Recovery Plan

For

Georgia pigtoe mussel (*Pleurobema hanleyianum*)

Interrupted rocksnail (*Leptoxis foremani*)

and

Rough hornsnail (*Pleurocera foremani*)

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Prepared by:

Jeffrey R. Powell
U.S. Fish and Wildlife Service
Ecological Services
Daphne, Alabama

and

Paul Hartfield
U.S. Fish and Wildlife Service
Ecological Services
Jackson, Mississippi

For
U.S. Fish and Wildlife Service
Southeast Region
Atlanta, Georgia

Approved: _____
Acting Regional Director

Date: 10/30/14

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By approving this document, the Regional Director certifies that the information used in its development represents the best scientific and commercial data available at the time it was written. Copies of all documents reviewed in development of the plan are available in the administrative record, located at the Daphne Ecological Services Field Office in Daphne, Alabama.

Literature citations should read as follows:

U.S. Fish and Wildlife Service. 2014. Recovery Plan for the Georgia pigtoe mussel, Interrupted rocksnail, and Rough hornsnail. Atlanta, Georgia. 55 pp.

Additional copies of this plan may be obtained from:

U.S. Fish and Wildlife Service
1208-B Main Street
Daphne, Alabama 36526
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EXECUTIVE SUMMARY

SPECIES' STATUS: The interrupted rocksnail, rough hornsnail, and Georgia pigtoe mussel were federally listed as endangered on November 2, 2010 (75 FR 67512). All three species are endemic to the Coosa River drainage of the Mobile River Basin in Alabama and Georgia; the Georgia pigtoe also occurs in a Coosa River tributary in Tennessee. All three species have disappeared from 90 percent or more of their historical ranges, primarily due to impoundment of riverine habitats. A single population of interrupted rocksnail is known to survive in the Oostanaula River, Georgia. Only two localized populations of rough hornsnail, one each in Yellowleaf Creek, Alabama, and the lower Coosa River, Alabama, are currently known. Surviving populations of Georgia pigtoe occur in the Conasauga River, Georgia, and possibly in the Coosa River (Weiss bypass), Alabama. According to the 2006 Alabama Wildlife Action Plan, the rough hornsnail is considered a Priority 1 (P1) species, and both the interrupted rocksnail and Georgia pigtoe are considered P1 species in Alabama and endangered in Georgia.

Approximately 258 km (160 mi) of stream channels in the Coosa River drainage have been designated as critical habitat for the interrupted rocksnail (101 km (63 mi)), rough hornsnail (27.4 km (17 mi)), and Georgia pigtoe mussel (153 km (95 mi)). The critical habitat is located in Cherokee, Clay, Coosa, Elmore and Shelby counties, Alabama; Gordon, Floyd, Murray, and Whitfield counties, Georgia; and Bradley and Polk counties, Tennessee. The Georgia pigtoe mussel has a recovery priority number of 5 which indicates the species faces a high degree of threat, but has a low recovery potential. The interrupted rocksnail and rough hornsnail have a recovery priority number of 2, indication both species are facing a high degree of threat and have a high recovery potential.

HABITAT REQUIREMENTS AND LIMITING FACTORS: The interrupted rocksnail, rough hornsnail, and Georgia pigtoe are all mollusks that require flowing water, stable stream channels with minimal sediment and algae growth, and adequate water quality. The Georgia pigtoe also requires a host fish, which is currently unknown. Primary threats to the species include extreme curtailment of habitat and range, small population sizes, and their resulting vulnerability to natural or human induced catastrophic events (e.g., droughts, pollution spills, etc.). Surviving populations are threatened by water quality and habitat deterioration.

RECOVERY STRATEGY**:** Over the last 75 years, the Coosa River Drainage has been converted from a free flowing water continuum to a scattered collection of isolated stream segments some of which now function as refugia for imperiled mollusks. Conservation and recovery of the Georgia pigtoe, interrupted rocksnail, and rough hornsnail (referred to hereafter as, the "GIPR" or the "three mollusks species") will require human intervention. It is known that human activities, human population numbers, and associated impacts will change within drainage watersheds. Therefore, to recover these species, it is essential to characterize and monitor aquatic habitats on a watershed scale, and respond to changing conditions rapidly, whether through negotiation and partnerships to alleviate threats, or through relocation or husbandry and reintroduction of endangered species populations to appropriate areas. This approach will require monitoring extant and reintroduced populations of the Georgia pigtoe, interrupted rocksnail, and rough hornsnail, and characterizing current conditions within

designated critical habitat units and their watersheds, along with routine periodic monitoring of habitat conditions.

RECOVERY OBJECTIVES: The recovery objectives over the next decade are to work to reduce threats in order to downlist the interrupted rocksnail and rough hornsnail to threatened status, and to protect the Conasauga River population of the Georgia pigtoe and prevent extinction of the species. Defining reasonable delisting criteria is not possible at this time given the current low number of populations and individuals, lack of information about the species' biology, and magnitude of threats. Therefore, this recovery plan establishes downlisting criteria for the two snails so they may be downlisted to threatened status. Criteria will be reevaluated as new information becomes available. We are not establishing downlisting or delisting criteria at this time for Georgia pigtoe, instead we are identifying preliminary measures to help us prevent its extinction until we can obtain further information on this species and determine recovery criteria for this animal.

RECOVERY CRITERIA:

Downlisting of the interrupted rocksnail and rough hornsail will be considered when we:

1. Protect and manage at least three geographically distinct populations for each species [To achieve this criterion, the populations can include the Oostanaula for the interrupted rocksnail and Yellowleaf Creek and Lower Coosa River for the rough hornsnail];

2. Achieve demonstrated and sustainable natural reproduction and recruitment in each population for each species as evident by multiple age classes of individuals, including naturally recruited juveniles, and recruitment rates exceeding mortality rates for a period of five years;

3. Develop and implement habitat and population monitoring programs for each population.

Recovery criteria for the Georgia pigtoe will be developed after we complete critical recovery actions and gain a greater understanding of the mussel species. In the interim, we identify the following actions that are necessary to help prevent the extinction of this animal:

1. Maintain and where possible implement habitat restoration activities and improve the Conasauga River population of the Georgia pigtoe;

2. Develop and implement a monitoring plan to evaluate population size in response to management actions;

3. Develop a captive propagation program and establish an ark population to help support the Conasauga River population of the Georgia pigtoe;

4. Conduct research, like identification of an appropriate fish host, that is important to gain better understanding of this mussel's life history; and

5. Identify, monitor, and where possible improve potential reintroduction sites in the historic range of the Georgia and reintroduce the species into these habitats.

ACTIONS NEEDED:

1. Protect these 3 mollusks by protecting the habitat integrity and quality of river and stream segments that currently support or could support the GIPR.

2. Promote voluntary stewardship as a practical and economical means of reducing nonpoint pollution from private land use.

3. Encourage and support community based stewardship planning and action within the historical ranges of the GIPR.

4. Develop and implement programs and materials to help educate the public on the need and benefits of ecosystem management, and to involve them in critical habitat watershed stewardship to protect listed species.

5. Conduct basic research on the Georgia pigtoe and apply the results toward their management and protection.

6. Develop and implement technology for maintaining and propagating the Georgia pigtoe in captivity [Note; since the publication of the draft recovery plan, we have completed a lot of research on the interrupted rocksnail and new research is nearing completion for the rough hornsnail. While we want to keep the idea of basic research for all 3 species, we will be approaching the highest priority unmet needs].

7. Reintroduce the interrupted rocksnail, rough hornsnail, and Georgia pigtoe into restored or suitable historical habitats, as appropriate.

8. Monitor GIPR population levels and distribution and periodically review recovery strategy.

ESTIMATED COSTS OF DOWNLISTING (Interrupted rocksnail and Rough hornsnail): The estimated costs associated with implementing all eight recovery actions are $775,000 over a five-year period. These costs include preliminary actions conducted for the Georgia pigtoe to prevent its extinction. Most of the costs associated with regulatory actions will be absorbed by existing programs.

DATE OF RECOVERY: The estimated date of reclassification of the interrupted rocksnail and rough hornsnail is 2019, and the Georgia pigtoe is undetermined at this time.

Year	Action								Total
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
2015	10	20	25	10	25	5	35	25	155
2016	10	20	25	10	25	5	35	25	155
2017	10	20	25	10	25	5	35	25	155
2018	10	20	25	10	25	5	35	25	155
2019	10	20	25	10	25	5	35	25	155
Total	50	100	125	50	125	25	175	125	775

* Costs may be absorbed under existing State and Federal programs
Dollar amounts listed above in thousands of dollars ($000s)

Table of Contents

PART I: BACKGROUND 10

Biological Assessment: Taxonomy, Life History, Habitat, Distribution, and Trends 10

Georgia Pigtoe Mussel *(Pleurobema hanleyianum) (*Lea 1852)) 10

Interrupted Rocksnail (Leptoxis foremani) (Lea 1843)) 13

Rough Hornsnail (Pleurocera foremani (Lea 1843)) 18

REASONS FOR LISTING/THREATS ASSESSMENT 23

ONGOING CONSERVATION EFFORTS 24

PART II: RECOVERY 26

Recovery Strategy 26

Recovery Objectives 26

Recovery Criteria 26

Listing/Recovery Factor Criteria 27

Recovery Narrative 28

REFERENCES CITED 36

PART III: RECOVERY IMPLEMENTATION SCHEDULE 43

APPENDIX 1

List of Stakeholders (* Invited Peer Reviewers) 50

Appendix 2

Summary of peer review

PART I: BACKGROUND

Biological Assessment: Taxonomy, Life History, Habitat, Distribution, and Trends

Georgia Pigtoe Mussel *(Pleurobema hanleyianum)* (Lea 1852))

Status

The Georgia pigtoe was listed as endangered on November 2, 2010 (75 FR 67512 – USFWS 2010).

Taxonomy

The Georgia pigtoe (*Pleurobema hanleyianum*) is a freshwater mussel in the family Unionidae (Figure 1). It was described in 1852 by I. Lea as *Unio hanleyianum* from the Coosawattee River in Georgia. It was placed in the genus *Pleurobema* by Simpson in 1900. The uniqueness of the Georgia pigtoe has been verified both morphologically (Williams *et al*. 2008) and genetically (Campbell *et al.* 2008).

The shell of the adult Georgia pigtoe reaches about 50 to 65 millimeters (mm) (2 to 2.5 inches (in)) in length. It is oval to elliptical and somewhat inflated. The posterior ridge is low and evenly rounded when evident. The anterior end is rounded, while the posterior margin is bluntly pointed below. Dorsal and ventral margins are curved, and the beaks rise slightly above the hinge line. The periostracum (membrane on the surface of the shell) is yellowish-tan to reddish-brown and may have concentric green rings. The beak cavity is shallow, and the shell interior is white to dull bluish-white (Parmalee and Bogan 1998, Williams *et al*. 2008).

Figure 1. Georgia Pigtoe *Pleurobema hanleyianum* (Lea 1852).

Photo courtesy Thomas Tarpley, Alabama Department of Conservation and Natural Resources

Life History and Habitat Needs

Little is known about the habitat requirements or life history of the Georgia pigtoe; however, it is currently found in shallow runs and riffles with strong to moderate current and coarse sand–gravel–cobble bottoms. Unionid mussels, such as the Georgia pigtoe, filter-feed on algae, detritus, and bacteria from the water column. The larvae of most unionid mussels

are parasitic, requiring a period of encystment on a fish host before they can develop into juvenile mussels. The fish host and glochidia (parasitic larvae) of Georgia pigtoe are currently unknown.

