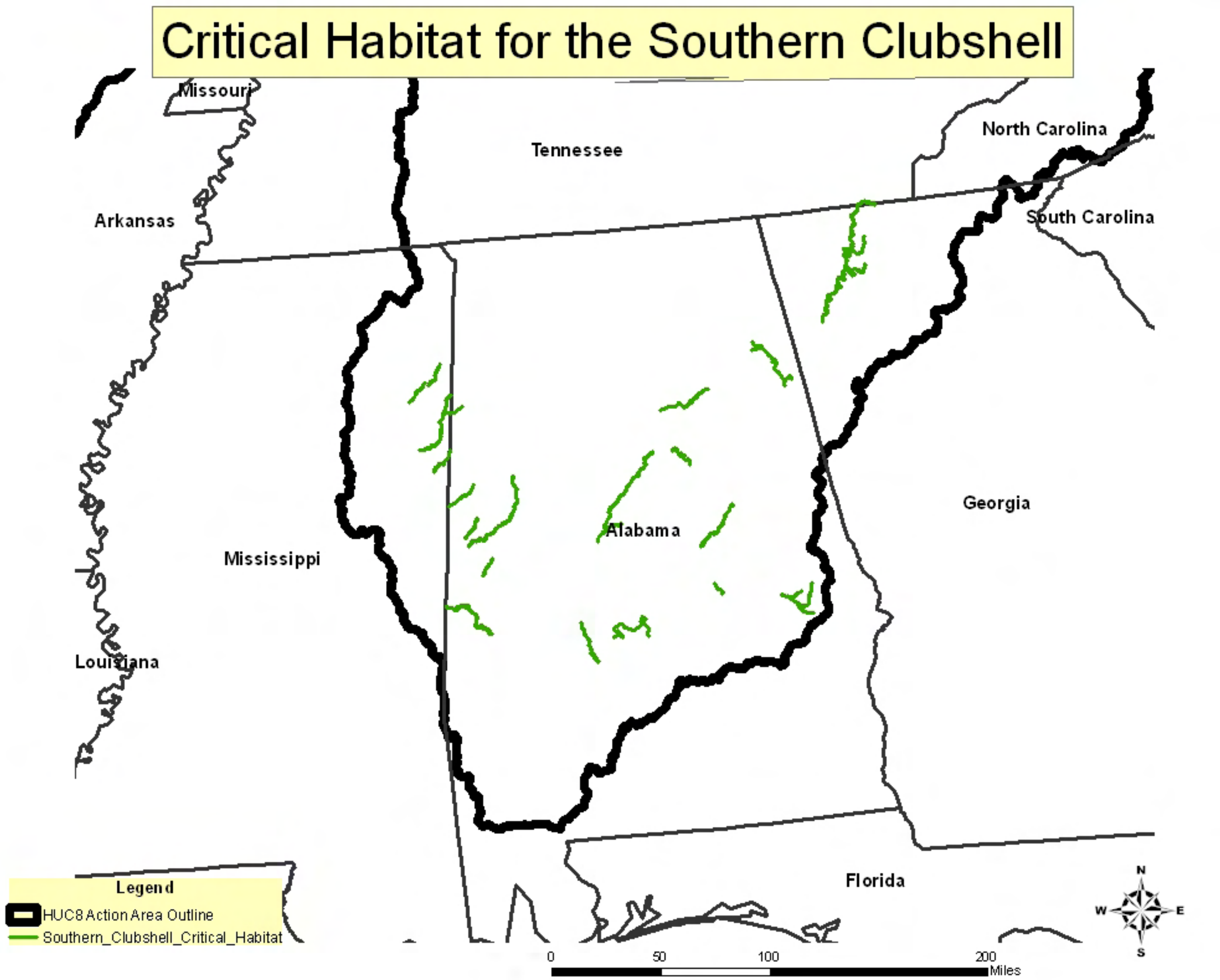

Figure C-2: Designated Critical Habitat for the Southern