Chipola Slabshell
(*Elliptio chipolaensis*)
Species Status Assessment
Version 1.0

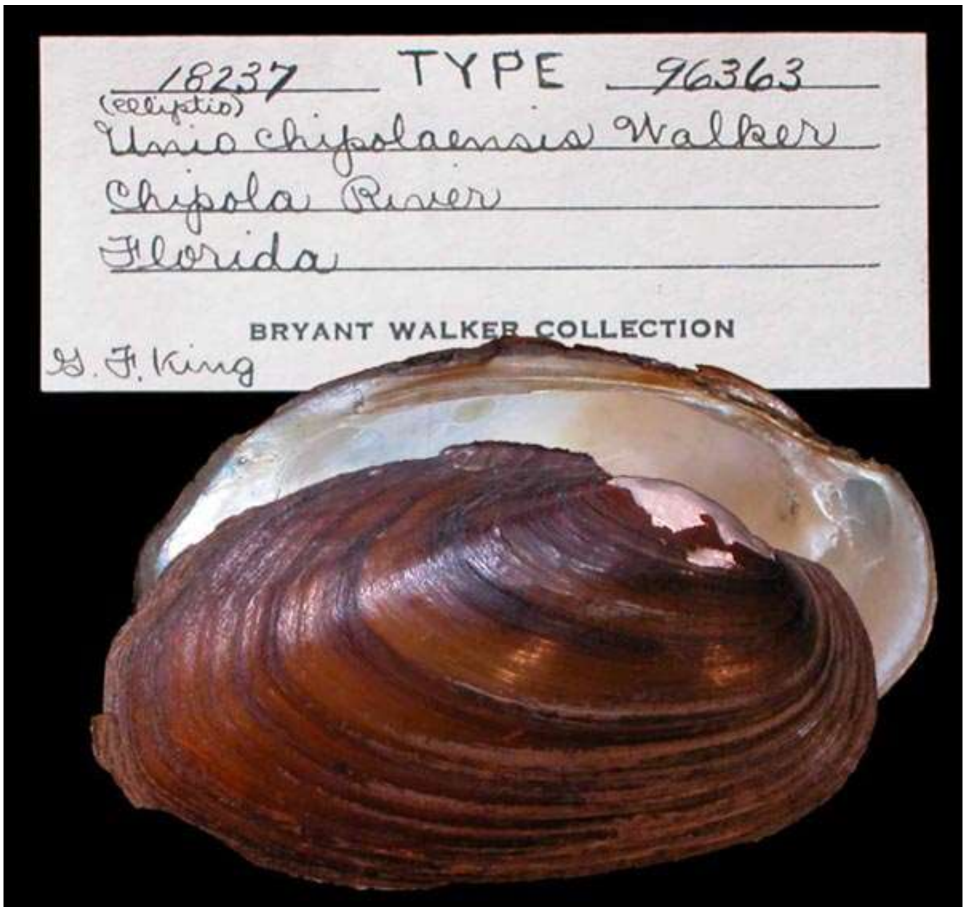

Photo: UMMZ, The Mussel Project

07-07-2020
U.S. Fish and Wildlife Service
South Atlantic- Gulf Region
Atlanta, GA

ACKNOWLEDGEMENTS

This document was prepared by Channing St. Aubin (USFWS – Panama City, FL Field Office) and Lindsay Dombrosie (Texas A&M Natural Resources Institute), with assistance from Dr. Sean Blomquist (USFWS – Panama City, FL Field Office), Maureen Walsh (USFWS – Panama City, FL Field Office), Michael Marshall (Texas A&M Natural Resources Institute), and Jenn Khan (Texas A&M Natural Resources Institute). SARP provided data. We would also like to recognize and thank the following individuals who served on the expert team for this SSA and provided substantive information and/or insights and valuable input into the analysis: Dr. Nate Johnson (US Geological Survey), Dr. Mike Gangloff (Appalachian State University), and Evan Collins (US Fish and Wildlife Service, Daphne, AL - Field Office. Valuable peer reviews of a draft of this document were provided by Susan Greda (Florida Fish and Wildlife Commission), Heather Bulger (US Army Corp of Engineers), and Dr. Jessica Graham (Southeast Aquatic Resource Partnership). We appreciate the time and effort of those dedicated to learning and implementing the SSA Framework, which resulted in a more robust assessment and final report.

Suggested reference:

U.S. Fish and Wildlife Service. 2020. Species Status Assessment Report for the Chipola slabshell (*Elliptio chipolaensis*). Version 1.0. July 2020. Atlanta, GA.

VERSION UPDATES

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EXECUTIVE SUMMARY

This species status assessment (SSA) reports the results of the comprehensive status review for the Chipola slabshell (*Elliptio chipolaensis* (Walker 1905)), documenting the species' historical condition and providing estimates of current and future condition under a range of different scenarios. The Chipola slabshell is a narrow ranging freshwater mussel species endemic to the Chipola River system in Alabama and Florida. The species generally occurs in large creeks and rivers, in slow to moderate current, and in silty sand substrates.

The SSA process can be categorized into three sequential stages. During the first stage, we used the conservation biology principles of resiliency, redundancy, and representation (together, the 3Rs) to evaluate individual mussel life history needs. The 3Rs are described further, below. The next stage involved an assessment of the historical and current condition of species' demographics and habitat characteristics, including an explanation of how the species arrived at its current condition. The final stage of the SSA involved making predictions about the species' responses to positive and negative environmental and anthropogenic influences. This process used the best available information to characterize viability as the ability of a species to sustain populations in the wild over time.

To evaluate the current and future viability of the Chipola slabshell, we assessed a range of conditions to allow us to consider the species' resiliency, representation, and redundancy. For the purposes of this assessment, populations were delineated using Management Units (MUs). MUs were defined as HUC10 watersheds that were identified as most appropriate scale for assessing population-level resiliency.

Resiliency, assessed at the population level, describes the ability of a population to withstand stochastic disturbance events. A species needs multiple resilient populations distributed across its range to persist into the future and avoid extinction. A number of factors, including (but not limited to) water quality, water quantity, and instream substrate may influence whether Chipola slabshell populations will occupy available habitat. As we considered the future viability of the species, more populations with high resiliency distributed across the known range of the species can be associated with higher species viability. Overall, the Chipola slabshell has moderate resiliency, with MU condition increasing from north to south within the species range.

Redundancy describes the ability of the species to withstand catastrophic disturbance events; for Chipola slabshell, we considered whether the distribution of resilient MUs within populations was sufficient for minimizing the potential loss of the species from such an event. Chipola slabshell historically ranged from the headwaters of the Chipola River in Florida to the Dead Lake Dam in the Lower Chipola River, and its distribution has extended beyond the historic range over the last twenty years into headwater areas and past a historical impoundment into a previously undocumented river basin (Figure EX1).

Representation characterizes a species' adaptive potential by assessing geographic, genetic, ecological, and niche variability. Chipola slabshell has exhibited historical variability in the size and range of the river system it inhabited. The species has been documented from small streams to rivers. This varioation has been maintained and is reflected in the designation of MUs for the species. However, the designation of formal representative units was not supported at this time.

Together, the 3Rs comprise the key characteristics that contribute to a species' ability to sustain populations in the wild over time (i.e., viability). Using the principles of resiliency, redundancy, and representation, we characterized both the species' current viability and forecasted its future viability over a range of plausible future scenarios. To this end, we ranked the condition of each MU by assessing the relative condition of occupied watersheds using the best available scientific information.

We assessed resiliency using the following population and habitat factors: occupancy (proportion of occupied HUC 12 subwatersheds within a HUC 10 watershed), abundance (including evidence of reproduction/recruitment) sedimentation index, and riparian canopy cover. Each watershed was rated as currently being in poor, fair, good or excellent condition for each of the resiliency factors. The conditions of each of these factors were combined to classify the resiliency of watersheds as very low, low, moderate or high. MUs with high and moderate resiliency were considered to exhibit resiliency, with low and very low resiliency scores not considered to exhibit resiliency. A count of watersheds exhibiting resiliency within and among MUs was used to assess redundancy. There are currently two MUs with resiliency, with an apparent north-south gradient in degree of resiliency (Figure EX2). The MUs meet the maximum species-level redundancy possible, although the resiliency of MU 3 is low and could be improved through further restoration activities to minimize sedimentation and maximize canopy cover.

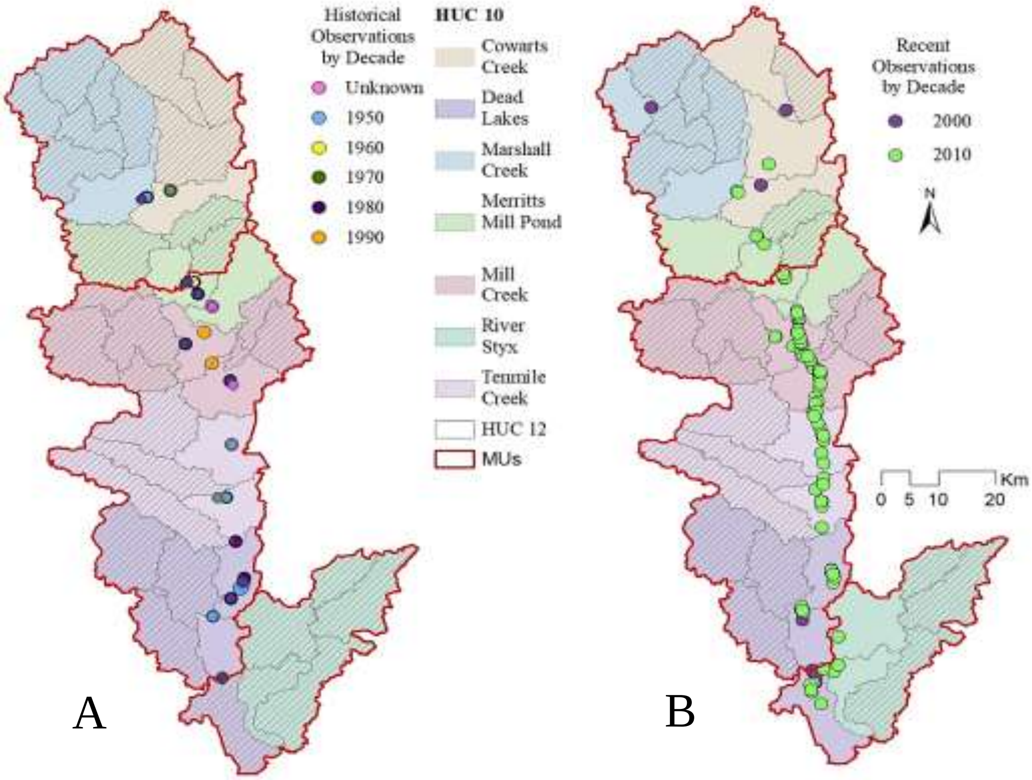

Figure EX1. Historical (A) and current (B) distribution of the Chipola slabshell. HUC 10 watersheds are included to highlight distribution patterns, with hatched HUC 12 subwatersheds indicating presumably unoccupied areas within each HUC 10 watershed. The three management units (MUs 1- 3; south to north) are outlined in red.

We assessed the future condition of Chipola slabshell under three plausible future scenarios. The scenarios incorporated a range of conditions associated with climate and land use change, including a Lower Range, Moderate, and Higher Range Scenario. We incorporated the best available information on management plans and conservation projects, while also analyzing spatially-explicit models of future land use and climate change (e.g., SRES/RCP models) as indicators of associated water quality conditions. Conservation actions were maintained at current levels. These three scenarios projected slabshell viability over 20 and 40-years representing approximately two generations for each period.

In the Lower Range Scenario, we project no change in MU resiliency and redundancy compared to the current condition. MUs 1 and 2 would retain resiliency (ranked high or moderate), and MU 3 lacks resiliency (ranked low). For this scenario, the Chipola slabshell population is expected to persist in much the same condition as it is found currently.

In the Moderate Range Scenario, a loss of resiliency and redundancy is expected. MUs 1 and 2 exhibit resiliency, but MU 3 will likely become extirpated given its resiliency (very low). Redundancy would be reduced to three watersheds and likely extirpation in two of eight currently extant watersheds. Only MU 2 retains more than one watershed with resiliency, and MU 3 retains only one occupied watershed (Merritts Mill Pond North) with low resiliency.

In the Higher Range Scenario, we anticipate impacts to resiliency in all management units. MU 1 exhibits moderate resiliency with a reduced capacity to mitigate stochastic events. MU 2 and 3 do not exhibit resiliency (low and very low, respectively), with MU 3 likely extirpated. MU 2 retains resiliency in the center of the Chipola slabshell range within the Mill Creek and Tenmile Creek watersheds, with sparse to no observable presence in the Merritts Mill Pond South and Dead Lake watersheds. Redundancy would be reduced to three watersheds with resiliency and likely extirpation in three of eight currently extant watersheds. Only MU 2 retains more than one watershed exhibiting resiliency, and MU 3 retains only one occupied watershed (Merritts Mill Pond North) with low resiliency.

The northern portion of the species range comprising the Chipola River headwaters was the most susceptible to change through time, but the linear distribution of the species within the mainstem also leaves the species vulnerable to catastrophic events. However, a catastrophic spill (fuel, chemical, etc.) from either a train derailment or tanker truck on I-10 or Hwy 20 crossing the Chipola River should not result in extirpation of the species. Estimates of current and future resiliency and redundancy for Chipola slabshell are generally good, and the species is estimated to persist in its single representative unit. If the Chipola River Basin provides adequate fresh water, suitable water quality and habitat, we anticipate the Chipola slabshell will survive and thrive in abundance (Figure EX2).