Distribution and Trends

The Georgia pigtoe was historically found in large creeks and rivers of the Coosa River drainage of Alabama, Georgia, and Tennessee (Johnson and Evans 2000; Williams *et al*., 2008). There are historical reports or museum records of the Georgia pigtoe from Tennessee (Conasauga River in Polk and Bradley Counties), Georgia (Conasauga River in Murray and Whitfield Counties, Chattooga River in Chattooga County; Coosa River in Floyd County, Etowah River in Floyd County, Coahulla Creek in Whitfield County), and Alabama (Coosa River in Cherokee County, Terrapin Creek in Cherokee County, Little Canoe and Shoal Creeks in St. Clair County, Morgan Creek in Shelby County, and Hatchet Creek in Coosa County) (Florida Museum of Natural History Malacology Database (FLMNH) *in litt.* 2006; Gangloff 2003). Based on these historical records, the range of the Georgia pigtoe included more than 480 km (300 mi) of river and stream channels. Additional historical Coosa River tributary records credited to Hurd (1974) (for example, Big Wills, Little Wills, Big Canoe, Oothcalooga, Holly Creeks) have been found to be misidentifications of other species (Gangloff *in litt.* 2006).

In 1990, the Service initiated a status survey and reviewed the molluscan fauna of the Mobile River Basin (Hartfield 1991). This led to extensive mollusk surveys and collections throughout the Coosa River drainage (Bogan and Pierson 1993a, Hartfield *in litt.* 1990-2001). At all localities surveyed in the Coosa River drainage, the freshwater mussel fauna had declined from historical levels, and at all but a few localized areas, the fauna proved to be completely eliminated or severely reduced due to a variety of impacts, including point and non-point source pollution, and channel modifications such as impoundment. Following a review of these efforts and observations, the Service reported 14 species of mussels in the genus *Pleurobema*, including the Georgia pigtoe, as presumed extinct, based on their absence from collection records, technical reports, or museum collections for a period of 20 years or more (Hartfield 1994).

The Service and others continued to conduct surveys in the Coosa River drainage for mollusks (Hartfield *in litt.* 1990-2001; Williams and Hughes 1998, Johnson and Evans 2000, Herod *et al*. 2001, Gangloff 2003, McGregor and Garner 2004, Johnson *et al*. 2005). Several freshly dead and live individuals of the Georgia pigtoe were collected during these mussel surveys in the Upper Conasauga River, Murray and Whitfield Counties, Georgia (Williams and Hughes 1998, Johnson and Evans 2000). Gangloff (2003) conducted mussel surveys of Coosa River tributaries in Alabama, including all known historical collection sites for the Georgia pigtoe, without relocating the species. McGregor and Garner (2004) surveyed the Coosa River dam tailraces for mollusks without encountering the Georgia pigtoe.

The Georgia pigtoe is currently known from a few isolated shoals in the Upper Conasauga River in Murray and Whitfield Counties, Georgia, and in Polk County, Tennessee (Johnson and Evans 2000, Evans 2001) (Figure 2). All recent collection sites occur within a 43-km (27-mi) reach of the river. Within this reach, the Georgia pigtoe is very rare (Johnson

and Evans 2000), and no demography estimates are available.

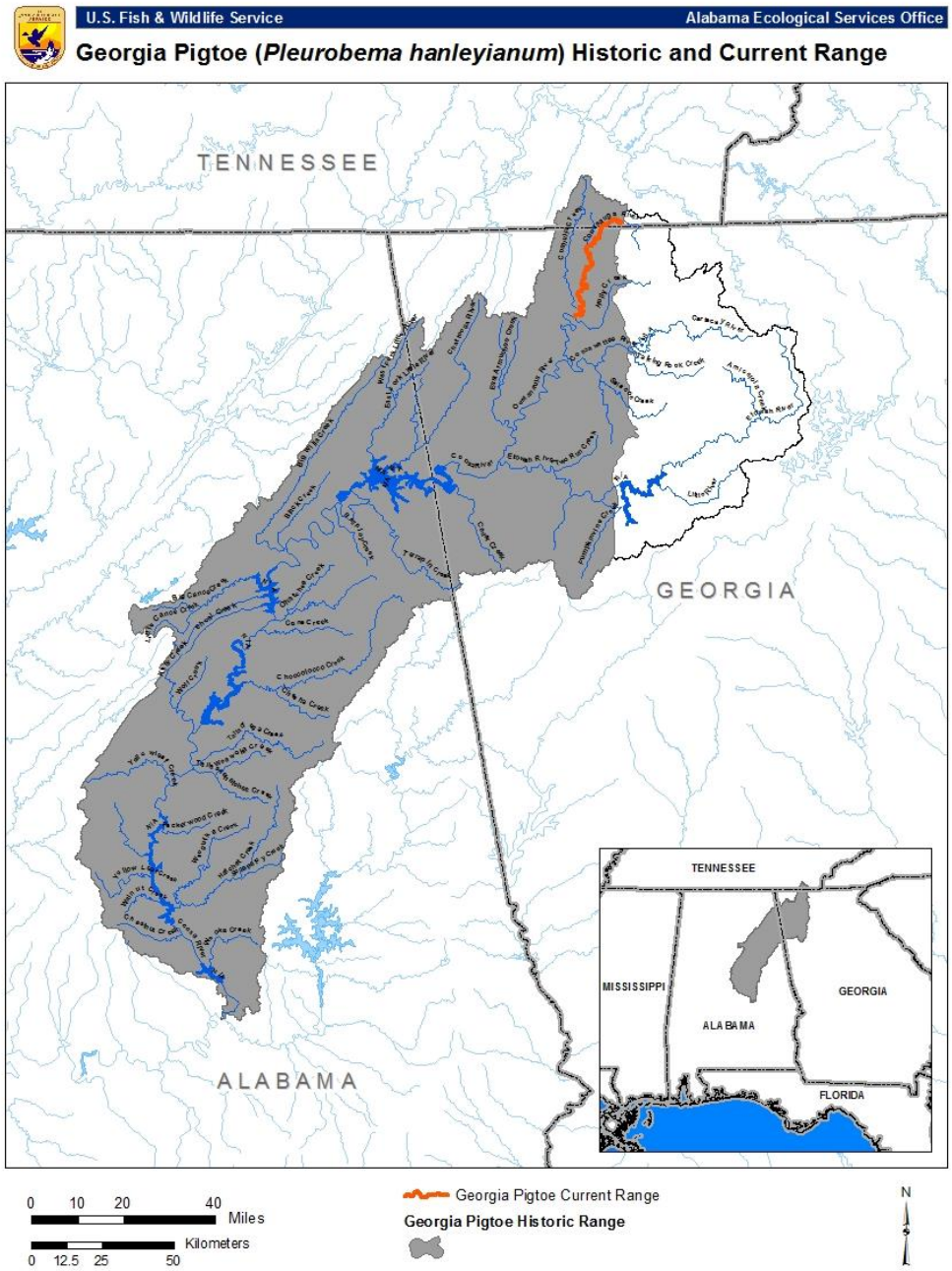

Figure 2. Historical and current distribution of the Georgia pigtoe mussel.

Critical Habitat

Critical habitat was designated for the Georgia pigtoe concurrently with listing on November 2, 2010 (75 FR 67512 – USFWS 2010) and includes the following three units:

- Unit GP 1: Conasauga River, 52 km (32 mi), Bradley and Polk Counties, Tennessee, and Murray and Whitfield Counties, Georgia.
- Unit GP 2: Terrapin Creek and Coosa River, 35 km (22 mi), Cherokee County, Alabama.
- Unit GP 3: Hatchet Creek, 66 km (41 mi), Coosa and Clay Counties, Alabama

The primary constituent elements of critical habitat for the Georgia pigtoe mussel, the interrupted rocksnail, and rough hornsnail are:

- Geomorphically stable stream and river channels and banks (channels that maintain lateral dimensions, longitudinal profiles, and sinuosity patterns over time without an aggrading or degrading bed elevation).

- A hydrologic flow regime (the magnitude, frequency, duration, and seasonality of discharge over time) necessary to maintain benthic habitats where the species are found. Unless other information becomes available, existing conditions at locations where the species occur will be considered as minimal flow requirements for survival.

- Water quality (including temperature, pH, hardness, turbidity, oxygen content, and chemical constituents) that meets or exceeds the current aquatic life criteria established under the Clean Water Act (33 U.S.C. 1251-1387).

- Sand, gravel, cobble, boulder, or bedrock substrates with low to moderate amounts of fine sediment and periphyton.

- The presence of fish host(s) for the Georgia pigtoe (currently unknown). Diverse assemblages of native chubs, minnows, stonerollers, and other stream adapted fish species will serve as a potential indication of host fish presence.

***Interrupted Rocksnail (Leptoxis foremani)* (Lea 1843))**

Status

The interrupted rocksnail was listed as endangered on November 2, 2010 (75 FR 67512 – USFWS 2010). Critical habitat was designated for the interrupted rocksnail concurrently at the time of listing.

Taxonomy

The interrupted rocksnail (*Leptoxis foremani*) is a small-to-medium-sized freshwater snail that historically occurred in the Coosa River drainage of Alabama and Georgia. The shell grows to approximately 22 mm (1 in) in length and may be ornamented by partial costae (folds in the surface). The shell is subglobose (not quite spherical), thick, dark brown to olive in color, occasionally spotted, and generally covered with fine striae (small ridges extending around the whorls). The spire (apex) of the shell is very low, and the aperture (opening) is large and subrotund (not quite round) and covered with an operculum when the snail withdraws into the shell (Figure 3).

The interrupted rocksnail, a member of the aquatic snail family Pleuroceridae, was described from the Coosa River, Alabama, by Lea in 1843. Goodrich (1922) placed the species in the "*Anculosa* (=*Leptoxis*) *picta* (Conrad 1834) group," which also included the Georgia rocksnail (*Leptoxis downei* (Lea 1868)). *L. foremani* was considered to inhabit the Lower Coosa River, with L. *downei* inhabiting the Upper Coosa drainage (Goodrich 1922). When a rocksnail population was rediscovered surviving in the Oostanaula River, Georgia, in 1997, it was initially identified as *L. downei* (Williams and Hughes 1998, Johnson and Evans 2000); however, Burch (1989) had previously placed *L. downei* within *L. foremani* as an ecological variant. *L. foremani* is recognized as the valid name for the interrupted rocksnail (Johnson *et al.* 2013).

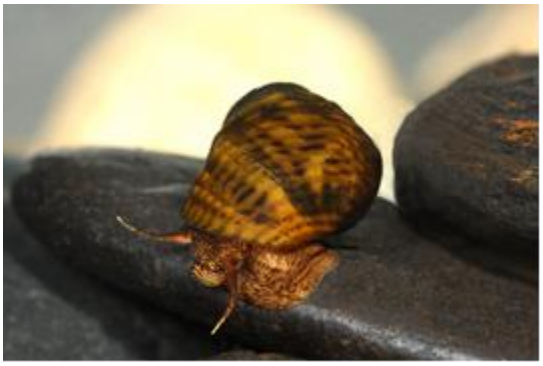

Figure 3. Interrupted Rocksnail *Leptoxis foremani* (Lea 1843).

