Georgia pigtoe
(*Pleurobema hanleyianum*)

5-Year Review:
Summary and Evaluation

Photo by Todd Fobian, Alabama Department of Conservation and Natural Resources

U.S. Fish and Wildlife Service
South Atlantic-Gulf Region
Alabama Ecological Services Field Office
Daphne, Alabama

5-YEAR REVIEW
Georgia pigtoe (*Pleurobema hanleyianum*)

I. GENERAL INFORMATION

A. Methodology used to complete the review: We announced initiation of this review in the Federal Register on August 30, 2016 (81 FR 59650) with a 60-day comment period and received no comments. The primary sources of information used in this analysis were the 2010 final listing rule (75 FR 67512), the 2014 and 2019 recovery plan and amendment (respectively), peer-reviewed reports, agency reports, unpublished survey data and reports, and personal communication with recognized experts. This review was completed by the U.S. Fish and Wildlife Service (Service), Alabama Ecological Services Field Office (AFO), Daphne, Alabama. All literature and documents used for this review are on file at the AFO. All recommendations resulting from this review are the result of thoroughly reviewing the best available information on the Georgia pigtoe. Comments and suggestions regarding this review were received from four peer reviewers from outside the Service (see Appendix A), evaluated, and incorporated as appropriate.

B. Reviewers

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C. Background:

1. **Federal Register Notice citation announcing initiation of this review:** August 30, 2016 (81 FR 59650)

2. **Species status:** Stable

While the Georgia pigtoe remains extant in isolated shoals, it is rare and represented by older/larger individuals (as documented in the Conasauga River in Tennessee/Georgia and Little/Big Canoe creeks in Alabama). Since listing (November 2, 2010), the species has been documented in Alabama in Little Canoe and Big Canoe creeks (T. Fobian pers. comm. 2019). Though not addressed in the 2010 listing documentation, single specimens have been documented from Hatchet Creek, Coosa County, Alabama (2001) (Williams et al. 2008, Gangloff pers. comm. 2020, ADCNR Natural Heritage Database 2020) and from the Coosa River Weiss Bypass (Cherokee County, Alabama) from 2002, genetically confirmed in 2005 (Campbell et al. 2005). For the purposes of this review, given the proximity and connectivity of the Little Canoe and Big Canoe Creek systems and the lack of genetics work on the specimens found at these locations, we have considered individuals from these two creeks to be from a single population. In addition, since there are only single occurrence records from the Weiss Bypass of the Coosa River and from Hatchet Creek, more surveys are required before it can be confidently declared that Georgia pigtoe populations exist at these locations.

Currently there are two (2) populations of the Georgia pigtoe (Figure 2). One exists in the Upper Conasauga River in Tennessee (Polk County) and Georgia (Murray and Whitfield counties). The other population is in Alabama in Little/Big Canoe creeks (St. Clair/Etowah counties). Regardless of the recent discoveries for the Georgia pigtoe, none of the documented populations have displayed natural recruitment or multiple age classes which may be indicative of a mussel community that is no longer capable of self-perpetuation.

3. **Recovery achieved:** 1 (0–25% species recovery objectives achieved).

4. **Listing history**

Original Listing
FR notice: 75 FR 67512
Date listed: November 2, 2010
Entity listed: Species
Classification: Endangered

5. **Associated rulemakings:**

Designation of Critical Habitat
FR notice: 75 FR 67512
Date listed: November 2, 2010
Entity listed: Species

6. **Review History:**

Each year, the Service reviews and updates listed species information for inclusion in the required Recovery Report to Congress (RRC). This is the first status review of the species since its listing in 2010.

7. **Species' Recovery Priority Number at start of review (**81 FR 59650**):** 5

Degree of Threat: High
Recovery Potential: Low
Taxonomy: Species

Table 1. Recovery Priority Numbers for listed species.

Degree of Threat	Recovery Potential	Taxonomy	Priority	Conflict
High	High	Monotypic Genus	1	1c
High	High	Species	2	2c
High	High	Subspecies/DPS	3	3c
High	Low	Monotypic Genus	4	4c
High	Low	Species	5	5c
High	Low	Subspecies/DPS	6	6c
Moderate	High	Monotypic Genus	7	7c
Moderate	High	Species	8	8c
Moderate	High	Subspecies/DPS	9	9c
Moderate	Low	Monotypic Genus	10	10c
Moderate	Low	Species	11	11c
Moderate	Low	Subspecies/DPS	12	12c
Low	High	Monotypic Genus	13	13c
Low	High	Species	14	14c
Low	High	Subspecies/DPS	15	15c
Low	Low	Monotypic Genus	16	16c
Low	Low	Species	17	17c
Low	Low	Subspecies/DPS	18	18c

Since its listing in 2010 through 2016, we reported the recovery priority number for the Georgia pigtoe as a 5 indicating a high degree of threat for extinction and a low recovery potential.

8. Recovery Plan

Name of Plan: Recovery plan for Georgia pigtoe mussel (*Pleurobema hanleyianum*), interrupted rocksnail (*Leptoxis foremani*), and rough hornsnail (*Pleurocera foremani*)
Date Issued: October 30, 2014

Name of Amendment to Recovery Plan: Recovery plan for the endangered Georgia pigtoe (*Pleurobema hanleyianum*)
Date Issued: September 26, 2019

II. REVIEW ANALYSIS

A. Application of the 1996 Distinct Population Segment (DPS) Policy

The Endangered Species Act (ESA) defines species as including any subspecies of fish, wildlife, or plant, and any distinct population segment of any species of vertebrate wildlife. This definition limits listing DPSs to only vertebrate species of fish and wildlife. Because the species under review is an invertebrate, the DPS policy is not applicable and will not be addressed further in this review.