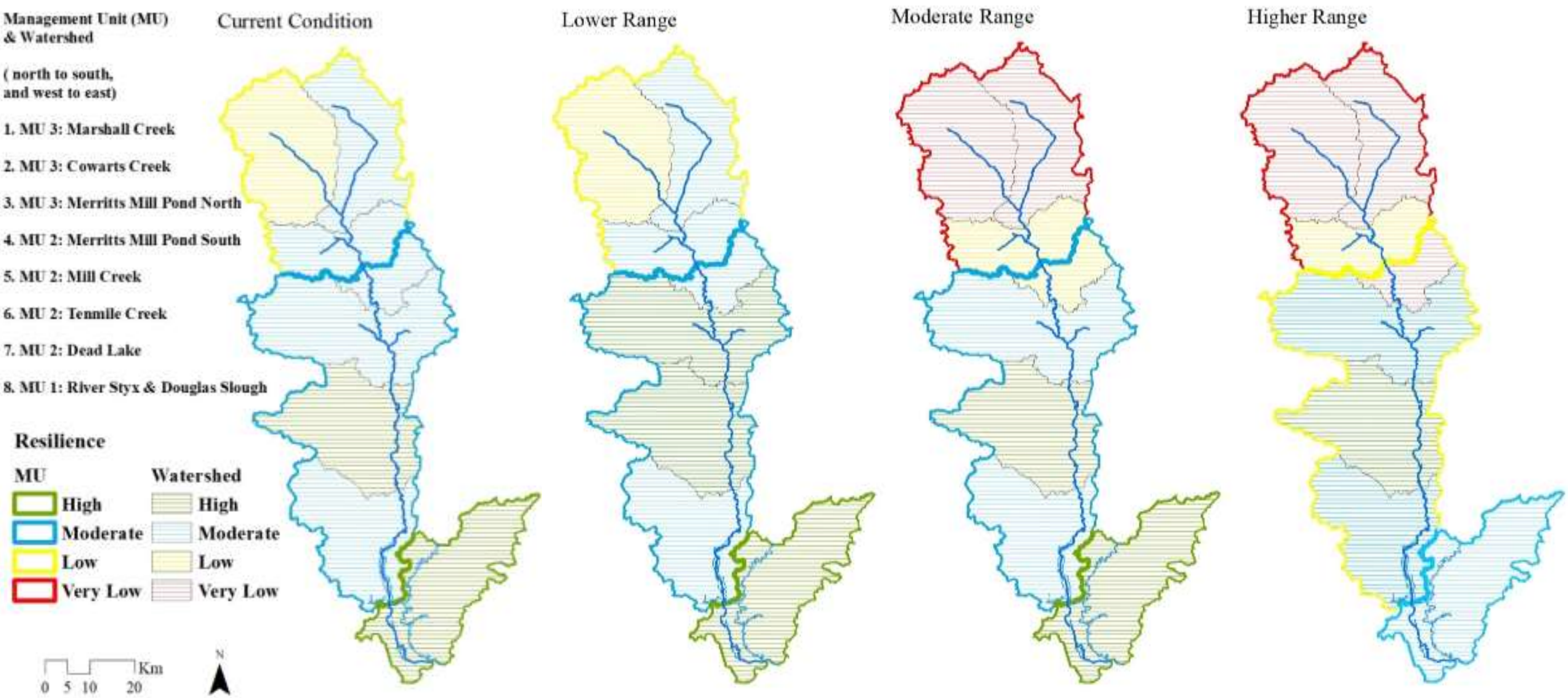

Figure EX2. Current and future condition for Chipola slabshell. Future condition is depicted as three scenarios (Lower, Moderate, and Higher Range) based on climate and land use change and the potential effects on Chipola slabshell viability 40 years from the current condition. Resiliency is denoted for each of the three Management Units (MUs), and the HUC 10 watersheds that comprise them. Occupied MUs are identified as having very low (i.e., no survival or survival uncertain; no longer observable), low, moderate, or high resiliency condition.

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INTRODUCTION

The SSA framework (U.S. Fish and Wildlife Service (USFWS), 2016, p. entire) is intended to be an in-depth review of the species' biology and threats, an evaluation of its biological status, and an assessment of the resources and conditions needed to maintain long-term viability. The intent is for the SSA to be easily updated as new information becomes available and to support all functions of the Ecological Services Program of the U.S. Fish and Wildlife Service (hereafter referred to as Service), from Candidate Assessment to Listing to Consultations to Recovery. This SSA will be a living document that may be used to inform ESA decision making, such as listing, recovery, Section 7, Section 10, and reclassification decisions.

The Chipola slabshell (*Elliptio chipolaensis*) is a narrow ranging freshwater mussel species endemic to the Chipola River system (Alabama and Florida). The species generally occurs in large creeks and rivers, in slow to moderate current, and in silty sand substrates. In 1989, the Chipola slabshell was among seven freshwater mussels in the Apalachicola-Chattahoochee-Flint (ACF) Rivers considered as potential candidates for listing under Endangered Species Act (ESA) protections. The Chipola slabshell was listed as federally threatened on Monday March 16th, 1998 (63 FR 12664) due to destruction or modification of habitat and the associated land use impacts on water quality. The Service completed the first recovery plan for the Chipola slabshell in 2003. In 2007, Critical Habitat was designated for the species (72 FR 64286).

We have developed this SSA Report to summarize the most relevant information regarding life history, biology, and considerations of current and future risk factors facing the Chipola slabshell. In addition, we forecast the possible response of the species to various future risk factors and environmental conditions to formulate a complete risk profile for the Chipola slabshell. The objective of this SSA is to thoroughly describe the viability of the Chipola slabshell based on the best scientific and commercial information available. Through this description, we determined what the species needs to support viable populations, its current condition in terms of those needs, and its forecasted future condition under plausible future scenarios. In conducting this analysis, we considered conditions in the past, current, and future, as well as the likely changes that are happening in the environment, to help us understand what factors are driving the viability of the species.

For the purpose of this assessment, we define viability as the ability of a species to sustain populations in the wild beyond a biologically meaningful time frame. Viability is not a specific state, but rather a continuous measure of the likelihood that the species will sustain populations over time (U.S. Fish and Wildlife Service (USFWS), 2016, p. 9). Using the SSA framework (Figure 0-1), we consider what the species needs to maintain viability by characterizing the status of the species in terms of its resiliency, representation, and redundancy (the 3 Rs; Wolf et al. 2015, entire; Smith et al. 2018, entire).

- Resiliency describes the ability of a population to withstand stochastic disturbance; resiliency is positively related to population size and growth rate and may be influenced by connectivity among populations.

- Redundancy describes the ability of a species to withstand catastrophic events by spreading risk among multiple populations or across a large area.

- Representation describes the ability of the species to adapt to changing environmental conditions over time characterized by the breadth of genetic and environmental diversity within and among populations.

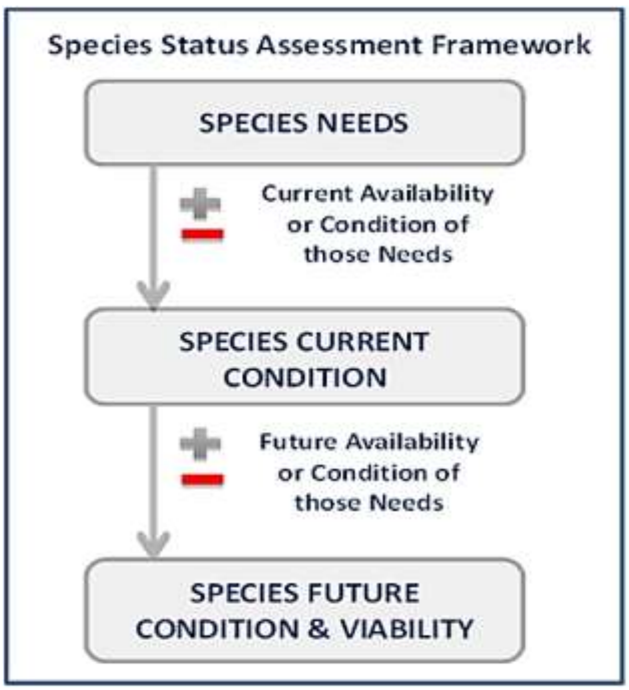


Figure 0-1. Species Status Assessment Framework.

This SSA Report provides a thorough assessment of the biology and natural history of the species, as well as an assessment of the demographic risks, stressors, and limiting factors determining the viability and risk of extinction for the Chipola slabshell. Importantly, this SSA report does not result in, nor predetermine, any decisions by the Service under the Act. Any future decision will be made by the Service after reviewing this document, along with the supporting analysis, any other relevant scientific information, and all applicable laws, regulations, and policies. The results of the decision will be announced in the Federal Register. The contents of this SSA Report provide an objective, scientific review of the available information related to the biological status of the Chipola slabshell.

To evaluate the biological status of Chipola slabshell we assessed a range of conditions to allow us to consider the 3 Rs for this species. This SSA report provides a synthesis of the species biology and natural history and assesses risks, stressors, and limiting factors in the context of determining the viability of the species. The format for this SSA includes: species biology (Chapter 2) and needs (Chapter 3), influences on viability (Chapter 4), current condition (Chapter 5), and future condition (Chapter 6).

CHAPTER 1 – SPECIES DESCRIPTION LIFE HISTORY, AND BIOLOGY

1.1 Taxonomy

Elliptio is the largest mussel genus in North America. This genus currently contains 38 species as recognized by the Integrated Taxonomic Information System (as of September 2019), the federal entity that maintains and reviews data for taxonomic classifications (Appendix A). All *Elliptio* occur in the United States; however, the genus is known to be polyphyletic and revisions are ongoing (Graf and Cummings 2007, p. 307). Williams et al. (2017, p. 37) suggest there may be closer to 30 species in the genus, as ongoing morphological and genetic work synonymizes species or removes species from the genus entirely. While a complete phylogeny for *Elliptio* does not exist, the relationships between some species have been clarified. *Elliptio waccamawensis* was placed in synonymy under *E. congarea* based on DNA sequence analyses (McCartney et al. 2016, p. 118). At least one species, *E. steinstansana*, has been moved to a new genus (*Parvaspina*; Perkins et al. 2017, pp. 754-755) following genetic analysis, with *E. spinosa* grouped outside of the main *Elliptio* clade but no revision of *E. spinosa* has been proposed at present (Perkins et al., 2017, p. 754). While *Elliptio* is now close to monophyly, it has not yet been fully achieved (Inoue et al. 2018, p. 692).

The Chipola slabshell was first described as *Unio chipolaensis* from specimens collected from the Chipola River by Bryant Walker (1905, p. 135). It has since been renamed as *Elliptio chipolaensis* according to the recognized naming priority for the genus accredited to Rafinesque in his 1820 monograph (Frierson 1927, pp. 5 – 8, 29). *Elliptio chipolaensis* remains a valid species (Graf and Cummings 2007, p. 307; Williams et al. 2017, p. 37) and meets the Endangered Species Act (ESA) definition of a species. Genetic testing is needed to corroborate the morphological evidence distinguishing the Chipola slabshell as a separate species from

Elliptio nigella, which is also endemic to the Apalachicola River system but is not a listed species. Other members of *Elliptio* are listed as endangered or threatened in addition to Chipola slabshell. *Elliptio steinstansana* occurs in North Carolina and has been federally endangered for over 30 years (1985; 50 FR 26572), while *E. spinosa* occurs only in Georgia, and was listed as endangered in 2011(76 FR 62927). In addition, *E. lanceolata* was listed as threatened in 2018, and occurs within the District of Columbia, Maryland, North Carolina, and Virginia (83 FR 14189).

The currently accepted taxonomic ranking for Chipola slabshell is described below*.

Phylum	Mollusca
Class	Bivalvia
Order	Unionoida
Family	Unionoidae
Subfamily	Ambleminae
Genus	*Elliptio*
Species	*Elliptio chipolaensis* (Walker, 1905) – Chipola slabshell

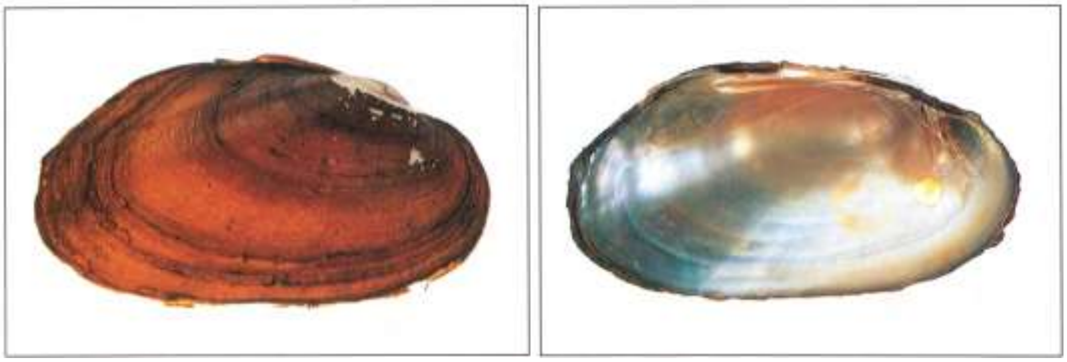
* Retrieved 21/09/2019 from the Integrated Taxonomic Information System on-line database, http://www.itis.gov

1.2 Morphological Description

The adult shell morphology was first described by Walker (1905, p. 36) and Clench and Turner (1956, pp. 175). Unless otherwise indicated, the description of the species is from these sources. As is typical of all *Elliptio* mussels, no sexual dimorphism is displayed in shell characters (Priester 2008, p. 41). The external shell is composed of two hinged halves or valves. The Chipola slabshell has a chestnut colored periostracum (outer shell; Figure 1-1 A) with 1-4 dark annuli bands (dark growth bands). Dark brown coloration may appear in the umbonal region (most prominent, highest part of each valve) and the remaining surface may exhibit alternating light and dark bands. The nacre (inner shell; Figure 1-1 B) is white to bluish-white with a salmon tint in the umbo cavity (the pocket located inside a valve underneath the umbo), becoming more intense dorsally and somewhat iridescent posteriorly. Within its range, Chipola slabshell is the only species with light and dark bands on periostracum and with salmon-colored nacre (Brim Box and Williams 2000, p. 36). The umbos are prominent, well above the hingeline. Internally, the umbo cavity is rather deep. The lateral teeth (longer ridges inside the shell near the hinge) are long, slender, and slightly curved, with two in the left and one in the right valve. The pseudocardinal teeth (structures located near the anterior-dorsal margin) are compressed and crenulate (finely scalloped or notched), with two in the left and one in the right valve. The shells can attain a length of 85 mm (FNAI 2001, n.p.), but are typically between 47 to 76 mm (Brim Box and Williams 2000, p. 37). Surveys between 2005 and 2007 found individuals could be as large as 80 mm, but were between 40 and 60 mm on average (n = 373; Priester 2008, p. 22 – 23).

Juvenile mussels are generally assumed to be the small-sized individuals near the low end of the detectable size range (<35 mm). Detection of very young juvenile mussels during surveys happens extremely rarely due to sampling bias (Shea et al. 2013, p.383). Because mussel surveys involve underwater, tactile and visual searches, mussels less than 35 mm are difficult to detect (Wisniewski et al. 2013, p.239). A true population distribution curve would contain many small juveniles with abundance decreasing sharply with age; however Priester (2008, p.30) documented a classic bell curve for the population size distribution of Chipola slabshell that is still informative for generalizations between age and size.