Clubshell Mussel

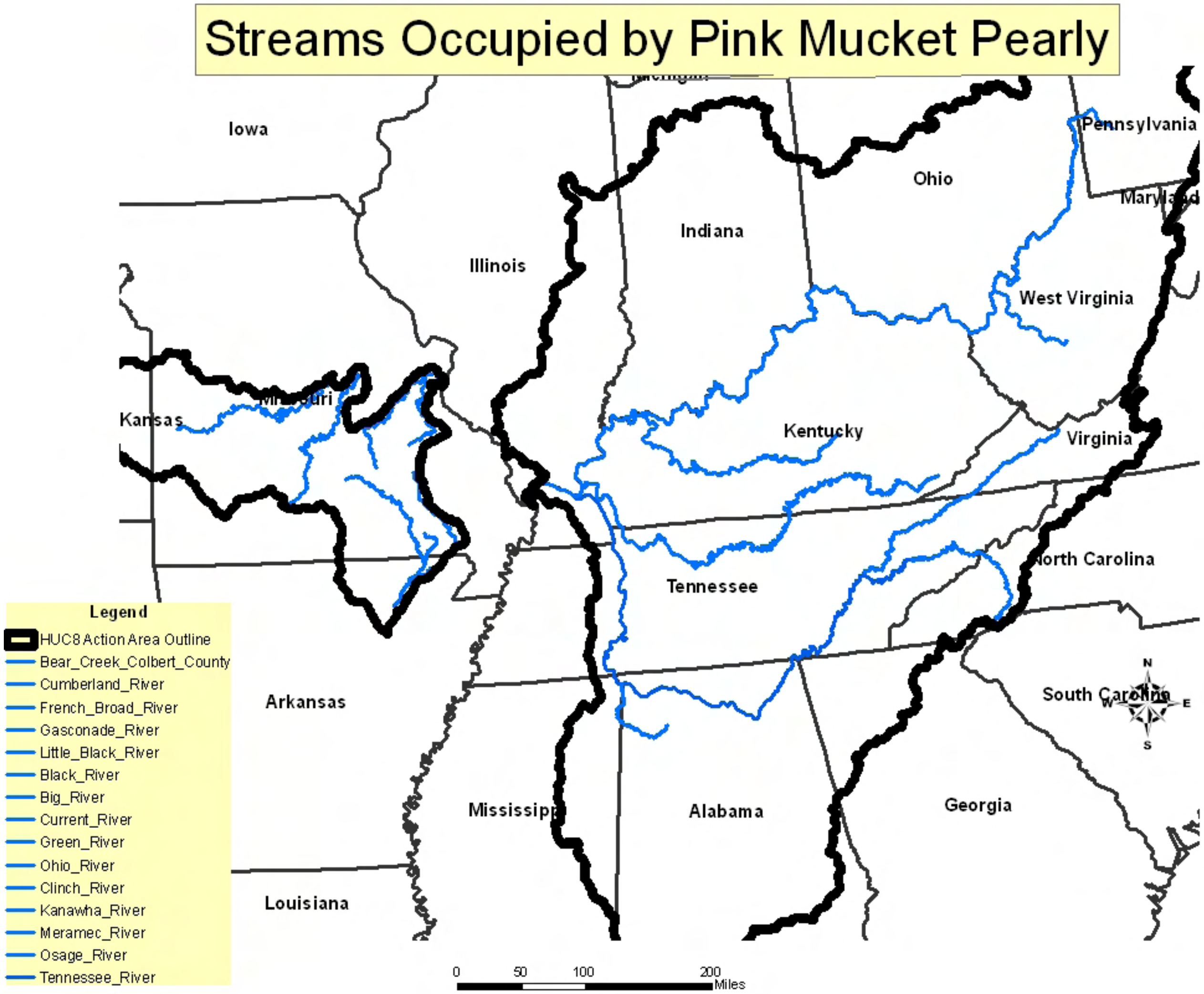

Figure C-3: Current Range of the Pink Pearly