B. Recovery Criteria

1. **Does the species have a final, approved recovery plan containing objective, measurable criteria?** Yes. In 2014 a final recovery plan was approved for the Georgia pigtoe, the interrupted rocksnail, and the rough hornsnail. The recovery plan identified "preliminary measures to help us prevent its extinction until we can obtain further information on this species and determine recovery criteria for this animal" (USFWS 2014). In September 2019, an amendment to the recovery plan was approved that identified recovery criteria for the Georgia pigtoe in terms of threats assessed under the five listing factors.

2. **Adequacy of recovery criteria.**

   a. **Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat?** Yes. The recovery criteria listed in the amendment were developed using the most recent and best available information for the species. The lead biologist for the species gathered information that included data from recent surveys and/or publications in Alabama, Georgia, and Tennessee. In addition, species experts were notified of the Service's process to complete the amendment and a request for public comment was announced in the Federal Register (84 FR 30764).

   b. **Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria?** Yes. All of the 5 listing factors aside from Factor B (overutilization for commercial, recreational, scientific, or educational purposes) have been addressed by the recovery criteria (see below). Factor B is currently not a threat and was not identified as a threat when the species was listed and therefore not addressed in the recovery plan.

      Factor A—The present or threatened destruction, modification, or curtailment of its habitat or range: Addressed by Criteria 1, 2, and 3

      Factor C—Diseases or predation: Addressed by Criteria 3

      Factor D—The inadequacy of existing regulatory mechanisms: Addressed by Criteria 3

      Factor E—Other natural or manmade factors affecting its continued existence: Addressed by Criteria 1, 2, and 3

3. **List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information:**

   Criteria (1): At least six (6) populations exhibit a stable or increasing trend, evidenced by natural recruitment, and multiple age classes.

   Status: Currently there are two (2) populations of the Georgia pigtoe (Figure 1). One exists in the Upper Conasauga River in Tennessee (Polk County) and Georgia

(Murray and Whitfield counties). The other population is in Alabama in Little/Big Canoe creeks (St. Clair/Etowah counties). However, neither natural recruitment nor multiple age classes have been documented in any of these populations. Single specimens were collected in both Hatchet Creek in 2001 (Gangloff pers. comm. 2020) and from the Weiss Bypass of the Coosa River in 2002 (Campbell et al. 2005) but not enough evidence has been collected at either location to consider these records as separate populations (see 'Background'). Therefore, the current status of the Georgia pigtoe does not meet the requirements of Criterion 1.

Criteria (2): At least four (4) populations (as defined in Criteria 1) occupy four of the six HUC8 watersheds (Conasauga, Coosawattee, Oostanaula, Upper Coosa, Middle Coosa, and Lower Coosa), and one (1) population occupies the main stem of the Oostanaula or the Coosa River to protect against extinction from catastrophic events and maintain adaptive potential.

Status: As of this review, only two (2) of the six (6) HUC8 watersheds (the Conasauga and Middle Coosa) contain Georgia pigtoe records (Figure 2). These records do not meet the definition of populations exhibiting the characteristics defined by Criteria 1. Single specimens were collected in both Hatchet Creek in 2001 (Gangloff pers. comm. 2020) and from the Weiss Bypass of the Coosa River in 2002 (Campbell et al. 2005), but neither have been reconfirmed since that time. Criterion 2 has not been meet.

Criteria (3): Threats have been addressed and/or managed to the extent that the species will remain viable into the foreseeable future.

Status: The main threats to the Georgia pigtoe are habitat and range modification from dam construction on the Coosa River and water quality issues in the mainstem Coosa River and Conasauga River and their tributaries from point and nonpoint source pollution. Whereas regulations on both the State and Federal levels have made improvements in point source pollution, nonpoint source pollution from land surface runoff continues to pose a threat to the Georgia pigtoe. Other manmade factors such as climate change will continue to threaten the species into the foreseeable future. Therefore, Criterion 3 has not been met.

C. Updated Information and Current Species Status

1. Biology and Habitat

a. Information on the species' biology and life history:

The shell of the Georgia pigtoe is oval to elliptical and somewhat inflated. Williams et al. (2008) previously reported a maximum shell length of 50 millimeters (mm) (2 inches (in)). However, recent measurements of a specimen from Big Canoe Creek have recorded a maximum length of 66 mm (2.6 in) (T. Fobian pers. comm. 2019). The posterior ridge of the shell 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). 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 for glochidia (parasitic larvae) of Georgia pigtoe are currently unknown.

b. Abundance, population trends, demographic features, or demographic trends:

The Georgia pigtoe is endemic to the Coosa River drainage of the Mobile River basin in Alabama, Georgia, and Tennessee (Figure 1). It has disappeared from 90 percent or more of its historical range, primarily due to the impoundment of riverine habitats. It is currently known from a few isolated shoals in the Upper Conasauga River in Murray and Whitfield counties, Georgia; in Polk County, Tennessee (Johnson and Evans 2000; Evans 2001; Johnson et al. 2005; MRBMRC 2010); and in the Big Canoe and Little Canoe creeks in St. Clair and Etowah counties, Alabama. Single records have been documented from the Weiss Bypass of the Coosa River (2002) and from Hatchet Creek (2001), though more surveys are required before it can be confidently declared that Georgia pigtoe populations exist at these locations.