The parasitic larvae, known as glochidia, are miniature bivalves, having two shells attached by a hinge ligament and a single adductor muscle (Haag 2012, p. 8). Glochidia form into three basic variations: hooked, hookless, and ax-head shaped. In the Chipola slabshell, the glochidia are hookless (Figure 1-2) which suggests that the gills are the primary target for infection (Williams et. al. 2014, p. 82). Females release the glochidia in conglutinates, which are clusters or aggregates of glochidia (eggs) that are formed in the water tubes of the female gills (Barnhart 2008, p. 375). The conglutinates of the Chipola slabshell (Figure 1-3) are approximately 13 mm long (Priester 2008, p. 31).



A B

Figure 1-1. Chipola slabshell periostracum (A) and inner shell with nacre (B).

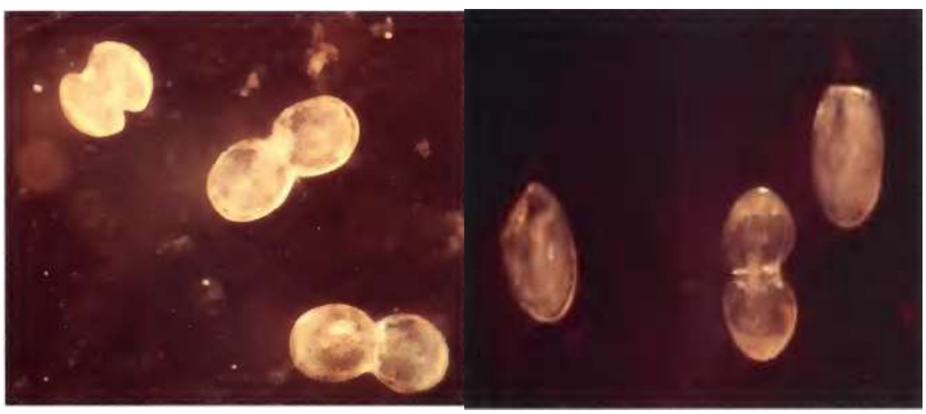


Figure 1-2. Hookless glochidia of Chipola slabshell (Priester 2008, p. 34).

Figure 1-3. Conglutinates of Chipola slabshell (Priester 2008, pp. 31-32).

1.3 Life History

The life history of freshwater mussels is unique. The following summary is from Haag 2012 (p. 37, 39, 42) unless otherwise noted. Freshwater mussels are free living for most of their lives, but nearly all species are dependent on a parasitic relationship between the larvae and a host fish. During spawning, males release sperm, and nearby downstream females uptake the sperm through the intake aperture during filter feeding and simultaneously release eggs from the gonads into the suprabranchial chamber for fertilization. Fertilized eggs are deposited in the demibranchs of the marsupial gills (Brim Box and Williams 2000, p. 35; Priester 2008, p. 30), where they are brooded until the eggs develop into mature glochidia. When mature glochidia are released and encounter a fish host, stimulation of sensory hairs within the shell of the glochidia causes the shell to clamp down. If the fish host is non-suitable, the glochidia are rejected. In suitable fish hosts, glochidia become encysted within the fish tissue and undergo metamorphosis. After metamorphosis is complete, juvenile mussels fall to the bottom of the water body and assume a free-living benthic existence (Figure 1-4).

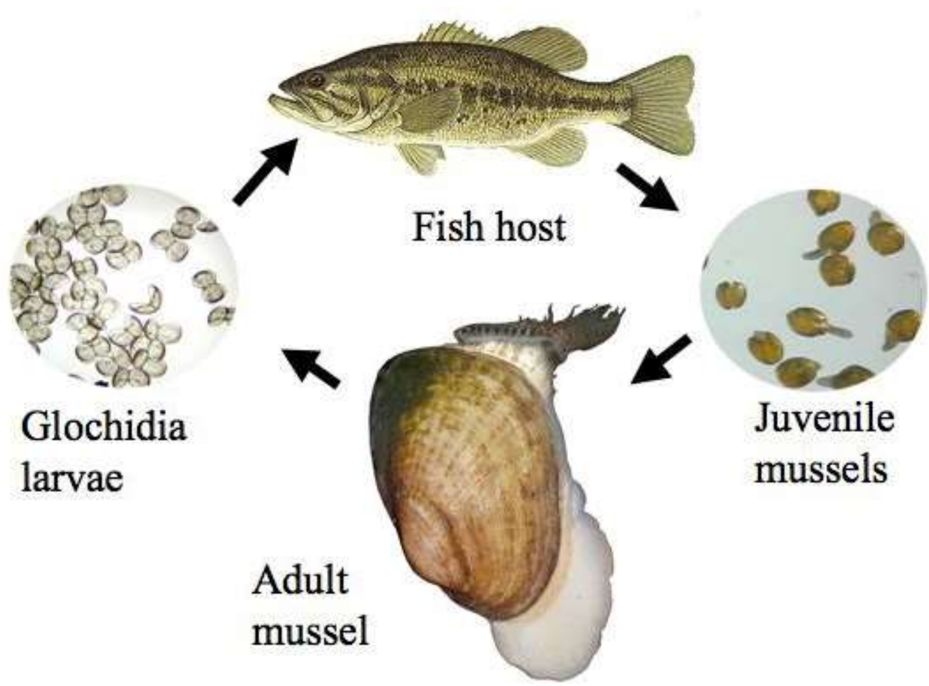


Figure 1-4. Generic illustration of the freshwater mussel reproductive cycle (FMCS 2019).

The Chipola slabshell is a short term brooder (tachytictic), meaning glochidia are carried for a short time and released the same spring or summer. Preliminary surveys suggest 30 to 50 % of females may be gravid throughout the month of June (Priester 2008, p.41). Females are gravid from early June to early July, with the eggs brooded until they develop into mature glochidia (Williams et. al 2014, p. 181). Host fish feed on conglutinates (which often resemble prey items of the host fish), thereby rupturing the conglutinate, freeing the glochidia, and bringing them into contact with the host gills. It is unknown exactly how many glochidia are produced per conglutinate in Chipola slabshell (Priester 2008, p. 31). Glochidia then encyst, where they remain attached to the host until transformation into a juvenile is complete, over a period ranging from 7-100 days (Haag 2012, p. 42).

Dispersal of juveniles is a function of the host's range. After transformation, a juvenile mussel will excyst from its host and begin living freely on the substrate below. The juvenile has two adductor muscles, rudimentary internal organs and a foot (Coker et al 1921, p. 157). Glochidia are reliant on host movement that is typically restricted to an area < 100 m and transformed juveniles typically drift a minimal distance (< 10 m) from the host after they excyst (Irmscher and Vaughn 2018, p. 268), Occasional high water flows and longer-distance host dispersal can serve to connect widely distributed species. Survival depends upon a number of factors including: appropriate substrate, no predation, available food sources and suitable water chemistry. Species needs and influences on viability are further discussed in Chapters 3 and 4. Based on the size, shell characteristics, and traits from similar species in the genus *Elliptio*, we believe that the Chipola slabshell reaches sexual maturity in 3-5 years and has an average lifespan in the range of 15-20 years (pers. Comm. Paul Johnson, ALDNR June 21, 2019).

1.3.1 Host Fishes

Chipola slabshell has the characteristics of a host-fish specialist. Some mussels are host-fish specialists that parasitize a few fish species (Yeager and Saylor 1995, p. 4; Neves et al. 1985, p. 13, 17), and others are generalists that parasitize a great variety of host fishes (Trdan and Hoeh 1982, p. 386). To date, only two host fishes have been identified for Chipola slabshell, redbreast sunfish and bluegill (Preister 2008, p. 47). Mussels that are known host-fish specialists tend to release glochidia in conglutinates (a strategy employed by Chipola slabshell), or use various means of attracting a fish host before releasing multiple glochidia. In general, densities of host-specialist mussels without elaborate host-attracting mechanisms such as Chipola slabshell are positively correlated with host-fish densities (Haag and Warren 1998, p. 297-306).

In 2006, host fish trials were conducted by Priester (2008, entire). Two potential fish hosts were identified: bluegill (*Lepomis machrochirus*) and redbreast sunfish (*Lepomis auritus*).

Largemouth bass were not available during the study so this species was not tested, though it is still considered a possible host fish and should be included in future transformation studies. In this study, both bluegill and redbreast sunfish had transformation rates above of 60% and 72%, respectively (Priester 2008, pp. 36 - 37). Based on O'Brien and Williams (2002, p. 149), a transformation rate above 30% is indicative of a primary fish host and indicates that the Chipola slabshell may use both fish species in this manner.

The habitat and reproductive requirements for Chipola slabshell hosts are similar. Adult bluegill and redbreast sunfish are frequently found in lakes, ponds, reservoirs and rocky to sandy sluggish streams of small to medium rivers. They feed upon snails, small crayfish, terrestrial and aquatic insects (e.g., mayflies and dragonflies), worms and small minnows. Reproduction occurs in sand or fine gravel substrates (Froese and Luna 2019, n.p.; Forese and Casal 2019, n.p.).

Haag and Warren (1998, p. 303) identified host fish availability and density as significant factors influencing where certain mussel populations can persist. Like other freshwater mussels, reproduction is dependent upon the presence of a host fish for glochidia to encyst upon and metamorphose into a transformed juvenile. While some migration or longer-range movements of the host fish for Chipola slabshell occur, their home ranges are typically limited. A study of two streams near Oak Ridge, Tennessee that tracked bluegill and redbreast sunfish determined movement to be minimal, < 100 m for two thirds of all tagged fish sampled quarterly over a three year period (Gatz and Adams 1994, p. 35). Although female mussels may produce 75,000 to 3.5 million glochidia (Coker et al. 1921, p. 144; Yeager and Neves 1986, p. 333), contact of the glochidia with a suitable host fish is a low-probability event. For context, Chipola slabshell glochidia only survive one to three days outside of the brooding demibranchs of the female mussel, during which time they must find a host to survive (Priester 2008, p. 48). Generally, contact between glochidia and host fish does not ensure successful larval development to the juvenile form, because some fish species have natural immunity to glochidial infestation and others acquire immunity following infestation (Watters and O'Dee 1996, p. 387). Glochidia that contact a host with natural immunity are rejected and die, usually within a few days to a week (Neves et al. 1985, p. 15, 17; Yeager and Neves 1986, p. 338; Waller and Mitchell 1989, p. 86). In the case of acquired immunity, glochidia experience decreased transformation rates with subsequent infections of an initially suitable host fish (Bauer and Vogel 1987, p. 399 – 400). The number of exposures associated with glochidial sloughing is variable (Watters and O'Dee 1996, p. 385, 387). The susceptibility of fish hosts to infection by mussel glochidia is also a function of the exposure history (i.e., age) and size of the host fish, with younger (i.e., naïve) and smaller fish being more susceptible, with fish host population characteristics being influenced by flows and floodplain connectivity (USFWS 2016b, p. 142). Strong cohorts of young, naive fish hosts may be expected to occur in years with above average floodplain inundation and connectivity during the growing season, and conversely, years with below average floodplain inundation are associated with smaller cohorts of susceptible age 0 fish hosts.

Bluegill and redbreast sunfish are thought to be ubiquitous throughout the range of Chipola slabshell (Priester 2008, pg. 45). Data from Florida Fish and Wildlife Commission (FWC 2019) over the last 20 years provides insight into the availability of the primary hosts for Chipola slabshell (Figure 1-5). The sampling methodologies employed by Florida Fish and Wildlife Commission and the degree to which they targeted the host fish is uncertain. While there are a few observations of the host fish in the tributaries of the Chipola River, a concerted effort has not been made to survey tributaries for bluegill and redbreast sunfish. The data available suggests these fish are lacking or occur at very low densities in hydrologic units not associated with the mainstem of the Chipola River (e.g., Marshall Creek, Cowarts Creek, Merritts Mill Pond). Similarly, host fish seem to be lacking or in very low densities in the Dead Lake hydrologic unit, though surveying in this region may be sparse. In general, redbreast sunfish and bluegill comprise 1/3 of the fish sampled during FWC surveys (Priester 2008, p. 52), and these species have been documented throughout the mainstem of the Chipola River. It would appear the density of the host fish species is sufficient to support normal mussel recruitment and dispersal rates, but the minimal host fish density required to support these life functions is uncertain. Further studies of fish and mussel population dynamics are necessary to quantify species-specific thresholds.