Mucket Mussel

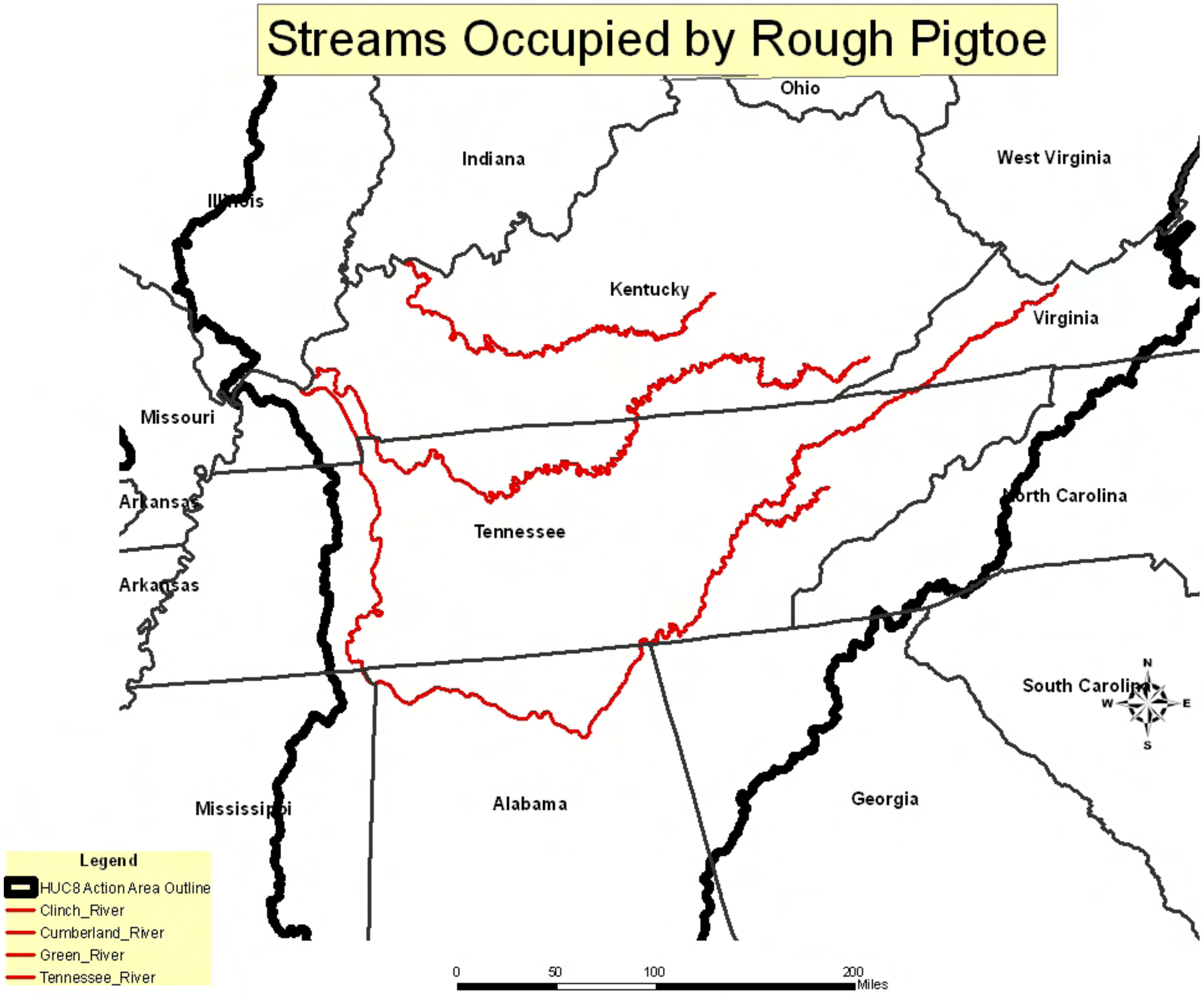

Figure C-4: Current Range of the Rough Pigtoe Mussel