Conasauga River Watershed: A 2005 survey from the Conasauga River in the Cherokee National Forest, Tennessee, found one relict shell measuring 62 mm (2.4 in) total shell length (Ahlstedt 2007). Recent surveys in Tennessee encountered the Georgia pigtoe in 2014 (2 live), 2015 (1 live), and 2018 (1 live individual measuring 58 mm (2.3 in) total shell length) in the Conasauga River (D. Hubbs pers. comm. 2018). While it remains extant in the short section of the river recently surveyed, it is rare and represented by older/larger individuals (D. Hubbs pers. comm. 2018).

Numerous records exist from 1999 for the Georgia pigtoe in the Conasauga River in Murray and Whitfield counties, Georgia (GADNR 2020); however, confirmed occurrence records become rare after that date. One shell was found in 2004 (GADNR 2020), and not until 2014 was its presence reconfirmed when a live individual was found in the Conasauga River along the Murray/Whitfield county line (GADNR 2020). A comprehensive survey of the Coosa Basin in Georgia was conducted by Georgia Department of Natural Resources (GADNR) from 2015-2017 (J. Wisnieski pers. comm. 2020). Approximately 160 sites were surveyed on all mainstem rivers and most tributaries, with the exception of the lower Chattooga River, and no shells or live Georgia pigtoe were found.

Upper Coosa River Watershed: A single specimen was collected in the Weiss Bypass of the Coosa River in 2002 (Campbell et al. 2005). The species was

confirmed using DNA barcoding and molecular phylogenetic analysis (Campbell et al. 2005).

Middle Coosa River Watershed : The most recent occurrences of the Georgia pigtoe in Alabama are from Little Canoe Creek (St. Clair/Etowah county line) in 2018 (1 fresh dead specimen measuring 49 mm (1.9 in) total shell length) and Big Canoe Creek (St. Clair County) in 2019 (2 live) (T. Fobian pers. comm. 2019). The two specimens in Big Canoe Creek were 57 and 66 mm (2.2 and 2.6 in) total shell length, indicating older individuals.

Lower Coosa Watershed: The Georgia pigtoe is believed to have possibly been found in Yellowleaf Creek (Shelby County) in 2016 (1 live) (Gangloff 2016), but this visual identification has not been confirmed due to inconclusive molecular diagnostics (M. Gangloff pers. comm. 2019). A 2001 record from Hatchet Creek, Coosa County, Alabama that was not included in the original listing document (75 FR 67512) has been recently verified (Williams et al. 2008; Gangloff pers. comm. 2020; ADCNR Natural Heritage Database 2020). This creek is also known to have been historically occupied by the species.

Coosawattee and Oostanaula Watersheds: No current records exist in these watersheds.

In all river reaches where the Georgia pigtoe has been located, the species remains rare and difficult to find, and no population estimates are available. In addition, no recruitment has been observed and shell measurements are indicative of older individuals.

c. Genetics, genetic variation, or trends in genetic variation:

Identifying Pleurobemini *(Bivalvia: Unionida*) species is difficult due to morphological convergence and phenotypic plasticity; therefore, genetic studies have been conducted to aid in identification. Campbell and others (2008) studied *Pleurobema* species in the upper Coosa River Basin and revealed that Georgia pigtoe is a member of one clade that is confined to the upper Coosa River system and includes southern clubshell (*P. decisum=P. chattanoogaense*), and Alabama clubshell (*P. troschelianum*). The southern clubshell is an exception to this range restriction, whose range spans across the Mobile Basin. Campbell and others (2008) used molecular phylogenetic methods to build patterns of relatedness between morphologically identified species and unknown specimens to determine their taxonomic identity. Georgia pigtoe is believed to be conspecific to the Alabama clubshell (*P. troschelianum*) based on the genetic similarity of several individuals exhibiting two divergent shell morphs (Campbell et al. 2008). This relationship was also confirmed by Inoue and others (2018). Phenetic distances and phylogenetic results from the study indicate that the upper Coosa forms of *Pleurobema* are distinct from those endemic to the western Mobile Basin. Endemism was found to be higher than previously recognized, both at the species level and for multispecies clades (Campbell et al. 2008). The above information

elucidates the genetic diversity that the species currently has and may emphasize the importance of maintaining genetic diversity in each of our extant populations.

d. Taxonomic classification or changes in nomenclature:

The Georgia pigtoe (*Pleurobema hanleyianum*) is a freshwater mussel in the Family Unionidae. 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).

No changes to taxonomic classification or nomenclature have occurred since this species was listed. Nomenclature is consistent and follows that in Williams et al. (2017) and the Freshwater Mollusk Conservation Society (2019) revised bivalve list.

e. Spatial distribution, trends in spatial distribution, or historical range:

The Georgia pigtoe was historically found in shoals of large creeks and small to large 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 (Coosawatee River in Murray County, Conasauga River in Murray and Whitfield counties, Chatooga River in Chatooga County, Coosa River in Floyd County, and Etowah River in Floyd 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) (USFWS 2010, Gangloff 2003, Gangloff pers. comm. 2020). Based on these historical records, the range of the Georgia pigtoe included more than 480 kilometers (km) (298 miles (mi)) of river and stream channels. Additional historical Coosa River tributary records credited to Hurd (for example, Big Wills, Little Wills, Oothcalooga, Holly creeks) have been found to be misidentifications of other species as Georgia pigtoe (USFWS 2010).