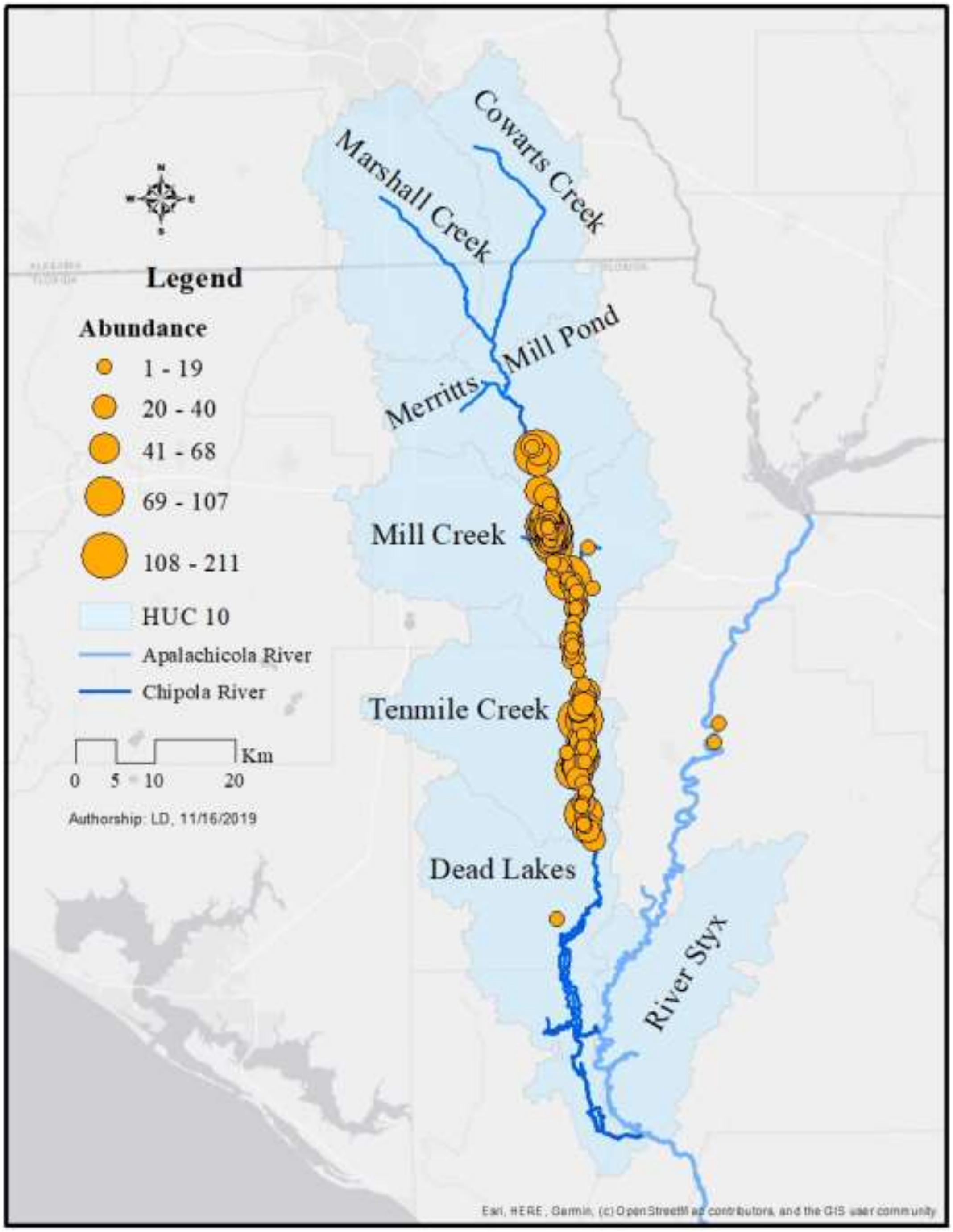


Figure 1-5. Presence and relative abundance of the known primary host fish for Chipola slabshell (bluegill and redbreast sunfish) obtained by FFWC from incidental sampling on the Chipola River over the last 20 years (2000 to 2018). 10-digit hydrologic unit code (HUC 10) watershed boundaries and their names are included for reference.

1.4 Diet

Freshwater mussels feed in two ways: first, by filter feeding on microscopic particulates that include phytoplankton, zooplankton, bacteria, and fine organic detritus and second, by deposit feeding in the sediment. Floodplain inundation may have both individual and population level effects via the supply of mussel food to the ACF system (USFWS 2016b, p. 145). The following summary is from Haag 2012 (p. 28 – 29) unless otherwise noted. Filter feeding starts at the inhalant aperature along a unidirectional flow established by the cilia on the gill surfaces. Material captured on the gills is transferred to the labial palps that sort edible food to the mouth. Deposit feeding occurs through two mechanisms: through the shell gape by suction generated from the cilia on the foot, or through pedal feeding, in which the material is moved directly into the shell by cilia on the foot. Pedal feeding may be the primary mode of food uptake for juveniles, as filter feeding structures are underdeveloped in newly transformed juveniles. Mussel diet varies among habitats and among species. Oligotrophic systems may be more abundant in phytoplankton, where as in other lentic systems, mussels may rely on bacteria and benthic sources. During her study, Priester (2008, p. 16) successfully maintained seven gravid female slabshells on an algae food source for a period of time. To date, there have not been any studies investigating the diet of the Chipola slabshell.

1.5 Habitat

The Chipola River and its tributaries comprise the primary habitat for Chipola slabshell. The Chipola River begins at the confluence of Marshall and Cowarts creeks in Jackson County, FL. The Chipola River Basin encompasses approximately 1,277 square miles (3307.415 km^2), extending from Houston County, Alabama, to just south of the Dead Lake in Gulf County, FL. The Chipola River flows through the Dougherty Karst Plain and is substantially spring fed; an inventory conducted in 2004 identified a total of 63 springs within the Chipola River basin (Barrios and Chelette 2004, p. 3). The highest magnitude spring, Jackson Blue Spring, forms the headwaters of the 270-acre Merritts Mill Pond, which forms the headwaters of Spring Creek, a tributary to the Chipola River. Merritts Mill Pond flowed freely into Spring Creek prior to 1860, and now the water level in the pond is managed (NWFWMD 2017, p. 9).

The Chipola River flows into the Apalachicola River (Figure 1-6), and as such is part of the Apalachicola, Chattachoochee, and Flint (ACF) River Basin. At the Chipola Cutoff, about 27 to 34 percent of the Apalachicola River's flow diverts through a natural cutoff to join the Chipola River (USFWS 2016b, p. 41; Mossa et al. 2017, p.122). Within 5 km (3.1 mi), the Chipola Cutoff joins the Chipola River, and downstream from this junction the channel is referred to as the Lower Chipola River. The Lower Chipola River rejoins the Apalachicola River about 15 miles (24 km) downstream (NWFWMD 2017, p. 9). Flows in the Lower Chipola River downstream of the Chipola Cutoff are directly affected by flows in the Apalachicola River. The irregular, wandering channel of the Lower Chipola rejoins the Apalachicola River at RKM 44.8, and this stretch of the Chipola River has been shown to support a high diversity and density of freshwater mussels (Kaeser et al. 2019, p. 665 -666).

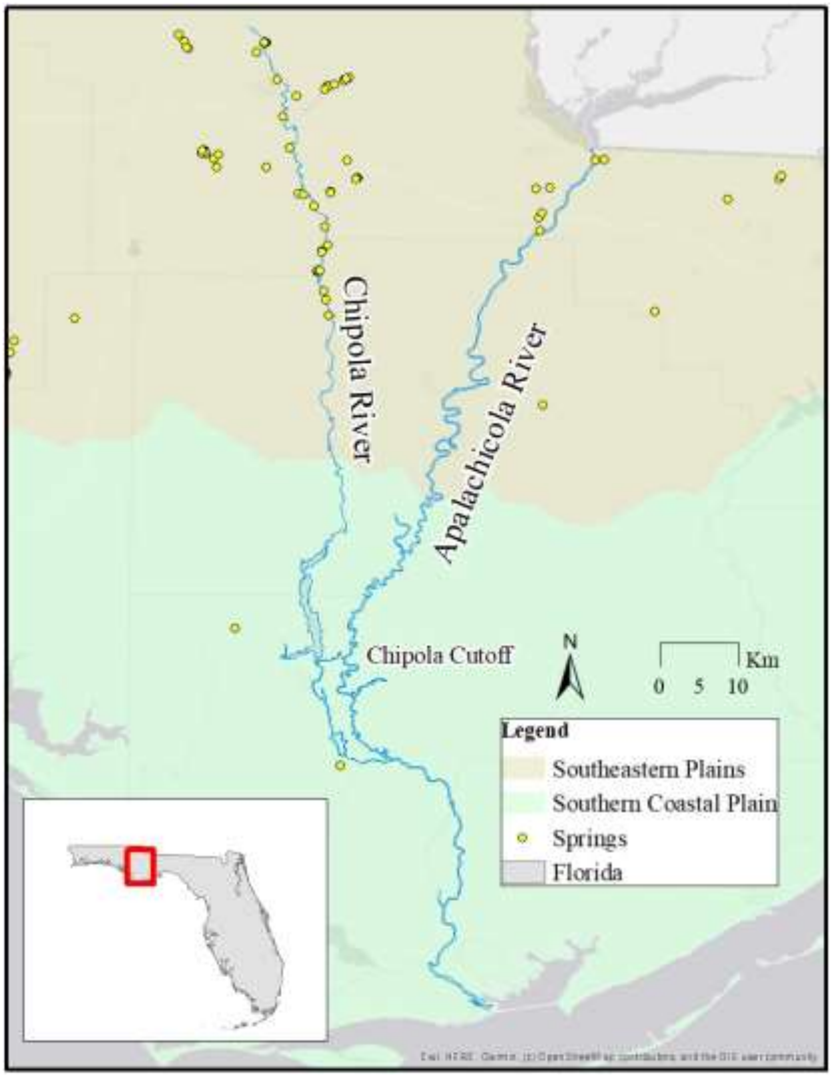


Figure 1-6. Apalachicola River and one of its tributaries, the Chipola River. The Chipola River comprises the historical range for the Chipola slabshell and occurs predominantly in Florida, with headwater streams in Alabama. Many springs contribute to water flow in the basin.

Waterbodies containing Chipola slabshell are located within the lower portions of headwater streams and also riverine forests in the Southeastern Plains and Southern Coastal Plain ecoregions. These forests predominantly consist of longleaf, slash, and pond pine (*Pinus palustris*, *P. elliottii*, and *P. serotina*, respectively); American beech (*Fagus grandifolia*); sweetgum (*Liquidambar styraciflua*); southern magnolia (*Magnolia grandiflora*); and white and laurel oak (*Quercus alba* and *Q. laurifolia*, respectively). The Chipola River basin has been recognized as a center of biodiversity and endemism in the Florida panhandle likely due to the unique and relatively undisturbed habitats (Denson et al. 2016). A great diversity of habitats exist within the Chipola River Basin, from xeric upland longleaf pine forests, to bottomland hardwood swamps, freshwater wetlands, numerous natural springs, and meandering creeks with multiple tributaries. Of its 259 square miles (670 km^2), 35 percent of the Chipola River Basin in Alabama is forested, 53 percent is agriculture or pasture, 10 percent is urban land uses, and one percent is surface water (ADEM 2006, p. 7-17). The bulk of the Chipola Basin occurs within Florida, where substantial portions of the property along the upper Chipola are preserved as forested public lands under the control of the Northwest Florida Water Management District or the Florida Department of Environmental Protection. The Apalachicola-Chipola Basin is significantly more forested in Florida, with 54 percent of the area within this landcover type, 13 percent in agriculture, 3 percent in urban land uses, 24 percent as wetlands and 5.5 percent as other (e.g., water, rangeland, barren land, utilities) (US FWS 2014).

The Chipola River has a relatively narrow floodplain, normally carries a small sediment load, and has a fairly consistent flow. In the higher elevation Southeastern Plains, streams are relatively low-gradient and sandy-bottomed, with the Southern Coastal Plain being lower in elevation and containing less relief (Figure 1-6; EPA 2013, pp. 13, 15). The average channel width is 7 m, with the ratio of valley width to channel width ranging from 10 in the north, to 131 in the middle to southern portions of the river above Dead Lake; these values correspond to a transition from a meandering pattern within the headwaters to a braided channel pattern in the mainstem of the river (Elliott et al. 2014, p. 12, 14). In general, the Chipola River is classified within the ACF Basin as having medium to high channel width, low-medium valley width, and a very low to low stream-channel gradient where 75% of the floodplain is classified as riverine wetland (Elliott et al. 2014, p. 56). While the Apalachicola River floodplain is extensive and dominated by wooded wetlands, the Chipola River floodplain contains similar wetlands but is much narrower in extent.

The Chipola slabshell is thought to be an endemic with low densities that at times can be locally abundant (Clench and Turner 1956, p. 176, Williams and Butler 1994, p. 73). Though Chipola slabshell has been found within tributaries of the Chipola River, this is not often the case. Of 166 Chipola slabshell records (1954 to 2018; USFWS 2019), 165 were successfully linked to stream order. Streams that are ranked 3rd order and lower are typically referred to as headwater streams (Figure 1-7). Few (n= 5) of the Chipola slabshell records were obtained from 3rd order or lower streams. The absence of Chipola slabshell from headwater streams could partially be due to sampling bias but more likely reflects host fish presence (Figure 1-5), habitat requirements, and barriers to movement on small streams. The Chipola River is a 5th order medium stream, with large rivers classified as 7th order or larger (e.g., Apalachicola River is 8th order). Of the records obtained from water bodies ranked higher than 3rd order, medium streams (stream order 4 to 6) contain 94 percent of Chipola slabshell observations (n = 141), with the remainder of observations (n = 5) occurring within the Apalachicola River.

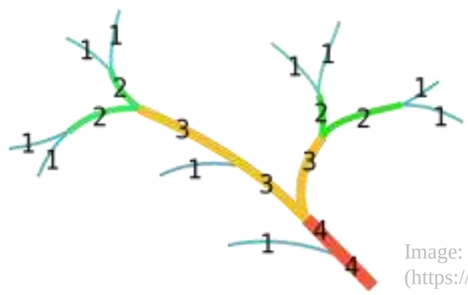


Figure 1-7. Strahler stream order methodology. Stream size is defined based on size and hierarchy of tributaries, such that first order streams form second order streams, which form third order streams at the confluence of two second order streams, and so on.

The Chipola slabshell inhabits silty sand substrates of large creeks and the main channel of the Chipola River in slow to moderate current (Williams and Butler 1994, p.73). Specimens are generally found in sloping bank habitats, with nearly 70 percent of the specimens found during the status survey were associated with a sandy substrate (Brim Box and Williams 2000, pp. 37). At the time of listing, Chipola slabshell appeared to be more tolerant of soft sediments than other threatened or endangered species in the ACF Basin (63 FR 12664); Chipola slabshell has potentially more habitat available than channel-dwelling species, and may co-occur with more silt-tolerant species in stream bank habitats with slower currents.

1.5.1 Critical Habitat

Under the Act and its implementing regulations, the Service was required to identify the physical or biological features essential to the conservation of Chipola slabshell in areas occupied at the time of listing, focusing on the features' primary constituent elements, in order to designate critical habitat (Figure 1-8). Primary constituent elements are those specific elements of the physical or biological features that provide for a species' life-history processes and are essential to the conservation of the species. These primary constituent elements were determined to be (72 FR 64285):

- A geomorphically stable stream channel (a channel that maintains its lateral dimensions, longitudinal profile, and spatial pattern over time without a consistent aggrading or degrading bed elevation);
- predominantly sand, gravel, and/or cobble stream substrate with low to moderate amounts of silt and clay; and
- permanently flowing water (to support host fishes)

Critical habitat was designated in the Chipola River main stem and seven tributaries occupying a stream length of approximately 228 km (72 FR 64285). This critical habitat unit consists of Chipola River and Dry, Rocky, Waddells Mill, Baker, Marshall, Big, and Cowarts Creeks in Houston County, Alabama, and in Calhoun, Gulf, and Jackson counties, Florida. The unit is also critical habitat for four other freshwater mussels (Unionoidae), including the fat threeridge (*Amblema neislerii*), shinyrayed pocketbook (*Hamiota subangulata*), Gulf moccasinshell (*Medionidus penicillatus)*, oval pigtoe (*Pleurobema pyriforme*).

