Pale Lilliput
(*Toxolasma cylindrellus*)

5-Year Review:
Summary and Evaluation

Photo Credit: Thomas Tarpley, ADCNR, Alabama Aquatic Biodiversity Center

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

July 2021

5-YEAR REVIEW

Pale Lilliput / *Toxolasma cylindrellus*

I. GENERAL INFORMATION

A. Methods used to complete the review:

In accordance with section 4(c)(2) of the Endangered Species Act of 1973, as amended (Act), the purpose of a status review is to assess each threatened species or endangered species to determine whether its status has changed and if it should be classified differently or removed from the Lists of Threatened and Endangered Wildlife and Plants. The U.S. Fish and Wildlife Service (USFWS) evaluated the biology, habitat, and threats of the pale lilliput (*Toxolasma cylindrellus*) to inform this status review. We announced initiation of this review on May 7, 2018 (83 FR 20092) with a 60-day comment period. We did not receive any public comments related to pale lilliput during the public comment period. The primary sources of information used in this analysis were the original listing rule (41 FR 24062), peer-reviewed reports, agency reports, unpublished survey data and reports, the species' recovery plan, and personal communication with recognized experts. This review was completed by the lead recovery biologists for the species in the USFWS, Alabama Ecological Services Field Office (ALFO), Daphne, Alabama. All literature and documents used for this review are on file at the ALFO. All recommendations resulting from this review are the result of thoroughly reviewing the best available information on the pale lilliput. We have not received significant new information since the last status review and the level of public interest is low and non-controversial; therefore, no peer review was conducted.

B. Reviewers

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C. Background

1. Federal Register Notice citation announcing initiation of this review:

83 FR 20092, May 7, 2018.

2. **Listing history:**

Original Listing
FR notice: 41 FR 24062
Date listed: June 14, 1976
Entity listed: Species
Classification: Endangered

3. **Associated rulemakings: N/A**

4. **Review History:**

Each year, the USFWS reviews and updates listed species information for inclusion in the required Recovery Report to Congress (RRC). Through 2014, we reported the recovery priority number for the pale lilliput as 5 indicating a high degree of threat for extinction and a low recovery potential. As of our 2015-2016 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.

A previous 5-year review was conducted in 2011, which recommended no change in status and keeping the endangered classification of the species (USFWS 2011).

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

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

6. **Recovery Plan:**

Name of Plan: "Recovery Plan for the Pale Lilliput Pearly Mussel *Toxolasma* (=*Carunculina*) *cylindrellus* (Lea, 1868)"
Date Issued: August 22, 1984

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. The plan lacks recent published and unpublished scientific information on the pale lilliput and its habitat.

   b) **Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria?**

   The recovery criteria clearly addresses factor A (the present or threatened destruction, modification, or curtailment of habitat or range) by specifying that a viable population should exist in the PRR, viable populations should be located in two additional rivers, populations should be protected from human-related natural threats, and improvements should be made in substrate quality with regard to siltation in the PRR watershed to achieve recovery. Listing factors B (overutilization) and C (disease/predation) are not addressed by the recovery criteria, however, we have no information to indicate that these factors have historically or currently affect the pale lilliput. Listing factor D (the inadequacy of existing regulatory mechanisms) and factor E (other factors) are not addressed by the recovery criteria but they are relevant to the species. Therefore, all relevant listing factors to the species are not addressed by the recovery criteria.

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:**

   The following four criteria were established in the 1984 recovery plan for pale lilliput (*Toxoplasma cylindrellus*; USFWS 1984).

   1. **A viable population[1] of *T. cylindrellus* exists in the Paint Rock River, Estill Fork, and Hurricane Creek. These three populations are dispersed throughout each river so that it is unlikely that any one event would cause the total loss of either population.**

      This recovery criteria has not been met. The previous 5-year review (USFWS 2011) provides details on past population surveys. The following addresses updated information since 2011 for each of the three populations.

[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 1984).

Estill Fork. In 2013, 9 individuals were found in Estill Fork and the population abundance was estimated to be approximately 720 individuals within a 1200 square meter sampling area (Johnson 2018).

Paint Rock River. The last record of the pale lilliput from the PRR mainstem is an observation of a live individual in 2000 (USFWS 2011). In 2008, the Alabama Department of Conservation and Natural Resources (ADCNR) surveyed 42 sites within the PRR mainstem and no pale lilliput specimens were collected.

Hurricane Creek. In Hurricane Creek, Ahlstedt (1998) reported only one relic specimen from collections made in 1991, and additional relic shells were collected in 1996 (USFWS 2011). We are not aware of any surveys in Hurricane Creek since the last 5-year review, therefore we have no updated information to assess the population condition.

While not listed as a recovery population, a Larkin Fork (a tributary to the Paint Rock River) population was recently reconfirmed. The last (since the 1960's) pale lilliput collected from Larkin Fork was from 1990 (USFWS 2011). In July 2021, ADCNR staff collected pale lilliput in several Larkin Fork localities (P. Johnson pers. comm. 2021).

Based upon these survey data, Estill Fork is the only population of the three identified in Criteria 1 within the PRR watershed known to support the pale lilliput where the species is consistently observed at abundances that may be considered viable (i.e. reproducing population large enough to maintain genetic variation). The PRR mainstream and Hurricane Creek may support viable populations, but data and surveys from these streams are lacking and, as such, they do not contribute to the recovery criteria.

2. **Through reestablishments and/or discoveries of new populations, viable populations exist in two additional rivers. Each of these rivers will contain a viable population that is distributed such that a single event would be unlikely to eliminate *T. cylindrellus* from the river system.**

This recovery criteria has been partially met. The discovery of a new population and reintroductions of individuals in several streams is a step toward meeting this recovery criteria. Future monitoring will determine the viability of those populations.