In 1990, the Service initiated a status survey and reviewed the molluscan fauna of the Mobile River Basin (Hartfield 1991). The resulting mollusk surveys showed that many of the fauna had either been completely eliminated or severely reduced (USFWS 2010). Following a review of these efforts and observations, the Service presumed the Georgia pigtoe extinct based on their absence from collection records, technical reports, or museum collections for a period of 20 years or more (Hartfield 1994).

Since that time, mollusk surveys in the Coosa River drainage continued, and the Georgia pigtoe was rediscovered in the Conasauga River in Tennessee (Williams and Hughes 1998; Johnson and Evans 2000; Gangloff 2003). Additional surveys rediscovered the species in Georgia and Alabama as well. Though additional surveys have been conducted, the species remains rare. A comprehensive survey of the Coosa Basin in Georgia was conducted by GADNR from 2015-2017 (J.

Wisnieski pers. comm. 2020). Approximately 160 sites were surveyed on all mainstem rivers and most tributaries, with the exception of the lower Chattooga River, and no shells or live Georgia pigtoe were found. Currently, the Georgia pigtoe's spatial distribution is limited to the Conasauga River in Tennessee (Polk County) and Georgia (Murray and Whitfield counties) and in Alabama's Little/Big Canoe creeks (St. Clair/ Etowah counties).

f. Habitat:

Little is known about the habitat requirements or life history of the Georgia pigtoe; however, it is most often found in shallow runs and riffles with strong to moderate current and coarse sand-gravel-cobble bottoms.

2. Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

a. Present or threatened destruction, modification or curtailment of its habitat or range:

The range curtailment for the Georgia pigtoe has predominately been through modification and destruction of river and stream habitats, primarily by the construction of large hydropower dams on the Coosa River. Dams eliminate or reduce river flow within impounded areas, trap silt and cause sediment deposition, alter water temperature and dissolved oxygen levels, change downstream water flow and quality, affect normal flood patterns, and block upstream and downstream movement of aquatic species (Watters 1996; Marcinek et al. 2005).

In addition, dam construction fragments populations leaving them more vulnerable to 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 can reduce population levels or eliminate habitat (Neves et al. 1997; USFWS 2000).

Historic causes of water quality degradation in the Coosa River and its tributaries included drainage from gold mining activities, industrial and municipal pollution events, and construction and agricultural runoff (Hurd 1974; Lydeard and Mayden 1995; Freeman et al. 2005). Although Federal and State water quality laws and regulations have greatly improved and generally reduced the impacts of point source discharges, nonpoint source pollution continues to affect and possibly threaten the Georgia pigtoe populations. Nonpoint source pollution from land surface runoff originates from virtually all land use activities and includes sediments; fertilizer, herbicide, and pesticide residues; animal or human wastes; septic tank leakage and gray water discharge; and oils and greases (USFWS 2010). Nonpoint source pollution can cause excess sedimentation, nitrification, decreased dissolved oxygen concentration, increased acidity and conductivity, and other changes in water chemistry that can seriously impact aquatic mollusks (USFWS 2010). Land use types within the range of the Georgia

pigtoe include pastures, row crops, timber, and urban and rural communities, all of which may contribute to nonpoint source pollution (USFWS 2010).

b. Overutilization for commercial, recreational, scientific, or educational purposes:

The Georgia pigtoe has become increasingly rare throughout its range; however, overutilization for commercial, recreational, scientific, or educational purposes is not believed to be a threat to its continued existence.

c. Disease or predation:

Studies on freshwater mussel disease have been conducted in recent years. Grizzle and Brunner (2009) indicate that while some parasites and bacteria have been found in freshwater bivalves, these do not appear to be infectious between individuals. A viral disease has been documented, occurring in an Asian species, the Chinese pearl mussel (*Hyriopsis cumingii*). The hypothesis of mussel declines caused by disease was recently raised by Haag (2019). Haag examined the mass enigmatic declines in mussel communities between the 1960s and the 1990s (Haag 2019). These population declines could not be explained by conventional threats such as habitat degradation, climate change, impoundments, etc. (Haag 2019). He raises the issue that mussel disease is an understudied factor and could be one potential explanation for the enigmatic declines (Haag 2019). Additionally, a novel densovirus has been discovered in pheasantshell mussels (*Actinonaias pectorosa*), a species that has experienced mass mortality, from the Clinch River in Tennessee and Virginia (Richard et al. 2020). The authors state that viral infection warrants attention as a factor in mussel mass mortality events either as a direct cause, indirect cause, or a factor interacting with other stressors.

Several animals sympatric with the Georgia pigtoe are known to eat freshwater mussels. The muskrat (*Ondatra zibethicus*) is probably the most common mammal predator of freshwater mussels and piles of shells are often seen near muskrat dens and feeding stations (Parmalee and Bogan 1998). Other mammals like mink (*Mustela vison*), raccoons (*Procyon lotor*), and river otters (*Lontra canadensis*) are also known to predate mussels. Some birds (especially waterfowl) and turtles are known to feed on mussels; and freshwater drum (*Aplodinotus grunniens*) feed almost exclusively on them (Parmalee and Bogan 1998). These natural predators appear randomly opportunistic in their foraging, usually consuming whatever mussel or clam (e.g., the exotic Asian clam (*Corbicula fluminea*)) is most prevalent and easiest to obtain. Threat of predation has not changed since the time of listing.