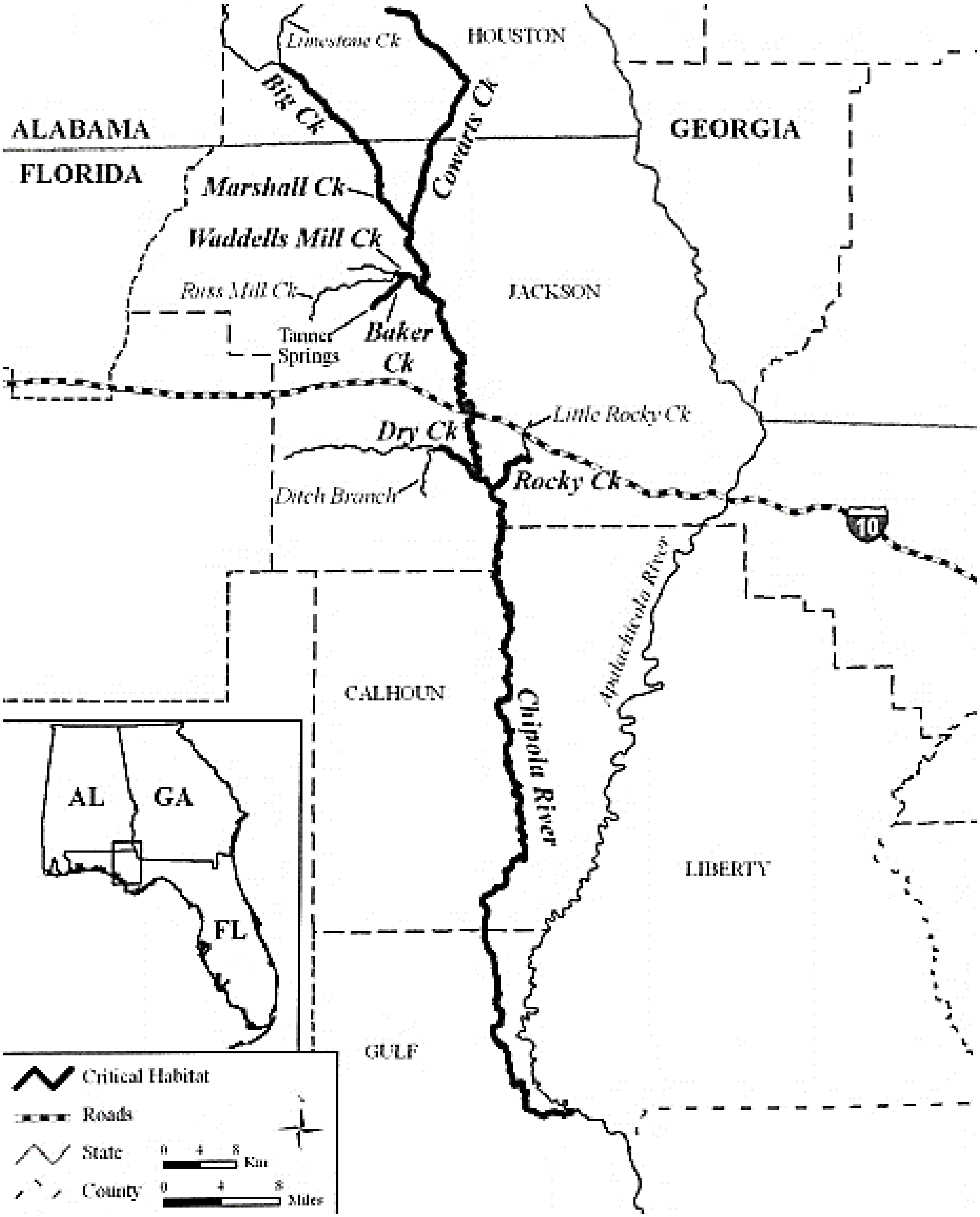


Figure 1-8. Designated critical habitat for Chipola slabshell (72 FR 64285).

1.5.2 Water Quality

Most mussels are considered sensitive to low dissolved oxygen (DO) levels and high temperatures (Fuller 1974, p. 240 – 241, 244 - 245). Juvenile mussels may spend their first few years buried in the sediments of the stream bed. Interstitial water (pore water) in sediments is generally less oxygenated than flowing water in the stream above (Sparks and Strayer 1998, p. 129). Sparks and Strayer (1998, p. 132) observed marked differences in behavior between juvenile eastern elliptio (*Elliptio complanata*), congener of the Chipola slabshell, that were exposed to DO levels of 2 mg/L and 4 mg/L. Most eastern elliptio juveniles exposed to a DO of 1.3 mg/L for a week died. Interstitial DO levels in streams of the eastern United States are usually less than 4 mg/L in the summer and may fall below 1 mg/L (Sparks and Strayer 1998, p. 132). Water temperature affects the amount of oxygen that can be dissolved in water and the toxicity of various pollutants. Pollutants are discussed further in Chapter 3 (Influences on Viability).

In general, Chipola slabshell requires water quality (including temperature, turbidity, dissolved oxygen, and chemical constituents) that meets or exceeds the current aquatic life criteria established under the Clean Water Act (CWA) (33 U.S.C. 1251– 1387). We believe the numeric standards for pollutants and water quality parameters that are adopted by the States under the CWA represent levels that are essential to the conservation of Chipola slabshell. The Surface Water Quality Criteria (62-302.530) provided by FDEP for Class III surface freshwater (designated uses: fish consumption; recreation, propagation and maintenance of a healthy, well-balanced population of fish and wildlife) are included in Appendix B. For example, the Surface Water Quality Criteria asserts that no more than ten percent of the daily average percent DO saturation values shall be below 67 percent in the Panhandle West bioregion where most Threatened or Endangered mussels occur (Figure 1-9). The Surface Water Quality Criteria standards should meet or exceed the life requisites of Chipola Slabshell. The Chipola River is also subject to additional protections that are discussed further in Section 3.4 (Conservation).

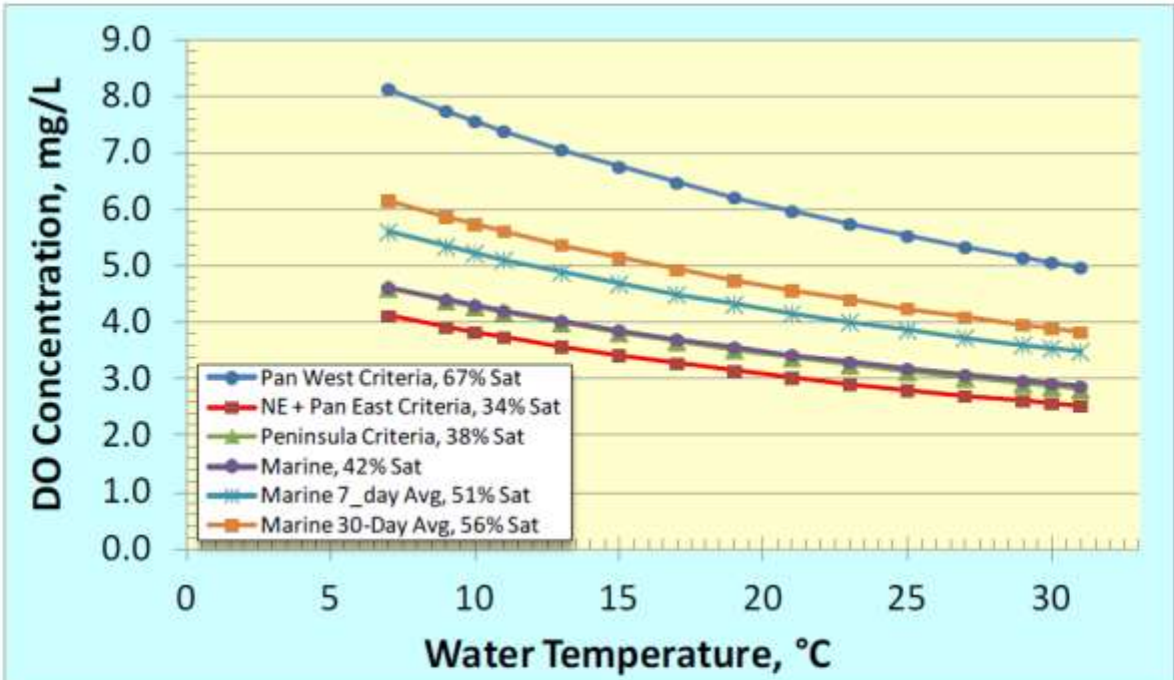


Figure 1-9. Dissolved oxygen concentrations resulting from the DO saturation criteria for Florida's fresh and marine waters over the range of expected water temperatures. These standards are a part of the Florida Surface Water Quality Criteria (62-302.530). The Pan West criteria pertains to waters in the panhandle region that contains Chipola slabshell habitat. Waters containing Chipola slabshell are Outstanding Florida Waters and subject to further protections in addition to these minimum standards.

Under moderate-flow conditions, ground water makes up the majority of the Chipola River's discharge and the quality of water discharged from the Chipola River springs is predominantly determined by the quality of ground water in the Floridan Aquifer. During a recent assessment of water quality in the Chipola River, The Service found water temperatures ranged from 9.2 to 30.7 °C throughout the year, with dissolved oxygen ranging from a low of 6.9 mg/l to supersaturation (Hemming et al. 2007, p. 21). Other water quality parameters and their values from eight sampling sites along the Chipola River are included here for reference (Hemming et al (2007, pp. 21 – 22). Specific conductance (uS/cm@25°C) ranged from 76 to 297 over the course of the river. Hydrogen ion concentration (pH) ranged from 7.1 to 8.3 in standard units during the sampling year. Relative turbidity (range river-wide <3.0 to 31.2 NTUs) seemed to vary more when compared to relative chlorophyll a concentration (0.3 to 8.2 ug/l as estimated via fluorescence). Neither turbidity nor chlorophyll a concentration (as estimated by community imbalance) violated water quality standards. Alkalinity was measured to be from 11 to 132 mg

CaCO3/l during the study and hardness was very similar ranging from 50 to 131 mg CaCO3/l. Almost all water quality parameters showed a significant correlation with the discharge rate as estimated by the U.S. Geological Survey gage on the Chipola River at Altha, Florida (USGS 02359000) with the only exception being pH.

There is a general gradient from north to south regarding nutrient yields in the Chipola River. The sources of nutrient (e.g., nitrogen, phosphorus) inputs are discussed further in Section 3.1.2, but are visualized in Figure 1-10 at the HUC 12 subwatershed scale using the 2012 Spatially Referenced Regression On Watershed attributes (SPARROW) models (Hoos and Roland 2019, entire). SPARROW assesses variability in total nitrogen (TN) according to five sources, including atmospheric deposition, agricultural fertilizer, municipal wastewater, manure from livestock, and urban land. Variable rates of TN delivery from source to stream were attributed to variation among catchments in climate, soil texture, and vegetative cover, including the extent of cover crops in the watershed. Variability in total phosphorus (TP) was determined by parent-rock minerals, urban land, manure from livestock, municipal wastewater, agricultural fertilizer, and phosphate mining. Varying rates of TP delivery were attributed to variation in climate, soil erodibility, depth to water table, and the extent of conservation tillage practices in the watershed. Future versions of this SSA could employ the outputs of the SPARROW model in spatial modelling of current and future condition; however the 2012 updated dataset was released January 6, 2020 and was not available for use in our present analysis.

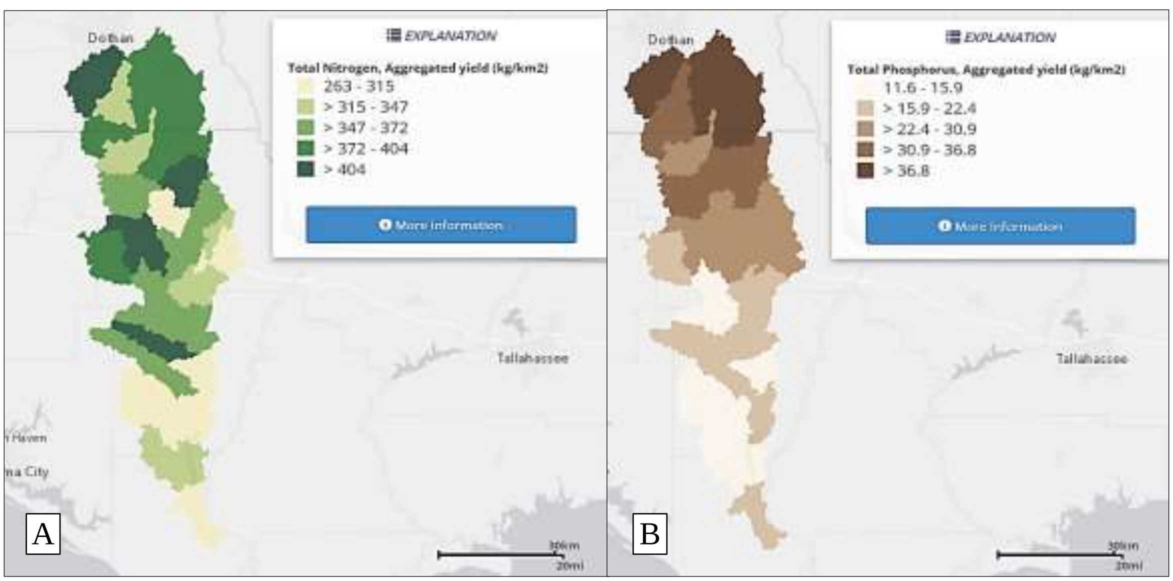


Figure 1-10. Aggregated yields (kg / km^2) for a) nitrogen and b) phosphorus within the Chipola River Basin from the 2012 SPARROW model (Hoos and Roland 2019, entire).

