

U.S. Fish and Wildlife Service

Five-Year Review: Summary and Evaluation

Conasauga Logperch (*Percina jenkinsi*)



Photo by Tennessee Aquarium
Conservation Institute

U.S. Fish and Wildlife Service
Southeast Region
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5-YEAR REVIEW

Conasauga Logperch (*Percina jenkinsi* Thompson 1985)

I. GENERAL INFORMATION

A. Methodology Used to Complete the Review

The U.S. Fish and Wildlife Service (Service) conducts status reviews of species on the List of Endangered and Threatened Wildlife and Plants (50 CFR 17.11 and 17.12), as required by section 4(c)(2)(A) of the Endangered Species Act of 1973, as amended (ESA) (16 U.S.C. 1531 *et seq.*). The purpose of a 5-year review is to assess if the endangered or threatened classification of a listed species is accurate or should be changed, based on new information. We announced initiation of this review in a *Federal Register* notice with a 60-day comment period (83 FR 38320). In the notice, we requested new information on the Conasauga logperch that has become available since the last 5-year review of this species.

In conducting the 5-year review, we relied on available information about historic and current distribution, population trends, life history, habitat conditions, and threats to the species. Much of the information in this document is taken from the November 2019 Conasauga Logperch Species Status Assessment (or SSA, Service 2019) that we developed to inform future ESA-related documents for the species. A SSA provides an assessment of a species' biology and resource needs, as well as an evaluation of current status and likelihood it will sustain populations in its natural habitats over time. To write the SSA, we used a variety of information resources, including peer reviewed scientific publications, data from species' experts in academia and Federal/state/private conservation programs, the final rule listing this species under the ESA, the 1985 Recovery Plan for the species, a 2011 Conasauga logperch 5-year review, and unpublished survey and monitoring reports. We received and addressed two public comments during the open public comment period, and this 5-year review was peer reviewed (see Appendix A for further detail). The SSA and a draft recovery implementation strategy are posted at:

<https://ecos.fws.gov/ServCat>. A draft 2019 recovery plan is posted on the Service's ECOS webpage at <https://ecos.fws.gov/ecp0/profile/speciesProfile?sId=8472>.

B. Reviewers:

Lead Region: Southeast Region, Kelly Bibb, 404-679-7132

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Cooperating Field Office: Tennessee Ecological Services, Warren Stiles

Peer Reviewers: Mary Freeman, US Geological Survey, Athens, GA
Patrick Rakes, Conservation Fisheries, Inc. (CFI), Knoxville, TN

C. Background

Federal Register Notice Announcing Review Initiation: August 6, 2018 (83 FR 38320)

Species Status: Declining. In our 2011 5-year review for the Conasauga logperch, we designated the Conasauga logperch's status as "Uncertain" due to limited survey data in our files from the upper half of the species' 36-mile range in the Conasauga mainstem and Jacks River (although we noted that evaluation of long-term trends in the downstream third of the range indicated the probability of encountering a Conasauga logperch in this lower reach declined from 1998 to 2008) (Hagler et al. 2011). To complete this 2019 review, both CFI and the University of Georgia (UGA) provided survey data and annual reports that showed low numbers of Conasauga logperch and reduced shoal occupancy (e.g., presence/absence) in both the upper and lower portions of the fish's historic range. Numbers in the middle portion of the historic range (RM 70 to RM 60) fluctuated over the available ten years of survey data (2010-2018; CFI, unpublished data).

Recovery Achieved: 1 (1=0-25% species recovery objectives achieved). Conservation partners in the basin have formed a strong alliance over the past decade, working to identify and minimize the impact of basin stressors on aquatic habitat and rare species (Note: the partnership's focus is on watershed-wide improvements to benefit Conasauga aquatic resources, including the Conasauga logperch and ten other federally-listed fish and freshwater mussels). Research has led to a greater understanding of likely stressors, knowledge of which Conasauga fish species appear to be declining, and reaches where habitat occupancy is low. Coordination among partners resulted in NRCS designating the Conasauga as a Working Lands for Wildlife Landscape in December 2016. Over the past five years, thousands of acres adjacent to the mainstem in Conasauga logperch habitat have been placed in conservation, and the Limestone Valley RC&D, Georgia Department of Natural Resources (GDNR), Nature Conservancy, and the Service increased staff in the basin to allow partners to more efficiently work with landowners, coordinate with other agencies, and fund/implement conservation and management actions to improve aquatic habitat quality.

Listing History: Federal Register notice: 50 FR 31597 Date listed: August 5, 1985
Entity listed: species, Conasauga logperch (*Percina jenkinsi*)
Classification: endangered

Review History:

Recovery Report to Congress: Each year, the Service reviews and updates listed species' information to benefit the required Recovery Report to Congress. Through 2013, we performed a recovery data call that included status recommendations, such as "Declining" for this fish. We continue to show this species' status recommendation in 5-year reviews. The last review for this species to inform the Recovery Report to Congress was conducted in 2019.

5-Year Reviews: In a 1991 5-year review (56 FR 56882), different species were simultaneously evaluated with no species-specific, in-depth assessment of the five factors as they pertained to

recovery. In particular, no changes were recommended to the status of this fish in the review. The August 2011 Conasauga logperch 5-year review recommended the listing classification of “endangered” remained valid and no change in status was appropriate.

Other: In addition to these formal federal reviews, conservation partners in the basin hold regular conference calls to discuss Conasauga aquatic species’ status (including the Conasauga logperch) and ongoing/future management actions to conserve these species. Larger groups, including local governments, academia, landowners, industry, and others met 2000, 2001, 2003, 2004, 2008, 2016, and 2019 to evaluate species’ status, share research results and discuss future needs, and develop/refine management plans and funding strategies to benefit aquatic resources.

Species’ Recovery Priority Number at Start of Review (48 FR 43098): 5, which indicates a species with a high degree of threat and low recovery potential.

Recovery Plans: Recovery plan for Conasauga logperch (*Percina jenkinsi*) Thompson and amber darter (*Percina antesella*) Williams and Etnier, U.S. Fish and Wildlife Service, Southeast Region, June 20, 1986.

A second plan, the Recovery Plan for Mobile River Basin Aquatic Ecosystem. U.S. Fish and Wildlife Service, Southeast Region. November 17, 2000, provided an updated recovery outline but did not replace the 1986 plan or provide updated recovery criteria.

II. REVIEW ANALYSIS

A. Application of the 1996 Distinct Population Segment (DPS) policy: The species is not listed as a DPS, and there is no relevant new information that would support DPS classification.

B. Recovery Criteria: Does the species have a final, approved recovery plan containing objective, measurable criteria? The species has a final recovery plan but no measurable recovery criteria. The 1986 recovery plan states that (1) the Conasauga logperch’s distribution is so restricted that a single catastrophic event could result in species’ extinction and (2) it is unlikely the present population could be sufficiently protected to allow removing the species from the Act’s protection unless other populations were found or extirpated populations were reestablished.

C. Updated Information and Current Species Status: The Conasauga Logperch SSA (Service 2019) provides updated information on the species’ biology and ecology. The SSA was prepared using the Service’s SSA framework and evaluates the species’ resilience, representation, and redundancy (Smith et al. 2018). Resilience is related to population size and growth and is the ability of a population to persist in response to stochastic demographic, environmental, and genetic processes and anthropogenic disturbances. Redundancy evaluates the number of discrete populations and their distribution across a geographic area – redundant species have risk spread among populations, which reduces the likelihood of impacts from large-scale or catastrophic

events. Representation is future adaptive capacity in response to natural or man-made events, measured as the breadth of patterns of ecological, geographic, and genetic diversity.

Service biologist Robin Goodloe, Georgia Ecological Services, prepared the SSA, with technical and scientific input from species' experts. A summary of the SSA is provided here; refer to the document for more detailed information on Conasauga logperch biology, current status, and threats, and an evaluation of future population conditions in the foreseeable future (to 2060) (SSA posted at <https://ecos.fws.gov/ServCat>).

1) Biology and Habitat

Distribution: The species, when listed, was known to occur only in a 16.5-mile reach (26.6 km) of the Conasauga River, from just upstream of the Minnewauga Creek confluence in Polk County, Tennessee (broken red line, Figure 1), downstream to the GA Hwy 2 bridge, Murray County, Georgia. This reach was designated critical habitat when the species was listed (note: the 1986 and 2000 recovery plans incorrectly state this reach was 18 km, or 11 miles, long). Surveys after 1986 doubled the species' known range to a 36-mile reach (58 km; solid red line; Figure 1), from the Jacks River 0.5 mile upstream of its confluence with the Conasauga, Polk County, Tennessee, downstream in the Conasauga River, through Tennessee, to Mitchell Bridge, Murray County, Georgia (Freeman 1989, 1990, Rakes and Shute 2005).

There are no data in museum or other fish collections that suggest the species previously was more widely distributed in the Conasauga or occurred in any other river basin (Thompson 1985), however, the earliest survey of the upper Coosa River (i.e., the Conasauga, Coosawattee, Etowah, Oostanaula, and Coosa Rivers upstream of Lake Weiss) did not occur until 1877, after agricultural development and deforestation during the Civil War altered the landscape (Jordan 1877, as cited in George et al. 2010). The Conasauga logperch's range may be restricted by competition with the Mobile logperch (*Percina kathae*), which is widespread in the Mobile Basin (Thompson 1985).

Life History: The Conasauga logperch is located most frequently in riffles and runs over extensive coarse gravel and small cobble (Rakes et al. 2015). It generally occurs at water depths greater than 0.5 meters (1.6 feet) with swift current (often greater than 0.5 meters/second or 1.6 feet/second) and often is found in the same shoals as the endangered amber darter (*Percina antesella*) (Freeman 1989, Golder Associates 2002, Johnson and Damon 1996). Even within suitable habitat, the darter is rare, typically observed at low densities of scattered individuals or pairs (Rakes and Shute 2005)

Little is known of the species' life history, although it is assumed similar to other logperch (Etnier and Starnes 1993, Mettee et al. 1996, Freeman et al. 2007). No data are available on the age at which Conasauga logperch mature, but captive propagation studies on the blotchside logperch (*Percina burtoni*) suggest the fish do not spawn until two years of age (Rakes and Shute 2005). Maximum lifespan is at least five years (Petty et al. 2015).

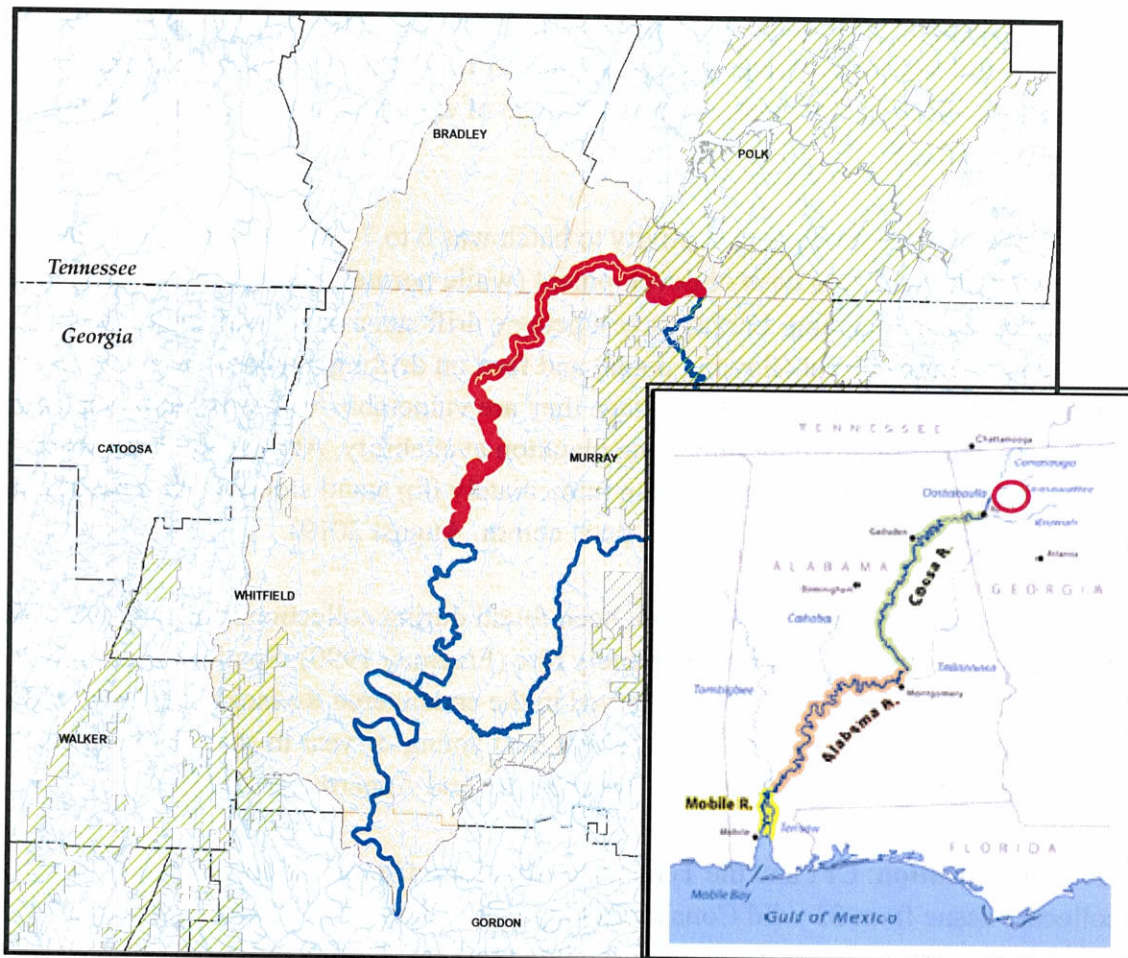


Figure 1. Conasauga logperch range (solid red) and critical habitat (yellow/red) in the Conasauga River. The Conasauga HUC8 is shaded pink. Hatched areas in the headwaters are the Cherokee National Forest in Tennessee and Chattahoochee National Forest in Georgia. Inset shows the location of the Conasauga River and other tributaries to the Coosa River, Mobile River Basin. The species general location is circled in red in the inset.