Discoveries

The pale lilliput was last collected from the Duck River main stem in 1980 (Ahlstedt et al. 2017) and from Big Rock Creek, a tributary to the Duck River in 1989 (USFWS 2011). The previous 5-year review considered it to be extirpated from the Duck River.

However, in May 2015, a new population of pale lilliput was discovered in Lick Creek, another tributary to Duck River in Maury County, TN (Figure

2). Three survey sites within Lick Creek produced 12 live individuals and fragments of relic shells (D. Hubbs pers. comm. 2018). Lick Creek was surveyed again in June 2016 and 10 gravid females were collected and taken to the Tennessee Wildlife Resource Agency's (TWRA) Cumberland River Aquatic Center (CRAC) for propagation (D. Hubbs pers. comm. 2018). Another collecting trip for brood stock that occurred in May 2018 only produced a mixture of fresh dead and weathering dead shells. Biologist with the TWRA have noted that since 2016, live individuals has been more difficult to locate (D. Hubbs pers. comm. 2018). This population is considered extant and represents a discovery of a new population within a river system distinct from the PRR. However, the small spatial extent of this population makes it susceptible to extirpation from stochastic events. Therefore, it does not meet the spatial distribution requirement of the recovery plan.

Reintroductions

In 2009, a strategy to implement reintroductions of at-risk mollusks was developed with the Plan for the Controlled Propagation, Augmentation, and Reintroduction of Freshwater Mollusks of the Cumberlandian Region (CRMRC 2009). However, captive propagation of the pale lilliput was not able to produce sufficient numbers for release until 2014 with the first stocking event occurring in September 2014, in the Duck River, in Marshall County, TN (Hubbs 2019). In September 2015, 1,100 pale lilliput juveniles were released at two locations in the PRR in Jackson County, AL (Johnson 2018). Since 2014, the Duck River has received over 3,500 reintroduced individuals (Johnson 2020) and the PRR approximately 3,600 (Johnson 2020). Additional stocking sites in the Elk River, Giles, TN; Bear Creek, Colbert County, AL; Big Rock Creek, Marshall County, TN; and Lick Creek, Williamson County, TN, have received over 1,500 individuals (Hubbs 2019; Johnson 2020).

The release sites have been monitored over the years to document survival, reproduction, and recruitment. Monitoring efforts conducted in 2018 documented juvenile individuals of the pale lilliput, indicating recruitment in the Duck River, Lick Creek, and the PRR in the vicinity of reintroduction sites (P. Johnson pers. comm. 2018). In the Duck River, a new recruit was found several hundred yards above the stocking site and appeared to be two years old (P. Johnson pers. comm. 2018). Evidence of recruitment consists of single, unmarked specimens. Therefore, further monitoring is needed to determine if the reintroduced populations have been successfully established and viable.

3. **The species and its habitat are protected from present and foreseeable human-related natural threats that may interfere with the survival of any of the populations.**

This criteria has been partially met. The natural pale lilliput populations are currently restricted to the upper reaches and tributaries of the PRR

watershed (Figure 1) and to the Lick Creek watershed in Maury County, TN (Figure 2). The majority of land in both watersheds is in private ownership and is mostly rural. Forests make up 86% (141,696 acres) of the land use land cover (LULC) in the PRR watershed, and agriculture covers approximately 9% (14,506 acres) (Figure 3). The Lick Creek watershed is approximately 72% (46,243 acres) forested and 20% crop land (Figure 3). While the total percentage of agricultural lands is relatively low in both watersheds, land used for crops and pastures are usually adjacent to flowing water when present (Barbour 2003). Table 1 provides a complete listing of LULC for both watersheds.

Table 1. LULC for the PRR and Lick Creek Watersheds

LULC Classification	PRR LULC		Lick Creek LULC	
	Acres	Percent	Acres	Percent
Forest	141696.43	85.99%	46242.80	71.78%
Agriculture	14506.49	8.80%	13200.08	20.49%
Barren Land	5.94	0.00%	17.11	0.03%
Developed	2585.50	1.57%	3880.03	6.02%
Herbaceous	5482.88	3.33%	994.32	1.54%
Open Water	74.11	0.04%	68.54	0.11%
Wetlands	433.34	0.26%	17.73	0.03%

To assess land protection in the pale lilliput watersheds, we use the U.S. Geological Survey's (USGS) Protected Areas Database of the United States (PAD-US), which is a comprehensive inventory of the nation's protected areas. These protected areas are publicly or privately held tracts of land that 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) which monitors and inventories common (not federally listed) species (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 substantial portion of the PRR watershed is covered by PAD-US tracts (Figure 4). Approximately 18% (29,561 acres) of the PRR watershed is classified as a PAD-US tract with a GAP code of 2, 1.5% (2,456 acres) has a code of 3, and 0.18% (295 acres) has a code of 4.

The Lick Creek watershed has less than 2% of land (586 acres) designated as GAP status 3 or 4 and there is approximately 12,800 acres of wildlife management area that directly buffers the Duck River proper.

Big Rock Creek, another major tributary to the Duck River where reintroduction efforts are ongoing, has seen habitat improvements through restoration partnerships. The Nature Conservancy (TNC), the Environmental Protection Agency and the Tennessee Department of Agriculture have been working on a long-term restoration project that involves native tree and shrub landscaping, streambank stabilization, and stream channel enhancements along the creek (D. Hubbs pers. comm. 2018).

Natural populations of the pale lilliput in the upper PRR (PRR, Larkin Fork, Estill Fork, and Hurricane Creek) and Lick Creek watersheds occur in rural areas dominated by forested land with little to no urban development. These populations are reasonably protected from foreseeable anthropogenic and natural threats, satisfying this recovery criterion for these natural populations. Additionally, past, current, and future threats are considerations for reintroduction site selection (CRMRC 2009). Therefore, when it is determined that these reintroduction efforts have been successful, it is reasonably certain that they will be protected from foreseeable anthropogenic and natural threats, satisfying this recovery criterion for these natural populations.