1.5.3 Stream Sediment and Flow

Adult unionid mussels are generally found in localized patches (beds) almost completely burrowed in the substrate with only the area around their siphons exposed (Balfour and Smock 1995, p. 255–268). Mussels engineer their habitat to enhance anchoring ability and increase local bed stability, through complex interactions between shell size, shape and sculpture, burrow behavior, anchor potential and bed composition (Sansom et al. 2018, p. 1477). The composition and abundance of adult mussels have been linked to bed sediment distributions (Neves and Widlak 1987, p. 5; Goodding et al. 2019, p. 549 - 550). Substrate texture (particle size distribution) affects the ability of mussels to burrow in the substrate and anchor themselves against stream currents (Lewis and Riebel 1984, p. 2025). Shear stress is a critical factor in affecting displacement during high flow events (Gangloff and Feminella 2007, p. 6). Where substrates are unstable, conditions are generally poor for mussel habitation. Strayer (1999b, p. 472) demonstrated in field trials that mussels in streams occur chiefly in flow refuges, or relatively stable areas that displayed little movement of sediment during flood events. Flow refuges conceivably allow relatively immobile mussels to remain in the same general location throughout their entire lives.

Chipola slabshell are associated with sandy substrates (Brim Box and Williams 2000, pp. 37). The characteristics of sediments within the Chipola River are summarized in Appendix C, which indicates a high proportion of sand. More importantly, the presence of smooth bedform mesohabitat is important for freshwater mussels within the Apalachicola and Chipola Rivers. In the Lower Chipola River (including the Chipola Cutoff and the mainstem south of Dead Lake), a third of the channel is composed of smooth, plane bedform habitats within which freshwater mussels are highly abundant (Kaesar et al. 2019 p. 663). The remarkable mussel abundance in the lower Chipola River was attributed to channel stability and an abundance of woody debris creating stable, fine sediment habitat that may be important to one or more critical life history stages of freshwater mussels including Chipola slabshell (Kaesar et al. 2019 p. 653). Texture and other aspects of substrate composition, including bulk density (ratio of mass to volume), porosity (ratio of void space to volume), and sediment sorting may also influence mussel densities (Brim Box 1999, p. 1– 86; Brim Box and Mossa 1999, p. 99– 117). Although several studies have reported adult habitat mussel selection by substrate composition, most species are found in a relatively broad range of substrate types (Tevesz and McCall 1979, p. 114; Strayer 1981, p. 411; Strayer and Ralley 1993, p. 255), with few exceptions. Freshwater mussels rarely occur in substrates composed of predominantly fine materials (more than 50 percent silt or clay by dry weight) (Brim Box and Williams 2000, p. 1–143); However, at least some species of juvenile unionids feed primarily on particles associated with sediments and pore water during their early development (Yeager et al. 1994, p. 221).

Ground water typically contributes to the majority of the Chipola River's discharge. The ground water contribution zone in Florida for the Chipola River springs is large and encompasses most of the river's surface water basin in Florida. The Chipola River discharge increases greatly as it passes through the many springs in the Dougherty Karst Plain (Barrios and Chelette 2004, p.7). In addition to the first magnitude Jackson Blue Spring (median 133 cfs), the Chipola River Basin has ten second magnitude (10 to 100 cfs) springs that significantly contribute to the flow rate of the Chipola River (Table 1-1), as well as numerous smaller springs (NWFWMD 2017, p. 9). The flow estimates from these springs are likely conservative, as the study was completed during a period of relatively low precipitation and low stage conditions (9/1/2003 to 6/4/2004; Barrios and Chelette 2004, p. 3).

Table 1-1. Second magnitude springs of the Chipola River Basin (adapted from Barrios and Chelette 2004, p. 4 - 6).

#	Second Magnitude Springs	Discharge (cfs)	Description
1	Baltzel Springs Group	51.78	Three spring vents north of Florida Caverns State Park
2	Black Hole Spring	65.19	Discharges to Dry Creek
3	Blue Hole Spring	19.66	Within Florida Caverns State Park
4	Daniel Springs Group	13.34	Seven spring vents that flow to Spring Branch and Marshall Creek
5	Lower Dry Creek (composite)	70.10	n/a
6	Gadsden Spring	26.64	Flows to Spring Lake
7	Hays Springs Group	17.34	Three vents north that flow to a spring run and the Chipola River
8	Mill Pond Spring	19.5	Discharges to Spring Lake
9	Rocky Creek Spring	29.13	Headwaters of Rocky Creek
10	Evergreen Spring	32.53	n/a

Flowing water is required for Chipola slabshell survival and reproduction, but there is no known minimal flow for perpetuation of the species. Both infection and settlement success may be influenced by discharge, or rates of change in discharge, but more data are necessary to inform our understanding of the mechanics (USFWS 2016b, p.140). Flowing water transports food items to the sedentary juvenile and adult life stages and provides oxygen for mussel respiration at depths that would be anoxic in a pond setting. Mussel population viability is likely dependent on features of the flow regime that influence fish host population density as well as features that directly affect adult and juvenile mussel survival. Mussel sites in the Chipola River generally have slopes >20% which helps to limit mussel mortality to < 1% of the local population during low-flow events (USFWS 2016b, p. 125). In addition, Chipola slabshell have been found to occupy areas 1 to 2 meters below the water surface, providing a buffer against the effects of low-flow conditions (USFWS 2016b, p. 129). Low flow events physically define the portion of the channel that remains permanently inundated; low flow events thereby define the extent of suitable mussel habitat (USFWS 2016b, p. 141). The 7 day, 10-year low-flows for the Chipola River at USGS station 02359000 (1986 to 2019) occurs at 400 cubic feet per second (Figure 1-11). The average discharge based on 86 years of records (1912-2019) at station 02359000 is 1200 cubic feet per second (cfs), with the 25th percentile at 660 and 75th percentile at 1580. The maximum discharge recorded occurred in 2019, at 6060 cfs with the lowest in 2012 at 350 cfs (USGS National Water Resources, 2019). Aggregate streamflow for the Chipola River Basin at the subwatershed (HUC 12) scale is depicted in Figure 1-12 B. Flows vary from 16.1 in the northern portion of the range to more than 61.1 cfs in the mid to southern extent, depicting the relative contributions of subwatersheds to the overall discharge of the Chipola River.

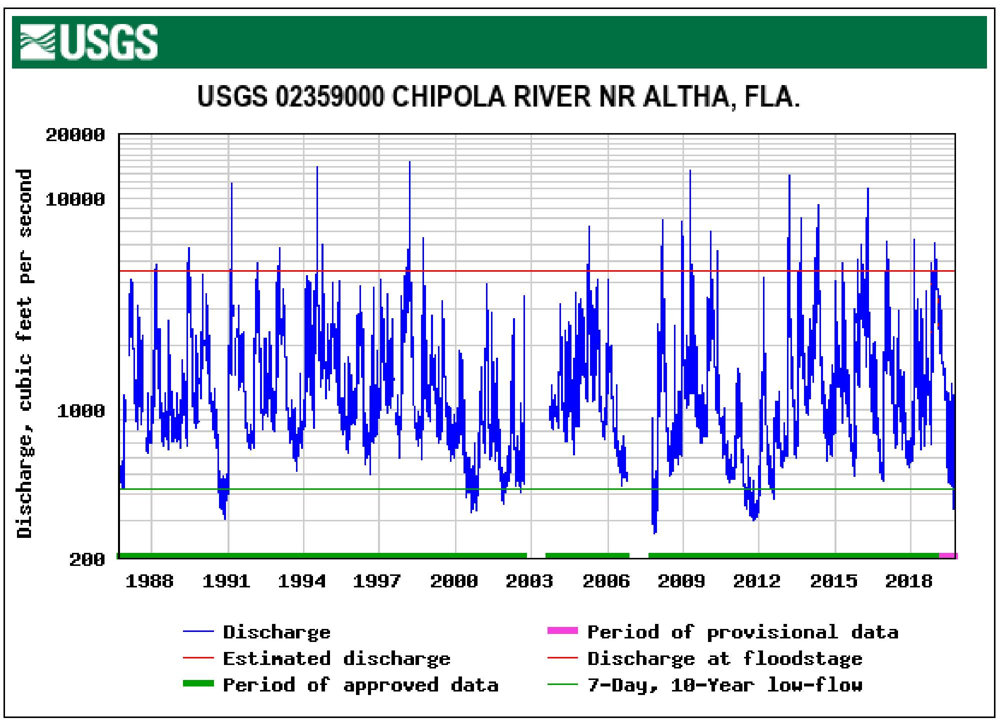


Figure 1-11. Water discharge from 1986 to 2019 for the Chipola River, with thresholds for floodstage and 7-day, 10-year low flows included (USGS National Water Resources, 2019).

Suspended sediment is generally greatest in the headwater and upper mainstem (northern) regions of the Chipola River, while streamflow increases from north to south (Figure 1-12 A). These processes have been assessed at the subwatershed (HUC 12) scale, and are interrelated; SPARROW 2012 base models attribute variability in suspended sediment (SS) transport in southeast streams to variable sediment export rates for different combinations of land cover and geologic setting (for upland sources of sediment) and by gains in stream power caused by longitudinal changes in channel hydraulics (for channel sources of sediment) (Hoos and Roland 2019, entire). Varying rates of SS delivery, like those for TP, were attributed to variation in climate, soil erodibility, and the extent of conservation tillage practices in the watershed, as well as to areal extent of canopy land cover in the 100-meter buffer along the channel (Figure 1-12 A). Variability in streamflow across the southeastern United States was explained as a function of precipitation adjusted for evapotranspiration, spring discharge, and municipal and domestic wastewater discharges to streams. Results from the streamflow model were used as input to the water-quality SPARROW models, but some locations with karst features had the largest errors; the Chipola River Basin error ranged from 17 to 33 % in favor of under predicting streamflow (Figure 1-12 B). The error within the Chipola River Basin was fairly uniform, and the metrics could be considered a conservative estimate of aggregated yield. Future versions of this SSA could employ the outputs of the SPARROW model in spatial modelling of current and future condition; however the 2012 updated dataset was released January 6, 2020 and not available for use in our present analysis.

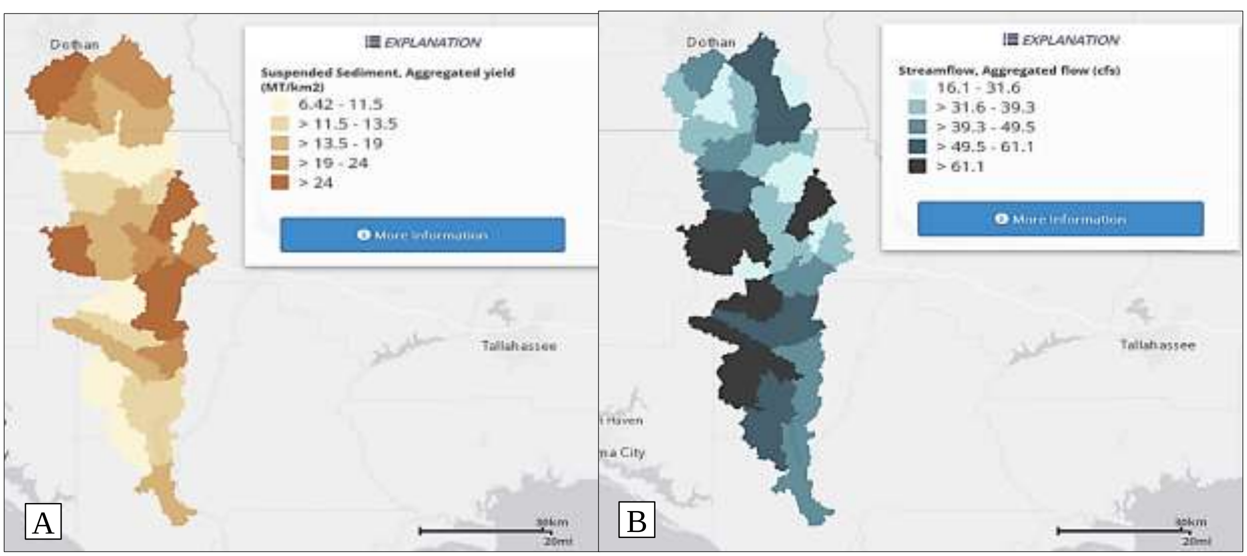


Figure 1-12. Aggregated yields for a) suspended sediment (MT/ km^2) and b) streamflow (cfs) within the Chipola River Basin from the 2012 SPARROW model (Hoos and Roland 2019, entire).

CHAPTER 2 – SPECIES NEEDS

2.1 Individual Level

Chipola slabshells require suitable conditions to flourish during each life stage and contribute to the next generation. The Chipola slabshell requires a stable stream channel, with continually flowing water of a quality meeting or exceeding current aquatic life criteria established under the Clean Water Act (Table 2-1). Individuals have been collected from large tributary creeks to the Chipola River and in the Chipola River main stem, in silty, sand substrates from slow to moderate current (Williams et. al. 2014, p.181). Host fishes such as redbreast sunfish and bluegill are needed in adequate abundance for Chipola slabshell to complete its lifecycle.

2.2 Population Level

For resilient populations to persist, the needs of individuals (suitable habitat structure, water quality, water quantity, food, and host fish presence) must be met at a broader scale, both spatially and temporally. Resiliency is measured using metrics that describe population condition and habitat. Resiliency is positively related to population size and growth rate and may be influenced by connectivity among populations. Generally speaking, populations need enough individuals, within habitat patches of adequate area and quality, to maintain survival and reproduction in spite of disturbance. Stream reaches with suitable water quality and habitat must be sufficient in size to support an adequate number of potential mates while avoiding inbreeding depression. Because the Chipola slabshell has limited mobility as adults, they do not have much ability to move when conditions are unfavorable, so populations are vulnerable to long-lasting or repeated disturbances or stochastic events (e.g., habitat loss, changes in water quantity or quality, afforestation).

2.3 Species Level

For a species to be viable, there must be adequate redundancy (suitable number, distribution, and connectivity to allow the species to withstand catastrophic events) and representation (genetic and environmental diversity to allow the species to adapt to changing environmental conditions). Redundancy relates to spreading risk among populations, and thus, is assessed by characterizing the number of resilient populations across a species' range. Redundancy improves with increasing numbers of populations (natural or reintroduced) and connectivity (either natural or human-facilitated). Increased distribution across the range of the species allows connected populations to "rescue" each other after catastrophes. The more resilient populations the species has, distributed over a larger area, the better the chances that the species can withstand catastrophic events. A catastrophic event is defined here as a rare, destructive event or episode involving multiple populations and occurring suddenly. Representation improves with the persistence of populations spread across the range of genetic and/or ecological diversity within the species. Long-term viability will require resilient populations to persist into the future; for the Chipola slabshell, this will mean maintaining high quality stream habitat and water quality to be protective of aquatic life.