Logperches feed on aquatic insect larvae and have an interesting habit of flipping stones with their snouts to expose prey underneath (Mettee et al. 1996, Freeman 1999).

CFI successfully propagated Conasauga logperch in captivity in 2011 (Petty et al. 2011). Courtship display was observed by mid-February, when water temperature fluctuated between 8 to 12°C (46-54°F). By the end of February, when water temperature was just above 13°C (55.4°F), courtship displays increased in frequency and duration. Spawning was documented when multiple males would stack on top of a female, who was often under or adjacent to a ceramic tile. There was no quivering or burying witnessed to indicate egg deposition. The first eggs were recovered by gravel washing the tank on March 1; most had been deposited in an area that had a large rock as cover and relatively fine sand substrate. There were a couple of clusters of eggs found in the cobble, but most were scattered single eggs. Larvae had a large yellow yolk sac and were relatively inactive. Over 1,000 eggs and larvae were collected, and survivorship from swim-up to juvenile (August) was 61%, with about 715 young produced.

(Note: swim up is a life stage that begins when larval fish have absorbed their yolk sac and swim upward toward the water surface to gulp air to fill the air bladder). Given that a passive method of collection was used, the true numbers of eggs produced per female is unknown (Petty et al. 2011).

The estimated time for eggs in captivity to hatch was 6 to 7 days, and the resulting larvae then took an additional 2 to 3 days of development (while normally buried in the sand) before swimming up and feeding. Larvae have a pelagic drift stage of several weeks, when they hold position in gentle current (flowing pools) and feed on drifting plankton or plankton-sized foods (much like cyprinids). At this stage they are vulnerable to downstream displacement by high flow events or anything impacting plankton availability. At the end of the stage they settle to a mostly benthic stage and can immediately flip small stones to find aquatic insect, etc. prey underneath (Pat Rakes, CFI, pers. comm. August 2019).

Juvenile Conasauga logperch have not been found during collections and may use different habitat than adults, or simply be extremely rare (Freeman 1990). Spatial variation in habitat use between age classes has been observed in the endangered Roanoke logperch, with adults and subadults found in run and riffle habitat, and young-of-year in shallow, stagnant backwaters and secondary channels (Rosenberger and Angermeier 2003).

Genetic Variation: CFI and the Tennessee Aquarium Conservation Institute (TNACI) collected tissue from 33 wild Conasauga logperch in August 2010 and April-June 2012. All individuals were analyzed using microsatellite markers. Results indicated this species has maintained relatively high levels of heterozygosity and allelic richness (Moyer et al. 2015), a situation unusual in a species with such low numbers (George et al. 2010). Effective population size (N_e) was estimated at 114 (95% CI 60-526). Despite the species' small N_e and restricted range, results suggest the risk of population decline and extinction due to inbreeding depression and genetic drift is low (Moyer et al. 2015).

Taxonomic Classification or Changes in Nomenclature: No changes (Integrated Taxonomic Information System 2019).

Abundance and Population Trends: Hagler et al. (2011) analyzed University of Georgia (UGA) museum records from 1988 to 2008 and repeat-sampled 17 historically-occupied shoals throughout the logperch's range in 2008 to evaluate species' occurrence (e.g., presence vs. absence at a given site). Conasauga logperch were observed in only 80 of 340 surveys (24%) during this 21-year period, and, in 65 of the 80 surveys, only 1 or 2 individuals were observed. Analysis of museum records supported the hypothesis that the probability of encountering a Conasauga logperch declined in the lower third of the species' known range (see red bars, Figure 2).

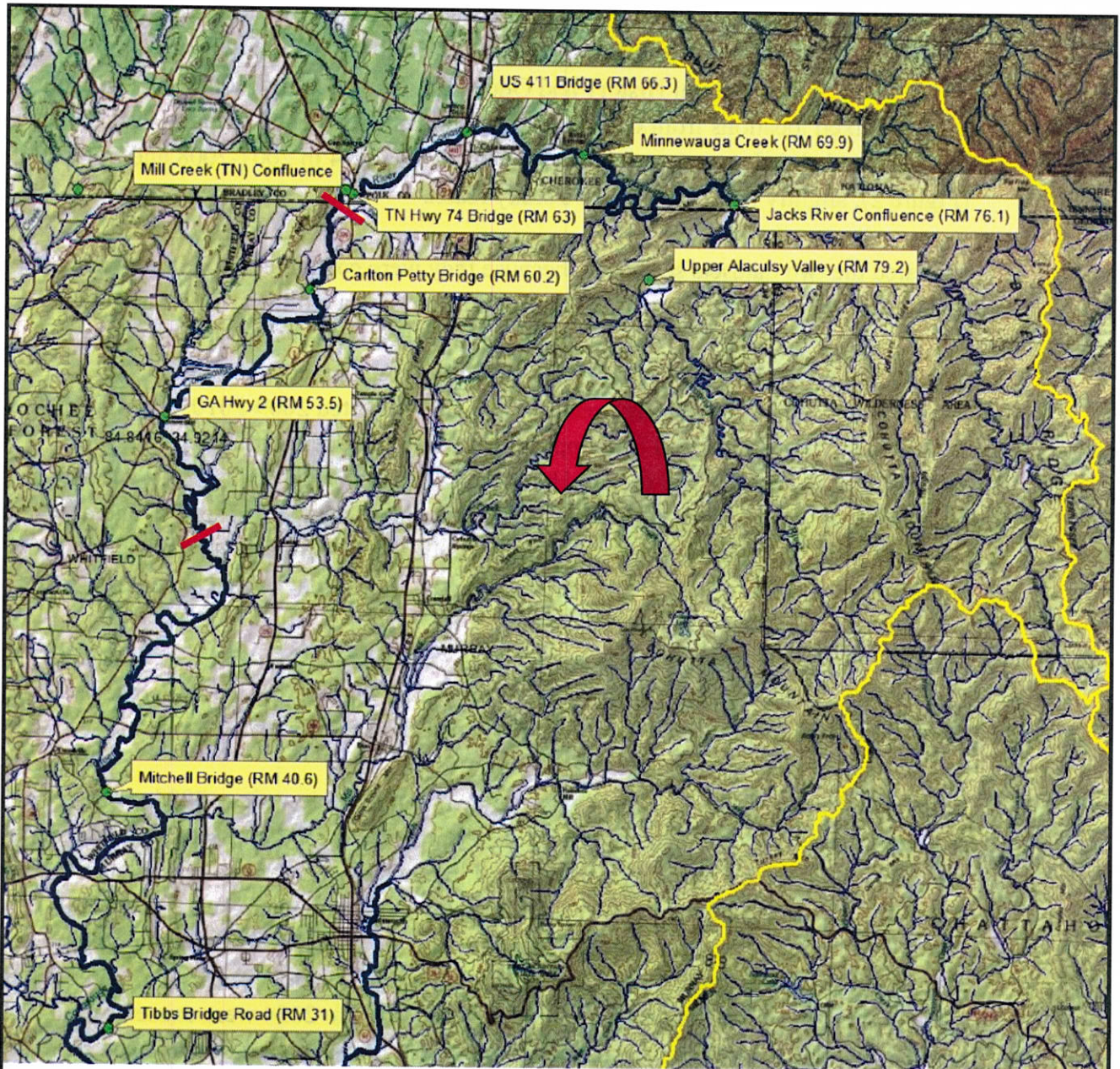


Figure 2. Key locations in the Conasauga mainstem. RM = River Mile. The red arrow represents the direction of river flow. The river above Minnewauga Creek lies within National Forest. Red bars mark the upper, middle, and lower portions of the range, as defined by Hagler et al. 2011).

To assess Conasauga logperch status since 2008 (e.g., since Hagler et al. 2011), we evaluated two long-term datasets with information on fish community composition in the Conasauga mainstem in Georgia and Tennessee and the lower Jacks River in Tennessee (Golder Associates 2010, Freeman et al. 2008, 2009, 2015; Hagler and Freeman 2012; Petty et al. 2013, Bumpers and Freeman 2017, Bumpers et al. 2019, and CFI unpublished survey data):

- CFI conducted snorkel surveys in the Cherokee National Forest (Conasauga River Mile 76.1-69.9 + 0.5 miles of Jacks River) from 1993 through 2016 and, in 2010, expanded their study reach downstream, usually to near the Mill Creek confluence upstream of the

Tennessee/ Georgia state line but occasionally as far downstream as Carlton Petty Bridge in Georgia, if water clarity allowed snorkeling at the lower sites (Figure 2).

- UGA’s Museum of Natural History and Odum School of Ecology collected fish using seines at fixed locations from GA Hwy 2 downstream to Mitchell Bridge 1995-2018. UGA expanded their survey reach upstream to TN Hwy 74 in 2007-2008 and 2014-2018 (Figure 2), slightly overlapping CFI’s study reach.

We evaluated the two datasets separately because they were conducted by different personnel using different methods in reaches of the mainstem Conasauga with varying water clarity.

Numbers of fish collected in 2012, and possibly later, were augmented by release of individuals propagated in 2011 from breeder stock CFI collected 2009-2010. From April 13- June 6, 2012, 336 propagated and fin-clipped Year 1 fish were released at selected sites between the Alaculsy Valley and the TN Hwy 74 Bridge. However, during 2012 surveys conducted after the release, only 14 of the 336 released logperch were observed, and all 14 were in the Cherokee National Forest. The limited collection of propagated fish suggests low survival, poor tag retention, and/or a lower capture rate or different habitat occupancy for young logperch.

The survey data, coupled with published literature results, suggest that, overall, the species is declining and utilizing less of its historic range (Figure 3). Specifically:

Cherokee National Forest: Conasauga numbers remained low since 2004 upstream of Minnewauga Creek in Tennessee’s Cherokee National Forest. CFI described their study area, following a 2003 fish survey, as a small to medium- sized river with relatively clean substrate, offering good habitat for Conasauga logperch and other species (CFI 2004). The following year, they reported a significant decline in darter numbers, including Conasauga logperch, noting that the reach was “*nearly a desert*” (Rakes and Shute 2006). CFI speculated declines in darter populations from 2003 to 2004 were caused by habitat scour, reduction in benthic forage, and displacement of fish due to flooding and high velocity flows caused by three hurricanes -- Frances, Ivan, and Jeanne – that drenched the area September 2004 (Shute and Rakes 2005; Rakes and Shute 2010). Bronze darters (*Percina palmaris*) observed July 2005 appeared emaciated and in poor condition (Rakes and Shute 2006), even though fine substrates were re-accumulating, riverweed coverage was returning, and small amounts of woody debris were reappearing (Rakes and Shute 2006).