4. **Noticeable improvements are made in substrate quality with regard to siltation from agricultural land use practices in the Paint Rock River watershed.**

   This criteria has been partially met. In the past, threats associated from non-point source pollution were exacerbated by a lack of riparian vegetation, livestock access, 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 in the Estill Fork, Hurricane Creek, and Larkin Fork drainages (USFWS 2011). These programs included: cattle access control (4 sites, 69 acres), vegetative, conservation 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, benefiting 75 acres), wetland restoration (1 site, 62.2 acres), and wetland wildlife habitat management (4 sites, 67.5 acres). Since 2010, the PRR watershed has had at least four low water ford structures removed, numerous

streambank stabilization projects completed, and several alternative water source projects implemented.

Additional agencies and environmental groups such as the USFWS' Partners for Fish and Wildlife Program, ADCNR's Alabama Aquatic Biodiversity Center (AABC) and landowner incentive programs), and TNC have conducted other restoration and enhancement projects in the PRR basin over the past several decades. Projects have included: streambank stabilization, riparian restoration, low water crossings, cattle exclusionary fencing, alternate water source development, and stream channel restoration (i.e., restoring natural meanders) (USFWS 2011).

In general, improvements in land use practices have occurred throughout the PRR watershed over the past decade. While, there are areas that can be enhanced, considerable progress has been made in order to meet this recovery criteria.

C. Updated Information and Current Species Status

Detailed information on the pale lilliput's biology, habitat, abundance, and threats are outlined in the final listing rule (41 FR 24062; USFWS 1976). Details below are provided for summary information, new information, and to provide context for the species status since its listing in 1976.

1. Biology and Habitat

a) Biology and Life History:

The pale lilliput is a small freshwater mussel usually measuring less than 44 millimeters (1.7 inches) in length. Its shell is moderately thin and somewhat compressed with a rayless, tawny to yellowish green hue (Figure 5) (Williams et al. 2008). The nacre is often purple to coppery in color (Parmalee and Bogan 1998, Williams et al. 2008). The pale lilliput is elongate and elliptical, becoming somewhat cylindrical in shape (Parmalee and Bogan 1998), with the female having an outline more oval in shape than that of the male.

It historically occurred in a wide variety of habitats from small creeks to large rivers. However, it currently seems to persist only in headwater-sized streams usually in less than three feet of water, with sand and gravel substrates, and where flows are slow to moderate, (Parmalee and Bogan 1998, Williams et al. 2008).

This species is a short-term brooder and is gravid from late summer or autumn into the following summer (Williams et al. 2008). The AABC has determined that the Northern Studfish (*Fundulus caetenotus*), Southern Studfish (*Fundulus stellifer*) (although this species does not co-occur with the pale lilliput), Blackspotted Topminnow (*Fundulus olivaceus*), and Blackstripe Topminnow (*Fundulus notatus*) are suitable host fish for the

pale lilliput (Johnson 2018). Females of the pale lilliput have been observed to migrate to the margins of streams when gravid which is thought to increase the likelihood of encountering a host fish.

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

The pale lilliput is restricted to the headwaters of the PRR (USFWS 1984) (Figure 1) where it appears to occur in extremely low numbers (McGregor and Shelton 1995, Ahlstedt 1998, Godwin 2002, Fobian et al. 2008), and to Lick Creek where it has been increasingly difficult to locate (D. Hubbs pers. comm. 2018). Since 2014, over 8,500 individuals have been reintroduced into several stream reaches within the species' historical range in AL and TN. Limited surveys and captures in natural and reintroduced habitats have prevented any assessment of population or abundance trends. For additional information refer to Section II.B.3.1. of this review.

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

The pale lilliput occurs in relatively low numbers and at isolated locations, so gene flow and genetic diversity is a concern for the long-term survival and recovery of the species.

The AABC and the TWRA continue to work towards the goal of reintroducing new populations or augmenting existing populations with propagated individuals (Johnson 2009; USFWS 2011). The AABC will continue to preserve genetic material from excess glochidia and propagated cohorts (that do not survive) to inform genetics of wild populations and management of reintroduction efforts (65 FR 56916, CRMCR 2009).

d) Taxonomic classification or changes in nomenclature:

A member of the freshwater mussel family Unionidae, the pale lilliput was originally described as *Unio cylindrellus* (Lea, 1868). According to Lea (1868), the type localities are Duck Creek (presumably the Duck River), Tennessee; Swamp Creek, Whitfield County, Georgia; and north Alabama (Figure 4) (Ortmann 1924, Parmalee and Bogan 1998, Williams et al. 2008). The pale lilliput has been considered a member of the genera *Carunculina, Unio, Toxolasma, Margaron,* and *Lampsilis* until it was finally reassigned to *Toxolasma* by Stansbery in 1971 (as summarized by 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 pale lilliput historically (Table 2) occurred from the middle reaches of the Tennessee River system, across northern Alabama, and in the Duck

River system in central Tennessee (Ortmann 1924, Ortmann 1925, Parmalee and Bogan 1998, Mirarchi 2004, Williams et al. 2008). It was previously considered extirpated from the Duck River (Ahlstedt et al. 2017); however, a population is now known to occur in Lick Creek, a tributary to Duck River in Maury County, TN. The only other known natural population for the pale lilliput is believed to be limited to the upper reaches of the PRR system, Jackson County, AL, and potentially in its headwaters in Franklin County, TN (Parmalee and Bogan 1998).

There is also a single record of pale lilliput from Swamp Creek, Whitfield County, GA, a Mobile River system tributary (Lea 1856). This record is either an exception to its distribution (Parmalee and Bogan 1998), a mistaken identification, or an invalid record (USFWS 2011); therefore we do not consider this part of the current or historic range for the species.