Table 2-1. General life history and resource needs of the Chipola slabshell.

Life Stage	Resources and/or circumstances needed for INDIVIDUALS to complete each life stage	Resource Function (BFSD*)	Information Source
Fertilized Eggs - early spring	• Clear, flowing water • Sexually mature males upstream from sexually mature females • Appropriate spawning temperatures • Presence of gravid females	B	- Berg et al. 2008, p.397 - Haag 2012
Glochidia - late spring to early summer	• Clear, flowing water • Just enough flow to attract drift feeding minnows • Presence of host fish for attachment	B, D	-Priester 2008 - Haag 2012
Juveniles - excystment from host fish to ~35 mm shell length	• Clear, flowing water • Host fish dispersal • Appropriate interstitial chemistry - Low salinity (~0.9ppt) - Low ammonia (~0.7 mg/L) - Low levels of copper and other contaminants - Dissolved oxygen >1.3mg/L • Appropriate substrate for settlement • Adequate food availability	F, S	- Dimmock and Wright 1993 - Sparks and Strayer 1998, p.132 - Augspurger et al. 2003, p.2574 - Augspurger et al. 2007, p.2025 - Strayer and Malcom 2012
Adult - >35 mm shell length	• Clear, flowing water • Appropriate substrate (silt-free gravel and stable, coarse sand • Adequate food availability (phytoplankton and detritus) • High Dissolved oxygen (> 3mg/L) • Water temperature <35ºC	F, S	- Yeager et al. 1994, p.221 - Nichols and Garling 2000, p.881 - Chen et al. 2001, p.214 - Spooner and Vaughn 2008, pp.308,315

* B=breeding; F=feeding; S=sheltering; D=dispersal

CHAPTER 3 – INFLUENCES ON VIABILITY

BACKGROUND

In this section, we describe the influences on the needs and viability of the Chipola slabshell, including both positive and negative influences on the viability of the species. The principal listing criteria for the Chipola slabshell was related to increased erosion and turbidity from habitat modification (63 FR 12664). Habitat modification has occurred through impoundments and land use change. Reducing threats to water quality and quantity must also continue to be addressed and managed in order to maintain a resilient population; therefore water contaminants are also considered, and linked to land use. While the availability of suitable substrate is an important habitat factor, these data are not available for most Chipola slabshell records. However, characterization of mussel habitat availability has been initiated in at least a portion of the Chipola slabshell range (Kaesar et al. 2019) and could inform future iterations of this SSA. The potential impacts of climate change (e.g., drought) are discussed and incorporated into future projections. The potential influence of invasive species is discussed but not considered a threat at this time. Diseases and predation of freshwater mussels remain largely unstudied and are not considered threats to the Chipola slabshell. The species and its habitats are not known to be targeted for significant scientific or educational collections, and the Chipola slabshell is not harvested for consumption and is not a commercially viable species. The positive influences of conservation include regulations, best management practices, streambank restoration projects, and the protection of land. In general, the most relevant factors are discussed here (Figure 3-1).

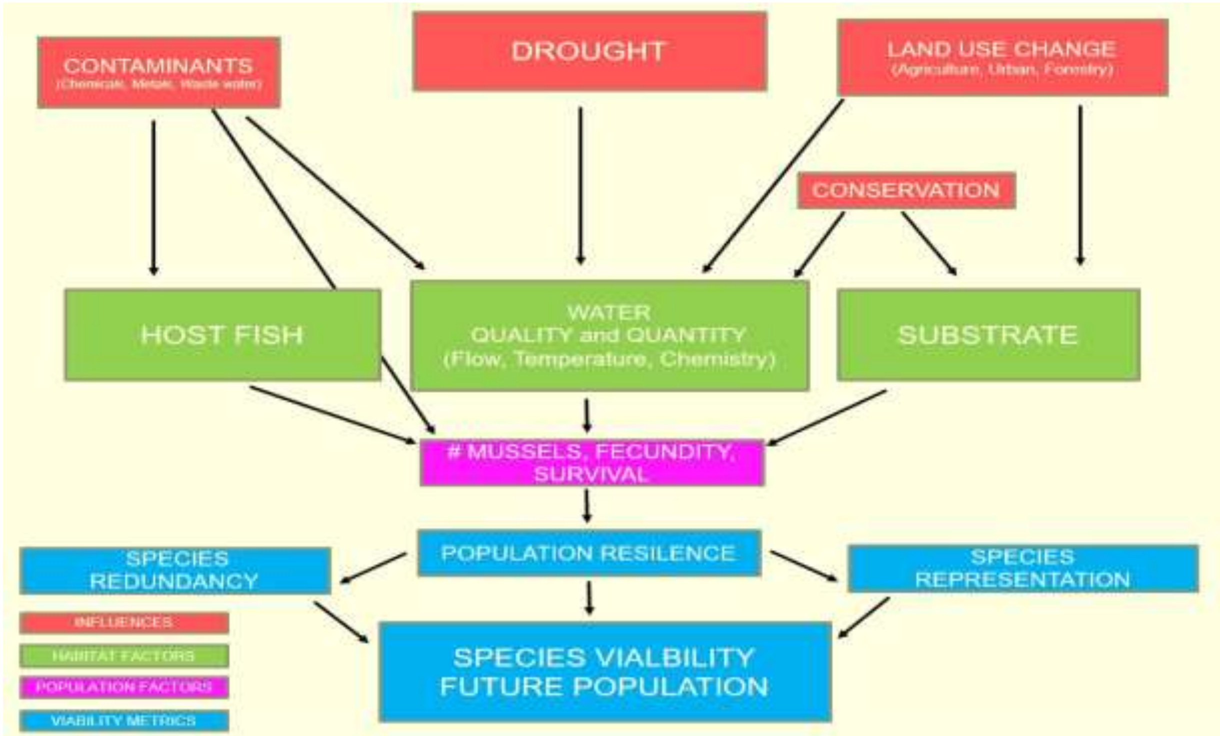


Figure 3-1. Influence diagram illustrating relationships between habitat and population factors, influences on these factors, and species viability

3.1 Habitat Destruction and Modification

Influences on the viability of the Chipola slabshell that result in the destruction or modification of the habitat include land use change (e.g., urbanization) and associated contamination or pollution (e.g., wastewater). These influences often result in impacts to habitat factors such as water quality (e.g., chemistry) and water quantity (e.g., flow). In the following sections, we discuss land use changes according to their impacts on habitat factors (water quality, stream sediment and flow).

3.1.2 Water Quality

Impoundments

Impoundments remain within tributaries of the Chipola River, but the mainstem which contains the majority of Chipola slabshell critical habitat is unobstructed. The mainstem of the Chipola River formerly contained one impoundment, the Dead Lake Dam. A 240-m sheetpile coffer dam was installed across a narrowing of the Chipola River near Wewahitchka, Florida in 1960. The primary purpose of the dam was to maintain the highest water level possible during drought conditions but also allow for some fluctuation (Hill et al. 1994, p. 512). Dams can seriously alter downstream water quality and riverine habitat (Allan and Flecker 1993, p. 36; Ligon et al. 1995, p. 190; Collier et al. 1996, entire), and adversely affect tailwater mussel populations (Cahn 1936, p.1; Ahlstedt 1983, p. 45; Layzer et al. 1993, p.66; Vaughn and Taylor 1999, p. 915). Extreme daily discharge fluctuations, bank sloughing, seasonal oxygen deficiencies, coldwater releases, turbulence, high silt loads, and altered host fish distribution have contributed to limited mussel recruitment and skewed demographics in other species (Sickel 1982, pp. 13 -14; Ahlstedt 1983, pp.45, 50; Layzer et al. 1993, pp. 68 – 69). The Dead Lake Dam was removed in 1987, with the final obstructions to natural flow in the channel removed in 1989 (Hill et al. 1994, p. 513). Oxygen stratification was completely eliminated with the removal of the dam. Oxygen levels in Dead Lake following dam removal were typically ample (8.0 – 8.5 mg/ liter) except during flood conditions when they dropped below 5 mg/liter (Hill et al. 1994, pp. 515, 518). When discharge from the Apalachicola River exceeds outflow from Dead Lake, decreased flows occur in the lake and dissolved oxygen drops, likely associated with decomposition of accumulated organic matter (Hill et al. 1994, p. 521).

Agriculture

Water pollutants associated with agricultural activity may adversely affect mussels. Additional nutrients often arrive in water bodies via runoff or by leaching into groundwater following the application of fertilizers. Excessive nutrients in the form of nitrogen or phosphorus promote the growth of filamentous algae in streams, which may render substrates unsuitable for mussels of all life stages and degrade water quality by consuming oxygen during night-time respiration and during decay to levels that mussels cannot tolerate. Stream ecosystems are impacted when nutrients are added at concentrations that cannot be assimilated. In addition, several studies have described adverse effects of pesticides on mussels (Fuller 1974, p. 215-257; Havlik and Marking 1987, p. 13; Moulton et al. 1996, p. 131, Chmist et al. 2019, p. 439). Commonly used pesticides were cited as the likely cause of a mussel die-off in a North Carolina stream, one of the first such documented acute poisonings (Fleming et al. 1995, p. 877-879).

Wastewater and its pollutants can alter stream water quality in a variety of ways. Ammonia is associated with nitrogenous fertilizers, wastewater from animal feedlots (e.g. livestock waste), and the effluents of older municipal wastewater treatment plants. Waste compounds such as ammonia cause a shift in glucose metabolism (Chetty and Indira 1995, p. 84) and alters the utilization of lipids, phospholipids, and cholesterol (Chetty and Indira 1994, p. 693). The bacteria and protozoans associated with wastewater discharges may adversely affect mussel reproduction. Glochidia are vulnerable to attack by bacteria and protozoans before and after they are released from the adult female mussel (Fuller 1974, p. 219; Goudreau et al. 1993, p. 221). Arsenic trioxide, which is used in the poultry industry as a feed additive, is lethal to adult mussels at concentrations of 16.0 parts per million (ppm), and ammonia is lethal at concentrations of 5.0 ppm (Havlik and Marking 1987, p. 3, 13). In streams, ammonia may occur at highest concentrations in substrate interstitial spaces where juvenile mussels live and feed (Whiteman et al. 1996, p. 794; Hickey and Martin 1999, p. 38; Augspurger et al. 2003, p. 2569-2575). Ammonia is lethal to juveniles at concentrations as low as 0.7 ppm total ammonia nitrogen, normalized to pH 8, and lethal to glochidia at concentrations as low as 2.4 ppm (Augspurger et al. 2003, p. 2569 - 2575).

Urbanization

While nitrogen from wastewater inputs originating from septic and sewer sources are also associated with urban centers, other forms of pollution are unique to these areas. Changes in land use and population present potential water resource challenges, including stormwater runoff and nonpoint source pollution (NWFMD 2018a, p.3). Various nonpoint source pollution that may be associated with urbanization can degrade water and substrate quality, adversely affecting mussel populations (Horne and McIntosh 1979, p. entire; Havlik and Marking 1987, p. 1–20). Naimo (1995, p. 341) suggested that chronic, low-level contamination of streams may explain the widespread decreases in mussel density and diversity. Mussels appear to be among the organisms most sensitive to heavy metals, several of which are lethal at relatively low levels (Havlik and Marking 1987, p. 3). Toxicity levels for Chipola slabshell are not known at this time, but generalizations can be made. Cadmium appears to be the most toxic for mussels (Havlik and Marking 1987, p. 3), although copper, mercury, chromium, and zinc may also impair physiological processes (Naimo 1995, p. 353–355). Highly acidic pollutants such as metals may contribute to mussel mortality by dissolving shells. Low levels of some metals may inhibit glochidial attachment. Mussel recruitment may be reduced in habitats with low but chronic heavy metal and other toxicant inputs (Yeager et al. 1994, p. 221; Naimo 1995, p. 341). Adults of some mussel species may tolerate short-term exposure to various contaminants by closing their valves, with juveniles and glochidia appear more sensitive than adults to heavy metals (Keller 1993, p. 701).

An assessment of sediment chemistry (contaminant residues in the sediment) in the Chipola River Basin and an examination chronic exposure was completed by The Service in 2007. Water quality on the Chipola River was unremarkable, with no violation of the State of Florida or State of Alabama water quality standards (Hemming et al. 2007, p. 21). However, survival of *Hyalella azteca* (indicator of toxicity for aquatic life) was reduced following exposure to sediment pore water in four of eight samples; elevated ammonia concentrations were detected, though these levels were within acceptable limits (Hemming et al. 2007, p. 29). Characteristics of solid-phase sediments were also within acceptable ranges, except that the ratio of simultaneous extracted metal (SEM) to acid volatile sulfide (AVS) exceeded the threshold value of 1 in two samples. SEM/AVS ratios greater than 1 suggest that the metal concentrations in the sediments exceed the sulfides and may be biologically available to cause toxicity (Di Toro et al. 1992, p. 100). The SEM/AVS ratios and metal concentrations of sediments collected from the Chipola River are included in Appendix C. Concentrations of As, Cu, Ni, Pb, and Zn were elevated some samples, but were not in exceedance of standards. The total concentrations of these trace elements could contribute to a reduction in overall habitat quality at those sites where they are elevated, however there were no statistically significant correlations between trace element concentrations and test metrics (*H. azteca* survival or growth; Hemming et al. 2007, p. 33).

Forestry

While forestry practices may have impacted water quality in the past, these practices have largely been phased out of use. Streams that lose vegetated riparian buffers suffer a loss in the natural ability to filter sediment, debris, and pollutants. When trees are removed from alongside streams, the more open areas are more visible and provide easier access to the channel for humans and animals. The loss of trees from the riparian area along streams exposes more of the surface water to direct sunlight, potentially leading to an increase in algal blooms and water temperature over time. Florida's Silviculture Best Management Practices (BMP) program originated in 1979 in an effort to reduce these impacts and is discussed further in Section 4.6, Conservation.