Numbers of Conasauga logperch have remained low since the 2004 hurricanes. CFI concluded that, although older, larger adults have been observed during multiple surveys since 2004, the reach in the Forest has insufficient habitat to support all critical Conasauga logperch life stages, and regular reproduction, recruitment, and occupancy probably do not occur (Petty et al. 2014).

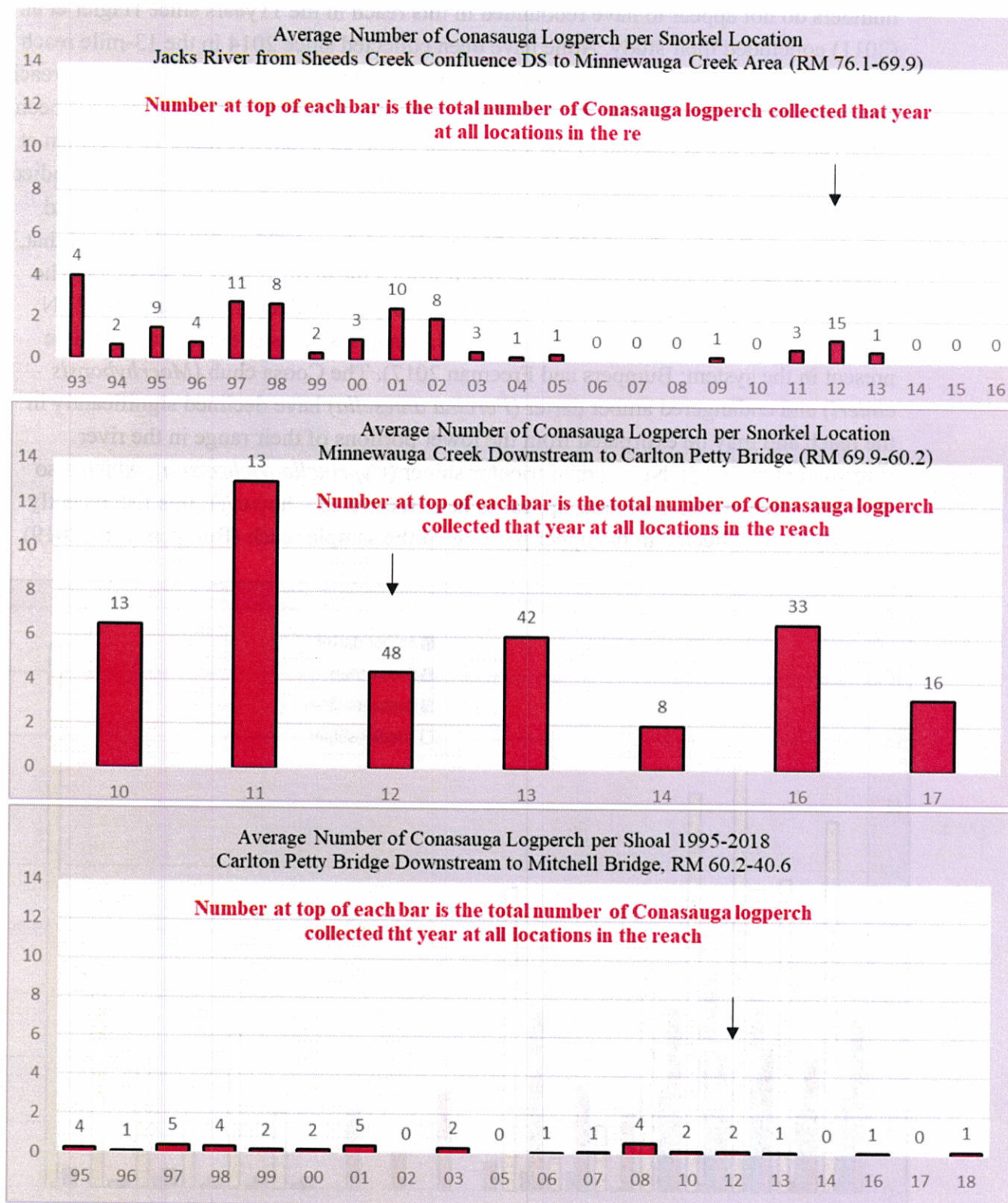


Figure 3. Average number of Conasauga logperch per collection effort, by river reach, with most upstream reach at top (data from Golder Associates 2010, Hagler et al. 2011, Freeman et al. 2008, 2009, 2015; Hagler and Freeman 2012; Bumpers and Freeman 2017, Bumpers et al. 2019, and Missy Petty at Conservation Fisheries 2019). Over 325 captive-propagated fish were released in suitable habitat from the Alaculsy Valley downstream to TN Hwy 74 in 2012 (black arrows; Petty et al. 2013).

Downstream of Carlton Petty Bridge to Mitchell Bridge: Conasauga logperch numbers do not appear to have rebounded in this reach in the 11 years since Hagler et al. (2011) concluded their study. None have been collected since 2014 in the 13-mile reach between GA Hwy 2 and Mitchell Bridge (RM 53.5-40.6), and only a handful in the reach between Carlton Petty Bridge and GA Hwy 2. Similar declines in other fishes have been observed in the lower portion of the Conasauga logperch’s range (Figure 4). Freeman et al. (2017) used time series analysis to evaluate changes in occurrence of 26 small-bodied shoal species downstream of GA Hwy 2. Their analysis of fish collections at 13 fixed sites between GA Hwy 2 and US Hwy 76, monitored from 1995 to 2014, indicated that, overall species richness declined in the reach from a mean of 22.9 to 19.4 species. The Coosa madtom (*Noturus sp. cf. N. munitus*) has not been collected downstream of TN Hwy 74 since 1999 (Figure 4, although, e-DNA analyses suggest the fish may still be present in the system; Bumpers and Freeman 2017). The Coosa chub (*Macrhybopsis etnieri*) and endangered amber darter (*Percina antesella*) have declined significantly in the reach and may be extirpated from the lower portions of their range in the river (Freeman et al. 2017). Numbers of tricolor shiner (*Cyprinella trichroistia*), which also declined in the previous decade, appear to have recovered – however, this fish recently has only been collected in the upper portions of the sample reach (Bumpers et al. 2019).

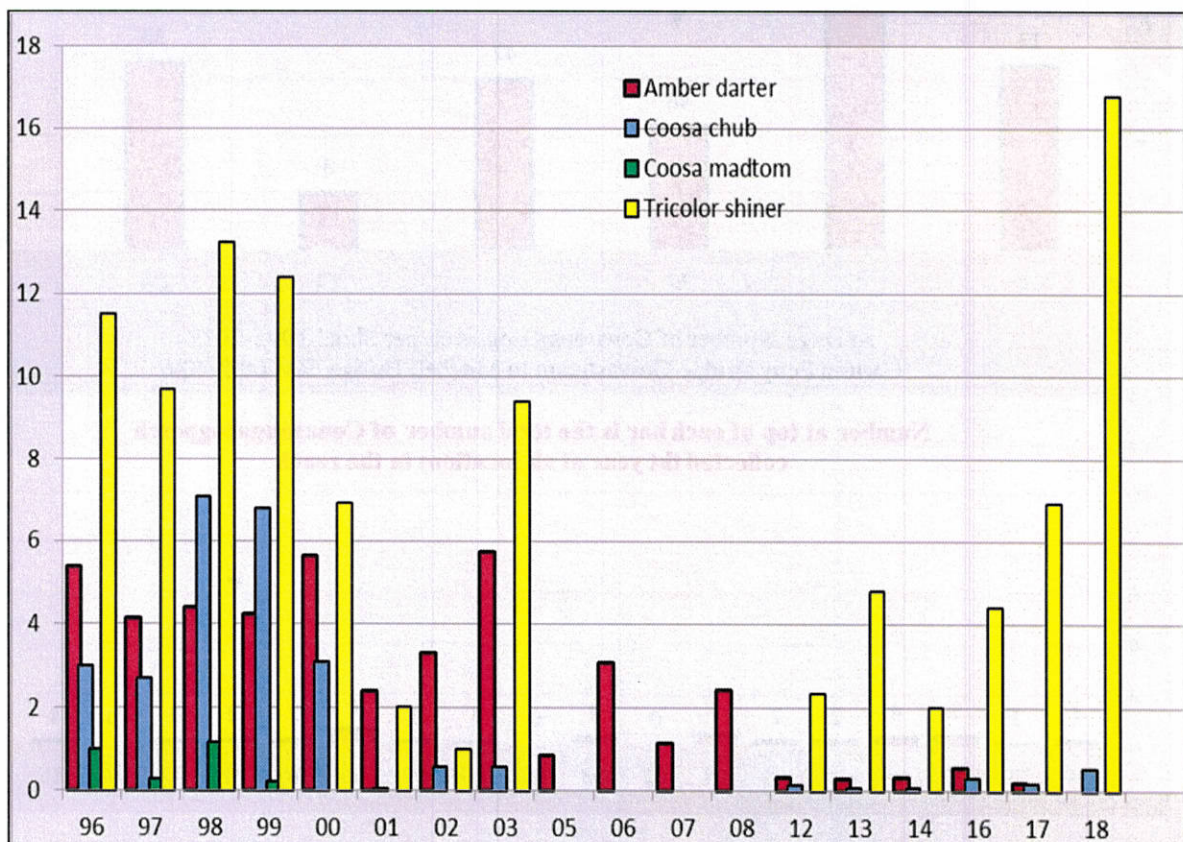


Figure 4. Mean number of individuals collected per shoal for four other fish species in the Conasauga mainstem. The 1996-2008 surveys were conducted only in Georgia, between GA Hwy 2 and US Hwy76; surveys 2012-2018 were expanded to cover upstream to TN Hwy74 (data compiled from Golder Associates 2010, Hagler and Freeman 2012, Freeman et al. 2015, Bumpers and Freeman 2017, Bumpers et al. 2019, and Philip Bumpers, University of Georgia, pers. comm. October 2019).

Downstream of Cherokee National Forest to Carlton Petty Bridge in Georgia: CFI has routinely observed Conasauga logperch in the upper middle portion of its historic range (RM 70 – 60) since comprehensive surveys in the reach began in 2010, including 13 individuals at a single location in 2011. Total numbers observed per year have varied, but are consistently higher than numbers in upstream and downstream reaches – variation may represent natural population fluctuations due to good or bad recruitment/survival years and/or differences in capture efficiency due environmental conditions (water depth, turbidity, temperature, etc.) at the time of the survey. We have insufficient data to evaluate trends in this reach.

- 2) **Changes in Habitat or Ecosystem Conditions:** Even as early as 1995, water quality visibly declined (as evidenced by decreasing water clarity) downstream from the TN Hwy 74 bridge crossing, with significant degradation within the first few miles in Georgia (Freeman 1995). Extensive mats of benthic algae were observed in 2000 and 2001 along a 28-mile reach of the Conasauga from TN Hwy 74 downstream past Tibbs Bridge (Freeman and Wenger 2001, Freeman et al. 2007), a reach that includes the lower half of the Conasauga logperch's historic range. Studies in the Conasauga mainstem over the last three decades have documented a decline in *Podostemum* and an increase in occurrence of algal and diatom mats, from upstream to downstream along the mainstem, and at particular shoals over time (Freeman and Freeman 2019). This was concurrent with increases in water turbidity from less than 2 NTUs (nephelometric turbidity unit) in the upstream national forest to greater than 10 NTUs in the Conasauga logperch's range (Argentina et al. 2010), even during periods of limited runoff.

Despite sediment, nutrient, and other issues, Conasauga fish populations were relatively stable until the mid-2000's, when long-term seine surveys at fixed sample sites in the mainstem downstream of GA Hwy 2 (RM 53.5-RM 31) documented a decline in abundance and/or occurrence of Conasauga logperch, endangered amber darters (*Percina antesella*), and a number of non-listed fish (Figure 4). During this time period, several changes in agricultural production occurred (Cindy Askew, NRCS, pers. comm., June 2008):

- A transition towards large-scale poultry production in the basin.
- Subsequent widespread use of poultry litter as a fertilizer for pastureland or row crops.
- A switch to use of Roundup® Ready® seed, which altered timing and application amounts of the herbicide glyphosate and “inert” ingredients in formulations

In addition, the Mill Creek basin, which includes the City of Cleveland, Bradley County, Tennessee, and the Sumac Creek basin, where the Georgia Ports Authority recently constructed a new inland port, are urbanizing, contributing to declining water quality.