Table 2. Accepted historical records (before 1975) for the pale lilliput.

River	County	State
Paint Rock River [1]	Jackson	Alabama
Larkin Fork [1,2]	Jackson	Alabama
Hurricane Creek [2]	Jackson	Alabama
Estill Fork [7]	Jackson	Alabama
Flint River [3]	Madison	Alabama
Elk River [2,3]	Franklin	Tennessee
Duck River [1,2,3,4,5]	Coffee	Tennessee
Buffalo River [3,5]	Lewis	Tennessee
Sequatchie River [6]	Marion	Tennessee
Little Sequatchie River [6]	Marion	Tennessee

[1]Stansberry 1976; [2]USFWS 2011; [3]Ortmann 1925; [4]Marsh 1885; [5]van der Schalie 1973; [6]Bogan and Parmalee 1983; [7]FMIZC

f) Habitat or ecosystem conditions:

The PRR flows southwest 60 miles along the southern edge of the Cumberland Plateau Physiographic Province a subunit of the greater Appalachian Plateaus before entering the Tennessee River (TRM 343.2). The last 13 river miles of the PRR are within the impounded reaches of Wheeler Reservoir (Ahlstedt 1998, Fobian et al. 2008). The watershed is sparsely populated and encompasses 458 square miles (Fobian et al. 2008). The landscape is predominately karst with about 760 known caves (Godwin 2002). The upper PRR is underlain by predominately Tuscumbia Limestone, while the lower PRR is underlain by Monteagle Limestone.

The PRR generally contains streamside zones that are well to moderately forested (Figure 3) (Godwin 2002). The upper reaches of the PRR primarily flow through narrow, forested floodplains with banks that may rise as much as 300 meters above the stream (Godwin 2002). The lower PRR consists of wide alluvial river valley floodplains with a narrow

riparian zones adjacent to pastures and row crops (Godwin 2002, Fobian et al. 2008).

Godwin (Godwin 1995, Godwin 2002) describes stream habitat conditions within the PRR watershed, and his notes are paraphrased below:

The PRR and tributaries (Estill Fork, Hurricane Creek, and Larkin Fork) are generally shallow with depths less than a meter; however depth will range from a few centimeters in riffles to over a meter in pools. Substrates are coarse sand, gravel, cobble, and bedrock. Water clarity ranges from very clear in the headwater portions to turbid in the lower reaches of the main stem. The channel widths are often around ten meters in width, but may exceed thirty meters in the lower sections of the PRR. Generally, the water is slow flowing, but water in the headwaters may be swift in places. Large pools in the main stem are sluggish. Flow is greatly diminished and may at times flow upstream at the lower end of the PRR due to management of Wheeler Reservoir. Pools and riffles alternate throughout the drainage basin, and beds of water willow (*Justicia americana*) occur along banks and in riffles.

The Lick Creek watershed encompasses approximately 100 square miles and is also heavily forested (Figure 3). Agriculture is the second highest LULC and mainly occurs along floodplains. The watershed is predominately underlain by Mississippian Chert and Ordovician Shale.

As described in section II.B.3, conservation and restoration projects have occurred in PRR and substrate and water quality have been improving since the last review.

2. Five-Factor Analysis

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

Although some development has occurred in the PRR watershed, it has been relatively low compared to other areas in the Tennessee Valley (Barbour 2003). One of the most damaging modifications may have been the U.S. Army's Corps of Engineers' channelization projects of the 1960s, which involved extensive stream channelization and removal of snags and riverbank timber in the PRR main stem, Larkin Fork, Estill Fork, and Hurricane Creek (Barbour 2003). Ahlstedt (1998) noted that riffle and shoal habitats have never recovered from those events and continue 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 and remediate these stream perturbations (Ahlstedt 1998).

In 1995, Godwin reported 100 potential non-point source impacts at 85 of his survey sites. Of the 100 impacts, 75 impacted sites were within the PRR main stem, 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 fording sites 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 impacts: sewage inflow, major logjam, siltation from construction, and drainage pipe, during the survey.

Lilliput 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 (USFWS 2011).

However, in recent years, many improvements have been made to the pale lilliput's habitat and to the areas surrounding its range. For additional information, refer to Sections II.B.3.3 and II.B.3.4 of this review.

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

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

c) Disease or predation:

At the time of listing, neither disease nor predation were considered as threats to the species, and there is still no evidence to indicate that they are currently threats to pale lilliput. However, since the 1970's, episodic mass mortality of freshwater mussels around the world has been documented (Richard et al. 2020). The following information has been summarized from a study by Richard et al. (2020), which was the first study to isolate issues of mussel die-off's in the southeast:

> There has been a lack of evidence directly linking these events to specific environmental changes. In addition, these mass die-offs appear to have disproportionately affected a single species in the communities where they have occurred. This has prompted speculation that viral infections could be the driving force behind such events. Since 2016, massive mortality events for the mussels in the Clinch River in Tennessee have been observed. Analysis of the affected mussels has shown a strong correlation between a novel densovirus and morbidity. Densoviruses can cause lethal epidemic diseases in other invertebrates such as shrimp, cockroaches, and moths. Continued studies are warranted to undisputedly link this virus or other viral infections to these massive mussel mortality events.

Regardless of the cause, it appears that there is currently an unknown mussel disease devastating mussel communities on a global level. Because

of the reduced range of existing populations, disease similar to events in the Clinch River mainstem could potentially emerge as a significant threat to either or both the Lick or PRR populations of the pale lilliput.