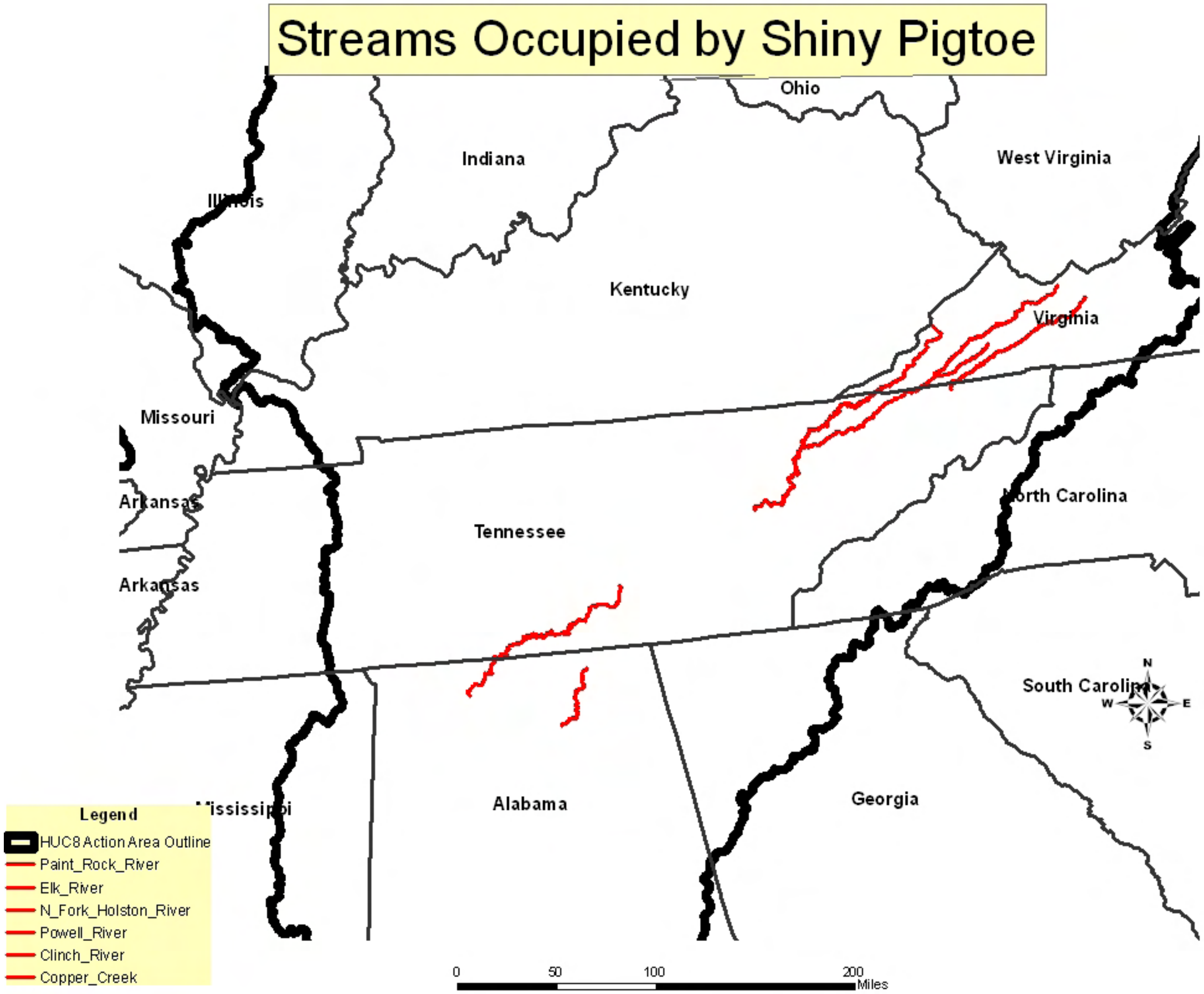

Figure C-5: Current Range of the Shiny Pigtoe Mussel