Due to the small population sizes and limited range of the Georgia pigtoe, we believe that predation currently represents a threat of low magnitude. However, predation does have the potential to develop into a significant threat in the future, particularly for individual populations.

d. Inadequacy of existing regulatory mechanisms:

The Georgia pigtoe is afforded limited protections by the State of Alabama under their Invertebrate Species Regulation (Alabama Administrative Code 220-2-.98), which prohibits taking, capturing, killing, or attempting to take, capture, or kill; possession, selling, trading for anything of monetary value, or offering to sell or trade for anything of monetary value the species without a permit. The State of Tennessee also protects the species through the Tennessee Nongame and Endangered or Threatened Wildlife Species Conservation Act (1974) (Tennessee Code Annotated 70-8-102). This act mandates that the State should assist in the protection of species or subspecies of wildlife indigenous to the state which may be found to be endangered or threatened within the state should be accorded protection in order to maintain and, to the extent possible, enhance their numbers. Under the Rules and Regulations of the State of Georgia Protection of Endangered, Threatened, Rare, or Unusual Species Prohibited Acts (Subject 391-4-10), any activities which are intended to harass, capture, kill, or otherwise directly cause death of any protected animal species are prohibited, except as specifically authorized by law or by regulation as adopted by Georgia's Board of Natural Resources; the sale or purchase of any protected animal species or parts thereof is prohibited and the possession of any such species or parts thereof is prohibited unless the possession is authorized by a scientific collecting, wildlife exhibition, or other permit or license issued by the Georgia Department of Natural Resources; and the destruction of the habitat of any protected animal species on public lands is prohibited. These state protections are not fully sufficient for alleviating the threats discussed in this section. Factors that influence habitat quality, such as water chemistry, also influence the species' status.

The Clean Water Act (CWA) is the primary federal law in the United States governing water pollution. One primary role of the CWA is to regulate the point source discharge of pollutants to surface waters. This is regulated by the permit process with a permit from the National Pollutant Discharge Elimination System (NPDES). The NPDES permit process is usually delegated by the Environmental Protection Agency (EPA) to its state cohort; in Alabama this authority has been delegated to the Alabama Department of Environmental Management (ADEM), in Tennessee to the Tennessee Department of Environment and Conservation (TDEC), and in Georgia to their Environmental Protection Division (GEPD). Currently ADEM (Alabama Administrative Code, Title 22, Section 22-22-1 et seq.), TDEC (Tennessee Code Annotated, 69-3-101 et seq.), and GEPD (Georgia Subject 391-3-6 et seq.) require that discharges not exceed state water quality standards. Since there is no information on this species' sensitivity to common pollutants, Federal (e.g., CWA) and state water quality laws may or may not be protective of the Georgia pigtoe.

Section 303d of the CWA requires each state to list its polluted water bodies and to set priorities for their clean up with a watershed restoration action plan called a "Total Maximum Daily Load" (TMDL) for each impaired water body. Table 1

lists the impaired waters currently identified under Section 303d within watersheds with populations of the Georgia pigtoe.

Table 2. Impaired waterbodies with Georgia pigtoe populations (ADEM 2020; ARC 2020). *Potential population.

Stream	County	State	Cause	Sources
Conasauga River	Murray/Whitfield	GA	Fecal coliform bacteria; PCPs	Nonpoint source and urban runoff
Coosa River	Cherokee	AL	Pathogens (E. coli)	Outside the state
Yellowleaf Creek*	Shelby	AL	PCBs	Contaminated sediments

Section 404 of the CWA regulates the discharge of dredged or fill material into waters of the United States, including wetlands. Any activities in waters of the United States are regulated under this program, and often include fill related to development, such as water resource projects, infrastructure development, and mining projects.

While a single construction project impacting waters in the range of the Georgia pigtoe (e.g., Section 404 or Section 26a permit) will usually not jeopardize the continued existence of the species, the collective encroachment associated with each added project on the Georgia pigtoe's finite habitat may have a larger impact, an additive impact that is usually not assessed on a permit-by-permit case.

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) is intended to protect against "unreasonable human health or environmental effects." While pesticides are usually tested on standard biological test media for toxicity testing, this toxicity information may not relate well to the Georgia pigtoe. Commercial applicators must also be tested and permitted on the proper application of pesticides, but applicators may not necessarily be aware of the presence of the Georgia pigtoe in the watersheds where pesticides are being applied. If applicators are aware of the presence of a rare species, they may be more likely to use proper application techniques.

While the Georgia pigtoe may have protections from both state and federal governments, people may be unaware of its presence and protected status, and fail to take any additional precautionary measures to aid in the recovery of this species. These protections are also inadequate to account for most threats related to habitat modification, non-regulated nonpoint source pollution, disease,

predation, invasive species, accidental spills, or changes to habitat related to climate change.

e. Other natural or manmade factors affecting its continued existence:

Climate change is also considered a potential threat to the Georgia pigtoe. The Fifth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC) concluded that the warming of the climate system is unequivocal (IPCC 2014). Numerous long-term climate changes have been observed including changes in arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns, and aspects of extreme weather including droughts, heavy precipitation, heat waves, and the intensity of tropical cyclones (IPCC 2014). There is uncertainty about the specific effects of climate change (and its magnitude) on the Georgia pigtoe; however, climate change is almost certain to affect aquatic habitats through changes in water availability and timing.