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. To date, no mussel culture facility has reported any disease issues in a hatchery environment (Johnson and Hubbs 2018). For propagation activities at the AABC, groundwater is the only source water used because it likely contains fewer pathogens than surface water (Johnson and Hubbs 2018). To further reduce the risk of pathogens, all the water in mussel grow-out ponds is exchanged every 30 days, and no resident native mussels occur on site (Johnson and Hubbs 2018). Adult brood stock is segregated from the cultured juveniles to lessen the chance of introducing disease from the brood stock's native stream (Johnson and Hubbs 2018).

Several animals sympatric with the pale lilliput are known to eat freshwater mussels. The muskrat (*Ondatra zibethicus*) is probably the most common mammal predator of freshwater mussels and piles of mussel 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., native mussels as well as the exotic Asian clam (*Corbicula fluminea*) is most prevalent and easiest to obtain.

Based on the preceding, we do not consider disease or predation as significant threats to the pale lilliput at this time.

d) Inadequacy of existing regulatory mechanisms:

The pale lilliput is 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 70-8-101 through 70-8-112). This state statute mandates that the State should assist 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 of the species.

The Clean Water Act (CWA) is the primary federal law in the United States governing water pollution. One role of the CWA is to regulate the point source discharge of pollutants to surface waters, achieved through the permitting process of 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 the species' sensitivity to common pollutants, it is unknown if federal (e.g., CWA) and state water quality laws are protective of the pale lilliput.

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 within watersheds occupied by the pale lilliput identified under Section 303d (ADEM 2018; TDEC 2019).

Table 3. Section 303d Impaired Water Bodies

Drainage	County	Pathogen	Source
Guess Creek (trib. to PRR)	Jackson, AL	Organic enrichment (BOD)	Pasture grazing
Clear Creek (trib. to PRR)	Jackson, AL	Pathogens (E. coli)	Pasture grazing
Bear Creek*	Colbert , AL	Nutrients; Mercury; E. coli	Agriculture; Atmospheric deposition; Pasture grazing
Duck River	Maury, TN	Phosphorus; Dissolved oxygen	Surface mining; Municipal point source discharge; Grazing in riparian zone
Big Rock Creek (trib. to Duck River)	Marshall, TN	Nitrate; Dissolved oxygen; Phosphorous; Sedimentation; E. Coli	Municipal point source discharge; Grazing in riparian zone
Rich Creek (trib. to Duck River)	Marshall, TN	Nitrate; E. coli	Grazing in riparian zone

Elk River*	Giles, TN	E. coli	Grazing in riparian zone

*Streams that contain reintroduction populations

Section 404 under 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. Because of the federal listing of pale lilliput and under the authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 *et. seq.*), the USFWS can provide guidance and recommendations to minimize the impacts of these types of projects on habitat and the species.

Section 26a of the TVA Act requires a TVA permit prior to the 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 the PRR drainage, TVA's Section 26a permits are usually applied for concurrently with the U.S. Army Corps of Engineers Section 404 permits.

While a single project (e.g., Section 404 or Section 26a permit) may have discountable or insignificant effects on the species, the collective effects of multiple projects may result in more substantial effects on the pale lilliput's finite habitat, though these effects may be difficult to foresee and estimate. Because these individual projects may not be evaluated or recorded through a formal consultation process with the USFWS, they are difficult to and not typically included in a cumulative effects analyses.

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) is intended to protect against "unreasonable human health or environmental effects" from distribution, sale, and use of pesticides. While pesticides are usually tested on standard biological test media (e.g., honey bees (*Apis* spp.), *Daphnia*, bluegill sunfish (*Lepomis macrochirus*), rainbow trout (*Oncorhynchus mykiss*), mice (usually *Mus musculus*)), the toxicity levels for these animals may not be the same for the pale lilliput; therefore FIFRA may not be as protective of pale lilliput as some other aquatic species tested. 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 pale lilliput.

Regardless of the 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.

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

Climate change is also considered a potential threat to the pale lilliput. 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 shifts have been documented 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 pale lilliput; however, climate change is almost certain to affect aquatic habitats in their watersheds. Climate change has the potential to increase the vulnerability of the pale lilliput 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). Because the pale lilliput migrates toward the bank and occupies shallow habitats while spawning, changes of flows due to drought may lead to increased mortality or failed reproduction.

Human-induced random events such as toxic spills could also jeopardize the lilliput if pollutants are spilled within its watersheds. The known extent for the lilliput is already extremely limited and a spill event could potentially reduce the range even further.

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 USFWS assessed over 51 river miles (82 km) in the PRR basin and identified five high priority road crossings that likely function as fish barriers (USFWS 2011). These barriers may limit the range of *Fundulus spp.* that are the known hosts to the pale lilliput glochidia and directly influence this species' distribution.

D. Synthesis

The existence of the pale lilliput continues to be vulnerable because of its highly restricted range, small population size, and continued impacts to its habitat. Because the pale lilliput is limited geographically within the PRR and Lick Creek drainages, catastrophic events such as spills or natural events (e.g., drought) could greatly reduce the geographic distribution or genetic viability of the pale lilliput.

Habitat destruction or modification is presently the greatest threat to this species. Since agriculture is the predominant 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 pale lilliput.

Based on the preceding information in this review, we believe that the pale lilliput still meets the definition of endangered. This assessment is based on our knowledge of the species' life history, its narrow distribution, and current 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 adjacent to streams in the upper Paint Rock River watershed in AL and TN, Elk River, Giles, TN; Bear Creek, Colbert County, AL; Big Rock Creek, Marshall County, TN; and Lick Creek, Williamson County, TN to preserve the integrity of stream banks and the riparian zone, and address problem areas by utilizing cost-shares and other conservation initiatives.
- Conduct systematic population monitoring of extant and reintroduced populations including the documentation of potential threats.
- Conducts surveys in historically occupied watersheds and throughout currently occupied watershed to locate other extant populations and identify suitable release sites.
- Continue working with the AABC and CRAC to enhance propagation activities and to examine unknown components of life history and ecology.
- Update the recovery plan for the species with best available information and to include the importance of propagation/culture, enhancing our knowledge of basic biological processes, 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 pale lilliput, 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 recharge zone of the PRR and Duck River drainage basins.
- Conduct genetic and histology research to support fitness of propagation and culture work.
- Conduct a detailed analysis of habitat requirements, including physiochemical parameters of the stream habitat used by the pale lilliput.
- Encourage EPA, ADEM, and TDEC to develop water quality criteria for pollutants based on responses of native mollusk species, including the pale lilliput.