Photo courtesy, Thomas Tarpley, Alabama Department of Conservation and Natural Resources

Life History and Habitat Needs

Rocksnails (Pleurocera spp.) live in shoals, riffles, and reefs (bedrock outcrops) of medium to large rivers of Eastern North America to the Rockies. Their habitats are generally subject to moderate currents during low flows and strong currents during high flows. The interrupted rocksnail lives attached to bedrock, boulders, cobbles, and gravel and tend to move slowly, except in response to changes in water level (Figure 4). They lay their adhesive eggs within the same habitat (Johnson 2004). In a hatchery setting, mean clutch size for 2 year old interrupted rocksnails was around 8.83 (3 – 18 eggs/clutch), and clutch size of females 3+ years was 13.63 (2-21 eggs/clutch) (Figure 4) (Johnson *in litt.* 2009). Interrupted rocksnails are currently found in shoal habitats with sand-boulder substrate, at water depths less than 50 centimeters (cm) (20 in), and in water currents less than 40 cm/second (sec) (16 in/sec) (Johnson 2004). We know little of the life history of pleurocerid snails; however, they are considered generalist scrappers and generally feed by ingesting

periphyton (algae attached to hard surfaces) and biofilm detritus scraped off of the substrate by the snail's radula (a horny band with minute teeth used to pull food into the mouth) (Morales and Ward 2000). Interrupted rocksnails have been observed grazing on silt-free gravel, cobble, and boulders (Johnson 2004). They have survived as long as 5 years in captivity (Johnson *in litt.* 2006a).

Figure 4. Interrupted rocksnails attached to cobble-sized substrate (left). Rocksnails laying adhesive eggs in a spiral pattern (below).

Photos courtesy of Paul Johnson, Alabama Department of Conservation and Natural Resources

Distribution and Trends

The interrupted rocksnail was historically found in colonies on reefs and shoals of the Coosa River and several of its tributaries in Alabama and Georgia (Figure 5). The range of the rocksnail formerly encompassed more than 800 km (500 mi) of river and stream channels, including the Coosa River (Coosa, Calhoun, Cherokee, Elmore, Etowah, Shelby, St. Clair, and Talladega Counties), Lower Big Canoe Creek (St. Clair County), and Terrapin Creek (Cherokee County) in Alabama; and the Coosa and Lower Etowah Rivers (Floyd County), the Oostanaula River (Floyd and Gordon Counties), the Coosawattee River (Gordon County), and the Conasauga River (Gordon, Whitfield, and Murray Counties) in Georgia (Goodrich 1922, Johnson 2004, FLMNH *in litt.* 2006).

Snail surveys conducted within the historical range of the interrupted rocksnail (Bogan and Pierson 1993a, Williams and Hughes 1998) resulted in the collection of only a single live specimen from the Oostanaula River, Floyd County, Georgia, during 1997 (Williams and Hughes 1998). Intensive surveys of the Oostanaula, Coosa, Coosawattee, Etowah, and Conasauga Rivers since 1999 have located the species in about 12 km (7.5 mi) of the Oostanaula River upstream of the Gordon–Floyd County line (Johnson and Evans 2000, Johnson and Evans 2001). A captive colony was maintained at the Tennessee Aquarium Research Institute (TNARI) from 2000 through 2005 for study and propagation. In coordination with TNARI and the Service, the Alabama Department of Conservation and Natural Resources (ADCNR) developed a plan and strategy to reintroduce interrupted rocksnails from the TNARI colony into the Coosa River above Wetumpka, Elmore County, Alabama (ADCNR 2003). In 2003, 2004, and 2005, approximately 3,200, 1,200, and 3,000 juvenile snails, respectively, from the TNARI culture were released into the Lower Coosa River (ADCNR 2004; Johnson *in litt.* 2005a). In 2005, ADCNR established the Alabama Aquatic Biodiversity Center (AABC) at the Marion State Fish Hatchery for the culture of imperiled mollusk species, and the interrupted rocksnail TNARI colony was transferred to that facility.

Following its rediscovery, the interrupted rocksnail population size on shoals in the Oostanaula River declined from a high of 10 to 45 snails per square meter (m^2) (1.2 square yards (yd^2) in 1999 (Johnson and Evans 2001) to only 20 snails found during 6 search-hours in 2004 (Johnson *in litt.* 2003, 2004). The cause of decline was suspected to be some form of water contamination (Johnson *in litt.* 2003, 2004; Hartfield *in litt.* 2006). A July 2006 search for adults to use as hatchery stock failed to locate any rocksnails in more than 2 search-hours (Hartfield *in litt.* 2006). However, a subsequent search in August 2006 under lower flow conditions resulted in the collection of 89 snails in 4 search-hours at one shoal, and 2 rocksnails in 4 search-hours at another shoal (Johnson *in litt.* 2007a). In 2010, Dinkins (G. Dinkins, pers. comm.) reconfirmed that the rocksnail population continues to exist in the Oostanaula River downstream of the confluence of Armuchee Creek, and also reported a limited number of rocksnails approximately 2 miles (3.2 km) further downstream – representing a range extension for the species.

Since their reintroduction into the Lower Coosa River of Alabama, a few of the 2003 hatchery-cultured interrupted rocksnails were observed in the vicinity of the release site in

2004 (Johnson *in litt.* 2005c). An alternative site was selected for release in August 2005, and 18 snails were located 3 months following release (Pierson *in litt.* 2005). During a 40-minute search of this release area in 2006, two interrupted rocksnails were found (Johnson *in litt.* 2007b). Observations of only small numbers of reintroduced snails may be due to habitat size and dispersal, low fecundity of the species, predation, reproductive failure due to dispersal, or habitat disturbance (Johnson *in litt.* 2005b).

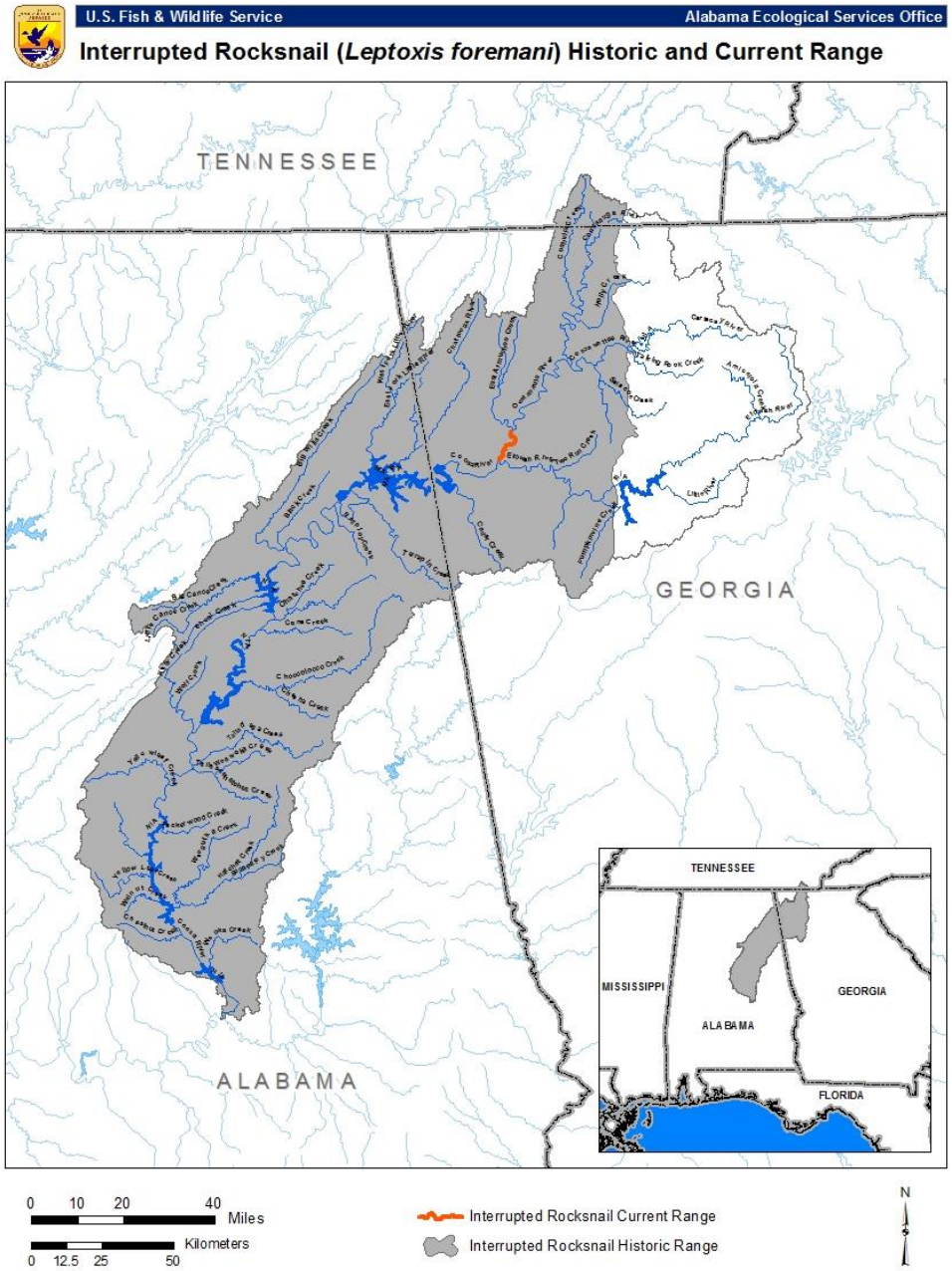

Figure 5. Historical and current distribution of the interrupted rocksnail.

Critical Habitat

Critical habitat was designated concurrently with listing on November 2, 2010 (75 FR 67512, USFWS 2010) and includes the following three units:

- Unit IR 1: Coosa River, 11 km (7 mi), Cherokee County, Alabama.
- Unit IR 2: Oostanaula River, 77 km (48 mi), Gordon and Floyd County, Georgia.
- Unit IR 3: Lower Coosa River, 13 km (8 mi), Elmore County, Alabama.

***Rough Hornsnail (Pleurocera foremani* (Lea 1843))**

Status

The rough hornsnail was listed as endangered on November 2, 2010 (75 FR 67512, USFWS 2010). Critical habitat was designated at the time of listing.

Taxonomy

The rough hornsnail's (*Pleurocera foremani*) shell is elongated, pyramidal, and thick. Growing to about 33 mm (1.3 in) in length, the shell has as many as nine yellowish-brown whorls (Figure 6). The aperture is elongated, angular, channeled at the base, and usually white nacre. The presence of a double row of prominent nodules or tubercles on the lower whorls above the aperture is the most distinctive feature that separates it from other hornsnails (Tryon 1873). These tubercles, along with the size and shape of the shell, distinguish the species from all other pleurocerid snails (*Elimia* spp., *Leptoxis* spp., *Pleurocera* spp.) in the Mobile River Basin. In a hatchery setting, however, the distinctive double row of tubercules do not appear until the second year of life (5-7 mm shell width) (Johnson *in litt.* 2009).

The rough hornsnail is a member of the aquatic snail family of Pleuroceridae. The species was described in 1843 by Lea as *Melania foremanii* (=*foremani*) (Tryon 1873). It was later placed in the genus *Pleurocera* by Tryon (1873), who noted that *P. foremani* closely resembled species of that genus. Goodrich (1935) reported a variation of a species of *Pleurocera* in the Cahaba River that resembled *foremani*, but later identified that variant as a "mutation" or form of brook hornsnail (*P. vestitum*) (Goodrich 1941). Goodrich (1944) considered that the Coosa River *P. foremani* might also be eventually found to be simply a variant of smooth hornsnail (*P. prasinatum*), another more widely distributed species in the Coosa River.

