

Alabama Lampmussel
(*Lampsilis virescens*)

5-Year Review:
Summary and Evaluation



Photo Credit: ADCNR, Alabama Aquatic Biodiversity Center

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

5-YEAR REVIEW
Alabama Lampmussel / *Lampsilis virescens*

I. GENERAL INFORMATION

A. Methods used to complete the review:

We announced initiation of this review in the Federal Register on May 7, 2018 (83 FR 20092) with a 60-day comment period and received no comments. The primary sources of information used in this analysis were the 1976 final listing rule (41 FR 24062), the 2012 5-year review, peer-reviewed reports, agency reports, unpublished survey data and reports, and personal communication with recognized experts.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 Alabama lampmussel. The Appendix provides a brief summary of the peer-review approach.

B. Reviewers

Lead Region:

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Lead Field Office:

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C. Background

1. Federal Register Notice citation announcing initiation of this review: 83 FR 20092, May 7, 2018.

2. Species status: Stable

3. Recovery achieved: 2 (26 - 50% recovery objectives achieved). Natural populations of the Alabama lampmussel has been recorded in the Paint Rock River (PRR), Estill Fork, Hurricane Creek, and the Emory River. The population rediscovered in the Emory River in 2011 requires additional monitoring to completely assess its status. Reintroduced populations in both Alabama and Tennessee require additional monitoring to determine whether natural reproduction and recruitment is occurring. Some habitat protections are in place in watersheds containing both natural and reintroduced lampmussel populations. In total, recovery of the species is progressing but no recovery criteria has been fully met.

4. Listing history:

Original Listing

FR notice: 41 FR 24062

Date listed: June 14, 1976

Entity listed: Species

Classification: Endangered

5. Associated rulemakings:

Experimental Population, Non-Essential, June 14, 2001, 66 FR 32250;
ETWP; Establishment of Nonessential Experimental Population Status for 16 Freshwater Mussels and 1 Freshwater Snail (Anthony's Riversnail) in the Free-Flowing Reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, AL

Experimental Population, Non-Essential, August 21, 2001, 66 FR 43808;
ETWP; Establishment of Nonessential Experimental Population Status for 16 Freshwater Mussels and 1 Freshwater Snail (Anthony's Riversnail) in the Free-Flowing Reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, AL; Correction

6. Review History:

Each year, the Service reviews and updates listed species information for inclusion in the required Recovery Report to Congress (RRC). Through 2012, we reported the recovery priority number for the Alabama lampmussel as a 5 indicating a high degree of threat for extinction and a low recovery potential. As of our 2013-2014 RRC, we changed the recovery priority number to an 8 indicating a moderate degree of threat and a high recovery potential. This change reflected advances made with propagation and reintroductions and the rediscovery of a population in Tennessee.

Five-year reviews: August 28, 2012

7. Species' Recovery Priority Number at start of 5-year review (83 FR 20092): 8

This number indicates:
Degree of threat: Moderate
Recovery potential: High
Taxonomy: Species

8. Recovery Plan

Name of plan: "A Recovery Plan for the Alabama Lamp Pearly Mussel
Lampsilis virescens (Lea, 1858)"
Date issued: July 2, 1985

II. REVIEW ANALYSIS

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

The Act 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

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?

No. Given that the recovery plan is over 30 years old, recent survey data is not incorporated into the recovery criteria. The plan also lacks recent published and unpublished scientific information on the lampmussel's life history and its habitat.

b. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)?

Yes. In 1976, the Alabama lampmussel, along with 158 other taxa, was listed as endangered due to declines in numbers due to factors 1 (destruction, modification, or curtailment of range),² (overutilization for commercial, sporting, scientific, or educational purposes), or 3 (disease or predation) or a combination of those identified factors. In the previous 5-year review, we wrote that the recovery plan does not address all five of the listing factors. While it is true that all five of the listing factors are not addressed in the recovery plan, only three factors were determined as potentially relevant to the Alabama lampmussel when it was listed in 1976. Furthermore, the 1976 rule did not specify which of the three identified factors were relevant to the Alabama lampmussel. The recovery criteria clearly addresses factor A (the present or threatened destruction, modification, or curtailment of habitat or range) by ensuring a viable population flourishes in the PRR, viable populations are located in two additional rivers within its historical range, and populations are protected from anthropogenic or natural threats. We have no information to indicate that overutilization or disease or predation currently threaten the Alabama lampmussel. Indeed, the Alabama lampmussel's designation as an endangered species under the Endangered Species Act (ESA), its protection under State statute in Alabama and Tennessee (see section D.4), and its inclusion in appendix I of the Convention on International Trade in Endangered Species of Wildlife, Fauna, and Flora CITES) protect it from threats due to overutilization. (See section D for a full review of the five listing factors). The recovery plan does not categorize threats under the five Endangered Species Act (ESA) listing factors.

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:

According to the recovery plan, the following criteria must be met to delist the lampmussel:

Criteria (1): A viable population¹ of *Lampsilis virescens* exists in the Paint Rock River above the impounded portion in Wheeler Reservoir, upstream to and including Larkin Fork, Estill Fork, and Hurricane Creek tributaries. This population should be distributed within this

¹ The recovery plan defines a viable population as, “a reproducing population that is large enough to maintain sufficient genetic variation to enable it to evolve and respond to natural habitat changes” (USFWS 1985).

stream such that it is unlikely a single adverse event would result in the total loss of that population.

Status (1): The most recent mussel surveys in the PRR system, located near the Tennessee and Alabama state line, (Figures 1 and 2) were conducted by the Alabama Department of Conservation and Natural Resources (ADCNR) between June and August of 2008 (Fobian et al. 2008). Thirty-nine mussel species were collected over a total of 47 sites: 42 within the PRR mainstem and 5 in the Estill Fork. The lampmussel was collected live at three sites, two in the PRR and one within Estill Fork. In addition, fresh dead (FD) individuals were collected at two sites (weathered dead at one site and a relic shell at the other site) within the mainstem of the PRR. Fobian et al. (2008) found that the Alabama lampmussel only represented 0.22% of the overall species abundance of the sites surveyed.

Prior to the ADCNR surveys, the last extensive mussel surveys of the PRR system were completed in the 1990's and early 2000's. In 1991, Ahlstedt (1998) only found one FD individual and one relict shell in Estill Fork. McGregor and Shelton (1995) found one live individual in the PRR mainstem and relic shells in both Hurricane Creek and Estill Fork. In 2002, Godwin spent 65.6 man hours at 52 sites in the PRR mainstem, Estill Fork, and Hurricane Creek and failed to collect any live Alabama lampmussels. This prompted Godwin (2002) to question "whether or not its extinction is eminent."

Other miscellaneous surveys (as recorded in the AFO species database or Heritage databases) have recorded a small number of additional records for the Alabama lampmussel between 1980 to the present in the PRR mainstem, Estill Fork or Hurricane Creek. Even though one fresh dead shell was discovered at the PRR and Larkin Fork confluence in 1997, no additional records from Larkin Fork proper have been documented since the late 1960s.

Given the low densities collected within the Estill Fork, Hurricane Creek, and PRR mainstem, and that Larkin Fork may no longer support a population of Alabama lampmussel, it is likely that a single adverse event could result in the total loss of any one of these populations and a viable population, as defined in the recovery plan, it not present in the the PRR. Recent reintroductions in the Estill Fork and the lower portions of the PRR ave the potential to increase resiliency within the PRR watershed by increasing densities and reduce the potential impact of adverse events on the population as a whole. However, the successful establishment of the these reintroductions remains to be determined.

Criteria (2): Through reintroductions and/or discoveries of new populations, a viable population is established in each of two additional streams within the historical range of this species. The population in each stream must be distributed such that a single adverse event would be unlikely to eliminate *Lampsilis virescens* from the river system. For these populations, surveys must show that three year classes exist including an adult year class naturally produced within each of the population centers and two younger year classes naturally produced within each of the population centers.

Status (2):

Discoveries

In April 2011, a population of the lampmussel was rediscovered in the upper Emory River (Dinkins et al. 2012) in Morgan County, Tennessee (Figures 1 and 3). The discovery was the first confirmed Alabama lampmussel collection in the upper Emory system since the late 1920's (Dinkins et al. 2012). Multiple sampling trips from April 2011 to January 2012 produced a total of 47 live and/or FD lampmussels at 13 locations spanning 11.3 river miles (18.2 km) of the upper Emory River immediately upstream of the confluence with the Obed River (Dinkins et al. 2012). A length frequency histogram of the lampmussels collected during the Emory River surveys indicated recruitment, with five to six age classes present with length frequencies ranging between 35 to 72 millimeters (mm) (Dinkins et al. 2012).