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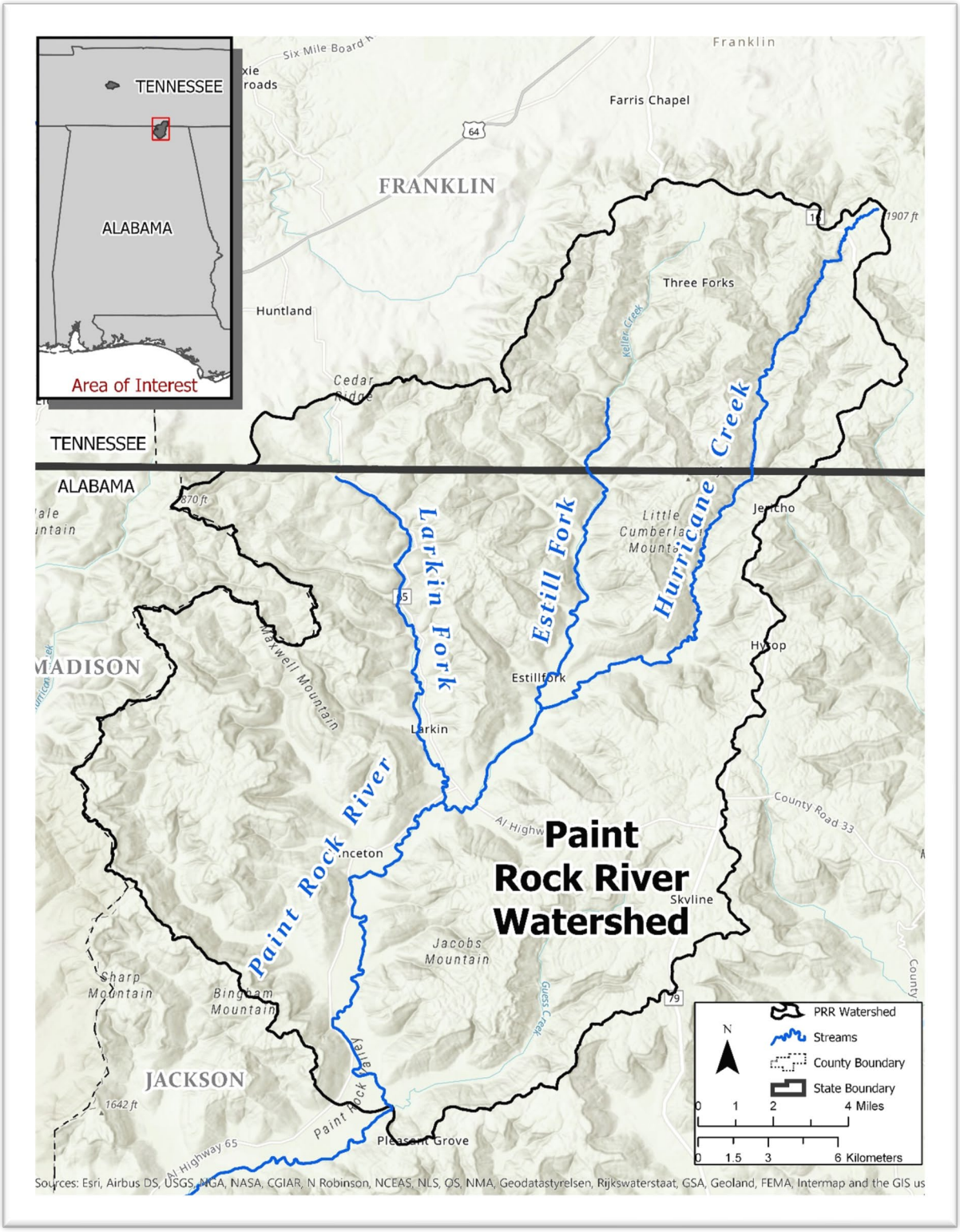

Figure 1. The Paint Rock River Watershed in Alabama and Tennessee. Map created by USFWS Alabama ESFO.