In a recent dissertation on the systematics of the Mobile River Basin *Pleurocera*, the rough hornsnail was found to be both morphologically and genetically distinct from other species in the genus (Sides 2005). This analysis also found that the rough hornsnail was genetically more closely allied to a co-occurring species in the genus *Elimia*, and concluded

that it should be recognized as *Elimia foremani* (Sides 2005). This association was also recognized by Whelan (2013); however, proper classification is contingent on a complete review of the family, Pleuroceridae. Therefore, for the purposes of this recovery plan, we will continue to use currently recognized nomenclature for the rough hornsnail (*Pleurocera foremani*).

Figure 6. Rough Hornsnail, *Pleurocera foremani* (Lea 1843).

Photo courtesy of Thomas Tarpley, Alabama Department of Conservation and Natural Resources

Life History and Habitat Needs

Rough hornsnails are primarily found on gravel, cobble, bedrock, and mud in moderate currents. They have been collected at depths of 1 m (3.3 ft) to 3 m (9.8 ft) (Hartfield 2004). The species appears to be very tolerant of silt deposition. Little is known regarding the life history characteristics of this species. Snails in the genus *Pleurocera* generally lay their eggs in a spiral arrangement on smooth surfaces (Sides 2005), whereas *Elimia* snails generally lay eggs in short strings (P. Johnson pers. comm. 2006). Although some attempts to induce rough hornsnails to lay eggs in captivity have been unsuccessful (Sides 2005), others have observed females laying eggs individually or in short "strips" (3-10 eggs) during late April into July (Johnson *in litt.* 2009) (Figure 7). Cultured rough hornsnails have become reproductively active in their 2nd year (Johnson *in litt.* 2009). Some adult individuals collected from the wild have survived in captivity for 3 years, suggesting a life span of 4 to 5 years in the wild (Garner *in litt.* 2009, Johnson *in litt.* 2009).

Figure 7. Uncharacteristic of most Pleurocerid snails, the rough hornsnail lays eggs in "strips" (top). Typical spiral pattern of most Pleurocerid species – e.g., *Pleurocera prasinata*, which is sympatric with the rough hornsnail (bottom left). Elimia species, like *Elimia hydei* in the Locust Fork Of the Black Warrior, lays eggs in strips similar to the rough hornsnail (bottom right) (P. Johnson, pers comm., 2012).

Photos courtesy of Paul Johnson, Alabama Department of Conservation and Natural Resources.

Distribution and Trends

The rough hornsnail is endemic to the Coosa River system in Alabama. Goodrich (1944) described the historical range as the Coosa River downstream of the Etowah River and at the mouths of a few tributaries. The Etowah River enters the Coosa River in Floyd County, Georgia; however, there are no known museum or site-specific records of the rough hornsnail that validate its range into the state of Georgia (Johnson *in litt.* 2006a). Historical museum records of the rough hornsnail in the Coosa River (FLMNH *in litt.* 2006, and elsewhere) indicate that the species occurred in Etowah, St. Clair, Shelby, Talladega, and Elmore

Counties, Alabama, a historical range of approximately 322 river km (200 river miles). There are also historical museum records of this species from nine Coosa River tributaries in Alabama, including Big Wills Creek in Etowah County; Kelly, Big Canoe, and Beaver Creeks in St. Clair County; Ohatchee Creek, Calhoun County; Choccolocco and Peckerwood Creeks in Talladega County; Yellowleaf Creek, Shelby County; and Yellow Leaf Creek in Chilton County (FLMNH *in litt.* 2006).

Until the fall of 2013, the rough hornsnail was only known from two locations: lower Yellowleaf Creek in Shelby County, Alabama; and the lower Coosa River below Wetumpka Shoals in Elmore County, Alabama (Figure 8). However, during the fall of 2013, Mr. Bob Winters (retired-Carnegie Museum of Natural History) reported what appeared to be rough hornsnails from lower Weogufka Creek in Lay Lake. Upon closer examination, Dr. Paul Johnson confirmed that the animals collected by Mr. Winters were in fact rough hornsnails. This new record resulted in the subsequent records of two additional populations (Powell pers. obsv. 2013): lower Walnut Creek in Chilton County, Alabama and lower Hatchet Creek in Coosa County, Alabama. This makes a total of five known populations of the rough hornsnail.

There were also museum records of the species from Wetumpka Shoals in the early 1990s (FLMNH *in litt.* 2006); however, the species has not been collected from this shoal reach in since that time (Johnson 2002). Until 2006, the rough hornsnail was only known from about a 50-m (55-yd) length of the stream, and at densities of 8 to 32 m^2 (1.2 yd^2) (Pierson *in litt.* 2006). Following publication of the proposed rule (74 FR 31114), an intensive survey of Yellowleaf Creek extended the range of rough hornsnails to about 1.6 km (1 mi) upstream of the previously known site (Powell *in litt.* 2009).

The population in the lower Coosa River downstream of Wetumpka Shoals is confined to two discrete areas (Hartfield pers. obsv. 2001, Crow *in litt.* 2008). No quantitative estimates have been made at these sites; however, at one site densities were estimated at 300 to 400 individuals (Crow *in litt.* 2008). Until the 2013 confirmed records in Hatchet, Walnut, and Weogufka creeks, numerous searches of unimpounded reaches of the Coosa River and the lower portions of tributaries to the Coosa had failed to locate any hornsnails (Bogan and Pierson 1993a, Garner, pers. comm. 2005, Hartfield *in litt.* 2006).

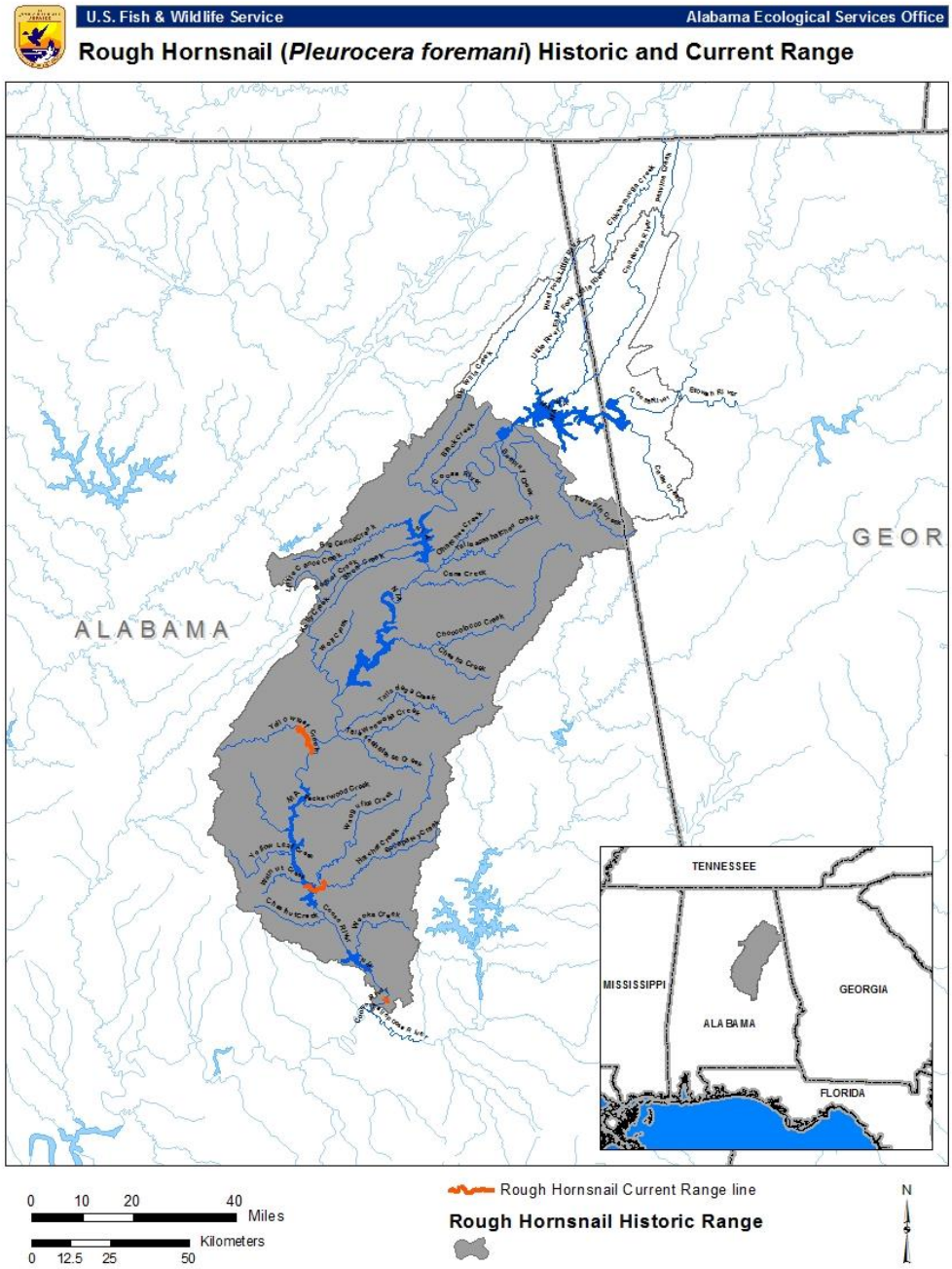

Figure 8. Historical and current distribution of the rough hornsnail.

Critical Habitat

Critical habitat was designated concurrently with listing on November 2, 2010 (75 FR 67512, USFWS 2010) and includes the following two units:

- Unit RH 1: Lower Coosa River, 21 km (13 mi), Elmore County, Alabama.
- Unit RH 2: Yellowleaf Creek, 6.4 km (4 mi), Shelby County, Alabama.

REASONS FOR LISTING/THREATS ASSESSMENT

Below, we present a summary of threats affecting the Georgia pigtoe, interrupted rocksnail, and rough hornsnail and their habitats. A detailed evaluation of factors affecting the species can be found in the listing determination and critical habitat designation (75 FR 67512, November 2, 2010). Primary concerns for each of the three species are related to extreme curtailment of habitat and range, small population sizes, and their resulting vulnerability to natural or human induced catastrophic events

Range Curtailment

All three species have experienced significant curtailment of their occupied habitats. The Georgia pigtoe has been eliminated from more than 90 percent of its historical range of 480 river km (298 river mi). It now inhabits only 43 river km (27 river mi). Interrupted rocksnail has been eliminated from 99 percent of a historical range of 800 river km (497 river mi), and is now known from 12 river km (7 river mi). The rough hornsnail has disappeared from more than 95 percent of a historical range of 321 river km (199 river mi) and now occurs in less than 1 river km (0.6 river mi). The primary cause of range curtailment for all three species has been modification and destruction of river and stream habitats, primarily by the construction of large hydropower dams on the Coosa River. This was compounded by fragmentation and isolation of the remaining free-flowing portions of the Coosa River and its tributaries, as well as their increased vulnerability to local historical events of water quality and habitat degradation.

Dams and Impoundments

The Georgia pigtoe, interrupted rocksnail, and rough hornsnail are all endemic to the Coosa River system. The Coosa River was impounded by six major dams constructed between 1928 and 1966. Today, more than 60 percent of the Coosa River and its 19 largest tributaries are inundated or affected by flow regulation (Marcinek *et al.* 2005).

Dam construction on the Coosa River had a secondary effect of fragmenting the ranges of aquatic mollusk species, leaving isolated habitats and relict populations separated by the dams as well as by extensive areas of uninhabitable, impounded waters. These isolated populations were left more vulnerable to, and affected by, natural events (such as droughts), runoff from common land-use practices (such as agriculture, mining, urbanization), discharges (such as municipal and industrial wastes), and accidents (such as chemical spills) that reduced population levels or eliminated habitat (Neves *et al.* 1997, U.S. Fish and Wildlife Service 2000).