The SSA described seven likely environmental stressors on aquatic resources in the basin (Table 1), many of which are related to these recent changes in land use in the basin:

Oh Table 1. Likely anthropogenic stressors for Conasauga logperch.

Stressor (Source)	Location
Fine sediment (legacy, agricultural, urban development)	Rangewide
Excess nutrients (agricultural fertilizer, glyphosate breakdown, human/animal waste)	Rangewide
Glyphosate-based herbicides (agriculture)	Rangewide
Increased impervious surface (urban development)	Mill and Sumac Creek basins now. Other basins in future
Lack/loss of riparian buffers (mostly removal in past for agriculture)	Rangewide
Loss of <i>Podostemum</i> (unknown cause)	Rangewide
Climate change (multiple anthropogenic causes)	Rangewide, and impacts likely to increase in the future

Fine Sediment (e.g., sand, silt, and clay): The detrimental effects of sediment on aquatic communities have been widely demonstrated and include (1) habitat degradation, (2) reduced productivity that affects the food chain, (3) lethal effects that kill individual fish, cause population reductions, or damage the capacity of the ecosystem to produce fish, (4) sub-lethal effects that injure the tissues or physiology of the organism but are not severe enough to cause death, and (5) behavioral effects that change activity patterns or alter the kinds of activity usually associated with an organism in an unperturbed environment (Newcombe and McDonald 1991, Wood and Armitage 1997). Specifically:

- Fine sediments in the water column increase turbidity, limit light penetration, transport sorbed contaminants, and potentially reduce primary productivity that affects the food chain (Davies-Colley and Smith 2001).
- Deposited silt and sediment can entomb and smother the stream bottom, filling interstices between cobble and gravel particles. This can alter the periphyton and macroinvertebrate communities (Puglsey and Hynes 1983, Soroka and MacKenzie-Grieve 1983, Newcombe and Jensen 1996) and bury fish eggs, larval nurseries, and adult foraging and resting habitat.
- Benthic food organisms may be smothered by silt, reducing food biomass and making items harder for visually-feeding fish to locate (Ryan 1991).
- Suspended sediment can reduce spawning success. Studies have shown that increased levels of suspended sediment reduced success of both salmonids and minnows, many of which depend on clear water for visual reproductive cues (Burkhead and Jelks 2001).
- Silt may have direct lethal effects on fish by clogging gillrakers and gill filaments (Bruton 1985, Newcombe and Jensen 1996). Acceptable levels may depend on the nature and concentration of the silt, water oxygenation and temperature, species and size of the fish, and concentration of suspended sediment to which it has become acclimated (Ryan 1991).

Excess Nutrients/Cultural Eutrophication: Water quality studies conducted 1997-2012 in the Conasauga documented both (1) an increasing trend in NO₂+NO₃ concentrations in a downstream direction and (2) comparatively higher concentrations of total nitrogen (around

threefold) in 2011-2012 samples vs 1997-2000 samples (Hagler and Freeman 2012). From 2012-2013, Lasier et al. (2016) found nutrient enrichment of Conasauga surface waters was widespread, with concentrations of NO₃ and phosphorus exceeding levels associated with eutrophication.

The chief effect of eutrophication is the stimulation of algal growth and shifts in the algal community, which can reduce water clarity and degrade water quality. Freeman and Wenger (2001) reported a large bloom of benthic algae in October 2000 that spanned almost 30 miles of high-quality shoal habitat from near the Tennessee Hwy 74 crossing to downstream of Tibbs Bridge. The bloom was evident below the Mill Creek (TN) and Perry Creek (GA) confluences, the first tributaries that drain watersheds with larger amounts of agricultural lands. The blooms occurred in shallow water (0.75m or less) along shoals; mats of algae covered *Podostemum*, and fishes were present in lower abundances in the areas with algal mats (Freeman et al. 2007). The same phenomenon was observed the following year, in October of 2001 and in years since, to a lesser extent (Freeman et al. 2007). Currently, water clarity is significantly reduced in the lower half of the Conasauga logperch's range, where the fish is now collected rarely, likely due to high concentrations of diatoms and other algae (Freeman and Freeman 2019) that may affect foraging and spawning success (Mary Freeman, USGS, pers. comm., November 2018).

Extensive algal blooms can alter habitat by covering gravel substrates where fishes forage and deposit eggs, and they can smother *Podostemum* (Freeman et al. 2017). Algal blooms limit light penetration, reducing growth, causing die-offs of plants in littoral zones, and lowering the success of predators that need light to pursue and catch prey (Lehtiniemi et al. 2005). High rates of photosynthesis associated with eutrophication can deplete dissolved inorganic carbon and raise pH to extreme levels during the day. When dense algal blooms eventually die, microbial decomposition severely depletes dissolved oxygen, creating hypoxic or anoxic 'dead zones' lacking sufficient oxygen to support most organisms. This can lead to fish kills, as well as more subtle changes in ecological structure and function, such as lowered biotic diversity and reduced recruitment in fish populations. Hypoxia and anoxia are more likely to occur in summer, when the solubility of oxygen decreases and oxygen demand (respiration rate) generally increases as temperature increases (National Academy of Science 2000).

Increases in nutrient loads can stimulate the proliferation of pathogens that adversely impact fish and mussel species (Coyner et al. 2003) and potentially alter the availability of carbon to the aquatic habitat. Smaller streams depend on annual leaf fall to support biological diversity and productivity (Wallace et al. 1997), and inputs of nitrogen and phosphorus to surface waters may accelerate decomposition of leaf packs by 50%, disrupting annual carbon usage patterns and food web functions (Rosemond et al. 2015). Nitrate has also been implicated as an endocrine-disrupting chemical due to its potential to be converted to nitric oxide, which can modify steroidogenesis in aquatic animals (Hamlin et al. 2008).

Likely sources of nutrients include:

- Widespread use of poultry litter as fertilizer for pastureland or row crops (Cindy Askew, NRCS, pers. comm., June 2008). Poultry litter is a mixture of manure, feathers, spilled food, and bedding material. Surface spreading of litter on agricultural fields allows runoff from heavy rains to carry nitrogen, phosphorus, and other chemicals from manure into nearby streams. Poultry litter has high relative concentrations of nitrogen, with an N:P ratio of 2:1 (Pierson et al. 2001). Since most crops and pasture grasses require an N:P ratio of 8:1, applying sufficient poultry litter to supply the nitrogen needs of crops and pasture will result in excess phosphorus application (Sharpley 1999, Sharpley et al. 2004). Phosphorus will bind to soil and is mobilized with sediment particles after heavy rains, and relatively high phosphorus concentrations have been measured in surface runoff for months following poultry litter application (Pierson et al. 2001).
- Suburban development, including lawn fertilizer, discharges or leaks from wastewater treatment plants, and poorly-maintained and/or sited septic tanks.
- Atmospheric nitrogen that is fixed by plants, through lightening, or other processes.

A largescale shift to use of Roundup-Ready® seed for major row-crop products:

Roundup®'s active ingredient is glyphosate, which impedes photosynthesis. Roundup Ready® soybean and corn seeds, which are genetically modified to allow seedlings to survive direct application of Roundup, were introduced in 1996 and 1998. National Resource Conservation Service (NRCS) personnel in the basin estimate that farmers in the Conasauga began using Roundup Ready® soybean and corn seeds extensively by 2005 (C. Askew, NRCS, pers. comm. June 2008).

In the Conasauga River, Lasier et al. (2016) collected post-rainfall surface water and sediment samples from the mainstem and major tributaries 2010-2013 and analyzed for glyphosate and one of its primary breakdown products, aminomethylphosphonic acid, or AMPA. Glyphosate was not detected in any surface water samples (N = 129). AMPA, however, was measured in 77% of the samples, with highest concentrations from the mainstem and tributaries draining the large farm in the study area. Thirteen samples from the farm sites contained concentrations between 1,000 and 5,700 µg/L (microgram/liter), and roughly 30% of the farm site samples exceeded 400 µg/L. Most of the elevated samples were collected during autumn and winter. The farm sites received discharges from tilled fields, pastures, and a dairy production facility. Glyphosate and/or AMPA were measured in almost all sediments collected from the main stem and tributaries and ranged from below detection levels to 2428 µg/kg, with mean concentrations for collection sites (n = 9) varying from 200 to 1100 µg/kg.

Most herbicide formulations are a mixture of an active ingredient (the pesticide) with a variety of “inert” chemicals, such as solvents and surfactants that help glyphosate better stick to leaves and penetrate plant tissue. The original Roundup® formulation included the active ingredient glyphosate, plus the surfactant polyethoxylated tallow amine (POEA). Other

glyphosate-based herbicides may include POEA or other surfactants (Defarge et al. 2018), and farmers often eschew Roundup® and mix generic glyphosate with dish soap or diesel as the surfactant.

Research has documented that glyphosate-based herbicides with POEA are more toxic to fish and other aquatic organisms than glyphosate alone (Folmar et al. 1979, Diamond and Durkin 1997), and POEA is more toxic than Roundup® (Tsui and Chu 2003), particularly in alkaline vs. acidic water (Diamond and Durkin 1997). Even below lethal levels, glyphosate-based herbicides appear to damage fish DNA (Cavalcante et al. 2008, Çavas and Könen 2007, Grisolia 2002, Guilherme et al. 2012), stress the liver, inhibit acetylcholinesterase in muscle and brain (Modesto and Martinez 2009); impact hormones and reproduction (Soso et al. 2007); and cause histopathological changes and gill tissue damage (Jiraungkoorskul et al. 2003). Langiano and Martinez (2008) noted an increase in plasma glucose and catalase liver activity in fish exposed to the herbicide, indicating, respectively, a typical stress response and activation of antioxidant defenses after Roundup® exposure. In addition, Roundup® induced several liver histological alterations that might impair normal organ functioning.

The breakdown of glyphosate by micro-organisms in water may stimulate eutrophication. Glyphosate is a phosphonic acid, with a direct carbon to phosphorus bond. Micro-organisms in soil are responsible for the degradation of glyphosate through two chemical pathways. One pathway produces AMPA; the second produces the compound sarcosine, which is oxidized to glycine and formaldehyde (Kishore and Jacob 1987). Both processes release inorganic phosphate. Vera et al. (2010) found that total phosphorus significantly increased in treated mesocosms due to Roundup® degradation, which favored the eutrophication process.

Increased Impervious Surface Associated with Urbanization: An urban area is defined as the entire landscape developed for residential, commercial, industrial, and transportation purposes, including cities, towns, suburbs, and exurban sprawl that has a density of >1 residential unit/2 ha (Wenger et al. 2009). Many studies have demonstrated that fish assemblages respond to a gradient of urbanization, with sensitive fishes disappearing as urbanization increases (Klein 1979, Wang et al. 2000, 2001, Walters et al. 2003, Roy et al. 2005, Walters et al. 2005). The conversion of a forested or agricultural landscape into parking lots, buildings, and lawns produces a cascade of impacts to stream systems, including changes to hydrology, geomorphology, water temperature, and stream chemistry (Paul and Meyer 2001). The general result is a decrease in the volume of water that evaporates or percolates into the ground and an increase in volume of surface runoff entering stream systems (Booth 1991).

Future urban growth in the Conasauga likely will concentrate in uplands drained by tributary systems, with the main impact on the mainstem being degraded water quality associated with increased sediment and urban contaminant loading.

Lack of Forested Riparian Zones: Much of the Conasauga mainstem within Conasauga logperch habitat, as well as the ditches and tributaries that drain many agricultural fields, lacks a forested riparian buffer or has only fringe vegetation at top of bank. Deforestation of riparian areas can influence the numbers and kinds of organisms in adjacent and downstream reaches. Jones et al. (1999) sampled fishes and stream habitats in Tennessee River tributaries downstream from deforested, but vegetated, riparian patches; all sample reaches were downslope from watersheds with at least 95% forest cover. Darters, sculpins, and benthic minnows decreased in numbers with increasing length of nonforested riparian patch, and sunfishes and water-column minnows increased. Habitat diversity decreased, and riffles became filled with fine sediments as upstream patch length increased. Results suggested that riparian forest removal leads to shifts in the structure of fish assemblages due to (1) decreases in fish species that do not guard hidden eggs or that are dependent on swift, shallow water that flows over relatively sediment-free substrates, or (2) increases in fishes that guard their young in pebble or pit nests or that live in slower, deeper water.