2015 surveys in the Emory and Obed Rivers failed to record any Alabama lampmussels (Dinkins and Faust 2015). However, suitable habitat for the species was observed within a one mile river reach in the Emory River downstream of its confluence with the Obed River (Dinkins and Faust 2015). Official monitoring in the Emory River has not occurred since 2015, and current knowledge of its range in this system is incomplete at this time. The lampmussel has only been collected within a single 11.3 mile stretch of the Emory River mainstem and, as such, is at risk from a single adverse event, and does not currently meet the above criterion as a viable population. Additional surveys are needed to document any tributary populations.

Reintroductions

The past 20 years has seen extensive reintroduction efforts for the Alabama lampmussel. In 2004, the Tennessee Aquarium Conservation Institute (TNACI formerly Tennessee Aquarium Research Institute, TNARI) collected brood stock from the PRR, cultured, and

released a total of 1,654 individuals into the Estill Fork, Jackson County, Alabama (Johnson 2004).

More recent culturing and reintroductions efforts have been conducted by the ADCNR's Alabama Aquatic Biodiversity Center (AABC). In April of 2010, AABC surveyed a site in the PRR (river mile 50.3) just north of Hollytree, Jackson County, Alabama, for the purpose of collecting lampmussel brood stock for culturing activities at the AABC labs (T. Fobian unpublished data) (Figure 4). A total of seven individuals were collected, including two gravid females. After glochidia were extracted, the brood females were tagged and relocated back to the site in May of 2010. Staff from the AABC continues to collect brood stock from this site (Johnson 2020).

The biologists at the AABC have reintroduced nearly 8,500 juvenile lampmussels in the lower PRR mainstem between 2010 and 2014 (Fobian and Johnson 2010; Johnson 2020). In 2018, 500 cultured lampmussels were reintroduced to sites at PRR river miles 21.2 and 33.3 in Madison and Jackson County, AL, respectively.

Five additional stream reaches within the Tennessee Valley area have also been stocked with cultured individuals. Bear Creek in Colbert County, AL, has received over 11,000 juveniles since 2011 (Johnson 2020). In 2018, Shoal Creek in Lauderdale County, AL and Lawrence County, TN was stocked with approximately 1,850 juvenile lampmussels (Johnson 2020). Between 2010 and 2018, close to 13,000 cultured lampmussels were released in the Elk River, Giles and Lincoln counties, TN (Johnson 2020). The Sequatchie River in Marion County, TN has also received over 4,800 Alabama lampmussels between 2013 and 2018 (Johnson 2020). A trial location in the Tennessee River in Marshall County, AL received 92 individuals in 2014 (Johnson 2018). Figure 5 identifies the hydrologic units (at a hydrologic unit code (HUC) 12 level) containing those river systems with the reintroduction location. It also shows which HUCs currently have natural Alabama lampmussel populations and those HUCs that historically had records for the species.

Monitoring of the reintroduction sites has periodically occurred over the years. In 2013, two tagged individuals were located at the Elk River reintroduction location (Johnson 2018). Bear Creek was last monitored in August 2016 and one individual was located (Johnson 2018). The Sequatchie River only contained shell fragments when monitored in 2014 (Johnson 2018). One month after the July 2018 reintroductions in the PRR, several tagged individuals were recovered. However, before the criterion of a viable population can be met, the reintroduced populations must demonstrate three year classes.

Monitoring efforts are still necessary at all of the reintroduction locations before it can be determined that viable populations have been established.

Criteria (3): The species and its habitat in each stream are protected from foreseeable anthropogenic and natural threats.

Status (3): Natural populations of the Alabama lampmussel are restricted to the upper reaches and tributaries of the PRR watershed and to the upper Emory River mainstem (Figure 1). The Emory River was historically degraded by land use practices, including coal mining, oil and gas drilling/exploration, and timber harvesting (Dinkins et al. 2012). Currently, 85% (26,646 acres) of the Emory watershed is classified as forested lands (Figure 6). The second highest land use classification is agriculture which covers 7.3% of the watershed (2,277 acres).

Figure 6 shows that the PRR watershed is also dominated by forested lands (86% or 141,574 acres). Agriculture covers approximately 9% of the watershed (14,501 acres). In the past, threats associated from non-point source pollution were exacerbated by a lack of riparian vegetation, livestock intrusion, and vehicle fording sites (Godwin 1995). Other threats to the PRR habitat included: sedimentation from mining, off-road vehicle use in streams, cropland erosion, timber harvest, dumping, sewage, logjams, construction, and drainage pipe discharges into the streams (Godwin 1995).

Between 2000 and 2010, the Natural Resource Conservation Service (NRCS) oversaw several conservation programs specifically in the Estill Fork, Hurricane Creek, and Larkin Fork drainages (S. Weaver pers. comm. 2011). These programs included: cattle access control (4 sites, benefiting 69 acres), conservation, vegetative cover (1 site, 1 acre), forage and biomass planting (8 sites, 93 acres), prescribed grazing (10 sites, 175 acres), residue management, no-till/strip-till farming (2 sites, 36 acres), riparian forest buffer (2 sites, 6.3 acres), streambank and shoreline protection (2 sites, 607 feet), tree/shrub establishment (2 sites, 57 acres), cattle watering facility (5 sites, 75 acres), wetland restoration (1 site, 62.2 acres), and wetland wildlife habitat management (4 sites, 67.5 acres).

Currently, the NRCS in Alabama works through the Wetland Reserve Enhancement Program and is available to landowners along the Paint Rock River (NRCS 2019). Landowners can voluntarily enroll in the this conservation easement program which provides/protects habitat for threatened and endangered species, improves water quality through natural water filtration, reduces flood potential, protects biological

diversity, and provides area for limited recreational activities (NRCS 2019).

Conservation activities have also been implemented in the Elk River watershed. As of 2015, the Tennessee Wildlife Resources Agency (TWRA) identified the Elk River as a priority for water quality improvement (Hubbs personal communication 2018). The TWRA has since partnered with other state, federal, and public agencies and private landowners to improve/create a riparian buffer along 26 miles of the Elk River in order to enhance the water quality in the watershed (Hubbs pers. comm. 2018).

The U.S. Geological Survey's (USGS) Protected Areas Database of the United States (PAD-US) is a comprehensive inventory of the nation's protected areas. These publicly or privately held tracts of land are dedicated to the preservation of biological diversity and/or the management of open space for recreational, natural, and/or cultural uses (USGS 2018). The PAD-US tracts are organized according to the USGS's GAP Analysis Program (GAP) (USGS 2018). GAP status codes reflect the level of biodiversity protection afforded by the management of that land tract (USGS 2018). GAP status codes 1 and 2 are areas managed for biodiversity (USGS 2018). GAP status 3 areas are managed for conservation but are also subject to extraction (e.g. mining or logging) (USGS 2018). GAP status code 4 areas are restricted access but have no known mandate for protection (USGS 2018).

According to the 2016 PAD-US inventory, a significant portion of the PRR watershed is covered by PAD-US tracts. 17.2% (28,343 acres) of the PRR watershed is classified as a PAD-US tract with a GAP code of either 2 or 4. Figure 7 shows the PAD-US tracts designated by their GAP codes within and surrounding the PRR and Emory River watersheds.

Fortunately, both natural populations of lampmussel in the upper PRR and upper Emory River occur in rural areas dominated by forested land (Figure 6) in private and public ownership with little to no urban development. While there are areas that could be enhanced or better managed for minimizing non-point source impacts, these populations are reasonably protected from foreseeable anthropogenic and natural threats.

Based on our review, no single recovery criteria has been fully achieved. However, we believe that the outlook for this species is positive if current reintroduction events, conservation activities, and habitat status persist and continue.

C. Updated Information and Current Species Status

1. Biology and Habitat

a) Biology and Life History:

The Alabama lampmussel (Figure 8) is a medium sized freshwater mussel usually measuring less than 75 mm (approximately 3 in.) in length with a moderately thick/moderately inflated shell that is often tawny to greenish yellow, with white nacre (Williams et al. 2008). It historically occurred in small creeks to large rivers; however, at present, it seems to only persist in small to moderate-sized streams in areas of slow to moderate current within sand and gravel substrates. The lampmussel has also been found in areas with stands of water willow (*Justicia americana*) (Williams et al. 2008).

This species is a long-term brooder and is gravid from late summer or autumn into the following summer (Williams et al. 2008). Dr. Paul Johnson's work at the Tennessee Aquarium Research Institute and AABC has successfully transformed lampmussels on several different fish species in the family Centrarchidae, including: green sunfish (*Lepomis cyanellus*), rock bass (*Ambloplites rupestris*), smallmouth bass (*Micropterus dolomieu*), spotted bass (*M. punctulatus*), largemouth bass (*M. salmoides*), and redeye bass (*M. coosae*) (Johnson 2018, Johnson 2011, Williams et al. 2008).

b) Abundance/population trends, demographic features or trends:

NatureServe is a global conservation network used to assess the status of endangered species. NatureServe ranks the Alabama lampmussel as critically imperiled (ALNHP 2019, NatureServe 2019). This ranking indicates that the species is at a very high risk of extinction due to extreme rarity with 5 or fewer populations (NatureServe 2019). The Alabama lampmussel has persisted at this level since the previous 5 year review.