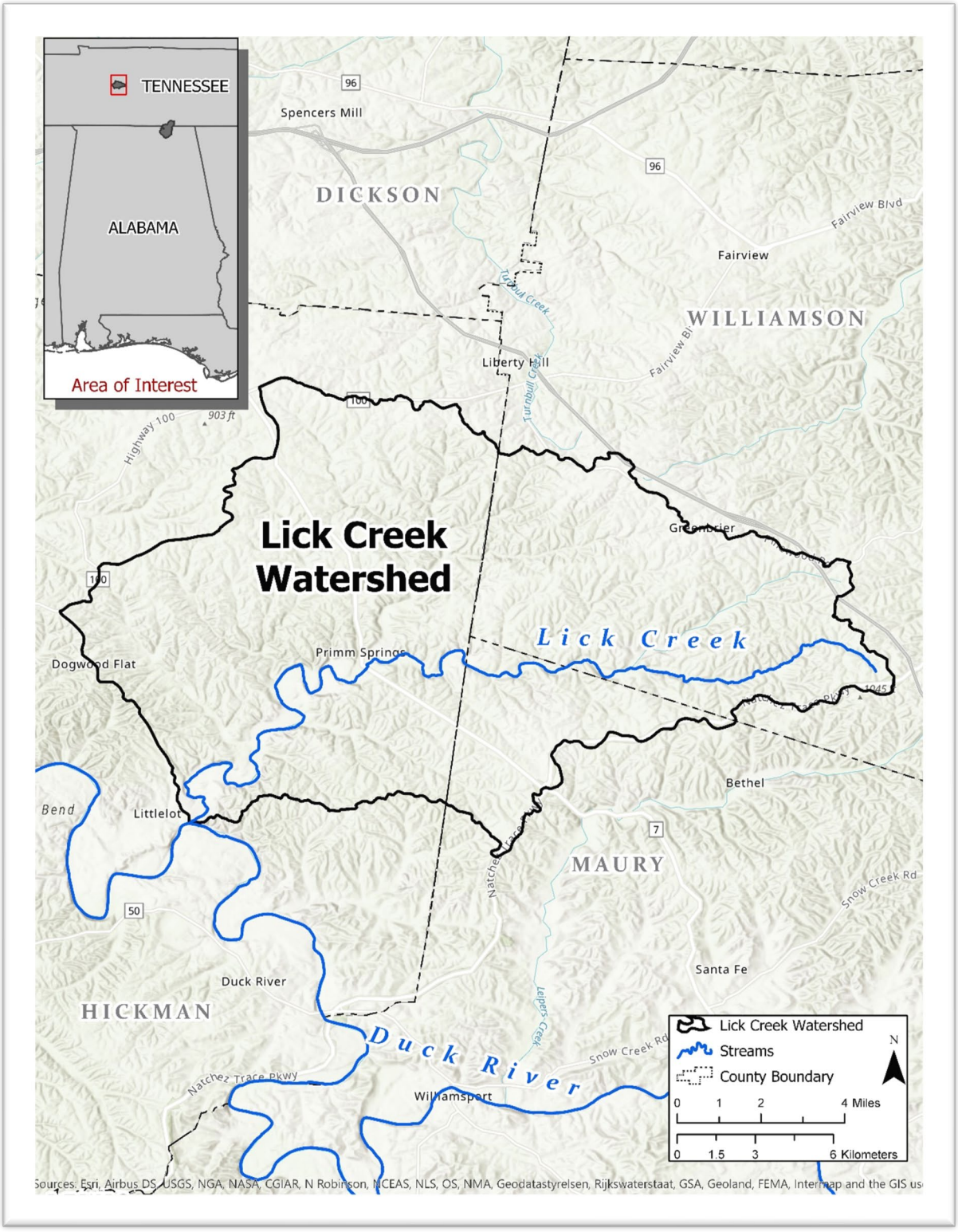

Figure 2. Lick Creek Watershed, tributary to the Duck River, in Tennessee. Map created by USFWS Alabama ESFO.