In addition to maintaining habitat for fish and other aquatic organisms, forested riparian buffers play a critical role in protecting stream habitat and water quality by (summarized in Pusey and Arthington 2003, Osborne and Covacic 1993):

- Trapping/removing sediment, nutrients, and contaminants from runoff. This function may be greatly reduced or circumvented in the Conasauga, where agricultural ditches conveying runoff bypass the buffer.
- Stabilizing streambanks by reinforcing and increasing soil cohesion and providing a protective surface matting. Turfgrasses and crops slow runoff, but their root systems are too shallow to provide much streambank stabilization.
- Storing and reducing the velocity of floodwaters, lessening the erosive force of a flood.
- Shading streams to moderate water temperatures. Lower water temperatures support higher dissolved oxygen levels which are important to maintain fisheries.
- Providing leaf litter and large woody debris. Large woody debris creates habitat diversity, provides nutrients for benthic invertebrates, leads to the formation of undercut banks and pools, and shelters fish from high flows and predators (Finkenbine et al. 2000). Leaf litter is an important source of food in smaller stream systems, although in medium-sized rivers, like the Conasauga, aquatic vegetation, algae, and other autochthonous sources likely provide most of the channel's organic matter (Schlosser and Karr 1981).
- Providing habitat for adult insects whose larval forms are aquatic and are a major food source for many freshwater fish.

Decline in the abundance of *Podostemum*: *Podostemum* is a filamentous dicotyledon that occurs in mid-order montane and Piedmont rivers of eastern North America, where it grows submerged and attached to rocks and stable substrates in swift, aerated water. Widespread population declines have been recorded across the species' range (Wood and Freeman 2017, Davis et al. 2018), including in the Conasauga River. Reasons for the decline are not known

but may be related to sedimentation, epiphytic over-growth, hydrologic changes that result in desiccation, and possibly increased herbivory (Wood and Freeman 2017).

The presence of *Podostemum* can alter the physical structure of the channel by changing flow regimes (Grubaugh and Wallace 1995), which can affect sedimentation, organic deposition, and nutrient concentrations in the sediments – flow velocity within *Podostemum* beds can be decreased by more than 50% compared to flow above the plant beds in a Piedmont stream (Grubaugh and Wallace 1995). The plant stabilizes channel substrate to which it is attached, slowing the rate of downstream bed movement. *Podostemum* has been shown to increase invertebrate productivity of Piedmont streams (Grubaugh and Wallace 1995). Conversely, reductions in *Podostemum* biomass have been found to substantially decrease macroinvertebrate biomass, which may trigger trophic cascades that negatively impact fishes and other large bodied consumers (Davis et al. 2018). One hypothesis for the association between benthic fishes and *Podostemum* is preference for sites with increased food availability, but the fishes may also use the plant as a refuge from predators or from swift currents (Argentina 2006).

Climate Change: The effects of climate change on aquatic species in the Conasauga River have not been studied. In the Southeast through the 21st century, variability in weather is predicted to increase, resulting in more frequent and extreme dry and wet years over the next century (Mulholland et al. 1997, Ingram et al. 2013). Climate models project that average annual temperatures will increase, cold days will become less frequent, the freeze-free season will lengthen by up to a month, heat waves will become longer, temperatures exceeding 95F will increase, sea levels will rise an average of 3 feet, the number of category 3 to category 5 hurricanes will increase, and air quality will decline (Ingram et al. 2013). Aquatic systems will be impacted by increasing water temperatures, decreasing dissolved oxygen levels, altered streamflow patterns, increased demand for water storage and agricultural irrigation, and increasing toxicity of pollutants (Ficke 2007, Rahel and Olden 2007). Reduced spring/summer rainfall, coupled with increased evapotranspiration and water demand (because of population growth), could lead to local extirpations if streams dry out more frequently (Ingram et al. 2013). Fishes not constrained by movement barriers could move upstream to cooler waters; however, even historically, the Conasauga logperch was not known to occur in the river in the Alaculsy Valley, where it may be too small, have unsuitable geomorphology, or have unsuitable water chemistry to support the species.

- 3) Current Condition:** In the Conasauga logperch SSA, we defined viability as the ability of the species to maintain a healthy population throughout its historic range in the wild until 2060. Using the SSA framework, we describe the species' viability by characterizing its resiliency, redundancy, and representation.

Resiliency: Resiliency (measured at the population level) is the foundational building block of the SSA Framework. For a species to be viable, it must be resilient enough to withstand

stochastic events and anthropogenic stressors. We assessed resiliency of the Conasauga logperch based on population and distribution factors outlined in Table 2.

Table 2. Population characteristics used to create condition categories in Table 3.

Condition	Population	Historic Range Occupancy
High	Multiple large populations	Well distributed within historic range
Moderate	Multiple small populations	Reduced use or absent from 25% of historic range
Low	Single large population	Reduced use or absent from 50% of historic range
Very Low	Single small population	Reduced use or absent from 75% of historic range

The Conasauga logperch historically was found in a 35.5-mile reach of the Conasauga River mainstem and the lower 0.5 mile of its tributary, the Jacks River. No other historic populations are known. The fish has been collected only occasionally in the Cherokee National Forest (RM 76.1-69.9) since 2004, despite release of 90 captive-propagated fishes in and upstream of this reach in 2012. Occupancy is extremely low from RM 60.2 downstream to RM 40.6, a reach where other species also have declined. The species currently is represented as a single small population that occurs in very low numbers in Tennessee downstream of the Cherokee National Forest (~RM 70 – 60; from Minnewauga Creek downstream to Carlton Petty Bridge). Resiliency, based on the factors in Table 2, is low to very low (Table 3).

Table 3. Conasauga logperch current conditions (resiliency).

Abundance	Historic Range Occupancy
Single small population	The species occurs in low numbers throughout its range and is absent from or declining in 26.3 miles (73%) of its historic range.
Very low	Low, approaching very low

Representation: CFI and the Tennessee Aquarium Conservation Institute collected tissue from 33 wild Conasauga logperch August 2010 and April-June 2012. Evaluation of microsatellite markers indicated the species has maintained relatively high levels of heterozygosity and allelic richness (Moyer et al. 2015), a situation unusual in a species with such low numbers (George et al. 2010). Effective population size (N_e) was estimated at 114 individuals (95% CI 60-526). Despite the species’ small N_e and restricted range, results suggest the risk of population decline and extinction due to inbreeding depression and genetic drift is low (Moyer et al. 2015).

Redundancy: A species needs to have multiple, resilient populations, distributed and connected throughout its range, to withstand catastrophic events (e.g., chemical spills, wildfire, hurricanes, droughts), stochastic factors, anthropogenic stressors, and other events that might decimate one or more populations. The Conasauga logperch has a single population in the Conasauga River. It is not known to have occurred in any other Conasauga tributary or in any other Upper Coosa river basin. Redundancy is zero.

Summary: The Conasauga logperch has low to very low resiliency and lacks redundancy, although genetic diversity (representation) was relatively high when evaluated in 2012. The species currently occurs in very low numbers in Tennessee downstream of the Cherokee National Forest (~RM 70 – 60; from Minnewauga Creek downstream to Carlton Petty Bridge), but rarely is found in the remainder of its 36-mile historic range, suggesting the species, as a whole, is highly vulnerable to stochastic factors, current anthropogenic-related habitat degradation, and/or catastrophic events.

- 4) **Future Condition:** In the Conasauga logperch SSA, we defined viability as the ability of the species to maintain a self-sustaining population throughout the known historic range in the Conasauga River through 2060. Self-sustaining populations are those that are sufficiently abundant and have sufficient genetic diversity to display the array of life-history strategies that will provide for persistence and adaptability over time (Committee of Scientists 1999) and in the face of environmental stochasticity, catastrophes, and changes in its biological and physical environment. We chose the 2060 timeframe to match a SLEUTH model that projected 2060 urban growth patterns for the US Southeast. A SLEUTH model simulates four types of urban growth patterns: spontaneous growth, new spreading urban centers, edge growth around existing urban areas, and road-influenced growth.

The Conasauga logperch is an endemic species with a small population limited to a single small geographical area – it is highly vulnerable to extinction (Moyle and Williams 1990), with natural stochastic processes playing a critical role in this vulnerability (Purvis et al. 2000). Fitness and genetic diversity decrease when populations become small, and this deterioration precipitates positive-feedback loops called extinction vortices. An extinction vortex refers to forces affecting small populations that cause them to spiral into a trend of increasingly smaller populations and endanger their long-term survival.

Gilpin and Soule (1986) were the first to conceptualize this process, describing how demographic, environmental, and genetic stochasticity could interact with each other and with deterministic factors, such as habitat loss, to mutually reinforce and accelerate the loss of small populations. Demographic processes include random fluctuations in the sex ratio, fecundity, or survival. Environmental processes include temporal changes in birth rate due to changes in weather, the food supply, predators, disease, stream flow, and other random variation. For species with very small geographic ranges, vulnerability is exacerbated by the threat of catastrophic events (natural or anthropogenic) that that can significantly reduce or extirpate a population (Angermeier 1995). In an analysis of 10 wildlife populations that went extinct, Fagan and Holmes (2006) found that all exhibited dynamics indicative of an extinction vortex before collapse.

Scenarios: In the SSA, we evaluated three future scenarios:

- Current stressors and conservation actions continue at a rate consistent with current levels of funding and manpower.
- Current stressors in the first scenario are exacerbated by high spring flows two years in a row.
- A best-case scenario, where conservation agencies work strategically, at a large enough scope, to reduce stressors and enhance resiliency.

Assumptions: Under all three scenarios, we assumed:

- The impact of climate change on Conasauga logperch habitat increased over time.
- Demographic, environmental, and genetic stochastic factors interact with each other and with deterministic factors, such as habitat loss, to affect small population viability.
- Urbanization in the Conasauga basin through 2060 concentrated in the Mill Creek-Tennessee and Sumac Creek drainages.
- Land in the Conasauga River's floodplains continued to be farmed through 2060, although crops and agricultural practices might change and alter the type and/or magnitude of threat.

Current Stressor/Conservation Action Scenario: Count data indicate the single Conasauga logperch population is declining, with reduced occupancy of habitat in both the upper 6.7 miles and lower 19.6 miles of its 36-mile historic range. However, in a 10-mile reach of the mainstem Conasauga River in Tennessee (~RM 70-60; from Minnewauga Creek downstream to Carlton Petty Bridge), Conasauga logperch persisted, albeit with fluctuating numbers, over the most recent ten years of survey data (2010-2018). If current conditions remain stable, we anticipate this remnant population could either (1) stabilize or (2) continue to decline, and perhaps go extinct, due to the combined effect of anthropogenic stressors and environmental, genetic, and demographic stochastic factors.

Current Stressor/Conservation Action with High Spring Flow Scenario: Spring floods may be a factor limiting *Percina* recruitment. Hagler and Freeman (2014) found evidence of a negative effect of increasing the minimum 10-day moving average in spring on reproductive success of an Upper Coosa basin relative, the amber darter (*Percina antesella*), suggesting these fish benefit from windows of low spring flow for spawning and recruitment success. High flows may damage eggs, wash larvae from nursery areas, prevent juveniles from migrating upstream to suitable adult habitat, and increase turbidity and sedimentation that degrades habitat. High spring flows in successive years that limit or eliminate juvenile recruitment could eliminate two age classes, which could significantly depress population numbers, particularly if life span does not exceed five years. Under this scenario, Conasauga logperch are likely to decline even more quickly than in the previous scenario.

Best-Case Scenario – Improving Resiliency, Redundancy, and Representation: We cannot increase the Conasauga logperch's redundancy – no other historic population for this

Conasauga endemic is known. Under a best-case scenario, Conasauga logperch resiliency can only be improved (to a degree), and current levels of representation maintained, if targeted management actions, applied immediately and at large-enough scale on priority tracts in the basin, improve habitat to increase carrying capacity. Research indicates that relatively small increases in carrying capacity tend to reduce extinction risk of small, isolated populations in constant environments (Schoener and Schoener 1983, Hilderbrand 2003, Griffen and Drake 2008), although adding environmental stochasticity flattens the relationship between carrying capacity and time to extinction (as cited in White et al. 2017). In a best case scenario, (a) sufficient personnel and funding will be provided to implement recovery measures, (b) at a watershed scale, (c) in a timely manner, (d) on the highest priority parcels, and (e) with provisions to protect habitat from foreseeable threats in the future so the sole population is more resilient to stochastic events and anthropogenic stressors, including climate change. Targeted management actions identified in the 2019 Conasauga Logperch Recovery Plan include:

5) Five-Factor Analysis

- a) **Present or threatened destruction, modification or curtailment of its habitat or range:** Threats to Conasauga logperch habitat or range, at the time the species was listed, focused on three factors: changes in land use in the Conasauga basin, the species' restricted range, and potential reservoir projects in Conasauga logperch habitat. The first two of these were discussed on pages 11-17 and 19 of this five-year review – they remain threats to the Conasauga logperch.