Natural Alabama lampmussel populations are restricted to the headwaters of the PRR (Figure 2) (Mirarchi 2004) and the upper Emory River (Figure 3) (Dinkins et al. 2012) and tends to occur in low numbers where found (McGregor and Shelton 1995, Ahlstedt 1998, Godwin 2002, Fobian et al. 2008, Dinkins et al. 2012). Since 2004, extensive reintroduction events have occurred in

northern Alabama and southern watersheds in Tennessee (Figure 5). For additional information on the species' abundance and population trends refer to Section II.B.3 of this review.

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

The population of lampmussels in the Emory River were genetically confirmed by Moyer and Ferguson (2011, 2012) after specimens from the Emory River were shown to be more genetically similar to lampmussels in the PRR than other morphologically similar species (pocketbook (*Lampsilis ovota*), wavy-rayed lampmussel (*L. fasciola*), and fluted shell (*Lasmigona costata*) found in the Emory River (Moyer and Ferguson 2011). Maximum parsimony and Bayesian phylogenetic methods revealed strong support for a clade consisting of the two populations (Emory River and PRR), indicating the individuals collected from the Emory River were indeed the Alabama lampmussel (Moyer and Ferguson 2012).

The Alabama lampmussel numbers are relatively low, even among the best remaining populations. Due to this, gene flow and diversity are of utmost concern regarding culturing and reintroduction efforts at the AABC labs. In order to minimize genetic diversity, the AABC utilizes as many different females for juvenile production as possible (Fobian and Johnson 2010, Johnson and Hubbs 2010) and is continuously utilizing new brood stock from the streams with natural populations (M. Buntin pers. comm. 2011).

Additionally, the AABC will continue to preserve genetic material from excess glochidia and propagated cohorts (i.e., individuals that do not survive) for later use per the Services' policy regarding the controlled propagation of species under the Endangered Species Act (USFWS and NOAA 2000).

d) Taxonomic classification or changes in nomenclature:

A member of the freshwater mussel family Unionidae, the Alabama lampmussel was originally described as *Unio virescens* (Lea, 1858). The type locality is the Tennessee River at Tuscumbia, Colbert County, Alabama (Figure 7) (Ortmann 1918, Parmalee and Bogan 1998). Parmalee and Bogan (1998) summarized the synonymy of the Alabama lampmussel; it has been considered a member of the genera *Unio*, *Margaron*, *Lampsilis*, and *Ligumia* at various times in history. It was first

considered a member of the genus *Lampsilis* by Simpson in 1900 (Parmalee and Bogan 1998).

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.

e) Spatial distribution, trends in spatial distribution, or historic range:

The Alabama lampmussel historically occurred from the headwaters of the Tennessee River in eastern Tennessee downstream to Bear Creek in northwestern Alabama (Mirarchi 2004, Williams et al. 2008). The following table (Table 1) summarizes streams with historical occurrences of the Alabama lampmussel.

Table 1. Historical river occurrences for the Alabama lampmussel

Historic Records		
River	County	State
Paint Rock River ^{1'2'5'7}	Jackson	Alabama
Bear Creek ^{2'4'5}	Colbert Franklin	
Little Bear Creek (tributary to Bear Creek) ^{2'5'6}	Franklin	
Spring Creek ^{2'3}	Colbert	
Anderson Creek (tributary to the Elk River) ^{4'5'6'7}	Lauderdale	
Tennessee River ^{1'2}	Colbert	
Estill Fork ⁸	Jackson	
Beech Creek (tributary to Brown Creek) ⁹	Marshall	
Larkin Fork ⁷	Jackson	
Emory River ^{4'5}	Roane Morgan	
Little Emory ³	Roane	
Coal Creek (tributary to the Clinch River) ^{2'4'5}	Anderson	

(ANSP 2019)¹, (UMMZ 2019)², (OSUM 2019)³, (Ortmann 1918)⁴, (Ortmann 1925)⁵, (Isom and Yokley 1968)⁶, (Isom and Yokley 1973)⁷, (Jorgensen and Sharp 1971)⁸, (Lewis 1876)⁹

It has been eliminated throughout a majority of its historical range, and is now restricted to only the upper reaches of the PRR system in Jackson County, Alabama, and potentially into Franklin County, Tennessee (Parmalee and Bogan 1998), and in the upper Emory River, Morgan County, Tennessee (Dinkens et al. 2012). However, through propagation efforts in both Alabama and Tennessee, the Alabama lampmussel has been reintroduced into more drainages within its historical range (Table 2).

Table 2. Alabama lampmussel reintroduction sites.

Reintroductions		
River	County	State
Paint Rock River	Jackson	Alabama
	Madison	
Estill Fork	Jackson	
Bear Creek	Colbert	
Shoal Creek	Lauderdale	
	Lawrence	
Elk River	Giles	Tennessee
	Lincoln	
Sequatchie River	Marion	

Figure 5 identifies the HUCs that contain the river systems with the reintroduced populations, current natural populations, and historical populations.

f) Habitat or ecosystem conditions:

Historically the Alabama lampmussel was found in small streams to large rivers with the Tennessee River watershed from its headwaters in eastern Tennessee approximately to Muscle Shoals, AL (Williams et al. 2008). Habitat in small streams is described has areas of moderate currents with sand and gravel substrates and it has been extirpated from large river habitats (Williams et al. 2008). Dinkins and Faust (2015) observed that this species occurs in slow moving streams with shallow, sandy substrates and in association with beds of water willow (*Justicia Americana*).

The Emory River lies in the Ridge and Valley physiographic province. It is a tributary to the lower Clinch River, which empties into the Tennessee River at Tennessee River Mile (TRM) 567.5, near Kingston, Tennessee.

The PRR flows southwest 96.6 kilometers (km) (60 miles) along the southern edge of the Cumberland Plateau section of the Appalachian Plateau Physiographic Province before it enters the Tennessee River (TRM 343.2) in Madison County, AL. The last 13 river miles are within the impounded reaches of Wheeler Reservoir (Ahlstedt 1998, Fobian et al. 2008). Carbonate rock and karst formations dominant the landscape (Godwin 2002). The upper PRR lies predominantly within the Tuscumbia Limestone geologic

formation while the lower PRR lies primarily within Monteagle Limestone.

The PRR generally contains streamside zones that are well to moderately forested (Godwin 2002). The upper sections of the PRR are primarily narrow floodplains that are forested along the streams with slopes that may rise as much as 300 meters (984 feet) above the streams (Godwin 2002), while lower reaches primarily consist of wide alluvial river valley floodplains with narrow riparian zones adjacent to pastures and row crops (Godwin 2002, Fobian et al. 2008). The PRR is surrounded by forested mountains with heavy agricultural production in the adjacent floodplain, primarily for soybeans, cotton, corn, milo, and beef cattle (Ahlstedt 1998, Fobian et al. 2008).

D. Five-Factor Analysis

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

The PRR and Emory River occur in rural areas dominated by forested land (Figure 6) with little to no urban development. The primary threats to these systems and to the locations with reintroduced populations originate from agricultural and livestock practices in the surrounding areas.

PRR Habitat

The PRR was substantially altered in the 1960s from a series of channel engineering projects which involved extensive stream channelization and removal of snags and riverbank timber in the mainstem PRR, Larkin Fork, Estill Fork, and Hurricane Creek (Barbour 2003). Ahlstedt (1998) noted that riffle and shoal habitats have never recovered from this effort and the restoration of natural hydromorphology continues to be aggravated by non-point source pollution associated with agricultural runoff. The mussel fauna may continue to decline until measures are taken to reduce these substantial stream alterations and perturbations (Ahlstedt 1998).

In 1995, Godwin surveyed the PRR to map and document sources of impairment to aquatic habitat in the watershed. This effort found 100 sources of impairment (termed impacts) at 85 survey sites. Seventy-five impacted sites were within the PRR mainstem, 18 in Estill Fork, 5 in Hurricane Creek, and 2 within Larkin Fork. The most common impact was lack of riparian vegetation (47%), followed by cattle access to the stream (19%), and shallow water fords for agricultural vehicles (14%).

Other documented impacts were sedimentation from mining and off-road vehicles (4% each), cropland erosion and timber harvest sites (3% each), and dumping of debris (2%). Godwin (1995) noted single occurrences of the following potential stressors: sewage inflow, major logjam, siltation from construction, and drainage pipe, during the survey.

Lampmussel habitat has also been disturbed and degraded by unauthorized removal of creek gravel from within the stream channel at several locations within the PRR drainage basin (D. Fears pers. comm. 2011).