Water and Habitat Quality

The disappearance of shoal populations of rough hornsnail, interrupted rocksnail, and Georgia pigtoe from unimpounded habitats in the Coosa River drainage is likely due to

historical pollution problems. Pleurocerid snails and freshwater mussels are highly sensitive to water and habitat quality (Havlik and Marking 1987, Neves *et al.* 1997). Historical causes of water and habitat degradation in the Coosa River and its tributaries included drainage from gold mining activities, industrial and municipal pollution events, and construction and agricultural runoff (for example, Hurd 1974, Lydeard and Mayden 1995, Freeman *et al.* 2005).

Climate Change

Small population sizes and limited distribution of the Georgia pigtoe, interrupted rocksnail, and rough hornsnail, make them more vulnerable to drought, severe storm events, and other potential effects of climate change. There is a growing concern that climate change may lead to increased frequency of severe storms and droughts (for example, Golladay *et al.* 2004, McLaughlin *et al.* 2002, Cook *et al.* 2004). During 2007-2008, a severe drought affected the Coosa River watershed in Alabama and Georgia. Streamflow for the Conasauga River at Tilton, Georgia, during September 2007, was the lowest recorded for any month in 69 years (U.S. Geological Survey 2007). Although the effects of the drought on the Georgia pigtoe, interrupted rocksnail, and rough hornsnail have not been quantified, mollusk declines as a direct result of drought have been documented (for example, Golladay *et al.* 2004, Haag and Warren 2008). Reduction in local water supplies due to drought is also compounded by increased human demand and competition for surface and ground water resources for power production, irrigation, and consumption (Golladay *et al*. 2004). Small population sizes and limited distribution of the Georgia pigtoe, interrupted rocksnail, and rough hornsnail, make them more vulnerable to drought and storm events.

ONGOING CONSERVATION EFFORTS

For more than 20 years, the Service has been working with State (AL, TN, and GA), non-governmental organization (NGO), and university biologists to locate extant populations of endemic fauna, including the Georgia pigtoe, interrupted rocksnail, and rough hornsnail, and to identify and restore their habitats. This has resulted in multiple projects on private lands as well as multiple outreach efforts (e.g., Coosa/Conasauga River Summit meetings in Georgia). In 1998, the Service began working with mollusk experts at the Tennessee Aquarium to develop life history information on imperiled mollusks and husbandry technology. During the following years, this evolved into a collaborative effort with the Alabama Department of Conservation and Natural Resources (ADCNR), World Wildlife Fund, The Nature Conservancy (TNC) and other partners to initiate propagation and reintroduction trials for several species. In 2003, following initial successes with several species, including the interrupted rocksnail and plicate rocksnail, ADCNR began to develop the Alabama Aquatic Biodiversity Center (AABC) at the State's Marion Fish Hatchery. In 2008, construction was completed, and the AABC is now a fully operational state-of-the-art facility dedicated to research, husbandry, management, and recovery of imperiled aquatic species. Since 2010, the mussel and snail culture facilities have been completed and in 2014, construction of a fish culture facility was initiated. Captive colonies of interrupted rocksnail and rough hornsnail are currently maintained in the AABC facility.

Concurrent with the development of husbandry technology and the AABC facility, the Mobile River Basin Mollusk Restoration Committee was formed to develop a basic plan and framework for the restoration of freshwater mollusk resources and their ecological functions to appropriate reaches of the Mobile River Basin through controlled propagation and reintroduction extirpated mollusk populations. The Committee is composed of representatives of the ADCNR, Geological Survey of Alabama (GSA), TNC, U.S. Geological Survey (USGS), University experts, and the Service. A Plan for the Population Restoration and Conservation of Freshwater Mollusks of the Mobile River Basin (Propagation Plan) was finalized in 2010 (Mobile River Basin Mollusk Restoration Committee 2010).

Following the finalization of the Mollusks Plan, a Strategic Habitat Conservation Plan for Mollusks of the Mobile River Basin (Strategic Plan) was also developed by the Service and partners to facilitate habitat assessment, restoration, and protection (USFWS 2008). The Strategic Plan identified 26 strategic habitat units (SHUs) that are believed to support more than 90 percent of the endemic mussels, aquatic snails, and fishes of the Basin, including most listed mussel, snail, fish, and reptile species, as well as most aquatic species currently considered imperiled or species of concern. These SHUs encompass the critical habitat units identified for the Georgia pigtoe, interrupted rocksnail, and rough hornsnail. Efforts are now in progress to characterize, protect, and monitor all SHUs, and to identify appropriate sites and conditions for reintroduction of imperiled species.

In 2012, the Service completed a formal Section 7 consultation and Biological Opinion for the Federal Energy Regulatory Commission (FERC) and the Alabama Power Company (APC) for the re-licensing of seven of APC's hydropower dams on the Coosa River (USFWS 2012). This consultation produced several key conservation measures that will benefit the conservation and recovery of the Georgia pigtoe, interrupted rocksnail, and rough hornsnail. These include: 1) restoration of a natural flow regime in the Weiss Bypass. This 21-mile section of the Coosa River has not experienced an ecologically beneficial flow since the early 1960s. 2) Enhancements to dissolved oxygen (DO) levels and flows below Logan Martin Dam. An adaptive management plan is under development to evaluate flows and DOs based on the response of the organisms downstream of the dam. 3) Improvements to drought operations. This will primarily affect fluctuating water levels in the Coosa River below Jordan Dam and Yellowleaf Creek, a tributary to Lay Lake and the most important known habitat for the rough hornsnail. 4) Also resulting from the FERC re-licensing was a settlement agreement that will provide a significant level of funding for aquatic habitat restoration, and to the AABC for culturing of imperiled aquatic species (including the Georgia pigtoe, interrupted rocksnail, and rough hornsnail). This funding will be available annually during the 30 year license.

PART II: RECOVERY

Recovery Strategy

Over the last 75 years, the Coosa River Basin has been converted from a free-flowing water continuum to a scattered collection of isolated stream segments, some of which now function as refugia for imperiled mollusks. Conservation and recovery of the Georgia pigtoe, interrupted rocksnail, and rough hornsnail will require human intervention. It is known that human activities, human population numbers, and associated impacts will increase within drainage watersheds. Therefore to recover these species, it is essential to characterize and monitor aquatic habitats on a watershed scale, and respond to changing conditions rapidly through negotiation and partnerships to alleviate threats, and/or through relocation or husbandry and reintroduction of endangered species populations to appropriate areas. This approach will require monitoring extant populations of the Georgia pigtoe, interrupted rocksnail, and rough hornsnail, and characterizing current conditions within designated critical habitat units and their watersheds, along with routine periodic monitoring of habitat conditions.

Recovery Objectives

The recovery objectives over the next decade are to work to reduce threats in order to downlist the interrupted rocksnail and rough hornsnail to threatened status, and to protect the Conasauga River population of the Georgia pigtoe and prevent extinction of the species. Defining reasonable delisting criteria is not possible at this time given the current low number of populations and individuals, lack of information about the species' biology, and magnitude of threats. Therefore, this recovery plan establishes downlisting criteria for the two snails so they may be downlisted to threatened status. Criteria will be reevaluated as new information becomes available. We are not establishing downlisting or delisting criteria at this time for Georgia pigtoe, instead we are identifying preliminary measures to help us prevent its extinction until we can obtain further information on this species and determine recovery criteria for this animal.

Recovery Criteria

Downlisting of the interrupted rocksnail and rough hornsail will be considered when:

1. Protect and manage at least three geographically distinct populations for each species [To achieve this criterion, the populations can include the Oostanaula for the interrupted rocksnail and Yellowleaf Creek and Lower Coosa River for the rough hornsnail];

2. Achieve demonstrated and sustainable natural reproduction and recruitment in each population for each species as evident by multiple age classes of individuals, including naturally recruited juveniles, and recruitment rates exceeding mortality rates for a period of five years;

3. Develop and implement habitat and population monitoring programs for each population.

Recovery criteria for the Georgia pigtoe will be developed after we complete critical recovery actions and gain a greater understanding of the mussel species. In the interim, we identify the following actions that are necessary to help prevent the extinction of this animal:

1. Maintain and where possible conduct efforts to improve the Conasauga River population of the Georgia pigtoe;
2. Develop and implement a monitoring plan to evaluate population size in response to management actions;
3. Develop a captive propagation program and establish an ark population to help support the Conasauga River population of the Georgia pigtoe;
4. Conduct research, like identification of an appropriate fish host, that is important to gain better understanding of this mussel's life history; and
5. Identify, monitor, and where possible improve potential reintroduction sites in the historical range of the Georgia and reintroduce the species into these habitats.

All recovery tasks identified in the *Recovery Narrative*, below are necessary to successfully address these criteria and benchmarks.

Listing/Recovery Factor Criteria

The following criteria (Factors A through E) apply to all three species, and are linked to specific recovery tasks and will serve to measure progress in removing threats to the species.

<u>Factor A: The present or threatened destruction, modification, or curtailment of its habitat or range.</u>

1. Remaining riverine habitat currently known for each species has been monitored and protected. Recovery Tasks 1.1, 1.2, 1.3, 1.41- 1.45, 2.1, 2.2, 3.1, and 3.2 will contribute to this criterion.
2. Although critical habitat was designated at the time of listing, there is still considerable information we do not know about the life history and specific habitat requirements for these species. Critical research and monitoring on life history and habitat requirements has been implemented. Recovery Tasks 1.1, 4.0, 5.1, 5.3, 5.4.1, and 5.42 will contribute to this criterion.
3. The range of each species includes three or more distinct drainages. This includes those locations where the species is known to occur. Recovery Tasks 7.1, 7.2, and 7.3 will contribute to this criterion.

Factor B: Overutilization for commercial, recreational, scientific, or educational purposes.

Overutilization is not currently a threat to any of the three species.

Factor C: Disease or predation.

There are no known threats to any of these species due to disease. There is no direct evidence at this time that predation is detrimentally affecting the Georgia pigtoe, interrupted rocksnail, or rough hornsnail. However, increasing their population sizes and ranges will reduce their vulnerability to threats of predation from natural or introduced predators. This is addressed under Factor A, above, and E, below.

Factor D: The inadequacy of existing regulatory mechanisms**.**

Under the consultation requirements of the Endangered Species Act, existing regulatory mechanisms (e.g., the Clean Water Act and associated State Laws, Rivers and Harbors Act, etc.) afford consideration of the species when projects are reviewed. Information derived under Recovery Tasks 1.2, 1.3, 1.4.1-1.4.5, 2.1, and 2.2 will facilitate these consultations.

Factor E: Other natural or manmade factors affecting its continued existence.

All threats affecting the Georgia pigtoe, interrupted rocksnail, or rough hornsnail, are influenced by their small population sizes and limited ranges. The following criteria shall serve to indicate a reduction in this threat:

1. Successful hatchery/captive propagation programs have been established for each species. Recovery Task 6.0 is essential to this criterion.

2. The range of each species has been extended to three or more distinct drainages. Recovery Tasks 7.1, 7.2, and 7.3 will contribute to this criterion.

3. Sustainable natural reproduction and recruitment has been demonstrated in each population. Recovery tasks 1.1, 2.1, 2.2, 3.1, 3.2, and 7.3 address this criterion.

Recovery Narrative

The following recovery outline and tasks were developed to be consistent with the overall strategy of the Recovery Plan for Mobile River Basin Aquatic Ecosystem (USFWS 2000), although these tasks are specifically to the Georgia pigtoe, interrupted rocksnail, and rough hornsnail.