Reservoir projects are not currently considered a threat to the species. The Dalton Lake and Jacks River reservoirs identified in the listing document will not be built. Dalton Lake was not considered a viable water supply option when the final listing document was published. The Jacks River project was authorized for study by Congress in 1945 but not for further planning. A third reservoir, the River Road Reservoir, was constructed by Dalton Utilities in uplands adjacent to the middle portion of the Conasauga River in the late 1990's; it began withdrawing water from the Conasauga River to maintain reservoir water elevations, then releasing water during low flow periods for downstream withdrawal, in 1999-2000. Dalton Utilities monitored aquatic communities and water quality from 1995 to 2010 to comply with their Corps of Engineers' Section 404 permit – these data did not indicate that reservoir operation, at least during the first few years post-construction, significantly impacted fish populations in shoals downstream of the reservoir, when compared to upstream reaches or to baseline conditions. The report, however, specifically excluded Conasauga logperch from impact conclusions due to the limited number of individuals collected during the study (Golder Associates 2008).

No new drinking-water or industrial-use reservoirs in the Conasauga basin currently are under Federal review.

Ongoing Conservation Efforts in the Basin: Multiple partners are working to reduce threats to the Conasauga River system and restore degraded habitat and rare species. Research to identify stressors on rare species in the Conasauga and on-the-ground management actions, include:

- Research by USGS, UGA, TNACI and others to identify stressors to aquatic systems in the Conasauga basin, including evaluation of water quality and algal blooms in the mainstem, response of fishes to stormwater runoff and other stressors associated with urbanizing areas, identification of tributaries delivering the greatest nutrient and contaminant loads, and evaluation of environmental estrogens and intersex fish.
- Monitoring fish population trends. UGA, USGS, GDNR, and CFI have surveyed fish communities in the Conasauga, with databases reaching back over two decades.
- Implementation of management actions to restore streams and floodplains in priority habitat for the Conasauga logperch and other rare aquatics in the Conasauga. National Forest Service land protects the River's headwaters (Chattahoochee and Cherokee National Forests). NRCS, The Nature Conservancy, Limestone Valley RC&D (LVRCD), Forest Service, and the Service have long worked in the Upper Coosa basin to improve water quality and wildlife habitat. Capacity to work with farmers and other private landowners in the basin increased FY18-FY19, as LVRC&D, GDNR, and the Service assigned additional biologists specifically to the Upper Coosa basin, in addition to the long-standing TNC, NRCS, and Forest Service presence in the basin.
- Land protection/conservation. Joint efforts by conservation partners, including the Corps of Engineers Savannah District and the Georgia – Alabama Land Trust, have permanently protected over 4,000 acres along the mainstem Conasauga downstream of the National Forests.
- Development of a Working Lands for Wildlife-Conasauga program to reduce nutrient input into the river and its tributaries, in addition to multiple conservation actions implemented under Farm Bill programs. Limestone Valley RC&D hired a biologist in FY18 specifically to work with NRCS to implement Working Lands for Wildlife projects.
- Incorporation, into the Savannah District Corps of Engineers' requirements for Clean Water Act Section 404 authorization process of required BMPs for culvert and pipeline installation to minimize erosion and sedimentation and allow for fish passage.
- Development of policies and ordinances, which can be adopted by participating local governments, that modify current development practices regarding infiltration of stormwater runoff, better site design, limits on mass grading, retention of riparian buffers, and sediment/erosion control.

- Regular meetings with partners to discuss recent biological monitoring trends, scientific research, threats, and possible solutions to alleviate those threats.
- b) **Overutilization for commercial, recreational, scientific, or educational purposes:** We do not have data or evidence indicating that overutilization is a threat to this fish.
- c) **Disease or predation:** We do not have data or evidence indicating that disease or predation are threats to this fish.
- d) **Inadequacy of existing regulatory mechanisms:** Habitat for the Conasauga logperch is protected, to varying degrees, under the State of Georgia's Endangered Wildlife Act of 1973 (O.C.G.A. 27-3-130 et seq.), Tennessee Nongame and Endangered or Threatened Wildlife Species Conservation Act of 1974 (Tenn. Code Ann. § 70-8-101), Georgia Erosion and Sedimentation Act (O.C.G.A. 12-7-1 et seq.), Tennessee Water Quality Control Act of 1977 (Tenn. Code Ann. § 69-3-102), other State laws and regulations regarding natural resources, the Federal Endangered Species Act (Act) of 1973, as amended (16 U.S.C. §1531 et seq.) and Clean Water Act (33 U.S.C. §1251 et seq.). The Georgia Endangered Wildlife Act limits protection of listed species to individuals found on State public lands (excluding Georgia Department of Transportation lands) -- individuals on private lands are not protected under State law (although they still are protected under the prohibitions of Section 9 of the Federal law). The Tennessee Nongame and Endangered or Threatened Wildlife Species Conservation Act of 1977 is more stringent – it makes it unlawful for any person to take, attempt to take, possess, transport, export, process, sell or offer for sale or ship nongame wildlife.

Georgia's Erosion and Sedimentation Control Act was passed in 1975 to protect Georgia's waters from soil erosion and sediment deposition. The Act requires an erosion, sedimentation, and pollution control plan for land-disturbing activities on sites >1 acre. The Act also mandates minimal stream buffer protection -- a 25-foot buffer between a permitted land-disturbing activity and a non-trout streams -- and a buffer variance may be obtained. The Tennessee Water Quality Control Act requires a 60-foot natural riparian buffer between a land-disturbing activity and a receiving stream designated as impaired or an Exceptional Tennessee waters. A 30-foot natural riparian buffer zone is required adjacent to all other streams.

Agriculture and forestry, the predominant land uses in the middle Conasauga basin, are fully or partially exempted from regulation under Georgia's Erosion and Sedimentation Control Act and the Tennessee Water Quality Control Act. The States address threats associated with agriculture and silviculture primarily through voluntary State BMPs. The Georgia Forestry Commission (GFC) and Tennessee Division of Forestry (TDF) are the lead agencies for statewide development, education, implementation and monitoring of forestry BMPs. A 2017 Statewide Forestry BMP Implementation and Compliance Survey

(GFC 2017) found correct BMP implementation was 92% (232 sites evaluated), and implementation of streamside management zone (SMZ) and stream crossing BMPs was 92.8% and 88.2%. The most common BMO deficiencies in the SMZs were insufficient widths, logging debris left in stream channels, poor water diversions/stabilization, and streambank tree harvesting. Deficiencies in stream crossing BMPs included stream crossing approach design, culvert sizing and installation, and the use of improper debris crossings and fill. Similarly, TDF conducted a survey in 2010 to determine how frequently forestry BMPs were implemented in the State (Sherrill et al. 2013). Over 200 harvest sites were visited between spring 2010 and the end of winter 2011 and evaluated for compliance with 53 individual BMPs. Implementation of BMPs to protect stream health was slightly lower than observed in Georgia, with an average of 78 and 88% of BMPs associated with SMZ and stream crossings installed correctly.

The degree of compliance with BMPs for agricultural activities has not been systematically measured in either state and represents a major regulatory inadequacy, particularly given the success of the forestry oversight programs.

e) Other natural or manmade factors affecting its continued existence: The Conasauga logperch is highly vulnerable to extinction due to stochastic or human-induced events, since it occurs only in small numbers in a short reach of a single river system. Stressors resulting from land use changes are likely to increase as the Cities of Atlanta and Chattanooga continue to expand northward and southward, respectively, into the Conasauga Basin. Climate change in the southeast is likely to impact aquatic systems by increasing water temperatures, decreasing dissolved oxygen levels, altering streamflow patterns, increasing demand for water storage and agricultural irrigation, and increasing toxicity of pollutants (Ficke 2007, Rahel and Olden 2007).

D. Synthesis: Given the low population numbers and limited range of the Conasauga logperch, a wide range of events, both stochastic and human-induced, alone or in combination, could cause species extinction. Localized drought, chemical spills, floods that significantly alter habitat, or other catastrophic events could affect all or part of the logperch's limited range. Long-term, chronic threats include sediment, nutrients, glyphosate-based herbicides and their surfactants, loss of riparian buffers and Podostemum, urbanization, and climate change. Our evaluation suggests the Conasauga logperch has low to very low resiliency and lacks redundancy, although genetic diversity (representation) was relatively high when evaluated in 2012. Based on this review, we believe the Conasauga logperch continues to meet the definition of an endangered species.

III. RESULTS

A. Recommended Classification: No change is needed.

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

A Conasauga Logperch Recovery Implementation Strategy (RIS) currently is under development and will include multiple action items that target habitat quality, such as:

- Implementing management actions and encouraging best management practices to improve water quality in the Conasauga River mainstem.
- Protecting key parcels via land acquisition, conservation agreements, and conservation easements in the basin.
- Promoting voluntary stewardship to reduce pollution and improve habitat.
- Working with local/county/state governments to develop and implement ordinances regulating stormwater management and earth-moving activities, establishing stormwater utility fee programs, and other actions to address urban stressors on aquatic systems.
- Conducting research to determine the species' demographics and threat sensitivity to aid recovery efforts for the Conasauga logperch.
- Increasing public awareness through outreach materials, festivals, planned snorkel and canoe/kayak trips, and other methods.
- Modifying State and local government policies and regulations to improve protection of the fish and its habitat and enhance enforcement of such policies and regulations.

When completed, the Conasauga Logperch RIS will be posted at the same site as the SSA: <https://ecos.fws.gov/ServCat>. A draft 2019 recovery plan is posted at: <https://ecos.fws.gov/ecp0/profile/speciesProfile?sId=8472>.

LITERATURE CITED

- Angermeier, P.L. 1995. Ecological attributes of extinction-prone species: loss of freshwater fishes of Virginia. *Conservation Biology* 9:143-158.
- Argentina, J.E., M.C. Freeman, and B.J. Freeman. 2010. The response of stream fish to local and reach-scale variation in the occurrence of a benthic aquatic macrophyte. *Freshw. Biol.* 55:643-653.
- Booth, D.B. 1991. Urbanization and the natural drainage system – impacts, solutions, and prognoses. *The Northwest Environmental Journal* 7:93-118.
- Bruton, M.N. 1985. The effect of suspensoids on fish. *Hydrobiologia* 125:221-241.
- Bumpers, P.M., and B.J. Freeman. 2017. Assessing causes of decline of aquatic species in the Conasauga River system. Report to the Georgia Department of Natural Resources, 2016-2017. Unpublished document in USFWS files, Athens, GA. 60 pp.
- Bumpers, P.M., J. Skaggs, and B.J. Freeman. 2019. Assessing the status and trends of fishes and water quality in the Etowah River. Final report to the Georgia Department of Natural Resources. Unpublished document in USFWS files, Athens, GA. 66 pp.
- Burkhead, N.M., and H.L. Jelks. 2001. Effects of suspended sediment on the reproductive success of the tricolor shiner, a crevice-spawning minnow. *Trans. Am. Fish. Soc.* 130:959-68
- Cavalcante, D.G.S.M., C.B.R. Martinez, and S.H. Sofia. 2008. Genotoxic effects of Roundup® on the fish *Prochilodus lineatus*. *Mutation Research-Genetic toxicology and Environmental Mutagenesis* 655:41-46
- Çavas T., and S. Könen. 2007. Detection of cytogenetic and DNA damage in peripheral erythrocytes of goldfish (*Carassius auratus*) exposed to a glyphosate formulation using the micronucleus test and the comet assay. *Mutagenesis* 22:263–268.
- Conservation Fisheries, Inc. 2004. Fish surveys of selected streams of the Chattahoochee National Forest with emphasis on imperiled species. Unpublished document in USFWS files, Athens, GA. 16 pp.
- Coyner, D. F., M.G. Spalding, and D.J. Forrester. 2003. Influence of treated sewage on infections of *Eustrongylides ingnotus* (Nematoda: Dioctophymatoidea) in eastern mosquitofish (*Gambusia holbrooki*) in an urban watershed. *Comparative Parasitology*, 70, 205–210.
- Davies-Colley, R.J., and D.G. Smith. 2001. Turbidity suspended sediment, and water clarity: a review. *J. American Water Resources Association* 37:1085-1101.
- Davis, D.A., E.B. Beaumont, and J.L. Wood. 2018. Investigating the decline of *Podostemum ceratophyllum* in West Virginia Rivers. *Proceedings of the West Virginia Academy of Science* Volume 90.
- Defarge, N., J. Spiroux de Vendômois, and G.E. Séralini. 2018. Toxicity of formulants and heavy metals in glyphosate-based herbicides and other pesticides. *Toxicology Reports* 5 (2018): 156–163.
- Diamond G.L., and P.R. Durkin. 1997. Effects of surfactants on the toxicity of glyphosate, with specific reference to Rodeo. Fayetteville, NY: Syracuse Environmental Research Associates.
<https://www.fs.fed.us/foresthealth/pesticide/pdfs/Surfactants.pdf>
- Etnier, D.A., and W.C. Starnes. 1993. *The fishes of Tennessee*. Univ. Tennessee Press, Knoxville. 681 pp.