Climate change has the potential to increase the vulnerability of the Georgia pigtoe to random catastrophic events, primarily through more intense or frequent droughts. Droughts can potentially have negative impacts on water quality (e.g. lower dissolved oxygen and higher temperature) and waste dissemination of point source discharges. Droughts may also reduce the amount of habitat available to the species by dewatering habitat, and may also lead to direct mortality by stranding mussels. Drought may also isolate sections of stream into stagnant pools. In Alabama, moderate drought conditions were recorded in 18% of months between the years 2010 and 2019 and approximately 8% of the months in this time period were considered severe droughts (NOAA 2020). In Georgia, approximately 13% of these months were considered moderate, 13% were severe, and 13% were extreme (NOAA 2020). In Tennessee, 8% of the months experienced moderate drought conditions (NOAA 2020). More intense storms are also predicted, resulting in episodic flooding (IPCC 2014). The increase in flooding may result in additional organics and pollutants that can, in turn, reduce dissolved oxygen concentrations, potentially resulting in death of aquatic species. Timing of floods could adversely influence spawning ability and availability of fish hosts.

Human-induced random events such as toxic spills could also jeopardize the Georgia pigtoe if pollutants are spilled within stream reaches it occupies. The known extent of habitat occupied by the species is already limited; therefore, a single spill event could substantially reduce its known range.

Barriers, such as those caused by poorly designed road crossings or dams, can limit movement of host fish. This may directly impact the ability of Georgia pigtoe to recolonize areas where it has been extirpated and may negatively impact the resilience of the species by reducing genetic diversity. Dispersal during larval encystment on a host fish is the primary method of long-range dispersal for freshwater mussels, particularly upstream.

The invasive Asian clam, *Corbicula fluminea*, could also be a potential threat to the Georgia pigtoe. In Haag's (2019) examination of the enigmatic mussel declines, in addition to disease, he proposed that *Corbicula* could also be responsible for these events (Haag 2019). *Corbicula* could impact mussel communities by competing for food; ingesting mussel sperm, glochidia, and juveniles; potentially being a vector of disease; or degrading water quality from their periodic mass dieoffs (Haag 2019). Asian clams have been present in the United States since 1938 and have been widespread in Alabama since 1962 and Georgia since 1971. Though we now understand more about the effects of Asian clams in aquatic systems, there is no reason to believe that this threat has changed since the listing of the species (USFWS 2015 and references therein).

D. Synthesis

Recovery targets for the Georgia pigtoe include the occurrence of multiple populations spread across the species' historical range, each of which has evidence of natural recruitment. Recovery will also involve alleviating the threats that habitat modification and water quality degradation pose to the Georgia pigtoe. Damming of the Coosa River and its tributaries has fragmented Georgia pigtoe habitat which has increased its susceptibility to climate change and human-induced random events and has greatly limited genetic exchange between existing populations. This species has experienced more than a 90% reduction of its historical range. The limited number of known populations, the reduced size of these populations, and lack of documented recruitment demonstrates the vulnerability of the species. Recent collections are limited to three locations and all known populations of the Georgia pigtoe appear to be non-reproductive and characterized by individuals in older age classes. At this time, the Georgia pigtoe continues to meet the definition of an endangered species under the ESA.

III. RESULTS

A. Recommended Classification:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_X_ No change needed

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

- Conduct qualitative and quantitative surveys within known habitats and continue surveys in other areas to find additional populations, including documentation of local threats.
- Acquire brood stock for captive propagation and host fish trials.
- Conduct genetic and histology research to inform propagation and culture work and ensure fitness of reintroduced populations.

- Investigate and identify potential sites for the future reintroduction of captively reared individuals.
- Document specific life history and habitat needs; examine unknown components of life history and ecology, including identification of host fish and physiochemical parameters of the stream habitats used by the Georgia pigtoe.
- Work with local landowners to preserve the integrity of stream banks and riparian zones with known habitat, and mitigate problem areas with appropriate conservation and restoration practices.
- Restore Georgia pigtoe critical habitat through activities such as bank stabilization, riparian buffer maintenance/augmentation, adherence to best management practices, and other watershed-scale conservation efforts.
- Develop contingency plans to respond to a spill or natural disaster, or other stochastic event within or upstream of occupied habitat.