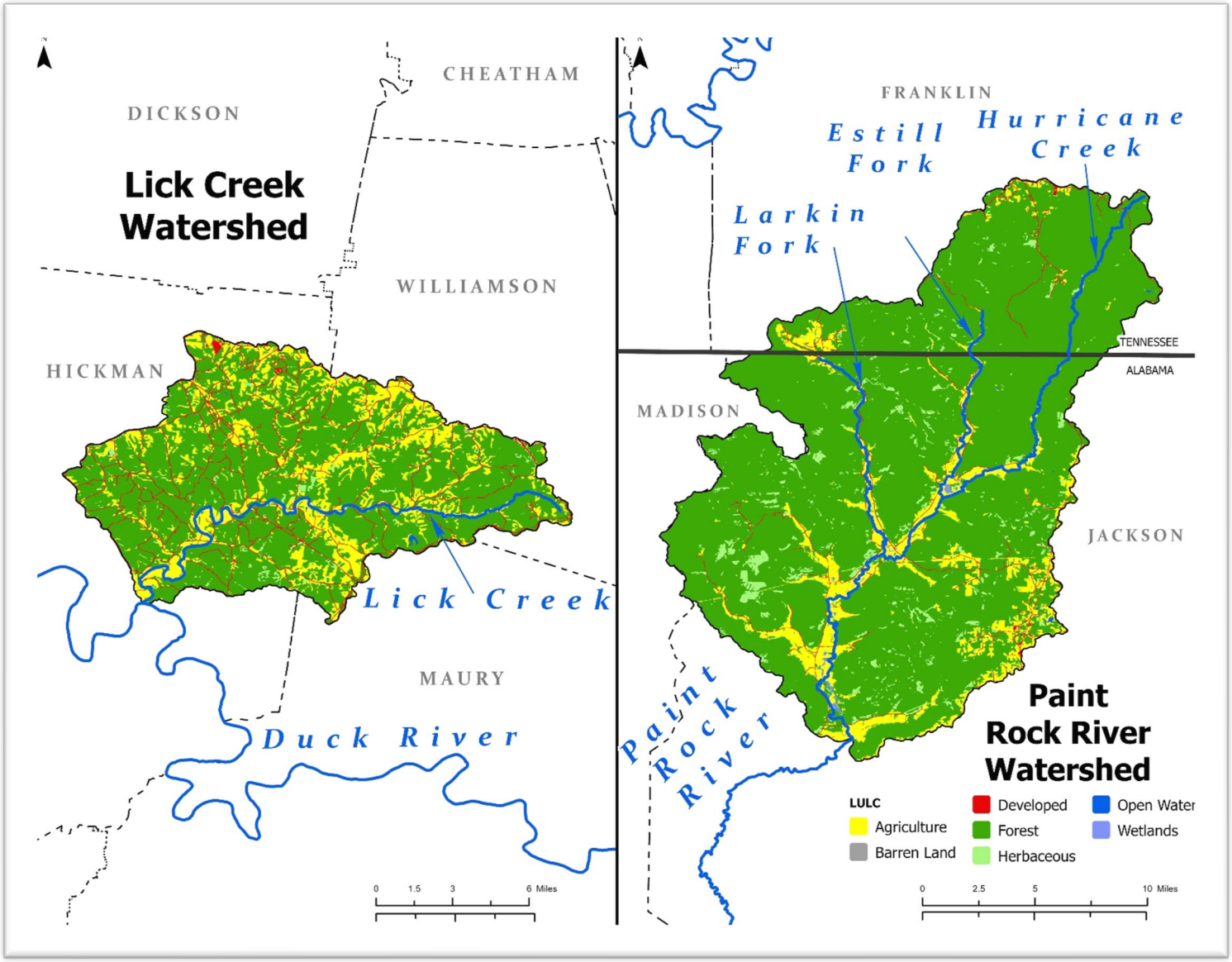

Figure 3. Land use land cover (LULC) for the Lick Creek, Tennessee (left) and Paint Rock River watershed, Alabama and Tennessee (right). Imagery was derived from the National Land Cover Database's 2016 national land cover map (Yang et al. 2018). Map created by USFWS Alabama ESFO.

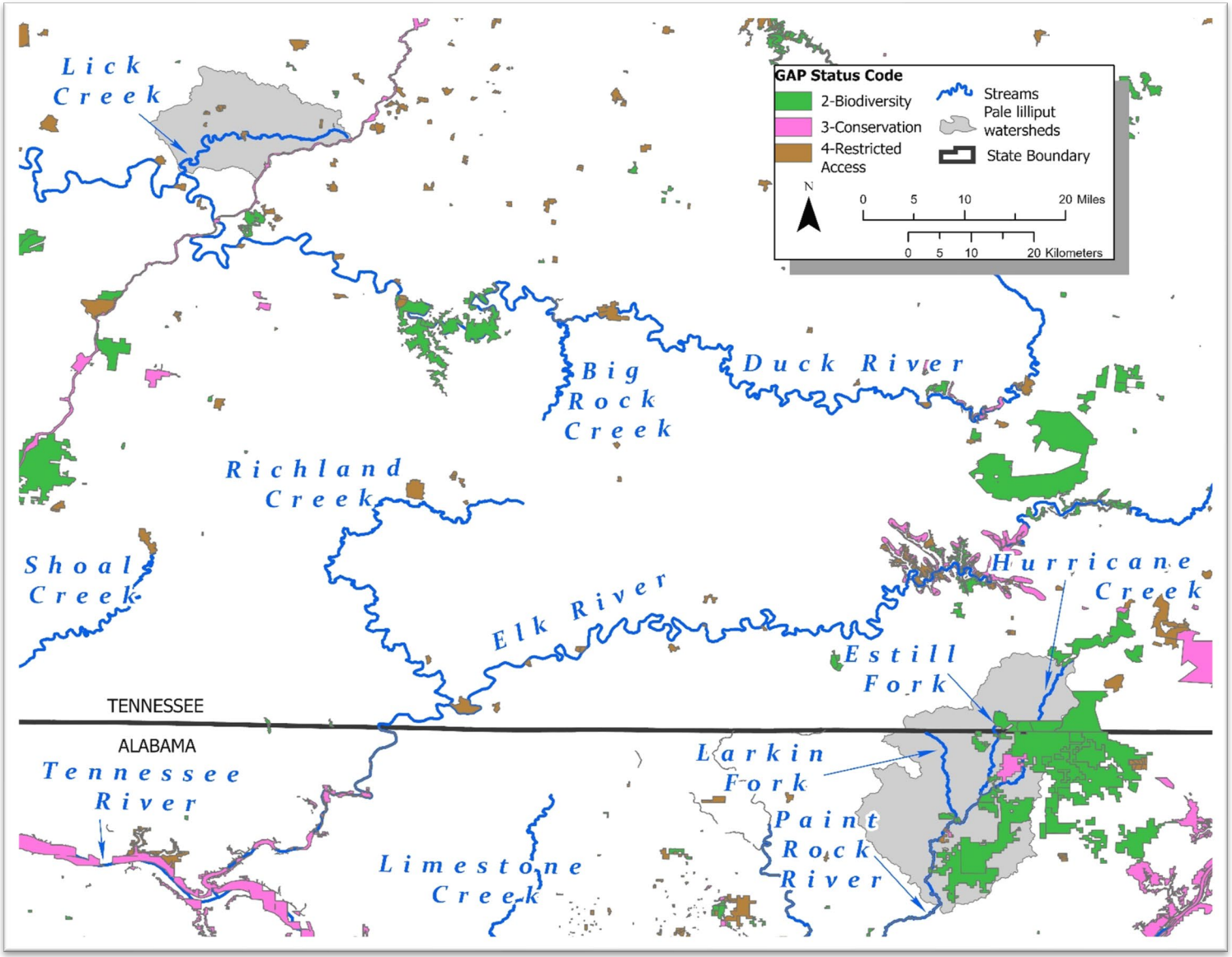

Figure 4. Protected Area tracts (e.g., those protected for biodiversity, conservation, and restricted access) in the Lick Creek and Paint Rock River watersheds in Tennessee and Alabama (USGS 2018). Map created by USFWS Alabama ESFO.

Figure 5. Type specimen of the pale lilliput (*Toxolasma cylindrellus*) collected from north Alabama located in the Smithsonian National Museum of Natural History (USNM 85300). Photo Credit: Daniel Graf, Smithsonian.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of the Pale Lilliput (*Toxolasma cylindrellus*)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

__X__ No change needed

Review Conducted By: Erin Padgett and Evan Collins, USFWS Alabama ES 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: 2021.09.23 15:55:27 -05'00' Date _____

* Since 2014, Southeast Region Field Supervisors have been delegated authority to approve 5-year reviews that do not recommend a status change.