Emory River Habitat

The Emory River population may historically have suffered from mining activity along the river (Hubbs pers. comm. 2018). Most mines adjacent to the Emory River are currently abandoned and the affected stream miles appear to be recovering from those activities (Hubbs pers. comm. 2018). However, impairment caused by livestock accessing the river is now apparent in these reaches (Hubbs pers. comm. 2018).

Habitat at Reintroduced Sites

Reintroduced populations now exist in the PRR, Estill Fork, Bear Creek, Tennessee River, Shoal Creek, Elk River and the Sequatchie River. Of these, the Elk River and the Sequatchie River have had several identifiable modifications to their habitats.

One of the Elk River's main threats comes from the activities associated with the operation and maintenance of the Tims Ford Dam (Hubbs pers. comm. 2018). Fluctuation in water levels below the dam has led to unstable river bank conditions. Additionally, the cold water released a Tim's Ford dam has altered the natural water temperature regime for miles downstream (Hubbs pers. comm. 2018).

The Elk River is also threatened by agricultural and animal husbandry practices in the area. Farm cultivation adjacent to the river banks has intensified erosion and sedimentation and increased the amount of fertilizers and pesticides introduced into the system (Hubbs pers. comm. 2018). Livestock access to the river has also furthered river bank instability (Hubbs pers. comm. 2018).

The Sequatchie River is also threatened by livestock access (Hubbs pers. comm. 2018). Surface coal mining in the area has also increased mineral levels such as iron and manganese in the water and has lowered some of the pH levels in the watershed (Hubbs pers. comm. 2018).

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

The Alabama lampmussel is not known to have any commercial value and overutilization has not been a problem. Based on the best available data, overutilization is not believed to be a threat at this time. However, because of the species' rarity any inadvertent collection could be a threat and could disturb natural reproduction.

3. Disease or predation:

Diseases of freshwater mussels are practically unknown. 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. Only one viral disease has been documented, occurring in a Asian species, the Chinese pearl mussel (*Hyriopsis cumingii*).

While information is limited, measures are being taken in the propagation of freshwater mussels to limit their risk to disease, especially when hatchery reared animals are being released into the wild. However, to date, no other mussel culture facility has reported any disease issues in a hatchery environment (Johnson and Hubbs 2018).

Several animals sympatric with the Alabama lampmussel 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 (*Lutra canadensis*) are also known to predate on 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.

We do not believe disease or predation to significantly threaten the Alabama lampmussel.

4. Inadequacy of existing regulatory mechanisms:

The Alabama lampmussel is afforded protections through Section 7 and Section 9 of the Endangered Species Act (ESA) which requires Federal agencies to ensure that their activities, in consultation with the Service, are not likely to jeopardize the continued existence of listed species or

adversely modify designated critical habitats.(section 7) and defines acts that are prohibited from occurring to endangered species. It is also afforded protection 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 assistance in the protection of species or subspecies of wildlife which are deemed to be endangered or threatened elsewhere by prohibiting the taking, possession, transportation, exploration, processing, sale or offer for sale or shipment within this state of species of wildlife listed on the United States' List of Endangered Wildlife unless such actions will assist in preserving or propagating the species.

Even when a Federal action is reviewed by the Service, and the status and presence of the Alabama lampmussel is identified prior to execution of the action, conservation measures may not be taken unless it is “likely to adversely affect” the species. In these cases, the Federal agency develops minimization and conservation measures with the Service through formal consultation. However, those actions that don’t require formal consultation may collectively magnify into larger problems for the species. One limitation of the ESA is that there are fewer opportunities to compel proponents of these “smaller” projects to enact conservation measures or review the collective impacts of these “smaller” projects.

While the Alabama lampmussel may have species 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 unless they specifically contact the Service for technical assistance.

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) and in Tennessee to the Tennessee Department of Environment and Conservation (TDEC). Currently ADEM (Alabama Administrative Code, Title 22, Section 22-22-1 et seq.) and TDEC (Tennessee Code Annotated, 69-3-101 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 Alabama lampmussel.

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 3 lists the impaired waters currently identified under Section 303d within watersheds with natural and reintroduced populations of the Alabama lampmussel

Table 3. CWA's Section 303d impaired waters for streams in Alabama lampmussel range (extant natural and reintroduced populations). (TDEC 2019. ADEM 2018)

State	County	Stream	Impairment
Alabama	Jackson	Guess Creek (tributary to the PRR)	Pathogens (from pasture grazing)
	Jackson	Clear Creek (tributary to the PRR)	E. coli
	Limestone	Tennessee River	Nutrients (from agriculture)
	Lauderdale	Tennessee River	Nutrients (from agriculture)
	Colbert	Bear Creek	Mercury
Tennessee	Morgan	Emory River	Mercury (from atmospheric deposition)
	Marion	Unnamed tributary to Sequatchie River	Sedimentation; Nitrates; E. coli (from pasture grazing)
	Marion	Sequatchie River	Mercury (from atmospheric deposition); E. coli (from pasture grazing)
	Lincoln	Elk River	E. coli (from pasture grazing)
	Giles	Elk River	E. coli (from pasture grazing)

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.

Section 26a of the Tennessee Valley Authority (TVA) Act regulates construction, operation, or maintenance of any dam, appurtenant works, or other obstruction affecting navigation, flood control, or public lands or reservations along or in the Tennessee River or any of its tributaries. Within these Tennessee River drainages, TVA's Section 26a permits are usually applied for concurrently with the Army Corps of Engineers (ACOE) Section 404 permits.

While a single project (e.g., Section 404 or Section 26a permit) will usually not jeopardize the continued existence of the Alabama lampmussel, the collective encroachment on the Alabama lampmussel's finite habitat may have a larger impact and 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 lampmussel. 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 lampmussel in the watersheds where pesticides are being applied.

Regardless of the Federal or state regulatory mechanism, enforcement of these regulations is necessary to provide the intended protections. In addition, many private operations are likely unaware of this species' presence and protected status and may not take any additional precautionary measures to aid in the recovery of this species.

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

Climate change is also considered a potential threat to the Alabama lampmussel. 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 lampmussel; however, climate change is almost certain to affect aquatic habitats in their watersheds. Climate change has

the potential to increase the vulnerability of the lampmussel to random catastrophic events, primarily through more intense or frequent droughts. Droughts can potentially have negative impacts on water quality (e.g. dissolved oxygen) 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 stagnate pools. In Alabama, moderate to extreme drought conditions were recorded in 26% of months between the years 2010 and 2019 and approximately 8% of the months in this time period were considered severe droughts (NOAA 2020).

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

Fish barriers, such as those caused by poorly designed road crossings, can limit fish movement, which would directly impact the distribution of freshwater mussel host fish. In 2010, the Service assessed over 51 river miles (82 km) in the PRR basin and identified five high priority road crossings that likely function as fish barriers (B. Bouthillier pers. comm. 2011).

E. Synthesis

The Alabama lampmussel continues to be in danger of extinction due to persistent threats in its highly restricted range. Natural populations are known to occur in the upper PRR and Emory River. However, these natural populations have a relatively low abundance. The species has been reintroduced into the lower PRR, Bear Creek, Estill Fork, Sequatchie River, Shoal Creek and Elk River. Surveys are needed to determine survival, reproductive success, and recruitment at reintroduced sites and identify if and when reintroduce populations are established and viable as defined in the recovery plan.

Habitat destruction or modification is presently the greatest threat to this species. Since agriculture is the predominant stream-side land use, partnerships with private landowners to implement conservation practices, easements, and/or best management practices on their properties are vital to the continued existence of the lampmussel.

Based on the preceding information in this review, we do not recommend that downlisting the Alabama lampmussel from endangered to threatened or reassigning a new recovery priority number at this time. This assessment is based

on our knowledge of the species' life history, its limited distribution, and potential threats to its habitat.

III. RESULTS

A. Recommended Classification: No change is needed.

IV. RECOMMENDATION FOR FUTURE ACTIONS

- Continue working with local landowners to preserve the integrity of stream banks and riparian zone, and mitigate problem areas by utilizing cost-shares and other conservation initiatives.
- Conduct systematic population monitoring of extant natural and reintroduced populations including documenting local threats.
- Specific life history and habitat needs have not been well documented; examine unknown components of life history and ecology
- Continue propagation and culture activities.
- Revise and update the recovery plan for the species to stress the importance of propagation/culture, enhancing our knowledge of basic biological processes (life history), and identify reintroduction as a primary recovery objective.
- Develop a contingency plan to respond to a spill or natural disaster within occupied habitat.
- Provide public outreach and education for the Alabama lampmussel, targeting property owners and farmers along the extant range.
- Continue to develop new partnerships and utilize conservation initiatives with landowners along the riparian habitats and within the PRR and Emory River watershed.
- Conduct genetic and histology research to inform propagation and culture work and ensure genetic fitness of reintroduced populations.
- Conduct a detailed analysis of habitat requirements, including physiochemical parameters of the stream habitat used by the Alabama lampmussel.