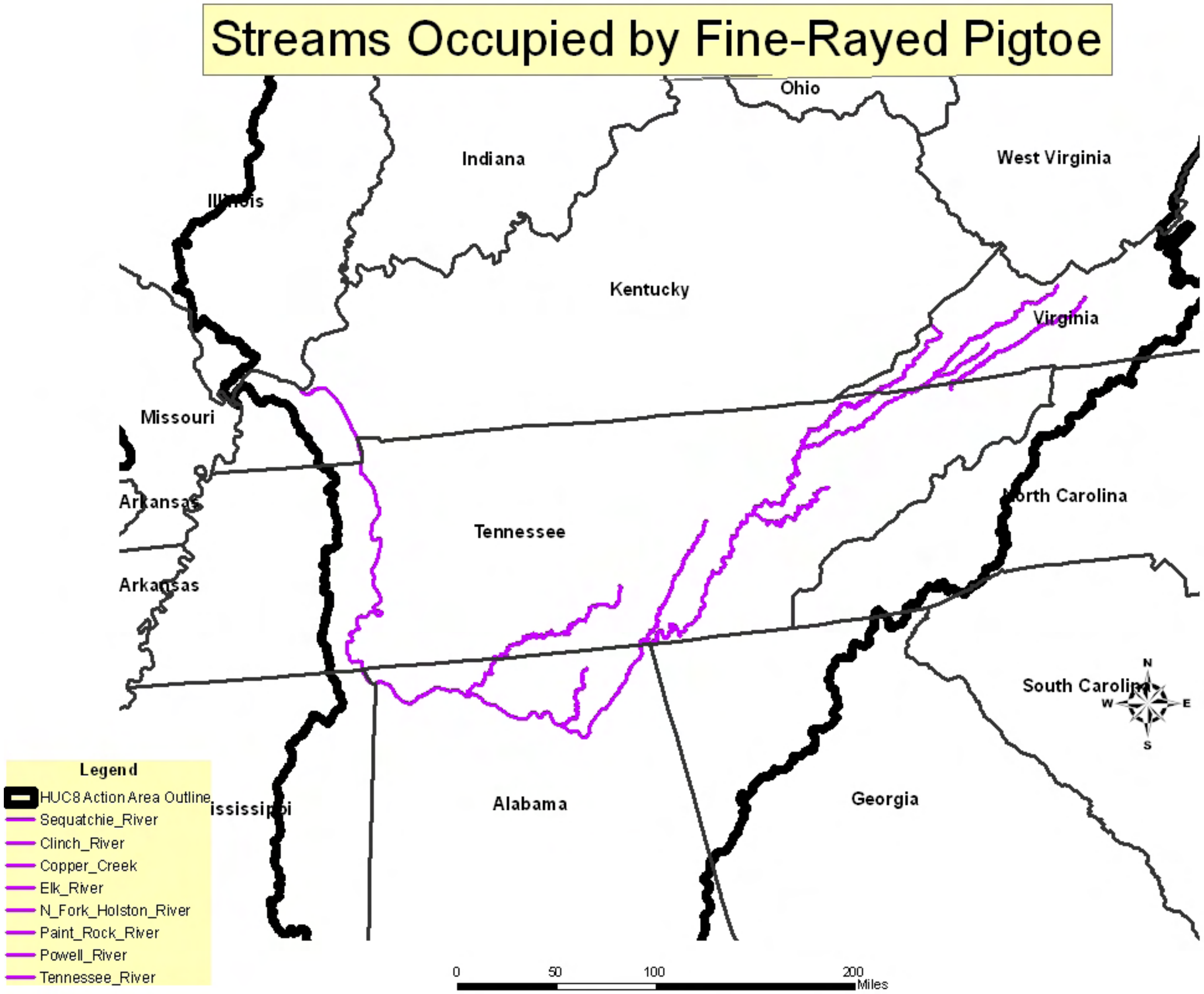

Figure C-6: Current Range of the Fine-Rayed Pigtoe Mussel