1 Protect these three mollusks by protecting habitat integrity and quality of river and stream segments that currently support or could support populations. Stemming the decline and loss of instream aquatic habitats throughout the known ranges of the GIPR is essential for maintenance and management of the species. River and stream reaches known to be occupied by endangered or threatened aquatic species are generally protected by provisions of the Endangered Species Act from projects and actions that

would adversely affect instream habitats. However, some stream and river reaches within the historical ranges of the Georgia pigtoe, interrupted rocksnail, and rough hornsnail may be, or can become suitable for eventual reintroduction of the appropriate species. Providing a higher degree of consideration for such areas will maintain and protect options that could be essential for the successful management of isolated populations within a fragmented ecosystem. Regulatory agencies, municipalities, businesses and industries, and private land owners should thoroughly consider and apply creative alternatives to habitat modification, waste disposal, and other impacts to streams within the historical ranges of the species, even if they have been extirpated. The key to successful recovery planning that minimizes impacts to both listed species and stakeholders is vigilant monitoring and management of remaining instream habitats through informed participation by all stakeholders.

1.1 Protect the Oostanaula River, Yellowleaf Creek, Consauga River, and Lower Coosa River and identify other stream and river reaches that could be restored to support these species. Identification brings recognition of special protection needs. River and stream reaches that historically supported these species should be recognized by regulatory agencies and given appropriate consideration to mitigate (i.e., avoid, minimize, or compensate for) adverse impacts.

1.2 Minimize instream impacts resulting from activities or permits conducted or issued by regulatory authorities. Major habitat modifications that have had the most serious impacts on the Georgia pigtoe, interrupted rocksnail, and rough hornsnail have been either constructed or authorized by Federal and/or State regulatory agencies. Such modifications in the future for flood control, navigation, water supply, mining, hydropower, etc., must be fully considered for need and alternatives. Practical alternatives such as purchasing riparian easements, implementing best management practices (BMPs), protection of headwater wetlands, etc., should be used where and when appropriate. All construction activities permitted or conducted by Federal, State, County, or other local regulatory authority within the historical ranges of the Georgia pigtoe, interrupted rocksnail, and rough hornsnail should effectively implement Best Management Practices (BMPs) for stormwater runoff and sediment control.

1.3 Work with States under the Triennial Review Process to ensure water quality standards and classifications provide for species survival and recovery. In many streams and rivers within the range of these three species, physical habitats remain adequate; however, water quality degradation has caused the extirpation of the species (e.g., historical low levels of oxygen below some Coosa River reservoirs). Although measures taken to improve water quality over the past three decades have generally been effective, in some stream segments they have been overwhelmed by local increases in urban and agricultural runoff, and/or industrial and municipal discharges. Protection of water quality into the future will require adherence to current standards and regulations. In some cases,

changes of the standards and criteria may be necessary. State water quality classifications, waste load allocation models, permit review processes, and other important water quality actions should be revised where appropriate studies have identified and quantified inadequacies.

1.4 Promote and support a watershed management approach to water quality. A watershed management approach synchronizes water quality monitoring, inspections, and permitting within a defined watershed. It has the potential of integrating imperiled species habitat concerns with all other water quality issues, including economic and human health, within the defined watershed. Such an approach allows a greater degree of public education about, and involvement with, local water quality issues and decisions. It may prove useful in providing community incentive to reduce nonpoint source impacts to water quality.

1.41 Develop coordinated plans to address sanitary wastewater treatment plant effluents within densely populated watersheds. Sanitary wastewater treatment plant effluents are a major contributor to stream eutrophication, particularly in urban areas (e.g., Conasauga, Coosawattee rivers). Some wastewater treatment plants may need to be upgraded as necessary to protect aquatic resources.

1.42 Encourage alternative disinfection measures for the treatment of sewage wastes in sensitive watersheds. Residual chlorine and certain other wastewater components resulting from disinfectant procedures are toxic to aquatic organisms. There may be adverse long-term impacts from these diluted discharges on the survival and reproduction of the Basin's endemic aquatic fauna. The nature and extent of such impacts are currently unknown. However, many listed and imperiled aquatic species have disappeared from receiving stream reaches. Alternative disinfectant techniques, such as treatment with ultraviolet radiation, ozone. etc., are available and should be considered for use in sensitive watersheds (i.e., Conasauga, Oostanula rivers).

1.43 Encourage compliance with current water quality discharge limitations and regulations. Current State and Federal enforcement programs should ensure consistent compliance with conditions and discharge limitations. Regulated industrial, sewage treatment plant, permitted discharges, and stormwater runoff should be monitored with sufficient frequency to encourage compliance with water quality standards. Unpermitted discharges should be identified and brought into compliance. Increased public involvement and attention to watershed conditions may provide opportunities for community based monitoring.

1.44 Encourage effective sediment control from all construction activities. Uncontrolled sediments from temporary and permanent ground disturbing activities (e.g., construction sites, unpaved roads, agricultural and silvicultural activities) contribute to river and stream degradation. Excess

sediments may smother stream bottom habitats and/or result in erosion and other channel changes. Such activities should be encouraged to use and maintain effective sediment control techniques and dispose of excess sediments such that these materials will not eventually reach surface waters.

1.45 Encourage consideration of standards for water withdrawal and water conservation from streams within the historical range of these species. Water withdrawal from streams for irrigation and other uses severely affects some streams in the Coosa Basin during low flow periods. Surface water demands for domestic, industrial, and irrigation purposes will likely continue to increase. Identifying and adopting ecologically sustainable flow standards applicable to water withdrawals will protect aquatic resources and communities, encourage consideration of alternative technology, and reduce future conflicts.

2.0 Promote voluntary stewardship as a practical and economical means of reducing nonpoint pollution from private land use. BMPs can be effective and practical actions identified to prevent or reduce nonpoint pollution from specific land use activities (ADEM 1989, MSDEQ 1994). For example, agricultural BMPs are designed to reduce sediments, animal wastes, fertilizers, and pesticides in stormwater runoff (Benthrup 2008). Mining BMPs address sediments and water quality parameters such as acidity and metal concentrations (e.g., ADEM 1989). Silviculture BMPs include actions to minimize sediments, nutrients, organics, chemicals, and stream canopy removal (MFA 1989, AFC 1993). BMPs are also available for urban, construction, and homeowner activities that address stormwater runoff quality and quantity (ASWCC 1992, MSDEQ 1994). BMPs are developed by State and industry planning partnerships with public participation, and can be effective when they are properly implemented and adequately maintained. BMPs, however, are not always fully implemented or maintained. Industry groups and organizations, and State resource agencies should continue to promote and improve BMPs when necessary as a non-regulatory approach to aquatic habitat management.

2.1 Work with State and private partners to promote land and water stewardship awareness within the historical ranges of these species. Local offices of State and Federal agencies and private organizations can become a primary source of encouragement and information for imperiled species and aquatic ecosystem management. For example, local offices (e.g, Soil and Water Conservation Districts, Natural Resources Conservation Service, State Forestry Commissions, private industry groups, environmental groups, etc.) can identify watersheds with listed species within their areas; inform local landowners of listed species presence, needs, and special management concerns; recommend appropriate BMPs; and mediate landowner concerns or conflicts with appropriate State and/or Federal agencies. In some watersheds, standard BMPs may need to be adjusted according to stream size, soil conditions, and land use intensity. Private industry groups can work with local

landowners to customize BMPs where needed to address watershed problems and practices.

2.2 Encourage the development and implementation of adequate Streamside Management Zones (SMZs) along all streams and rivers within the historical ranges of these species. Properly designed SMZs, acting as filter strips, can buffer the impacts of land use activities on water and stream bottom habitat quality. SMZs protect public and private property from erosion, reduce downstream sedimentation, and enhance fish and wildlife values for both game and nongame species. SMZs can also reduce nutrient levels in tributary streams in the Basin, which will help control eutrophication in Basin reservoirs. Some farmlands adjacent to streams and rivers may qualify for SMZ assistance through the U.S. Department of Agriculture's Farm Bill Program. SMZs are widely recognized as cost effective habitat management practices. For example, the American Forest and Paper Association's Sustainable Forestry Initiative requires its members to meet or exceed existing SMZ state standards. SMZs may be custom designed to protect stream habitat while achieving individual landowners management objectives. For example, the Natural Resources Conservation Service recommends SMZs from 22-91 meters (50-300 feet), with varying restrictions, depending on soil, slope, topography, and land use. Other government agencies and private groups make similar recommendations. SMZs are also effective in controlling urban and suburban stormwater runoff.

3.0 Encourage and support community based watershed stewardship planning and action within the historical ranges of these species. Protection**,** restoration, and management planning for imperiled aquatic habitats is best accomplished by partners and stakeholders within a watershed. Such grassroots community planning educates participants about aquatic species, their habitat needs, and sensitivities; acknowledges local activities, problems, and their effects on water; and leads to buy-in to local solutions. Stewardship partnerships are essential in watersheds supporting listed or other imperiled aquatic species, and should be encouraged within any of the Basin's watersheds. Resource and regulatory agencies should offer support, materials, and technical and facilitation assistance when requested. One such organization, the Alabama Rivers and Streams Network (Network), already has the private/government representation needed to define, plan, prioritize, facilitate, and implement recovery tasks at the Basin, drainage, and watershed levels. Members of the Network can provide institutional, technical, and fiscal support as appropriate to accomplish recovery objectives.

3.1 Coordinate stream habitat and restoration and management actions within the historical ranges of these species. The above recovery tasks approach encourages stream habitat restoration and management on three

levels: Federal and State regulations; private activities, public education and involvement; and research. Implementation of these tasks will involve multiple partners including State and Federal agencies, municipal and county governments, environmental and recreational organizations, civic groups, educational and research institutions, business and industry groups, landowners, and interested individuals. Successful implementation requires development of partnerships, coordination of on-going activities, determination and prioritization of needed actions, and monitoring recovery progress the species historical ranges.

3.2 Work with private landowners to help identify potential or perceived issues with actions that contribute towards the recovery of these species. Landowners and other watershed inhabitants may feel threatened by the presence of listed aquatic species, and be reluctant to participate in watershed stewardship planning or action. In such cases, informal Memorandum of Understandings, Candidate Conservation Agreements, Safe Harbor Agreements, or other innovative avenues to assure and guarantee private land uses within watersheds may be considered.

4.0 Develop and implement programs and materials to help educate the public on the need and benefits of ecosystem management, and to involve them in watershed stewardship to protect these listed species.
Only an informed and proactive public can bring about ecosystem stabilization and rehabilitation. Successful species and habitat management and recovery will require public involvement, monitoring, and commitment of resources. Educational materials and programs should describe the concept and need for ecosystem management, its long-term economic and environmental advantages, and public and individual stewardship responsibilities.

5.0 Conduct basic research on these species and apply the results toward their management and protection. The biology and ecology of the Georgia pigtoe, interrupted rocksnail, and rough hornsnail are poorly known. Information on habitat requirements, life stage sensitivity to contaminants, and the identification of mussel host fish for the Georgia pigtoe is essential to the recovery of the species, and to the management and protection of their communities and habitats. All partners should be aware of research efforts and results, so that information can be immediately applied.

5.1 Survey and monitor the status of existing populations of these species. Periodic surveys of occupied stream reaches, as well as those known to be historically occupied by the species, should be monitored for the status of the species, as well as of their habitats.

5.2 Conduct detailed physical and molecular genetic analyses of these species. As noted previously, these species are poorly known. Physical information, in conjunction with genetic biochemical comparisons of populations, may provide information important to population management and recovery.