V. REFERENCES

- The Academy of Natural Sciences Philadelphia (ANSP). Malacology Collection 2019. Available at <http://clade.ansp.org/malacology/collections/>.
- Ahlstedt, S. A. 1998. Status survey for federally listed endangered freshwater mussel species in the Paint Rock River system, northeastern Alabama, U.S.A. *Walkerana* (for 1995-1996) 8(19):63-80.
- Alabama Department of Environmental Management (ADEM). 2018 Alabama 303(d) List. Available at www.adem.state.al.us/programs/water/303d.cnt. Accessed on June 10, 2019.
- Alabama Natural Heritage Program (ALNHP). 2019. Rare Species List. Available at alnhp.org/index.php. Accessed on June 20, 2019.
- Barbour, M. S. 2003. Paint Rock River watershed non-point source pollution. Unpublished report to the Alabama Department of Environmental Management, Montgomery, Alabama. Alabama Natural Heritage Program, Montgomery, Alabama. 184pp.
- Dinkins, G. R., H. D. Faust, and S. A. Ahlstedt. 2012. Assessment of native mussels in upper Emory River and selected tributaries, Morgan County, Tennessee. Prepared by Dinkins Biological Consulting, LLC, for The Nature Conservancy, Nashville, TN. 23pp.
- Dinkins, G. R. and H. D. Faust. 2015. Assessment of native mussels in selected reaches within the Obed Wild and Scenic River. Dinkins Biological Consulting, Powell, Tennessee.
- Fobian, T. B., M. L. Buntin, J. T. Garner, and P. D. Johnson. 2008. Assessment of freshwater mussel populations in the Paint Rock River Basin, Jackson Co., Madison Co., and Marshall Co., Alabama; Section 6; Fiscal Year 2007-2008 Annual Report. Alabama Department of Conservation and Natural Resources, Marion, Alabama. 49pp.
- Fobian, T. B. and P. D. Johnson. 2010. Site plan for the proposed augmentation of the Alabama lampmussel, *Lampsilis virescens* (I. Lea, 1858), in Paint Rock River, Jackson, Madison and Marshall Counties, Alabama. Alabama Department of Conservation and Natural Resources, Marion, Alabama. 12pp.
- Godwin, J. C. 1995. Survey of non-point source pollution in the Paint Rock River watershed. Alabama Natural Heritage Program, Montgomery, Alabama. 109pp.
- _____. 2002. Monitoring of federally listed and rare mussels in the Paint Rock River. Prepared for the Alabama Department of Conservation and Natural Resources.

Montgomery, Alabama. 80pp.

Grizzle, J. M. and C. J. Brunner. 2009. Infectious diseases of freshwater mussels and other freshwater bivalve mollusks. *Reviews in Fisheries Science* 17(4):425-467.

Intergovernmental Panel on Climate Change (IPCC). 2014. Synthesis Report. Contribution of Working Groups I, II, and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds)]. Geneva, Switzerland. 151 pp.

Isom, B. G. and P. Yokley. 1968. Mussels of Bear Creek watershed, Alabama and Mississippi, with a discussion of the area geology. *American Midland Naturalist* 79(1):189-196.

Isom, B. G. and P. Yokley. 1973. The mussels of the Flint and Paint Rock River systems of the southwest slope of the Cumberland Plateau in North Alabama – 1965 and 1967. *American Midland Naturalist* 89(2):442-446.

Johnson, P. D. 2004. Mobile Basin Mollusk Recovery Activities Completed Under USFWS Contract # 1148-40181-98 and The Nature Conservancy contract # GAFO 06267. Preliminary Summary Report to the U.S. Fish and Wildlife Service, Mississippi Field Office.

_____. Agreement F11 AP00133 Final Report, January 18, 2018. U.S. Fish and Wildlife Service Assistance with Propagation, Reintroduction, Research and Monitoring of Federally Listed Mollusks in Alabama.

_____. 2020. Alabama Aquatic Biodiversity Center – Cumberlandian Reintroduction Efforts – Feb. 2020. Unpublished raw data.

Johnson, P. D. and D. Hubbs. 2010. Proposed reintroduction of Alabama lampmussel, *Lampsilis virescens*, in the Elk River, Lincoln County, Tennessee. Alabama Department of Conservation and Natural Resources, Marion, Alabama. 9pp.

Johnson, P. D. and D. Hubbs. 201. Proposed reintroduction of Alabama lampmussel, *Lampsilis virescens*, in the Bear Creek, Colbert County, Alabama. Alabama Department of Conservation and Natural Resources, Marion, Alabama. 12pp.

_____. 2018. Proposed reintroduction of Alabama Lampmussel, *Lampsilis virescens* (Lea, 1858), in the Shoal Creek, Lauderdale Co., Alabama and Lawrence Co., Tennessee. Alabama Department of Conservation and Natural Resources, Marion, Alabama. 9pp.

Jorgensen, S.E. and R.W. Sharp (eds). 1971. Proceedings of a symposium on rare and endangered mollusks (Naiads) of the United States. Bureau of Sport Fisheries and Wildlife, U.S. Department of the Interior. Twin Cities, MN.

- Lewis, James. 1876. Fauna of Alabama. Freshwater and land shells. Ala. Geol. Surv., Proj. Rep., 61-100.
- McGregor, S. W. and D. N. Shelton. 1995. A qualitative assessment of the unionid fauna of the headwaters of the Paint Rock and Flint Rivers of north Alabama and adjacent areas of Tennessee, 1995. Geological Survey of Alabama, Tuscaloosa, Alabama. 78pp.
- Mirarchi, R. E. (editor). 2004. Alabama Wildlife, Volume One. A checklist of vertebrates and selected invertebrates: Aquatic mollusks, fishes, amphibians, reptiles, birds, and mammals. The University of Alabama Press, Tuscaloosa, Alabama. 209pp.
- Moyer, G. R. and E. Diaz-Ferguson. 2011. Genetic identification of putative *Lampsilis virescens* specimens collected in the Emory River, TN. United States Fish and Wildlife Service Conservation Genetics Lab, Warm Springs, Georgia. 10pp.
- _____. 2012. Identification of endangered Alabama lampmussel (*Lampsilis virescens*) specimens collected in the Emory river, Tennessee, USA via DNA barcoding. Short Communication. *Conservation Genetics* DOI 10.1007/s10592-012-0328-z. Published online: 01 March 2012.
- National Oceanic and Atmospheric Administration (NOAA). National Centers for Environmental Information, Climate at a Glance: Statewide Time Series. 2020. Retrieved on January 29, 2020 from <https://www.ncdc.noaa.gov/cag/>.
- Natural Resources Conservation Service (NRCS), 2019. Agricultural Conservation Easement Program. Accessed at <https://www.nrcs.usda.gov/wps/portal/nrcs/main/al/programs/easements/acep/>.
- NatureServe. 2019. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available <http://explorer.natureserve.org>. Accessed: June 20, 2019.
- The Ohio State University (OSUM) Division of Molluscs, Bivalve Collection 2019. Available at https://www.asc.ohio-state.edu/eeob/molluscs/biv_base4.html.
- Ortmann, A. E. 1918. The naiades (freshwater mussels) of the upper Tennessee Drainage. With notes on synonymy and distribution. *Proceedings of the American Philosophical Society* 57(4):521-626.
- _____. 1925. The naiad-fauna of the Tennessee River system below Walden Gorge. *The American Midland Naturalist* 9(7):321-372.
- Parmalee, P. W. and A. E. Bogan. 1998. The freshwater mussels of Tennessee, University of Tennessee Press, Knoxville, Tennessee.

- Tennessee Department of Environment and Conservation (TDEC). 2019. Final 2018 List-EPA Approved Lists of Impaired Waters. Available at <https://www.tn.gov/environment/program-areas/wr-water-resources/water-quality/water-quality-reports---publications.html>. Accessed on June 10, 2019.
- University of Michigan's Museum of Zoology Mollusk Collection (UMMZ) 2019. Available at <https://lsa.umich.edu/ummz/mollusks/collections.html>.
- U.S. Fish and Wildlife Service (USFWS). 1985. A Recovery Plan for the Alabama Lamp Pearly Mussel, *Lampsilis virescens* (Lea, 1858). USFWS, Jackson, Mississippi. 40pp.
- U.S. Fish and Wildlife Service and National Oceanic and Atmospheric Administration (USFWS and NOAA). 2000. Policy regarding the controlled propagation of species listed under the Endangered Species Act. *Federal Register* 65(183): 56919-56922.
- U.S. Geological Survey, Gap Analysis Program (GAP). 2018. Protected Areas Database of the United States (PAD-US): U.S. Geological Survey data release, <https://doi.org/10.5066/P955KPLE>. Accessed on June 10, 2019.
- Williams, J. D., A. E. Bogan, and J. T. Garner. 2008. Freshwater mussels of Alabama and the Mobile Basin in Georgia, Mississippi, and Tennessee, University of Alabama Press, Tuscaloosa, Alabama.
- Williams, J.D., A.E Bogan, R.S. Butler, K.S. Cummings, J.T. Garner, J.L. Harris, N.A. Johnson, and G.T. Watters. 2017. A revised list of the freshwater mussels (Mollusca: Bivalvia: Unionida) of the United States and Canada. *Freshwater Mollusk Biology and Conservation* 20:33-58.
- Yang, L., Jin, S., Danielson, P., Homer, C., Gass, L., Case, A., Costello, C., Dewitz, J., Fry, J., Funk, M., Grannemann, B., Rigge, M. and G. Xian. 2018. A New Generation of the United States National Land Cover Database: Requirements, Research Priorities, Design, and Implementation Strategies, p. 108–123.