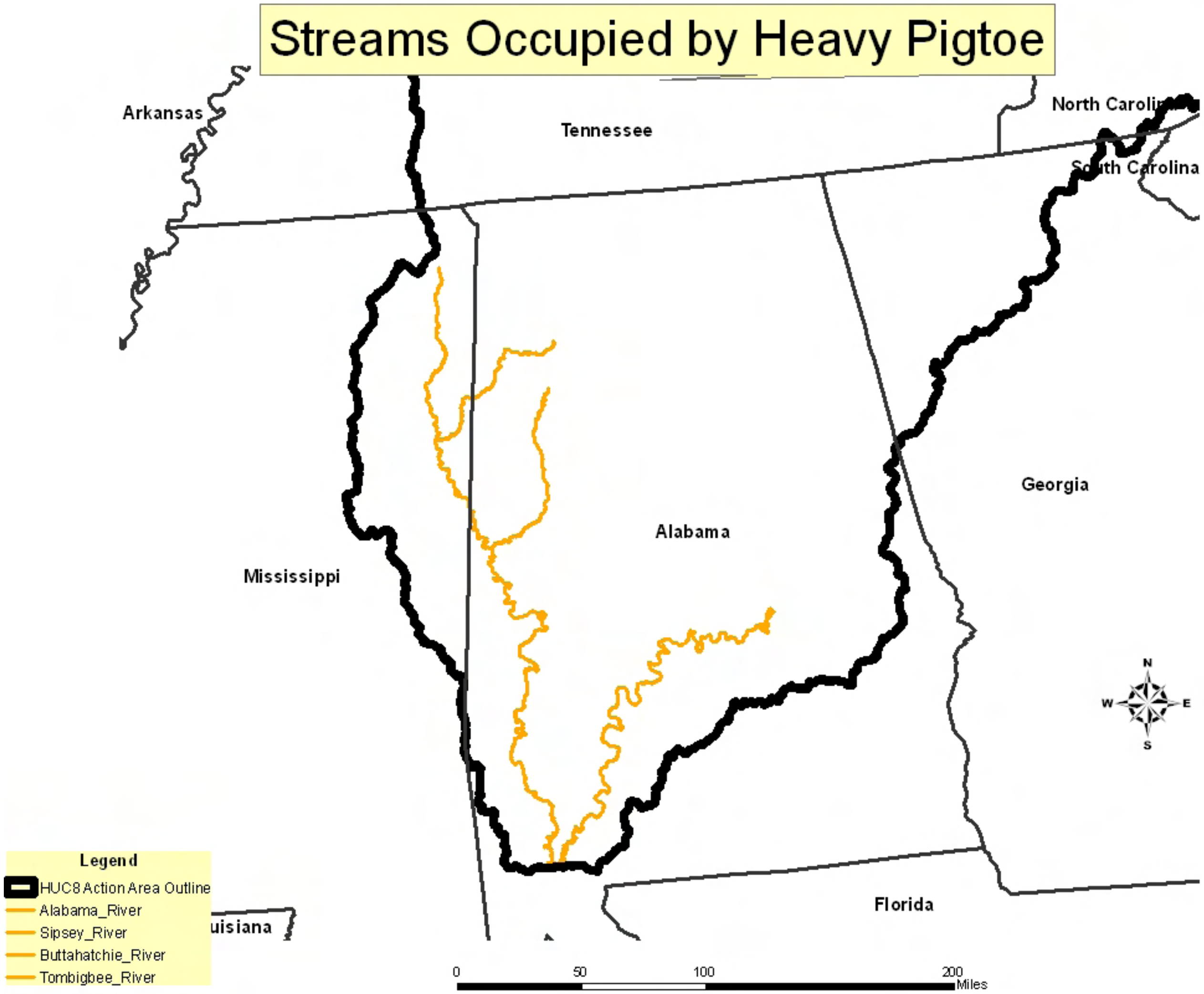

Figure C-7: Current Range of the Heavy Pigtoe Mussel