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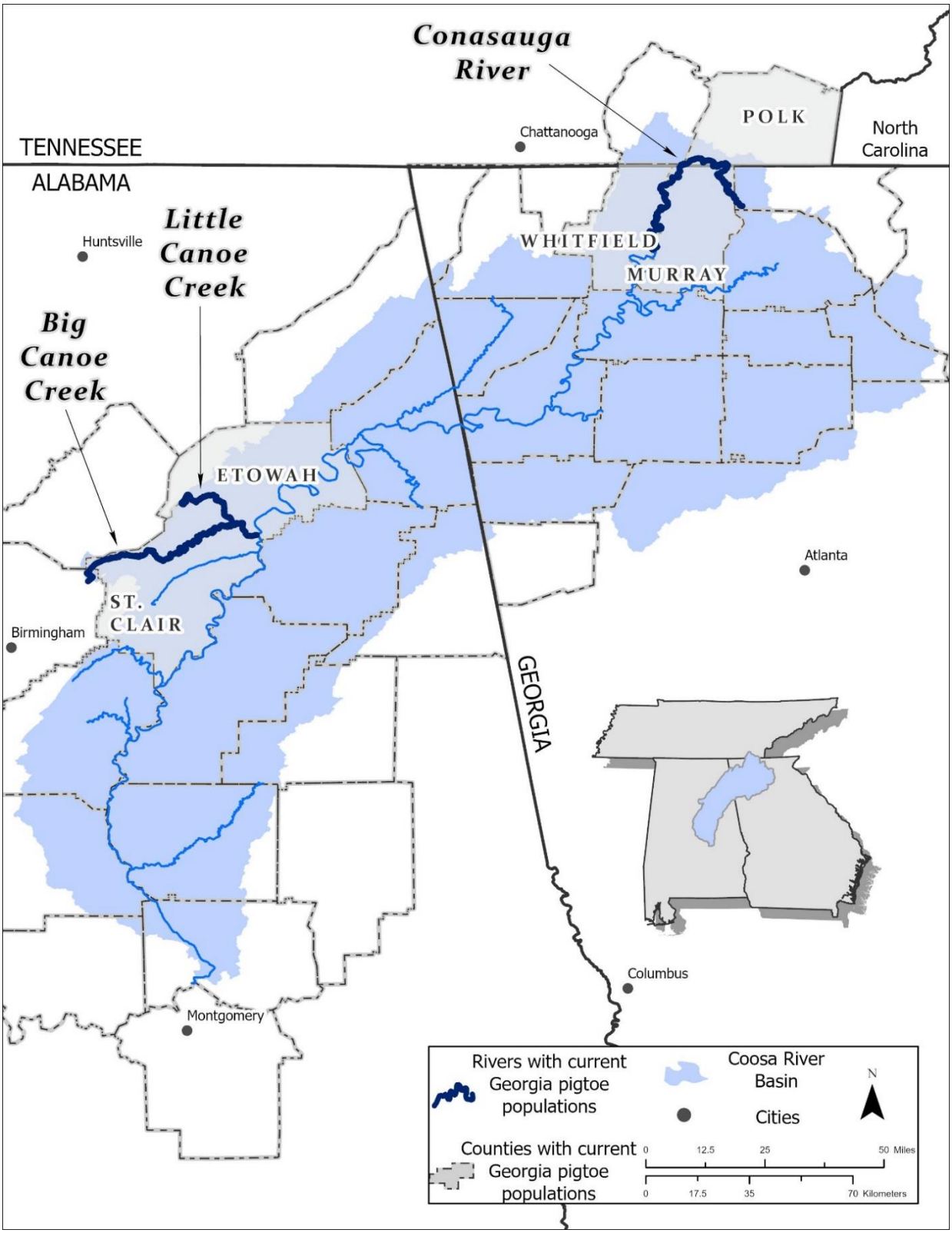

Figure 1. Overview of the Coosa River Basin and counties and rivers with current Georgia pigtoe populations.