Provided new/updated information

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Dr. Paul D. Johnson, Program Supervisor
ADCNR, Alabama Aquatic Biodiversity Center, Marion, AL

Mr. Don Hubbs, State Malacologist
TWRA, Camden, TN

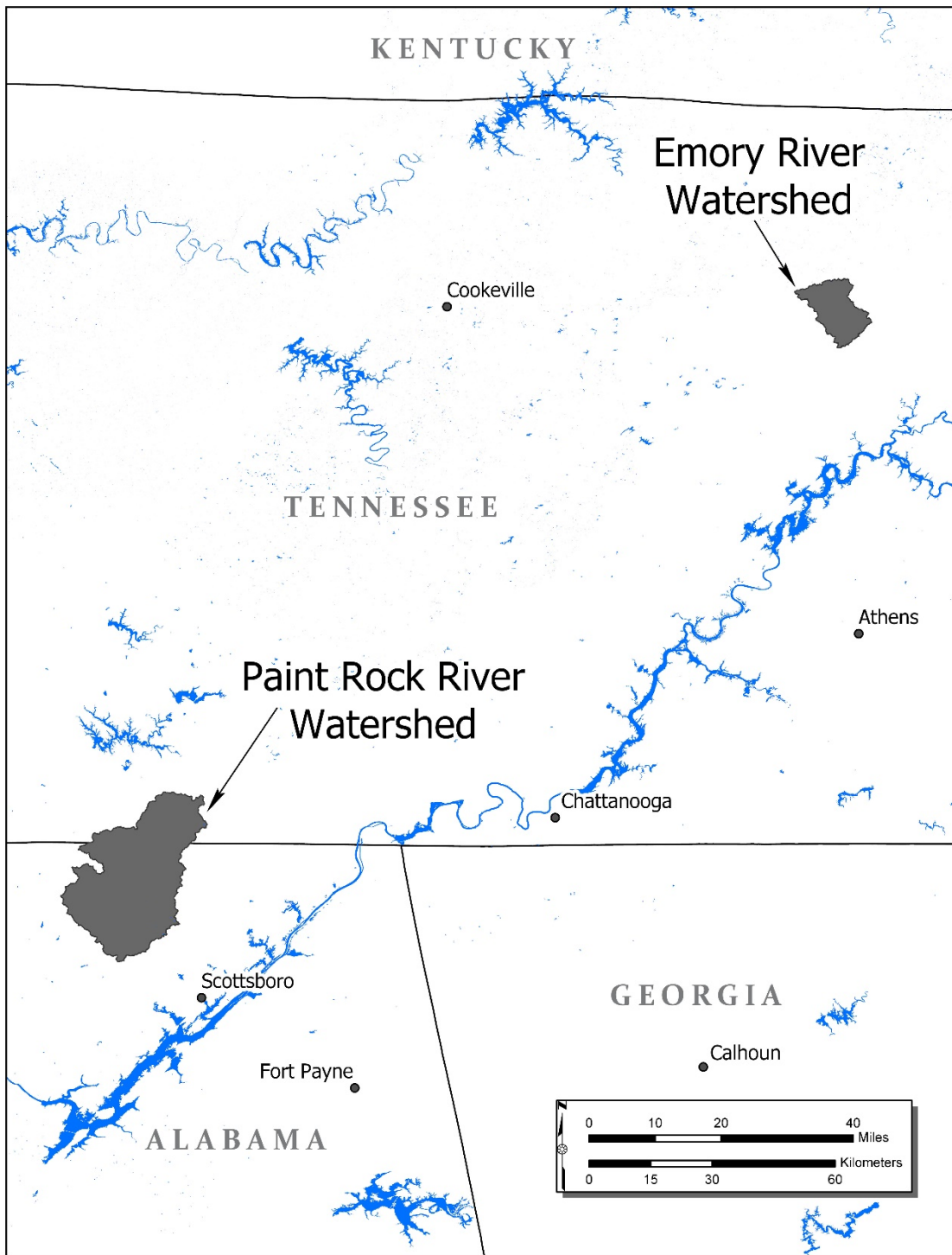


Figure 1. Current range of the Alabama lampmussel (*Lampsilis virescens*). Map created by the USFWS Alabama Ecological Services Field Office, Daphne, Alabama

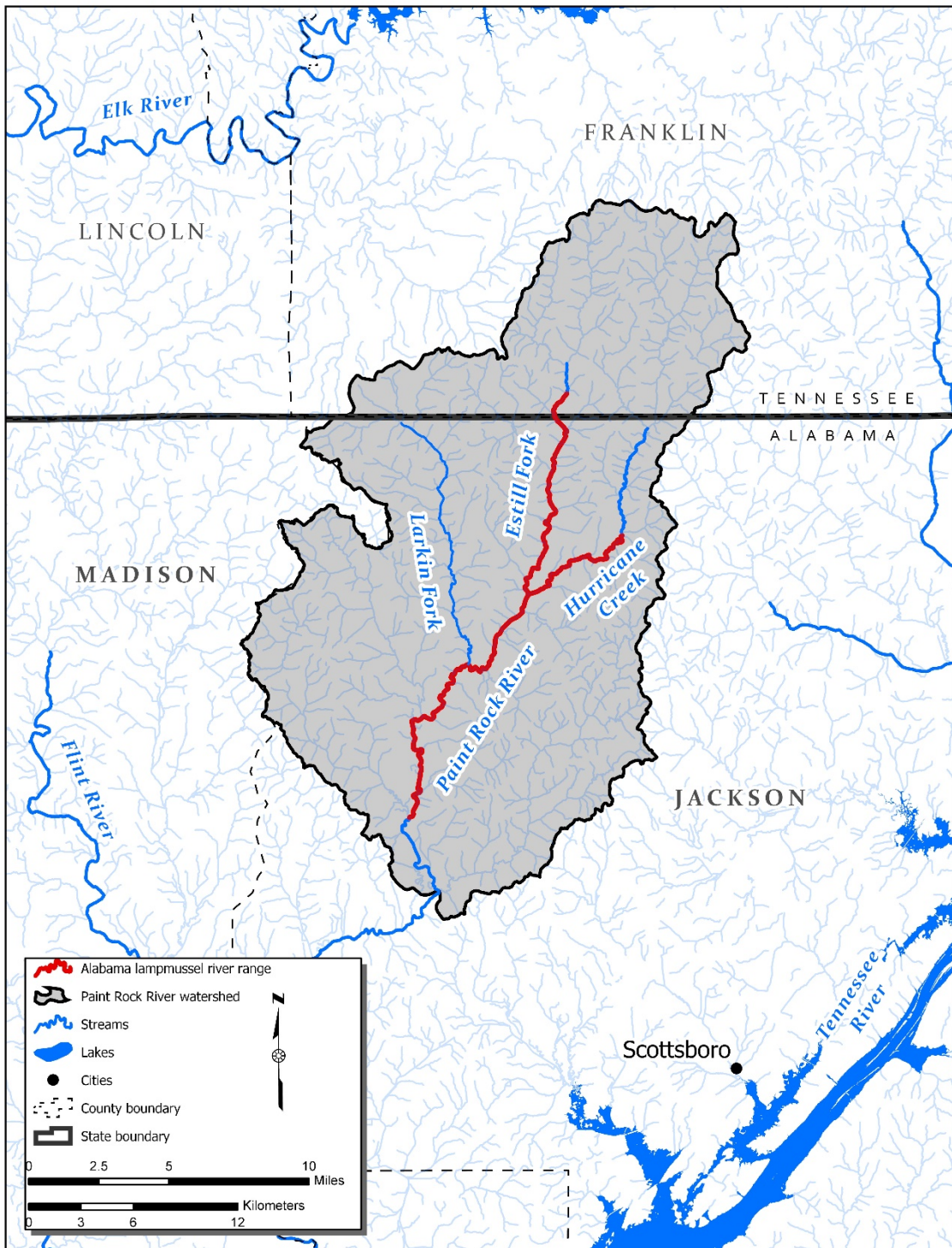


Figure 2. Current range of the Alabama lampmussel within the PRR watershed. Map created by the USFWS Alabama Ecological Services Field Office, Daphne, Alabama