5.3 Determine contaminant sensitivity for each life stage. It is known that juvenile and adult life stages of aquatic mollusks may differ in sensitivity to contaminants. The technology and methodology should be developed to determine sub-lethal and lethal levels of pesticides, herbicides, and common contaminants and discharges to the various life stages of the listed species.

5.4 Conduct life history research on these species, to include reproduction, food habits, age and growth, mortality factors, etc. Life history information may provide insight into past declines, current status of these species, weak links in the life cycle, and management guidance for their recovery.

5.41 Identify breeding periods and reproduction strategies for the three species, and the host fish of Georgia pigtoe. Most mussels are dependent upon a host fish for completion of their life cycle. Hosts for many endemic mussel species in the basin are currently unknown. Identification and protection of host fish is critical to the continued survival of the Georgia pigtoe.

5.42 Determine nutritional requirements of the life stages of these species. It is possible that the juvenile forms feed on different items than adults. Such requirements may be limiting factors in the survival of these species. Nutritional requirements must be known for successful captive propagation of the Georgia pigtoe, interrupted rocksnail and rough hornsnail (see Task 6).

6.0 Develop and implement technology for maintaining and propagating these species in captivity. Populations of the three species are isolated from potentially suitable, or restorable historical habitats by large expanses of impounded, or otherwise severely altered, river and stream reaches. Maintenance of genetic flow between extant populations, and reintroduction of species into restored habitats, will require human intervention. Populations of many species are currently too low to justify translocation of wild stock between drainages. Captive propagation will be required for recovery of these species (see Task 7). Large numbers of juveniles and adults will also be needed for research to determine sensitivity of the species to common contaminants (Task 5.3).

7.0 Reintroduce Georgia pigtoe, interrupted rocksnail, and rough hornsnail into restored historical habitats, as appropriate. This step will be possible only

when, and if, successful captive propagation technology is developed (Georgia pigtoe), or improved (interrupted and rough hornsnails). Reintroduction will be closely coordinated with appropriate State agencies and affected private landowners. No reintroduction of species should be made without the concurrence of the appropriate State wildlife resource agencies, the knowledge and consensus of adjacent landowners, and preparation of the appropriate documentation identified in the Plan for the Population Restoration and Conservation of Freshwater Mollusks of the Mobile River Basin (Propagation Plan) (Mobile River Basin Mollusk Restoration Committee 2010), prepared under the Service's policy for controlled propagation (USFWS 1999).

7.1 **Identify sites for reintroduction of these species.** Potential sites for reintroduction consist of streams within the historic ranges of the species that meet the substrate, flow, water quality, and other environmental requirements for these species (see USFWS 2010). Such sites need to be identified and monitored for suitability. This includes those with desired water quality, substrate composition, aquatic community composition, and watershed land uses should be characterized. Priority should be given to stream reaches with appropriate habitat, diverse faunal assemblages, minimal land use impacts, and active watershed management programs.

7.2 **Reintroduce these species into high priority sites.** Reintroductions should be conducted and documented in a rigorous, scientific manner, as outlined in the Restoration Plan (MRBMRC 2010).

7.3 **Monitor reintroduced populations.** Reintroduced populations of Georgia pigtoe should be monitored annually for three years beginning the third year after the release, and triennially thereafter for six years. The interrupted rocksnail and rough hornsnail should be monitored annually for three years after the release and again during year five (MRBMRC 2010).

8.0 **Periodically review the recovery progress and strategy.** The species will be monitored under Tasks 5.1 and 7.3. Changes in distribution (losses and gains), habitat quality, etc. should be used to focus recovery efforts and adjust priorities as needed.

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PART III: RECOVERY IMPLEMENTATION SCHEDULE

Recovery plans are intended to assist the Service and other stakeholders in planning and implementing actions to recover and/or protect endangered and threatened species. The following Implementation Schedule indicates task priorities; task numbers; task descriptions; task duration; potential stakeholders and responsible agencies; and estimated costs. It is a guide for planning and meeting the objectives discussed in Part II of this plan. The Implementation Schedule outlines recovery actions and their estimated costs for the first 5 years of this recovery program. Downlisting and delisting dates cannot be estimated at this time for the Georgia pigtoe. Downlisting dates have been estimated for the interrupted rocksnail and rough hornsnail. The cost estimates provided identify foreseeable expenditures that could be made to implement the specific recovery tasks during a 5-year period. **Actual expenditures by agencies and other partners is contingent upon appropriations and other budgetary constraints**.

Recovery tasks are assigned numerical priorities to highlight the relative contribution they may make toward species recovery. Priorities in column one of the Implementation Schedule are assigned as follows:

Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2 – An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

Priority 3 – All other actions necessary to meet the recovery objective.

While the ESA assigns a strong leadership role to the Service for the recovery of listed species, it also recognizes the importance of other Federal agencies, States, and other stakeholders in the recovery process. The "Responsible Agency" column of the Implementation Schedule identifies partners who can make significant contributions to specific recovery tasks. **The identification of agencies and other stakeholders within the Implementation Schedule does not constitute any additional legal responsibilities beyond existing authorities (e.g., ESA, CWA, etc.). Recovery plans do not obligate other stakeholders to undertake specific tasks and may not represent the views nor the official positions or approval of any agencies or stakeholder groups involved in developing the plan, other than the Service.**

Key to acronyms used in the Implementation Schedule

ACWP	Alabama Clean Water Partnership
ADCNR	Alabama Department of Conservation and Natural Resources, Fisheries Section
ADEM	Alabama Department of Environmental Management
ALDOT	Alabama Department of Transportation
AFC	Alabama Forestry Commission
OWR	Alabama Office of Water Resources
APC	Alabama Power Company
ASMC	Alabama Surface Mining Commission
BI	Businesses and Industries
COE	U.S. Army Corps of Engineers
ES	Ecological Services Division of the FWS
GSA	Geological Survey of Alabama
GDNR	Georgia Department of Natural Resources
FWS	U.S. Fish and Wildlife Service
NRCS	Natural Resource Conservation Service
USGS	U.S. Geological Survey/Water Resources Division
GSA	Geological Survey of Alabama
NGO	Non-governmental Organizations (The Nature Conservancy, World Wildlife Fund, National Fish and Wildlife Foundation, Alabama Rivers Alliance, Alabama Forestry Association)
R4	Region 4, U.S. Fish and Wildlife Service, Atlanta, GA
RI	Research Institutions (e.g., USGS Cooperative Research Units, Universities)
TBD	To be determined

IMPLEMENTATION SCHEDULE											
PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION	RESPONSIBLE PARTY		COST ESTIMATES ($K)					COMMENTS
				R4 FWS	Other	FY15	FY16	FY17	FY18	FY19	
1	1.1	Protect the Oostanaula River, Yellowleaf Creek, and Lower Coosa River and identify other stream and river reaches that could be restored to support these species	Continuous	ES	ADCNR, USGS, BI, RI, GDNR	10	10	10	10	10	Costs absorbed under existing programs
1	1.2	Minimize instream impacts resulting from activities or permits conducted or issued by regulatory authorities	Continuous	ES	Appropriate State and Federal agencies						Costs absorbed under existing programs
3	1.3	Work with States under the Triennial Review Process to ensure water quality standards and classifications provide for species survival and recovery	Continuous	ES	COE, EPA, ASMC, ADCNR						Costs absorbed under existing programs
3	1.41	Develop coordinated plans to address sanitary wastewater treatment plant effluents within severely impacted	Continuous	ES	EPA, ADEM, NGO						Costs absorbed under existing programs

		watersheds									
3	1.42	Encourage alternative disinfection measures for the treatment of sewage wastes in sensitive watersheds	Continuous	ES	EPA, ADEM, NGO, GDNR						Costs absorbed under existing programs
2	1.43	Encourage compliance with current water quality discharge limitations and regulations	Continuous	ES	EPA, ADEM, NGO, GDNR						Costs absorbed under existing programs
1	1.44	Encourage effective sediment control from all construction activities	Continuous	ES	EPA, ADEM, ALDOT, ALFC, NGO, ACWP, NRCS, GDNR						Costs absorbed under existing programs
2	1.45	Encourage consideration of standards for water withdrawal and water conservation from streams within the historic range of these species	Continuous	ES	OWR, ADEM, EPA, USGS, ADCNR, GDNR						Costs absorbed under existing programs
1	2.1	Work with State and private partners to promote land and water stewardship awareness within the historical ranges of these species	Continuous	ES	ACWP, EPA, ADEM, ADCNR, GSA, NGO, AFC, NRCS	20	20	20	20	20	Costs absorbed under existing programs

1	2.2	Encourage the development and implementation of adequate Streamside Management Zones (SMZs) along all streams and rivers within the historical ranges of these species	Continuous	ES	ACWP, EPA, ADEM, ADCNR, GSA, NGO, AFC, NRCS, GDNR						Costs absorbed under existing programs
1	3.1	Coordinate stream habitat and restoration and management actions within the historical ranges of these species	Continuous	ES	ADNCR, ACWP, GSA, NGO, ADEM, GDNR	25	25	25	25	25	
2	3.2	Work with private landowners to help identify potential or perceived issues with actions that contribute towards the recovery of these species	Continuous	ES	ADCNR, ACWP, GSA, RI, BI, GDNR						Costs absorbed under existing programs
2	4.0	Develop and implement programs and materials to help educate the public on the need and benefits of ecosystem management, and to involve them in watershed stewardship to protect these listed species	Continuous	ES	ACWP, ADCNR, NGO, BI, GDNR	10	10	10	10	10	
1	5.1	Survey and monitor the status of existing	10 years	ES	ADCNR, RI,	25	25	25	25	25	

		populations of these species			GSA, GDNR						
3	5.2	Conduct detailed physical and molecular genetic analyses of these species	Continuous	ES	ADCNR, RI, GDNR						Determination based on needs
3	5.3	Determine contaminant sensitivity for each life stage	Continuous	ES	EPA, RI, ADCNR, COE						Determination based on needs
2	5.41	Identify breeding periods and reproduction strategies for the three species, and the host fish of Georgia pigtoe	5 years	ES	ADCNR, RI, GDNR						Determination based on needs
2	5.42	Determine nutritional requirements of the life stages of these species	Continuous	ES	ADCNR, RI, GDNR						Determination based on needs
1	6.0	Develop and implement technology for maintaining and propagating these species in captivity	Continuous	ES	ADCNR, RI	5	5	5	5	5	
1	7.1	Identify sites for reintroduction of these species	Continuous	ES	ADCNR, GSA, GDNR	25	25	25	25	25	
2	7.2	Reintroduce these species into high priority sites	Continuous	ES	ADCNR						Determination based on needs

2	7.3	Monitor reintroduced populations	10 years	ES	ADCNR, GSA, RI, NGO, GNDR	10	10	10	10	10	
2	8.0	Periodically review the recovery progress and strategy	Continuous	ES	ADCNR, GSA, RI, NGO, GDNR	25	25	25	25	25	

APPENDIX 1

List of Stakeholders (* Invited Peer Reviewers)

Charles "Chuck" Sykes, Director
Alabama Department of Conservation and Natural Resources,
Division of Wildlife and Freshwater Fisheries
64 North Union Street
Montgomery, AL 36130
dcnr.wffddirector@dcnr.alabama.gov

Stan Cook, Fisheries Chief
Alabama Department of Conservation and Natural Resources
64 North Union Street
Montgomery, AL 36130
Stan.cook@dcnr.alabama.gov

Patti Powell, Director
Alabama Department of Conservation and Natural Resources, State Lands Division
64 North Union Street
Montgomery, AL 36130
Patti.powell@dcnr.alabama.gov