- Fagan, W.F., and E.E. Holmes. 2006. Quantifying the extinction vortex. *Ecology Letters* 9:51-60.
- Ficke, A., C.A. Myrick, and L.J. Hansen. 2007. Potential impacts of global climate change on freshwater Fisheries. *Reviews in Fish Biology and Fisheries* (2007) 17:581-613.
- Finkenbine, J.K., J. W. Atwater, and D. S. Mavinic. 2000. Stream health after urbanization. *Journal of the American Water Resources Association* 36:1149-1160.
- Folmar L.C., H.O. Sanders, and A.M. Julian. 1979. Toxicity of the herbicide glyphosate and several of its formulations to fish and aquatic invertebrates. *Arch Environ Contam Toxicol* 8:269-278.
- Freeman, B.J. 1989. Life history studies on the amber darter (*Percina antesella*) and the Conasauga logperch (*Percina jenkinsi*) in the Conasauga River in Georgia and Tennessee. Annual report September 1989. Unpublished manuscript in the files of Georgia Ecological Services, Athens, GA. 20 pp.
- Freeman, B.J. 1990. Life history studies on the amber darter (*Percina antesella*) and the Conasauga logperch (*Percina jenkinsi*) in the Conasauga River in Georgia and Tennessee. Summary Report October 1990. Unpublished manuscript in the files of Georgia Ecological Services, Athens, GA. 18 pp.
- Freeman, B.J. 1995. Surrogate spawning studies on the amber darter (*Percina antesella*). Unpublished document in USFWS files, Athens, GA. 16 p.
- Freeman, B.J. 1999. Identification and mapping of critical habitats in the Conasauga River corridor of Georgia and Tennessee. Annual Report Fall 1999. Unpublished manuscript in the files of Georgia Ecological Services, Athens, GA. 39 pp.
- Freeman, B.J., and S. Wenger. 2001. Identification and mapping of critical habitats in the Conasauga River corridor of Georgia and Tennessee. 2000 Annual Report. Unpublished manuscript in USFWS files, Athens, GA. 47 pp.
- Freeman, B. J., M.M. Hagler, S. J. Wenger, G. B. Anderson, and R. A. Katz. 2007. Identification and mapping of critical habitats in the Conasauga River corridor of Georgia and Tennessee. 2006 Annual report to the Georgia Department of Natural Resources, Atlanta. Unpublished manuscript in USFWS files, Athens, GA. 69 pp.
- Freeman, B. J., M.M. Hagler, S. J. Wenger, G. B. Anderson, and R. A. Katz. 2008. Identification and mapping of critical habitats in the Conasauga River corridor of Georgia and Tennessee. 2007 Annual report to the Georgia Department of Natural Resources, Atlanta. Unpublished manuscript in USFWS files, Athens, GA. 69 pp.
- Freeman, B. J., G. B. Anderson, M.M. Hagler, and N.A. Pontzer. 2009. Identification and mapping of critical habitats in the Conasauga River corridor of Georgia and Tennessee. 2008 Annual report to the Georgia Department of Natural Resources, Atlanta. Unpublished manuscript in USFWS files, Athens, GA. 45 pp.
- Freeman, B.J., M.M. Hagler, and P.M. Bumpers. 2015. Assessing causes of decline of aquatic species in the Conasauga River system. Report to the Georgia Department of Natural Resources, 2013-2014 Summary Report. Unpublished manuscript in USFWS files, Athens, GA. 59 pp.
- Freeman, M.C., M.M. Hagler, P.M. Bumpers, K. Wheeler, S.J. Wenger, and B.J. Freeman. 2017. Long term monitoring data provide evidence of declining species richness in a river valued for biodiversity conservation. *Journal of Fish and Wildlife Management* 8:418-434.

- Freeman, M.C., and B.J. Freeman. 2019. Evidence of spatial and temporal changes in benthic habitat conditions in the Conasauga River mainstem. Proceedings of the Georgia Water Resources Conference, Athens, GA.
- George, A.L., D.A. Neely, and R.L. Mayden. 2010. Comparative conservation genetics of two endangered darters, *Percina rex* and *Percina jenkinsi*. Proc. SE Fishes Council 52:1-12.
- Georgia Forestry Commission. 2017. Results of Georgia's 2017 silvicultural best management practices implementation and compliance survey. <http://www.gfc.state.ga.us/forest-management/water-quality/bmps/BMP%20Survey%202017%20Results%20Report%20Final%20Corrected%20by%20Scott%20Jan112018%20410pm.pdf>. Accessed December 2018.
- Gilpin, M.E., and M.E. Soule. 1986. Minimum viable populations: process of species extinctions. Pages 19-34 in M. E. Soulé, ed. Conservation biology: the science of scarcity and diversity. Sinauer Associates, Inc., Sunderland, Massachusetts.
- Golder Associates, Inc. 2002. Evaluation of the biological community in the Conasauga River from 1995 to 2001. Final Report June 2002. Unpublished manuscript in the files of Georgia Ecological Services, Athens, GA. 126 pp.
- Golder Associates, Inc. 2008. Comprehensive report. Assessment of potential impacts on protected fish and mussel species from River Road Reservoir releases. 1995-2006. Final Report Feb. 2008. Unpublished manuscript in the files of Georgia Ecological Services, Athens, GA.
- Golder Associates, Inc. 2010. Comprehensive report: assessment of potential impacts on protected fish and mussel species from River Road Reservoir releases 1995-2009. Unpublished document in Georgia Field Office, US Fish and Wildlife Service, files. Athens, GA.
- Griffen, B.D., and J.M. Drake. 2008. Effects of habitat quality and size on extinction in experimental populations. Proc R Soc B Biol 275:2251–2256.
- Grisolia, C. 2002. A comparison between mouse and fish micronucleus test using cyclophosphamide, mitomycin C and various pesticides. Mutat Res 518:145–150.
- Grubaugh, J.W. and J.B. Wallace. 1995. Functional structure and production of the benthic community in a Piedmont river: 1956-1957 and 1991-1992. Limnology and Oceanography 40:490-501.
- Guilherme, S., M.A. Santos, and C. Barroso. 2012. Differential genotoxicity of Roundup® formulation and its constituents in blood cells of fish (*Anguilla anguilla*): considerations on chemical interactions and DNA damaging mechanisms. Ecotoxicology 21: 1381.
- Hagler, M.M., M.C. Freeman, S.J. Wenger, B.J. Freeman, P.L. Rakes, and J.R. Shute. 2011. Use of recent and historical records to estimate status and trends of a rare and imperiled stream fish, *Percina jenkinsi* (Percidae). Can. J. Fish. Aquat. Sci. 68:739-748.
- Hagler, M.M., and B.J. Freeman. 2012. Assessing causes of decline of aquatic species in the Conasauga River system. 2011-2012 Summary Report Unpublished report submitted to the Georgia Department of Natural Resources.
- Hamlin, H. J., C.B. Moore, T.M. Edwards, I.L.V. Larkin, A. Boggs, W.J. High, K.L. Main, and L.J. Guillette, Jr. 2008. Nitrate-induced elevations in circulating sex steroid concentrations in female Siberian sturgeon (*Acipenser baeri*) in commercial aquaculture. Aquaculture, 281, 118–125.

- Hilderbrand, R.H. 2003. The roles of carrying capacity, immigration, and population synchrony on persistence of stream-resident cutthroat trout. *Biological Conservation* 110:257-266.
- Integrated Taxonomic Information System. 2018. ITIS Standard Report Page: *Percina antesella*. <http://www.itis.gov> (Accessed August 15, 2018).
- Ingram, I., K. Dow, L. Carter, and J. Anderson, eds. 2013. *Climate of the Southeast United States: variability, change, impacts, and vulnerability*. Washington, DC. Island Press.
- Jiraungkoorskul, W., E. S. Upatham, M. Kruatrachue, S. Sahaphong, S. Vichasri-Grams, and P. Pokethitiyook. 2003. Biochemical and histopathological effects of glyphosate herbicide on Nile tilapia (*Oreochromis niloticus*). *Environmental Toxicology* 18:260-267.
- Johnston, C.E., and K.B. Damon. 1996. Long-term monitoring of rare fishes in the Conasauga River, Georgia and Tennessee. Interim Report December 1996. Unpublished manuscript in the files of Georgia Ecological Services, Athens, GA. 20 pp.
- Jones, E.B.D, III, G.S. Helfman, J.O. Harper, and P.V. Bolstad. 1999. Effects of riparian forest removal on fish assemblages in Southern Appalachian streams. *Conservation Biology* 13:1454-1465.
- Kishore, G.M., and G.S. Jacob. 1987. Degradation of glyphosate by *Pseudomonas* sp. PG1982. *The Journal of Biological Chemistry* 262:12164-12168.
- Klein, R. D. 1979. Urbanization and stream quality impairment. *Water Resources Bulletin* 15: 948-963.
- Langiano, V.C., and C.B. Martinez. 2008. Toxicity and effects of a glyphosate-based herbicide on the Neotropical fish, *Prochilodus lineatus*. *Comp. Biochem. Physiol. C. Toxicol. Pharmacol.* 147:222-231.
- Lasier, P.J., M.L. Urich, S.M. Hassan, W.N. Jacobs, R.B. Bringolf, and K.M. Owens. 2016. Changing agricultural practices: potential consequences to aquatic organisms. *Environmental Monitoring and Assessment* 188:672.
- Lehtiniemi, M. et al. 2005. Turbidity decreases anti-predator behaviour in pike larvae., *Esox Lucius*. *Environmental Biology of Fishes* 73:1-8.
- Mettee, M.F., P.E. O'Neil, and J. M. Pierson. 1996. *Fishes of Alabama*. Oxmoor House, Birmingham. 819 pp.
- Modesto, K.A., and C.B.R. Martinez. 2009. Roundup® causes oxidative stress in liver and inhibits acetylcholinesterase in muscle and brain of the fish *Prochilodus lineatus*. *Chemosphere* 78:294-299.
- Moyer, G.R.; A.L. George, P.L. Rakes, J.R. Shute, and A.S. Williams. 2015. Assessment of genetic diversity and hybridization for the endangered Conasauga logperch (*Percina jenkinsi*). *Southeastern Fishes Council Proceedings*: No. 55.
- Mulholland, et al. 1997. Effects of climate change on freshwater ecosystems of the Southeastern United States and the Gulf Coast of Mexico. *Hydrological Processes* 11:949-970.
- Moyle, P.B., and J.E. Williams. 1990. Biodiversity loss in the temperate zone: decline of the native fish fauna of California. *Conservation Biology* 4:275-284.
- National Academy of Science. 2000. *Clean Coastal Waters: Understanding and reducing the effects of nutrient pollution*. Chapter 4. What are the effects of nutrient over-enrichment? National Academies Press.