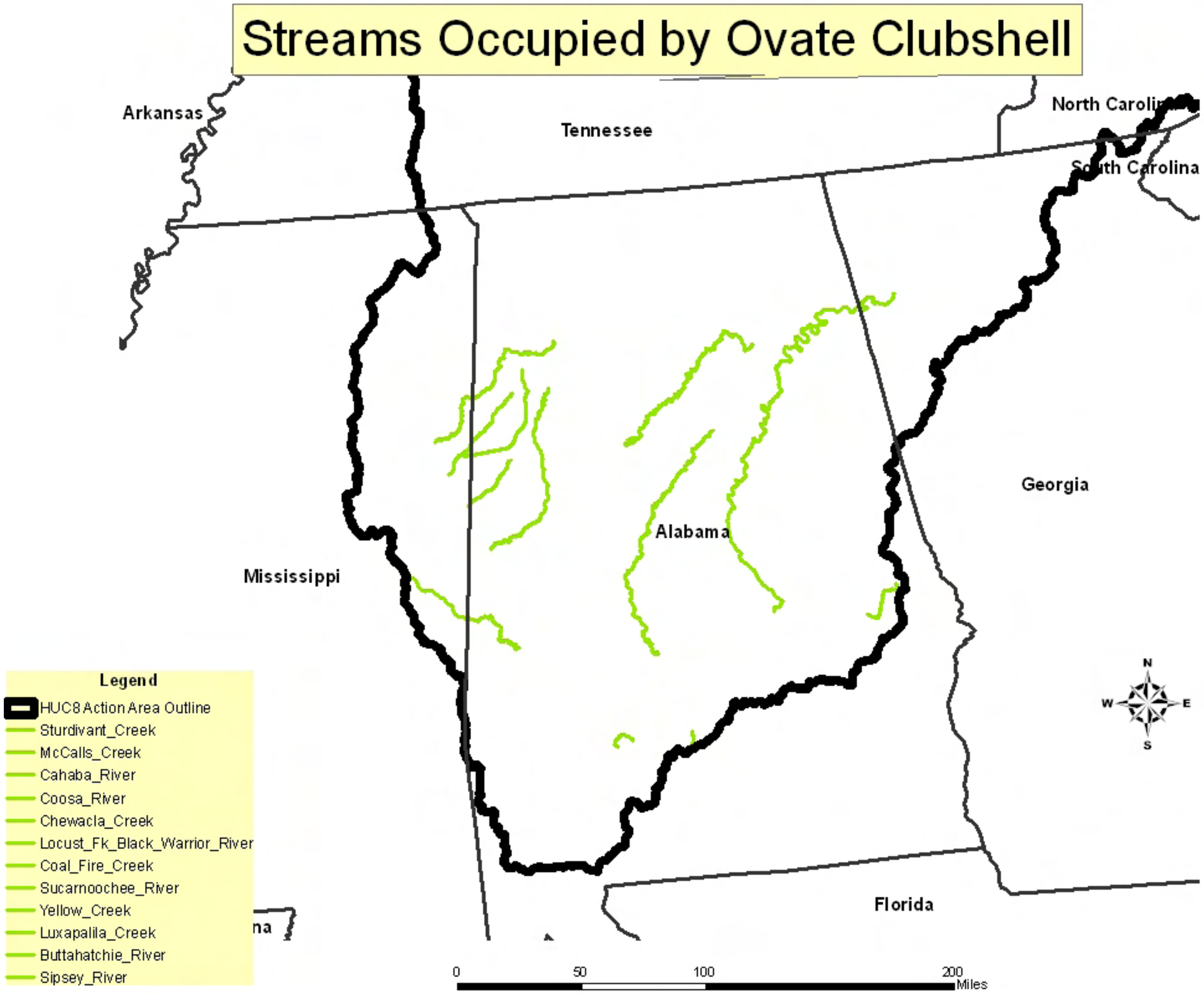

Figure C-8: Current Range of the Ovate Clubshell Mussel