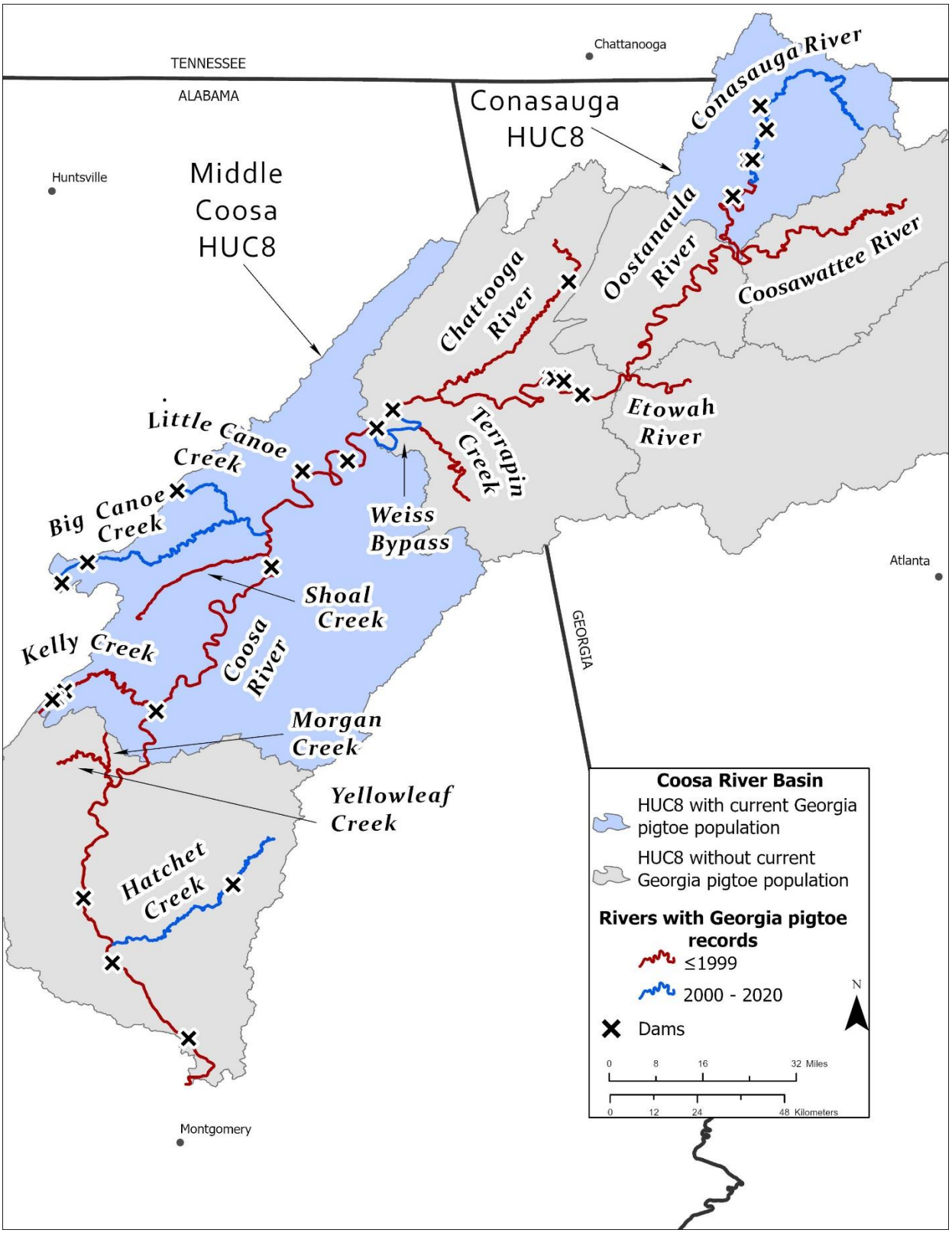

Figure 2. HUC8 watersheds with and without current Georgia pigtoe populations and records.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Georgia pigtoe (*Pleurobema hanleyianum*)

Current Classification:

Recommendation resulting from the 5-Year Review:

_____ Downlist to Threatened
_____ Uplist to Endangered
_____ Delist
__X__ No change needed

Review Conducted By: Jennifer Grunewald and Erin Padgett, Alabama Ecological Services Field Office

FIELD OFFICE APPROVAL:

Field Supervisor, Alabama Ecological Services Field Office, Fish and Wildlife Service

Approve WILLIAM PEARSON Digitally signed by WILLIAM PEARSON Date: 2021.05.05 14:15:59 -05'00' Date _____

LEAD REGIONAL OFFICE APPROVAL:

Assistant Regional Director – Ecological Services, Fish and Wildlife Service

Approve JOHN TIRPAK Digitally signed by JOHN TIRPAK Date: 2021.05.13 06:14:19 -05'00' Date _____

Appendix A. Summary of peer review for the 5-year review of Georgia pigtoe (*Pleurobema hanleyianum*)

A. Peer Review Method: The list of potential peer reviewers and the draft 5-year review was provided by the AFO to the RO Recovery Coordinator. The RO Recovery Coordinator distributed the draft document via email to the peer reviewers, received the peer review comments, and provided these to the AFO.

Peer Reviewers: Ani Escobar, Coosa Basin Aquatic Biologist, Wildlife Resources Division, Georgia Department of Natural Resources (GADNR); Jason Wisniewski, Tennessee Wildlife Resources Agency; Michael Gangloff, Ph.D., Appalachian State University; Todd Fobian, Environmental Affairs Supervisor, Alabama Department of Conservation and Natural Resources (ADCNR)

B. Peer Review Charge: Peer review was requested from the reviewers, specifically, we asked for comments on:

- Have we assembled the best available scientific and commercial information?
- Is our analysis of this information correct and properly applied?, and
- Can you identify any additional new information related to Georgia pigtoe that has not been considered in this review?

The reviewers were also asked to complete the Conflict of Interest form and return it with any notes, comments, or questions that they were willing to provide along with their peer review.

C. Summary of Peer Review Comments and Response:

Ani Escobar, Coosa Basin Aquatic Biologist, Wildlife Resources Division, GADNR: Ms. Escobar provided editorial and grammar suggestions for clarification. She also provided recommendations in the "Recommendations for Future Actions" section. Her suggestions were accepted.

Jason Wisniewski, Tennessee Wildlife Resources Agency: Mr. Wisniewski provided information addressing the survey effort conducted by GADNR. GADNR completed a comprehensive survey of the Coosa Basin in Georgia from 2015-2017, totaling approximately 160 sites and no shells nor live Georgia pigtoe were collected. This information was added to the appropriate sections throughout the document.

Michael Gangloff, Ph.D., Appalachian State University: Dr. Gangloff commented that the descriptions of the populations should be more clear. He confirmed that DNA material was not retrieved from the 2016 Yellowleaf Creek specimen and he added clarifying language in the "Genetics, genetic variation, or trends in genetic variation" section. His suggestions were adopted in the document.

Todd Fobian, Environmental Affairs Supervisor, ADCNR: Mr. Fobian provided editorial and grammatical suggestions, as well as collection information for the species from ADCNR's Natural Heritage Database that were not included in our review. These collections were

made by Dr. Michael Gangloff, so the Service contacted Dr. Gangloff for verification. Of the two collections, one was verified by Dr. Gangloff and included in our report. Mr. Fobian commented that the document should define "current" collections and adjust maps accordingly. These comments were accepted by the Service.