- Newcombe, C.P., and J.O.T. Jensen. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. *North American Journal of Fisheries Management* 16:693-727.
- Newcombe, C. P., and D. D. MacDonald. 1991. Effects of suspended sediments on aquatic ecosystems. *Canadian Journal of Fisheries Management* 11:72-82.
- Osborne, L.L., and D.A. Kovacic. 1993. Riparian vegetated buffer strips in water-quality restoration and stream management. *Freshwater Biology* 29:243-258.
- Paul, M. J., and J. L. Meyer. 2001. Streams in the urban landscape. *Annual Review of Ecology, Evolution and Systematics* 32: 333-365.
- Petty, M.A., P.L. Rakes, and J.R. Shute. 2011. Preventing extinction of the endangered Conasauga logperch, *Percina jenkinsi*: the role of mate selection in successful captive propagation of this rare species. Third Interim Report. Unpublished manuscript in the files of Georgia Ecological Services, Athens, GA. 6 pp.
- Petty, M.A., P.L. Rakes, C. Ruble, and J.R. Shute. 2013. Preventing extinction of the endangered Conasauga logperch, *Percina jenkinsi*: 2012 surveys, releases, and monitoring. Fourth Interim Report. Unpublished manuscript in the files of Georgia Ecological Services, Athens, GA. 76 pp.
- Petty, M.A., P.L. Rakes, C.L. Ruble, and J.R. Shute. 2015. Preventing extinction of the endangered Conasauga logperch, *Percina jenkinsi*: 2013 and 2014 post-release surveys and monitoring. Final report to U.S. Fish and Wildlife Service. Unpublished manuscript in the files of Georgia Ecological Services, Athens, GA. 10 pp.
- Petty, M.A., P.L. Rakes, J.R. Shute, and C.L. Ruble. 2014. Captive propagation and population monitoring of rare southeastern fishes in Tennessee: 2013. Final Report. Unpublished manuscript in the files of Georgia Ecological Services, Athens, GA.
- Pierson, S.T., M.L. Cabrera, G.K. Evanylo, H.A. Kuykendall, C.S. Hoveland, M.A. McCann, and L.T. West. 2001. Phosphorus and ammonium concentrations in surface runoff from grasslands fertilized with broiler litter. *Journal of Environmental Quality* 30:1784-1789.
- Pugsley, C. W., and H.B.N. Hynes. 1983: A modified freeze-core technique to quantify the depth distribution of fauna in stony streambeds. *Canadian Journal of Fisheries and Aquatic Sciences* 40: 637-643.
- Purvis, A., J.L. Gittleman, G. Cowlishaw, and G. Mace. 2000. Predicting extinction risk in declining species. *Proc.R. Soc. Lond. B Biol. Sci.* 267:1947-1952.
- Pusey, B.J., and A.H. Arthington. 2003. The importance of the riparian zone to the conservation and management of freshwater fish. A review. *Marine and Freshwater Research* 54:1-16.
- Rahel, F.J., and J.D. Olden. 2007. Assessing the effects of climate change on aquatic invasive species. *Conservation Biology* 22:521-533.
- Rakes, P.L., and J.R. Shute. 2005. Propagation of the endangered Etowah darter, *Etheostoma etowahae*, and the endangered Conasauga logperch, *Percina jenkinsi*. Final Report August 2005. Unpublished manuscript in the files of Georgia Ecological Services, Athens, GA. 13 pp.
- Rakes, P.L., and J.R. Shute. 2006. Population monitoring of rare southeastern fishes in the Conasauga River and Hiwassee River Drainage: 2005. Final Report for 2005 field season. Unpublished manuscript in the files of Georgia Ecological Services, Athens, GA. 13 pp.

- Rakes, P.L., M.A. Petty, and J.R. Shute. 2015. Fish surveys of selected streams of the Chattahoochee National Forest to monitor imperiled fish species: 1999-2015. Final Report. Unpublished manuscript in the files of Georgia Ecological Services, Athens, GA. 17 pp.
- Rosemond, A. D., J.P. Benstead, P.M. Bumpers, V. Gulis, J.S. Kominoski, D.W.P. Manning, K. Suberkropp, and J.B. Wallace. 2015. Experimental nutrient additions accelerate terrestrial carbon loss from stream ecosystems. *Science*, 347, 1142–1145.
- Rosenberger, A., and P.L. Angermeier. 2003. Orogenetic shifts in habitat use by the endangered Roanoke logperch (*Percina rex*). *Freshwater Biology* 48:1563-1577.
- Roy, A. H., C.L. Faust, M.C. Freeman, and J.L. Meyer. 2005. Reach-scale effects of riparian forest cover on urban stream ecosystems. *Canadian Journal of Fisheries and Aquatic Sciences* , 62, 2312-2329.
- Ryan, P.A., 1991. Environmental effects of sediment on New Zealand streams: a review, *New Zealand Journal of Marine and Freshwater Research*, 25:207-221.
- Schlosser, I.J., and J.R. Karr. 1981. Water quality in agricultural watersheds: impact of riparian vegetation during base flow. *Water Resources Bulletin* 17:233-240.
- Schoener, T.W., and A. Schoener. 1983. The time to extinction of a colonizing propagule of lizards increases with island size. *Nature* 302:332-334.
- Sharpley, A. 1999. Agricultural phosphorus, water quality, and poultry production: are they compatible? *Environment and Health Symposium: Reducing the Environmental Impact of Poultry Production: Focus on Phosphorus. Poultry Science* 78:660–673
- Sharpley, A.N., R.W. McDowell, and P.J.A. Kleinman. 2004. Amounts, forms, and solubility of phosphorus in soils receiving manure. *Soil Sci. Soc. Am. J.* 68:2048–2057.
- Sherrill, M. J. Kirksey, and W. Clatterbuck. 2013. Implementation of forestry best management practices in Tennessee. Results from the 2010 forestry BMP implementation survey. Accessed December 2018. <https://www.tn.gov/content/dam/tn/agriculture/documents/forestry/AgForBMPimpl2013.pdf>
- Smith, D.R., Allan, N. L., McGowan, C. P., Szymanski, J. A., Oetker, S. R., and Bell, H. M. 2018. Development of a Species Status Assessment Process for Decision under the U.S. Endangered Species Act. *Journal of Fish and Wildlife Management*. Volume 9 (1): 1-19.
- Schlosser, I.J., and J.R. Karr. 1981. Water quality in agricultural watersheds: impact of riparian vegetation during base flow. *Water Resources Bulletin* 17:233-240.
- Schoener, T.W., and A. Schoener. 1983. The time to extinction of a colonizing propagule of lizards increases with island size. *Nature* 302:332-334.
- Sharpley, A. 1999. Agricultural phosphorus, water quality, and poultry production: are they compatible? *Environment and Health Symposium: Reducing the Environmental Impact of Poultry Production: Focus on Phosphorus. Poultry Science* 78:660–673
- Sharpley, A.N., R.W. McDowell, and P.J.A. Kleinman. 2004. Amounts, forms, and solubility of phosphorus in soils receiving manure. *Soil Sci. Soc. Am. J.* 68:2048–2057.
- Soso, A. B., L. J. G. Barcellos, M. J. Ranzani-Paiva, L. C. Kreutz, R. M. Quevedo, D. Anziliero, M. Lima, L. B. da Silva, F. Ritter, A. C. Bedin, and J. A. Finco. 2007. Chronic exposure to sub-lethal concentration of

- a glyphosate-based herbicide alters hormone profiles and affects reproduction of female Jundia (*Rhamdia quelen*). *Environmental Toxicology and Pharmacology* 23:308-313.
- Thompson, B.A. 1985. *Percina jenkinsi*, a new species of logperch (Pisces, Percidae) from the Conasauga River, Tennessee and Georgia. *Occ. Pap. Mus. Zool. LSU* 61:1-23.
- Tsui, M.T.K., and L.M. Chu. 2003. Aquatic toxicity of glyphosate-based formulations: comparison between different organisms and the effects of environmental factors. *Chemosphere* 52:1189–1197.
- U.S. Fish and Wildlife Service. 2019. Species status assessment report for Conasauga logperch (*Percina jenkinsi*). South Atlantic-Gulf Region, Georgia Ecological Services, Athens, GA.
- Vera, M.S., L. Lagomarsino, M. Sylvester, G.L. Pérez, P. Rodríguez, H. Mugni, R. Sinistro, M. Ferraro, C. Bonetto, H. Zagarese, and H. Pizarro. 2010. New evidences of Roundup® (glyphosate formulation) impact on the periphyton community and the water quality of freshwater ecosystems. *Ecotoxicology* 19:10-21.
- Wallace, J. B., S.L. Eggert, J.L. Meyer, and J.R. Webster. 1997. Multiple trophic levels of a forest stream linked to terrestrial litter inputs. *Science*, 277, 102–104.
- Walters, D.M., D.S. Leigh, and A.B. Bearden. 2003. Urbanization, sedimentation, and the homogenization of fish assemblages in the Etowah River Basin, USA. *Hydrobiologia* 494:5–10.
- Walters, D. M., M.C. Freeman, D.S., Leigh, B.J., Freeman, and C.M. Pringle. 2005. Urbanization effects on fishes and habitat quality in a southern Piedmont river basin. *Am. Fisheries Society Symposium* 18 pp.
- Wang, L.Z., J. Lyons, and P. Kanehl. 2001. Impacts of urbanization on stream habitat and fish across multiple spatial scales. *Environmental Management* 28: 255-266.
- Wang, L. Z., J. Lyons, P. Kanehl, R. Bannerman, and E. Emmons. 2000. Watershed urbanization and changes in fish communities in Southeastern Wisconsin streams. *Journal of American Water Resources Association*, 36, 1173-1189.
- Wenger, S.J., A.H. Roy, C.R. Jackson, E.S. Benhardt, T.L. Carter, S. Filoso, C.A. Gibson, W.C. Hession, S.S. Kaushal, E. Marti, J.L. Meyer, M.A. Palmer, M.J. Paul, A.H. Purcell, A. Ramirez, A.d. Rosemond, K.S. Schofield, E.B. Sudduth, and C.J. Walsh. 2009. Twentysix key research questions in urban stream ecology: an assessment of the state of the science. *Journal of the North American Benthological Society* 28:1080–1098.
- White, R.S.A, B.A. Wintle, P.A. McHugh, D.J. Booker, and A.R. McIntosh. 2017. The scaling of population persistence with carrying capacity does not asymptote in populations of a fish experiencing extreme climate variability. *Proceedings of the Royal Society B: Biological Sciences* 284.
- Wood, P. and P. Armitage. 1997. Biological effects of fine sediment in the lotic environment. *Environmental Management* 21:203-217.
- Wood, J., and M. Freeman. 2017. Ecology of the macrophyte *Podostemum ceratophyllum* Michx. (Hornleaf riverweed), a widespread foundation species of eastern North American rivers. *Aquatic Botany* 139:65-74.

U.S. FISH AND WILDLIFE SERVICE

5-YEAR REVIEW OF CONASAUGA LOGPERCH (*PERCINA JENKINSI THOMPSON 1985*)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review

Downlist to Threatened

Uplist to Endangered

Delist

No change is needed

Appropriate Listing/Reclassification Priority Number, if applicable: NA

Review Conducted By Robin B. Goodloe, Ph.D.
Supervisory Fish and Wildlife Biologist
Georgia Ecological Services

FIELD OFFICE APPROVAL:

Approve



Donald W. Imm, Ph.D. Field Supervisor
Georgia Ecological Services

Date

3 Dec 2019

APPENDIX A: Summary of public comments and peer review for the 5-year review of the Conasauga logperch (*Percina jenkinsi*)

- A. **Public Comments Received:** We received two public comments – one from a private citizen and one from The Sierra Club. The private citizen encouraged us to continue to protect this fish at the highest level. This 5-year review evaluation process is one tool for us to ensure protection is at the appropriate level for listed species. The Sierra Club indicated threats to this fish have not significantly changed and noted that they would be opposed to any status change, but did not provide support data.
- B. **Peer Review Method:** Warren Stiles, FWS Tennessee Field Office, reviewed a draft of this document. We also requested review of the 5-year review from personnel at the GDNR, USGS, University of Georgia Museum of Natural History, and CFI. Comments were received from Dr. Mary Freeman, USGS, and Patrick Rakes, CFI.
- C. **Peer Review Charge:** Reviewers were charged with providing a review of the document including any other comments and/or additions appropriate to include. Reviewers were not asked to comment on the legal status of the species.
- D. **Summary of Peer Review Comments/Report:** Mr. Rakes provided information elaborating on Conservation Fisheries, Inc., 2011 Conasauga logperch captive propagation efforts. Dr. Freeman and Mr. Stiles both corrected a few nomenclature errors and made several suggestions to clarify information about the species' life history and stressors.
- E. **Response to Peer Review:** We evaluated comments received and incorporated them as appropriate.