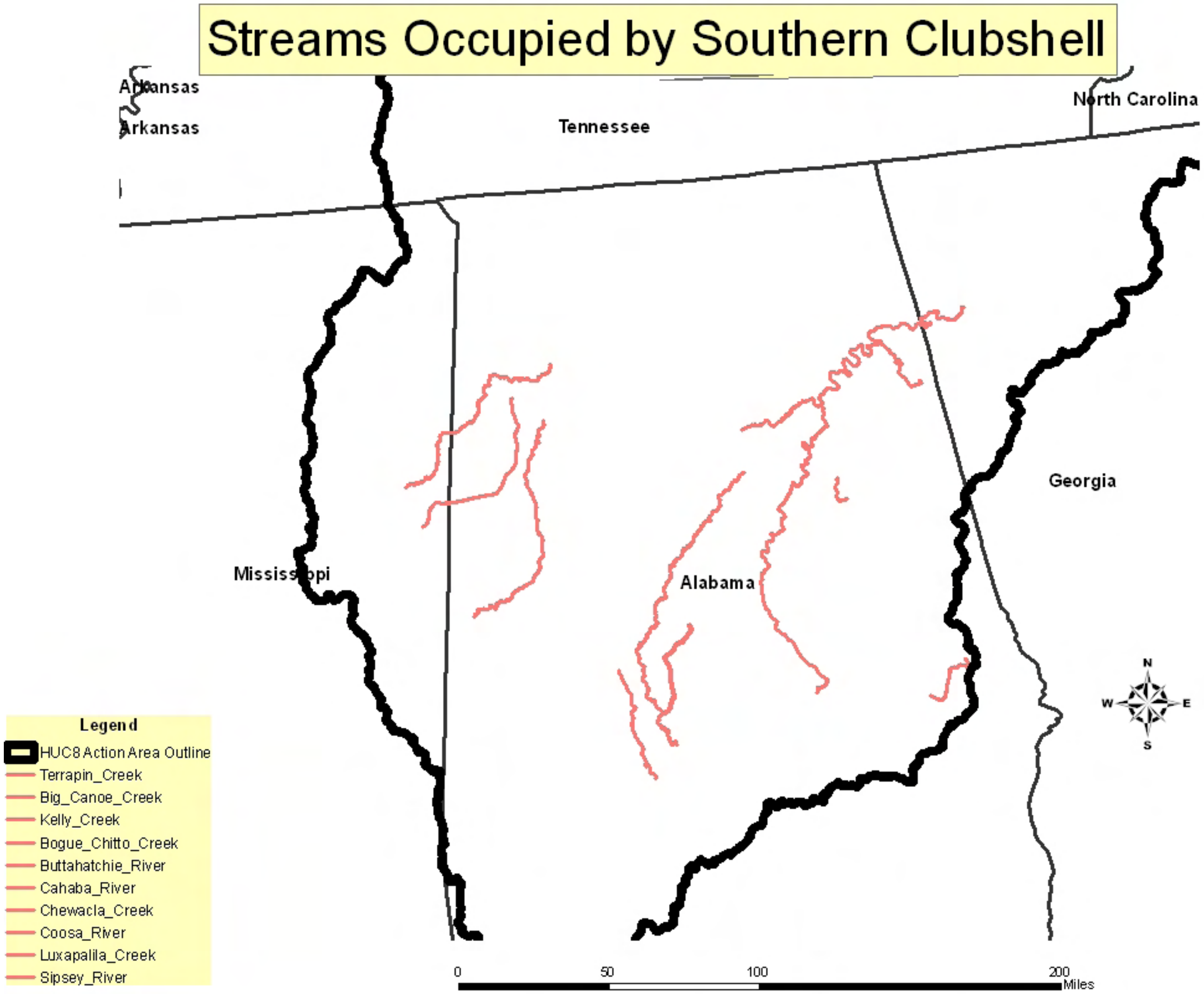

Figure C-9: Current Range of the Southern Clubshell Mussel