Lance LeFleur, Director
Department of Environmental Management
P.O. Box 301463
1400 Coliseum Boulevard
Montgomery, AL 36110
director@adem.state.al.us

Allison Jenkins, Executive Director
Alabama Clean Water Partnership
P.O. Box 3623
Montgomery, AL 36109
ajenkins@elmore.rr.com

J. Brian Atkins, Division Director
Department of Economic and Community Affairs, Office of Water Resources
401 Adams Avenue, Suite 434
Montgomery, AL 36104
Brian.atkins@adeca.alabama.gov

Dr. Berry "Nick" H. Tew, Jr.
State Geologist & Director
Geological Survey of Alabama
420 Hackberry Lane
P.O. Box 869999
Tuscaloosa, AL 35486
ntew@gsa.state.al.us

Dr. Patrick E. O'Neil, Director
Water Investigations Division
Geological Survey of Alabama
420 Hackberry Lane
P.O. Box 869999
Tuscaloosa, AL 35486
poneill@gsa.state.al.us

Stuart McGregor, Aquatic Biologist
Geological Survey of Alabama
420 Hackberry Lane
P.O. Box 869999
Tuscaloosa, AL 35486
smcgregor@gsa.state.al.us

Joe McInnes, Director
Alabama Department of Transportation
1409 Coliseum Boulevard
P.O. Box 303050
Montgomery, AL 36130
mcinnesj@dot.state.al.us

Linda Casey, State Forester
Alabama Forestry Commission
P.O. Box 302550
Montgomery, AL 36130
Linda.Casey@forestry.alabama.gov

Stephen M. Cauthen, Executive Director
Alabama Soil and Water Conservation Committee
P.O. Box 304800
Montgomery, AL 36130
Steve.cauthen@swcc.alabama.gov

Dr. William Puckett, State Conservationist
USDA National Resource Conservation Service
P.O. Box 311
3381 Skyway Drive
Auburn, AL 36830
William.Puckett@al.usda.gov

Athena Clark, Director
U.S. Geological Survey, Alabama Water Science Center
AUM TechnaCenter
75 TechnaCenter Drive
Montgomery, AL 36117
athclark@usgs.gov

Dr. Elise Irwin, Assistant Unit Leader Fisheries
U.S. Geological Survey,
Alabama Cooperative Fish and Wildlife Research Unit
3301 Forestry, Wildlife, Science Bldg
602 Duncan Drive, Auburn Univ.
Auburn, AL 36849
eirwin@ag.auburn.edu

Dwight Cooley, Refuge Manager
U.S. Fish and Wildlife Service
Wheeler National Wildlife Refuge
2700 Refuge Headquarters Road
Decatur, AL 35603
Dwight_cooley@fws.gov

U.S. Fish and Wildlife Service
Refuge Manager
Mountain Longleaf NWR
P.O. Box 5087
Anniston, AL 36205
mountainlongleaf@fws.gov

*Dr. Paul D. Johnson, Supervisor
Alabama Aquatic Biodiversity Center
Alabama Department of Conservation and Natural Resources
Marion, AL
Paul.Johnson@dcnr.alabama.gov

*Jeff Garner, State Malacologist
Alabama Department of Conservation and Natural Resources
County Road 275
Florence, AL
bleufer@aol.com

Ben Raines, Environmental Reporter
Press-Register
P.O. Box 2488
Mobile, AL 36652-2488
braines@aol.com

Paul Freeman, Freshwater Ecologist
The Nature Conservancy of Alabama
2100 First Avenue North
Suite 500
Birmingham, AL 35203
pfreeman@tnc.org

Jim Godwin, Biologist
Alabama Natural Heritage Program
Auburn University
jgodwin@alnhp.org

Tim L. Gothard;
Executive Director
Alabama Wildlife Federation
3050 Lanark Road
Millbrook, AL 36054
timg@alabamawildlife.org

Cindy Lowry, Executive Director
Alabama Rivers Alliance
2027 Second Avenue North
Suite A
Birmingham, AL 35203
clowry@alabamarivers.org

Dr. William Deutsch, Program Manager
Alabama Water Watch
203 Swindell Hall
Auburn University, AL 36849
deutswg@auburn.edu

*Steve Krotzer, Biologist
Alabama Power Company
600 North 18th Street/12N-0830
P.O. Box 306
Birmingham, AL 35201
jdgrogan@southernco.com

Mike Godfrey, Manager
Alabama Power Company
600 North 18th Street/12N-0830
P.O. Box 306
Birmingham, AL 35201
JGODFREY@southernco.com

Jason Carlee, Supervisor
Alabama Power Company
600 North 18th Street/12N-0830
P.O. Box 306
Birmingham, AL 35201
JCARLEE@southernco.com

*Nathan Whelan
University of Alabama
Box 870345, Tuscaloosa, AL 35487
nathan.whelan@gmail.com

*Dr. Lori Tolley-Jordan
Department of Biology
Jacksonville State University
Jacksonville, AL 36265
ljordan@jsu.edu

Commissioner, Cherokee County
Cherokee County Administration Building
260 Cedar Bluff Road, Suite 103
Centre, AL 35960
MattSims@CherokeeCounty-AL.GOV

Commissioner, Clay County
Key Concept Services, Inc.
PO Box 1032
Ashland, AL 36251
commissionerwatts@yahoo.com

Commissioner, Coosa County
Coosa County Courthouse
P. O. Box 115
Rockford, AL 35136
fbrooks@coosacountyal.com

Commissioner, Elmore County
P.O. Box 785 – 110 East
Bridge Street
Wetumpka, AL 36092
j.faulk@elmoreco.org

Commissioner, St. Clair County
165 5th Avenue, Suite 100
Ashville, AL 35953
info@stclairco.com

Commissioner, Talladega County
P.O. Box 6170
County Courthouse
Talladega, AL 35161-6170
commission@talladegacountyal.org

APPENDIX 2:
Summary of Peer Review

A. Peer Review Method:

The U.S. Fish and Wildlife Service (Service) announced the availability of the draft recovery plan in the *Federal Register* on July 3, 2013 (78 FR 40162). In addition, a draft copy of the recovery plan was emailed to Mr. Jeffrey Garner and Dr. Paul Johnson (Alabama Department of Conservation and Natural Resources), Dr. Lori Tolley-Jordan (Jacksonville State University), and Dr. Nathan Whelan (Auburn University) for additional comments. Since at least one of these species occurs in the upper Coosa Basin in Georgia and in Tennessee, comments were also solicited from the Service's Georgia and Tennessee Ecological Field Offices. Responses from reviewers were either provided by email or in "track changes" in the original document. All of the reviewers are considered experts with at least one of the species and are familiar with the habitats where the species occur.

B. Summary of Peer Review Comments:

Section: Executive Summary

Comment: One reviewer commented on the overall lack of suitable habitat for the interrupted rocksnail and questioned whether it could ever be recovered.
Response: This is a good question, but we believe there is enough suitable habitat either available or restorable within the species historic range to provide recovery opportunities for the interrupted rocksnail.

Comment: One reviewer stressed the importance of habitat restoration activities in the Conasauga River because the populations of Georgia pigtoe are so small and fragmented.
Response: This is true and we believe we address this question adequately in the "Recovery Narrative."

Comment: One reviewer pointed out that life history research and propagation techniques for the interrupted rocksnail have been completed and it is close to completion for the rough hornsnail .
Response: We agree with this statement and added a note under the "action needed" section to reflect this point.

Comment: One reviewer did not believe the estimated dollars for recovery were sufficient to meet the recovery actions.
Response: The costs identified are estimates to get to the preliminary goal of downlisting two snails and continued work to prevent extinction of the mussel. We believe the costs identified in the recovery plan are reasonable estimates and also share that these are guides to help all partners develop budget requests to contribute to the recovery action.

Comment: One reviewer wanted to know if the estimated dollars included funds for land acquisition.
Response: No. Funds were only estimated for activities specific to the recovery action. This plan is focused in restoration and management. However, if a high priority opportunity arises for a land acquisition that could benefit one of these species, we would coordinate with partners and evaluate it in relation to our recovery program to determine if it is a good opportunity.

Comment: One reviewer questioned what recovery strategy ensured that reintroductions would not adversely affect existing populations.
Response: Every effort is made to eliminate the negative impacts of a reintroduced population of animals to currently existing animals. For example, strict guidelines and methods are followed, according to the MRBMRC (2010), to eliminate the exposure of a hatchery-induced disease. Also, according to the MRBMRC (2010), any augmentation of the same species is highly discouraged, only reintroductions are conducted. These example strategies were developed to protect existing listed species populations.

Comment: One reviewer suggested revising the language slightly in the Recovery Criteria for the Georgia pigtoe to better explain how to monitor Georgia pigtoe and consider habitat.
Response: We agree with the suggestions on how to monitor the Georgia pigtoe and modified the language in the Recovery Criteria and Recovery Actions Needed of the Executive Summary and also in the Recovery Criteria and Narrative Outline of the Recovery section in order to reflect this suggestion.

Section: Background
Comment: One reviewer suggested using Pleurocera spp. when talking generally about "rocksnails."
Response: We agree and modified the language in the appropriate places.

Comment: Several reviewers suggested adding additional citations.
Response: All suggested citations were added as appropriate.

Comment: Two reviewers suggested modifying the historic distribution maps for the interrupted rocksnail and rough hornsnail to better reflect their known ranges.
Response: Those maps were modified accordingly to more clearly represent their respective ranges.

Comment: One reviewer suggested removing the sentence in the "Taxonomy" section under the rough hornsnail section that stated, "this variant, however, is no longer extant in the Cahaba River," suggesting it is only speculative.
Response: We agree with the suggestion and removed the sentence.

Comment: One reviewer suggested changing the photo credit under Figure 1.
Response: We agree and modified the photo credit.

Comment: One reviewer pointed out that there are also records of the Georgia pigtoe from the Coahulla Creek (Conasauga Basin), Whitfield Co., GA.
Response: We agree and modified the historic range of the Georgia pigtoe in the "Distribution and Trends" section.

Comment: One reviewer corrected a statement in the third paragraph in the *Taxonomy* section for the rough hornsnail stating that there is recent evidence suggesting the rough hornsnail may actually be an *Elimia* sp. rather than a *Pleurocera* sp. based upon the recent dissertation of Nathan Whelan (Whelan 2013). However, the reviewer also points out that the classification change would require a complete review of the family Pleuroceridae.
Response: We appreciate the suggestion and modified the last paragraph to reflect the work of Whelan (2013) but also note that the changing of the genus of the rough hornsnail is contingent upon a complete review of the family Pleuroceridae.

Comment: One reviewer suggested adding designated critical habitat to the range maps for each species.
Response: We decided not to do this just for clarity purposes (Maps though can be referenced separately at 75 FR 67512; November 2, 2010).

Comment: One reviewer recommended elaborating more about ongoing restoration efforts in the Upper Coosa Basin under the "Ongoing Conservation Efforts" section.
Response: We agree with the comment and modified the opening section to reflect this change.

Comment: One reviewer strongly encouraged us to add a recovery objective, for each species, that included the investigation of basic biological parameters, including, feeding biology, dissolved oxygen requirements, temperature tolerance levels, and pH thresholds.
Response: We strongly agree with this recommendation. There is a significant need to increase our understanding of the basic biological needs of these species. Although we did not modify the "recovery objectives," we did modify language in the "recovery narrative" to reflect these recommendations.

Modification of the proposed recovery date and implementation schedule
In the draft recovery plan we proposed that we could reach our recovery goals for the rough hornsnail and interrupted rocksnail by 2017. However, due to the release of the recovery plan, the date was moved up until 2019.