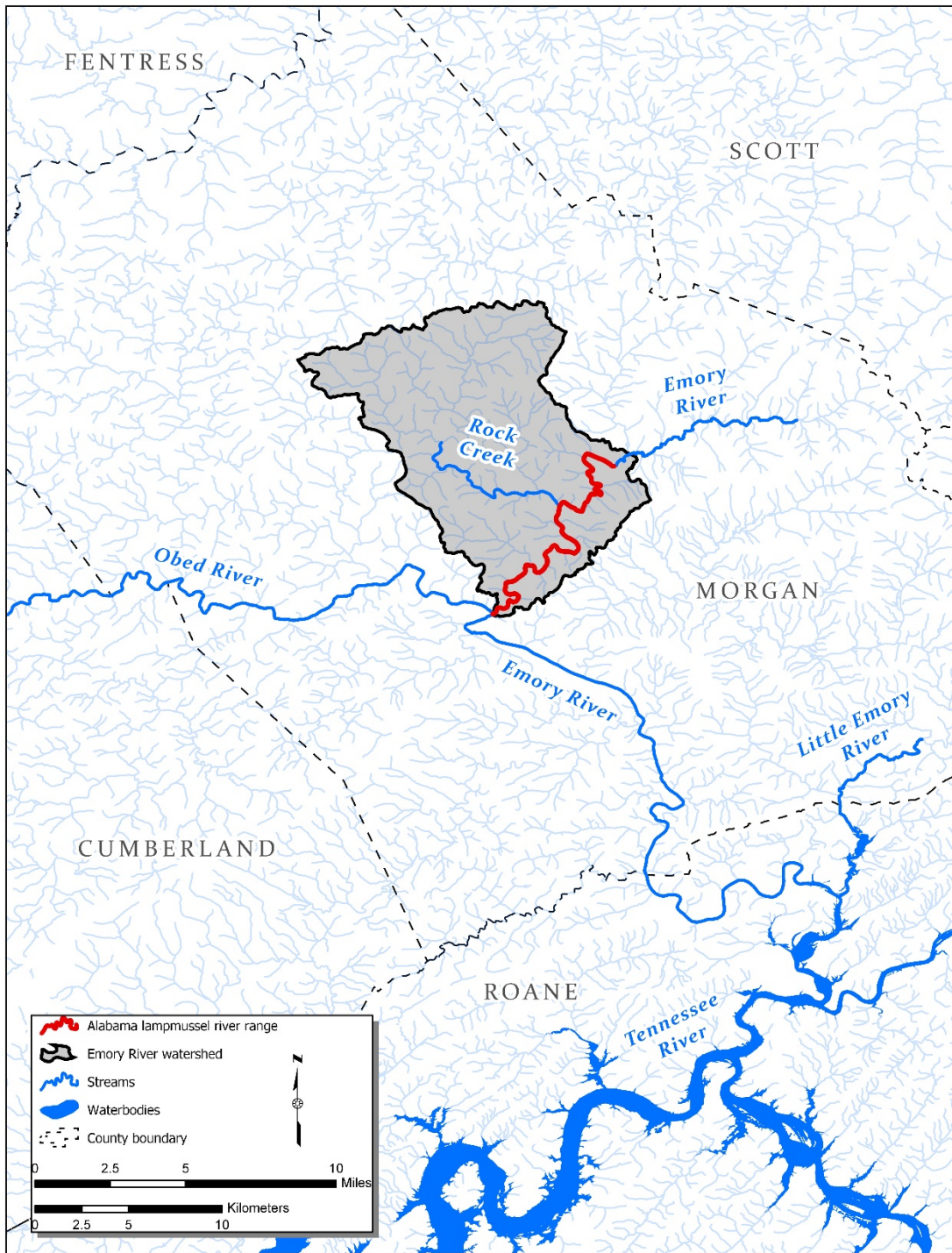


Figure 3. Current range of the Alabama lampmussel within the Emory River watershed. Map created by the USFWS Alabama Ecological Services Field Office, Daphne, Alabama.



Photo Credit: ADCNR

Figure 4. Alabama lampmussel culture work (2010) at the ADCNR Alabama Aquatic Biodiversity Center in Marion, Alabama. A) Juvenile lampmussels cultured in hatchery pond within a suspended upwelling system. B) AABC biologist, Todd Fobian, tagging juveniles prior to release. C) Tagged juvenile being released at reintroduction site.

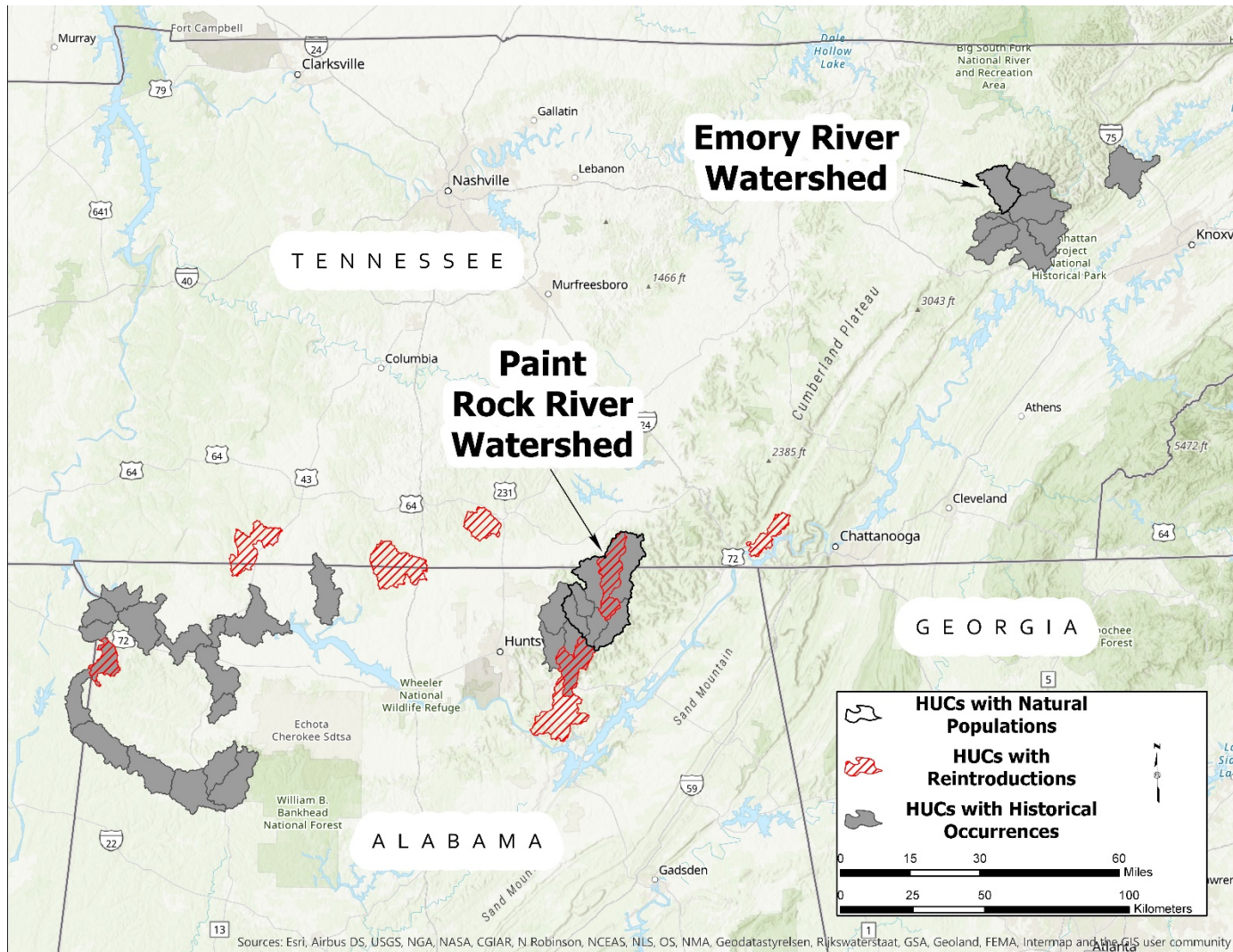


Figure 5. Historical range, extant natural populations, and watersheds where reintroductions have occurred for the Alabama lampmussel. Map created by the USFWS Alabama Ecological Services Field Office, Daphne, Alabama

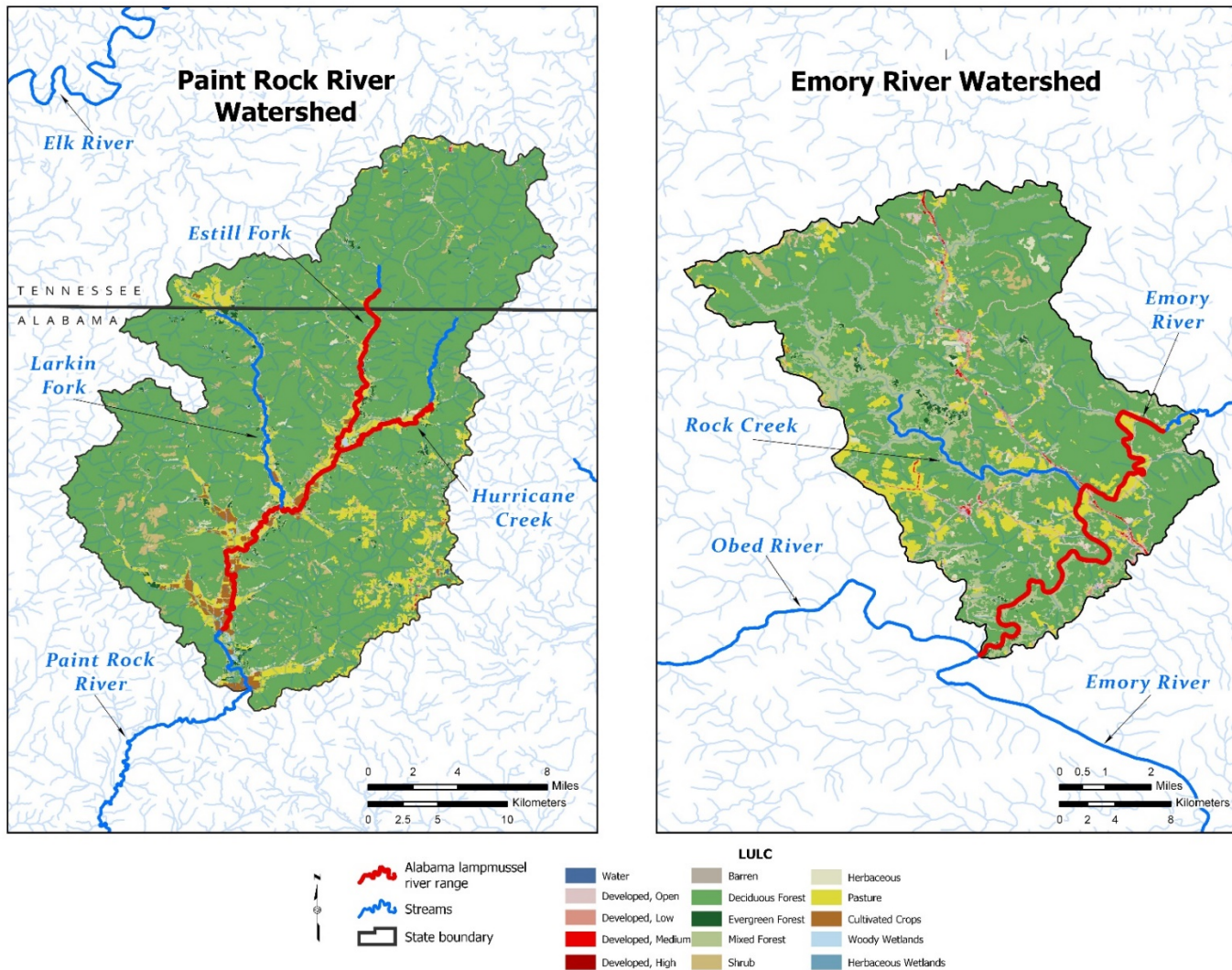


Figure 6. Land use land cover (LULC) within the PRR and Emory River watersheds (Yang et al 2018). Map created by the USFWS Alabama Ecological Services Field Office, Daphne, Alabama.

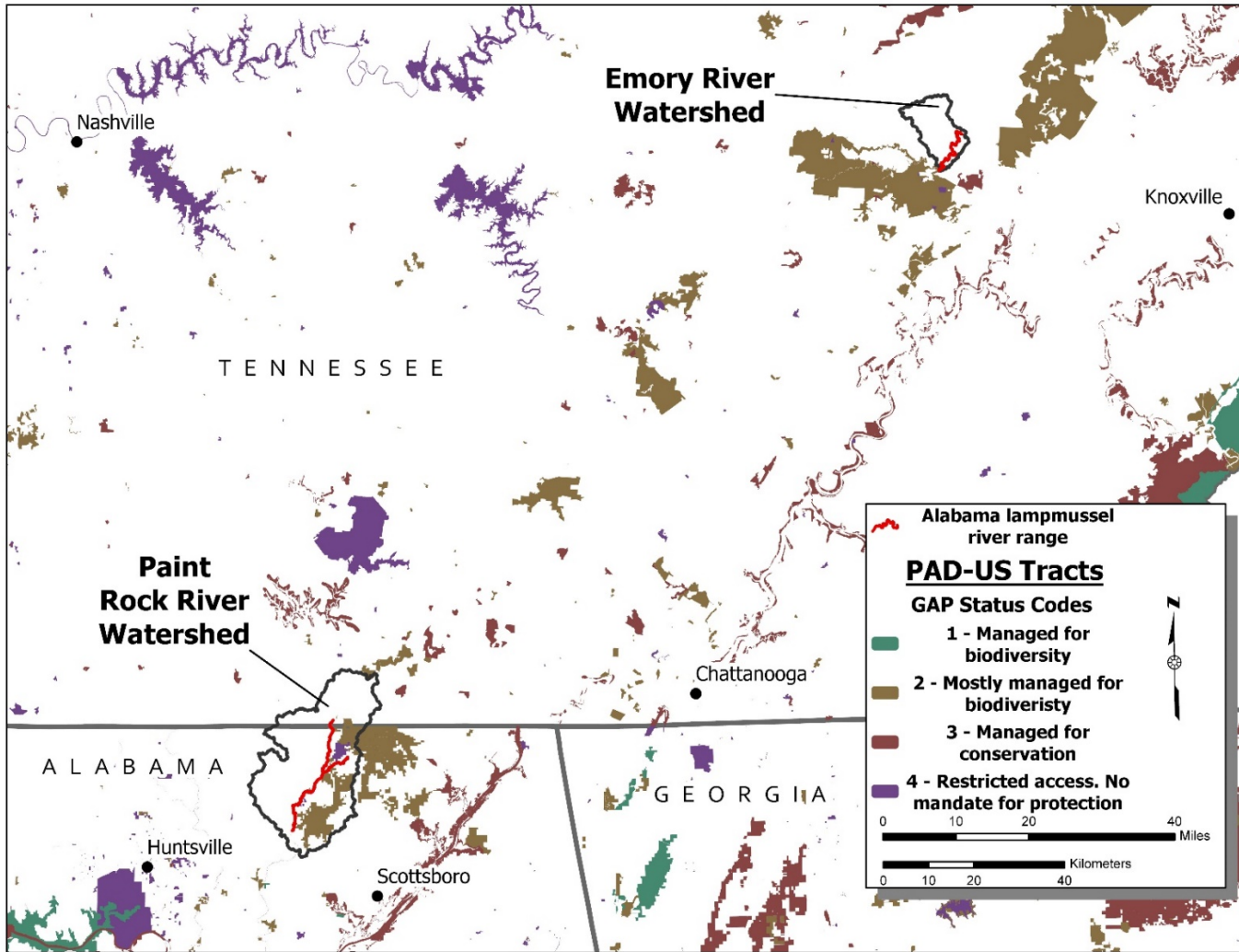


Figure 7.. Distribution of protected areas within and surrounding the PRR and Emory River watersheds. These areas (PAD-US Tracts) are coded according to their management type (USGS 2018). Map created by the USFWS Alabama Ecological Services Field Office, Daphn



Photo Credit: Daniel Graf, Smithsonian Institution Department of Invertebrate Zoology

Figure 8. Type specimen of the Alabama lampmussel collected from the Tennessee River at Tuscumbia, Alabama. Specimen is kept in the Smithsonian National Museum of Natural History, Washington D.C. (USNM 84927).

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of the Alabama Lampmussel (*Lampsilis virescens*)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

 X No change needed

Review Conducted By: Evan Collins and Erin Padgett, USFWS Alabama Ecological Services Field Office

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve _____ Date _____

APPENDIX

Summary of peer review for the Alabama Lampmussel (*Lampsilis virescens*): 5-Year Review

Peer Review Method:

This document was peer-reviewed internally by Jeff Powell (AFO) and Anthony Ford (Tennessee ES Field Office). No formal public comments were received. Since minimal new information was obtained that indicated changes in conditions since the last 5-year review in 2012, we did not seek external independent peer review of this document. As we continue to support exciting recovery actions with partners, we look forward to having additional data and surveys for our next 5-year review and its peer review.