3.1.3 Stream Sediment and Flow

Sedimentation is one of the most significant pollution problems for aquatic organisms (Williams and Butler 1994, p. 55), and has been determined to be a major factor in mussel declines (Ellis 1936, pp. 39-40). Unstable channels do not favor mussels in part because adults and juveniles are relatively sedentary animals. They are unable to move quickly or across great distances from unsuitable to suitable microhabitats on and in the stream bed. There are direct adverse effects to mussels in aggrading (filling) and degrading (scouring) channels. In degrading channels, mussels lose the substrate sediment in which they anchor themselves against the current (Vannote and Minshall 1982, p. 4106; Kanehl and Lyons 1992, p. 7; Hartfield 1993, p. 133; Brim Box and Mossa 1999, p. 99–117). In aggrading channels with actively eroding stream banks, excess sediment fouls the gills of mussels, which reduces feeding and respiratory efficiency, disrupts metabolic processes, reduces growth rates, and physically smothers mussels (Ellis 1936, p. 39; Vannote and Minshall 1982, p. 4105–4106; Aldridge et al. 1987, p. 18). The Chipola slabshell attracts host fishes with visual cues, luring fish into perceiving that their glochidia are prey items. Such a reproductive strategy depends on clear water during the critical time of the year when mussels are releasing their glochidia (Hartfield and Hartfield 1996, pp. 372 - 374), and turbidity is a limiting factor impeding sight-feeding fishes (63 FR 12664). Channel instability also indirectly affects mussels and their fish hosts in several ways. Channels becoming wider and shallower via bank erosion develop more extreme daily and seasonal temperature regimes, which affects dissolved oxygen levels and many other temperature-regulated physical and biological processes. Shallow water increases the likelihood of predation, and erosion decreases habitat complexity and fish abundance leading to lower mussel recruitment (63 FR 12664).

Flow impacts are varied between low-flow and high-flow conditions. When water flows decrease, the concentration of water pollutants increases, thus increasing the adverse effects that can negatively impact the Chipola slabshell. High flow volumes can be both beneficial and harmful. Floods can help remove accumulated silt deposits, algal growth and harmful organic material from sediments, improving habitat for juvenile Chipola slabshell. However, floods are often associated with habitat destruction and direct mortality, both to juveniles and adults that are stranded in unsuitable habitat (72 FR 64286). It is thought that mussel beds often occur in flow refugia where shear stresses during moderately frequent floods (every 3- 30 years) do not displace freshwater mussels or their sediment beds (Strayer 1999, p. 475). It is likely that large woody debris helps to stabilize sediments in the Coastal Plain ecoregion where Chipola slabshell occur (Metcalf and Morris, p. 4 - 5). Mussel foot presence, mussel length, burial depth, and shell curvature were also factors that limited displacement, with shell orientation to flow not significantly lowering entrainment velocity (Thompson et al. 2016, pp. 1184 – 1185). Generally speaking, Chipola slabshell which live in habitats with large woody debris are expected to be the most secure during high flows.

A water and sediment quality survey of threatened and endangered freshwater mussel habitat in the Chipola River Basin, Florida contained conflicting results (Hemming et al. 2007). The highest risk score of six included pore-water toxicity, porewater metals, altered sediment chemistry, and elevated porewater ammonia (Figure 3-2). The largest driving factor may be elevated metals in the sediment pore-water, where juvenile mussels tend to feed. Although these factors may pose risk to the natural life history of freshwater mussels, related factors such as ambient water quality, whole sediment metals, and in-situ benthic macroinvertebrate communities did not show agreement with the elevated risk assessment at those sites. The elevated risk areas did not correspond to an apparent decrease in species richness (number of federally listed threatened or endangered species) of imperiled taxa. It should be noted that 2006 was a drought year, and these samples represent low-flow conditions.

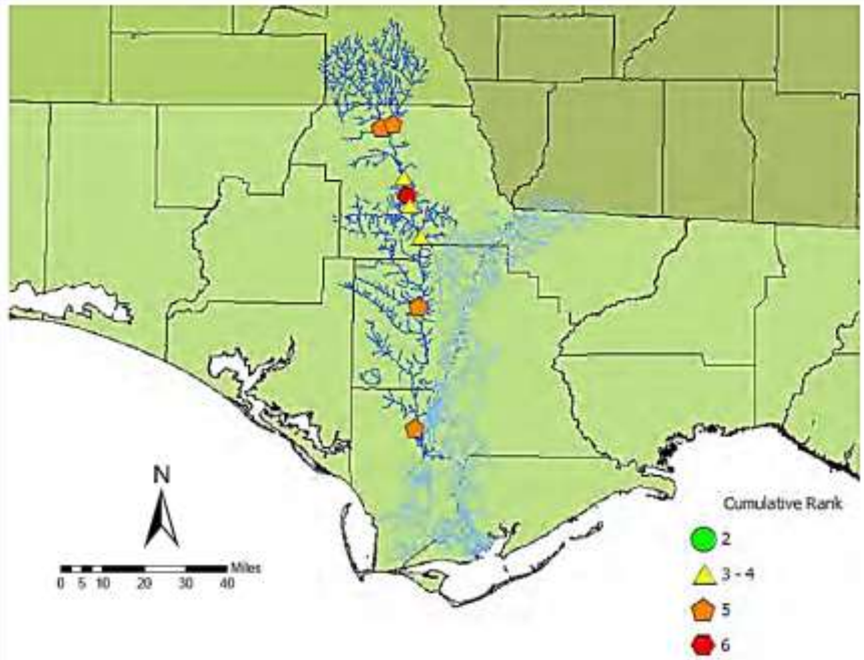


Figure 3-2. Cumulative risk score estimated for freshwater mussel species in the Chipola River, Florida (Hemming 2007, p. 48). Water quality standards violations, toxicity test differences from controls, exceeded sediment analyte guidelines, elevated pore-water contaminants, or abnormal in-situ benthic macroinvertebrate assemblages each represented one risk point, and points were summed for each incidence of each parameter by site.

Impoundments

Although the Dead Lake Dam was removed in 1987, some effects of past impoundment remain. By stalling water that would otherwise move, impoundments disrupt the many ecological processes driven by the variable flow of water, sediment, nutrient, and energy, as well as, increasing depth and sediment deposition (Williams et al. 1992, p.7; Ligon et al. 1995, p.188, Sparks 1995 pp. 172 -173). Impoundments result in the elimination of riffle and shoal habitats and subsequent loss of mussel resources (van der Schalie 1938, p.57; Scruggs 1960, p. 39; Stansbery 1970, p. 20; Layzer et al. 1993, p.69; Lydeard and Mayden 1995, p.804; Sickel and Chandler 1996, p. 38 - 45; Watters 1996, p.83). Most riverine species are unable to successfully reproduce and recruit under impounded conditions (Fuller 1974, p. 247; Neves et al. 1997, pp. 63 - 64). When dammed, impacts on stream biota include thermal alterations, and a variety of changes in channel characteristics, habitat availability, and flow regime (Allan and Flecker 1993, p. 36). Habitat alterations result in fish community shifts that favor colonization by fewer native and more nonindigenous mussel species. Channel instability and the redistribution of accumulation of sediments from the Dead Lake dam likely continues to have negative effects on aquatic life within the immediate area of the former impoundment.

Removal of the Dead Lake Dam permitted the return of connectivity and natural flow conditions, but the local sediment and detritus load is likely still high. The following description of the condition of Dead Lake following dam removal is from Hill et al. 1994 (p. 515, 518, 521 - 522). Even with the accumulated detritus, the species richness of fish almost doubled after the dam was removed, with anadromous fish able to travel through the lake to spawn or seek critical thermal refugia in the upper Chipola River. The benefits of dam removal from Dead Lake were associated with periodic low water levels that facilitated habitat improvements for aquatic life such as substrate compaction and stability, and oxidation of bottom sediments. Some turbidity remained in Dead Lake, with submerged native vegetation returning only to shallower and less turbid major tributaries. Sustained improvement in Dead Lake habitat may require successive annual summer low water. Very high flood waters (>500-yr flood) could help to remove 27 years of accumulated detritus in areas not exposed by extreme low water. Channel instability has been reported in the Chipola River within the Dead Lake HUC 10 from river mile (RM) 40 to 50 which spans Dead Lake. This instability may have been particularly pronounced during drought conditions in summer 2006 causing high local mussel mortality; the reach between RM 40 and 50 is also believed to be susceptible to a large amount of sediment redistribution following high flow events (USFWS 2007, p. 19). Dead Lake itself currently provides habitat only for silt tolerant species (USFWS 2003, p. 32).

Water management in the ACF system affects the waters of the Apalachicola, Chipola Cut, and lower Chipola where Chipola slabshell occur. As part of the Endangered Species Act consultation process, the U.S. Fish & Wildlife Service provided a biological opinion (BO) regarding the U.S. Army Corps of Engineers' (USACE) *Update of the Water Control Manual (WCM) for the Apalachicola-Chattahoochee-Flint River Basin (ACF) in Alabama, Florida, and Georgia*. The action proposed by the USACE pertains to the operation of its 5 federal facilities (dams), individually and in concert, under the Water Control Manual (WCM) (Figure 3-3). The proposed action is implemented through releases from Woodruff Dam, which affects species and habitat features from immediately below the dam to as far as 100 miles (160 km) downstream (USFWS 2016b, p. 18, 139). About 14% of the currently occupied range of the Chipola slabshell area (13.8 river miles, or 22 km) falls within the action area of this consultation. The WCM incorporates actions for fish and wildlife conservation, including actions for federally-listed mussels. These are outlined in the WCM (p. 7-10 – 7-15) and include providing minimum discharge (cfs) during drought operations and maximum fall rate to minimize stranding of mussels as flow from JWLD declines. Additionally, the BO requires USACE to incorporate adaptive management of operations within the constraints and limited flexibilities of the WCM to avoid and/or minimize incidental take of federally listed species, including Chipola Slabshell, in the Apalachicola, Chipola Cut and lower Chipola River. The USACE is implementing both Incidental Take and Adaptive Management monitoring plans as part of this process.

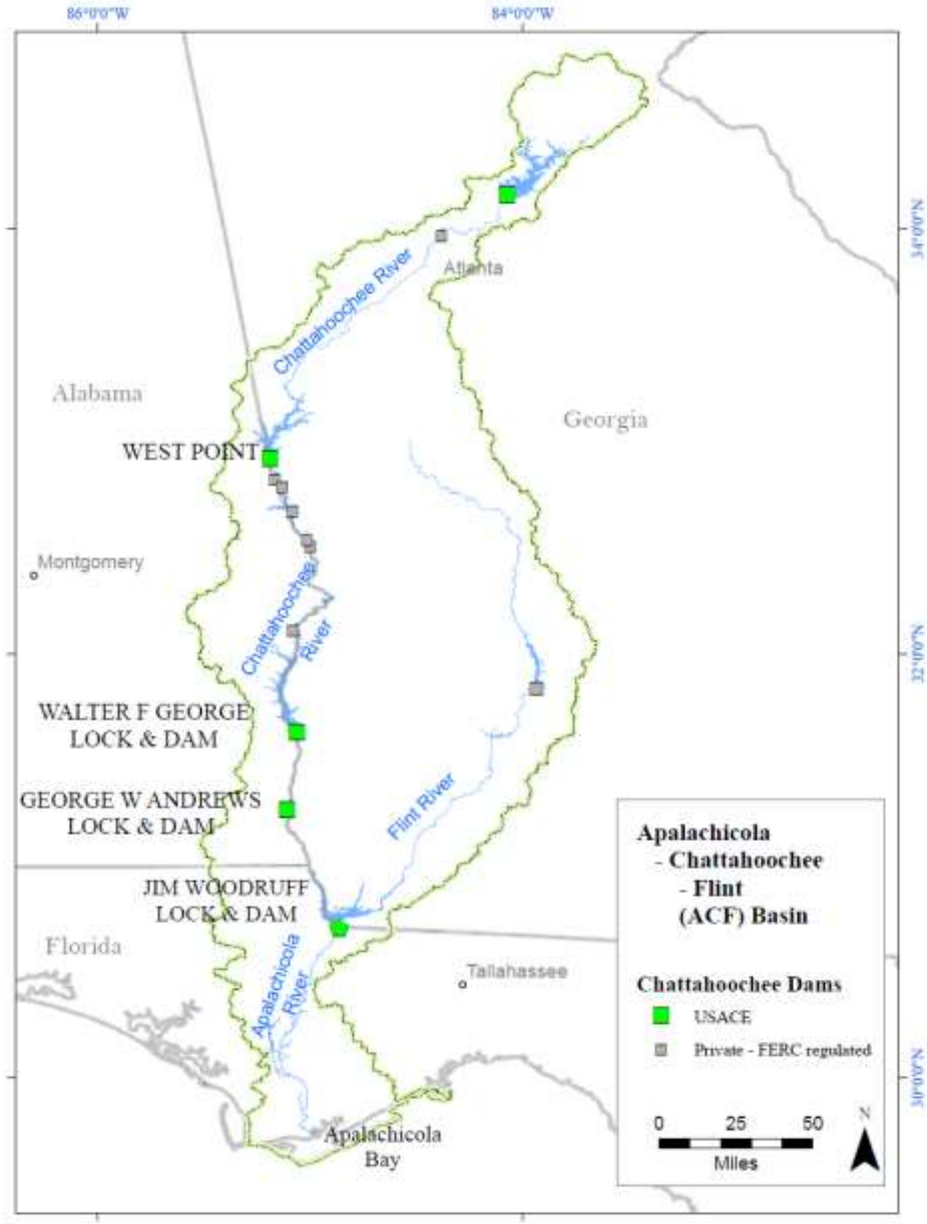


Figure 3-3. Dams within the ACF Basin (USFWS 2016b, p. 18). Both federal and private dams are indicated. The Jim Woodruff Lock and Dam is the closest impoundment to the Chipola slabshell population.

Most of the Chipola slabshell range is in the Chipola River upstream of the WCM action area and is unaffected by alterations to the flow regime, while affected portions of the range are not appreciably altered in their conservation capacity. During the summer of 2006, fall of 2010, and from 2013-2015 during USACE take monitoring, listed mussels were found exposed and stranded at elevations up to approximately 10,000 cfs. No Chipola slabshell mortality was documented during these flows, but there has been a cumulative take estimate of 24 Chipola slabshell under USACE take monitoring (USFWS 2016b, p. 188). The Service determined that the WCM would have a negative, but not appreciable, impact on the survival and recovery of the Chipola slabshell due to mortality and other adverse effects if flows are reduced to 4,500 cfs, or if additional recolonization and subsequent mortality occurs at flows above 5,000 cfs. Further, the WCM would have a negative, but not appreciable, impact on the survival and recovery of the Chipola slabshell due to reduced recruitment if flows inundate the floodplain for less than 30 consecutive days between March and August. The WCM reduces the amount of floodplain habitat available to fish hosts, which likely rely upon floodplain habitats for spawning and rearing habitat. Fewer days of floodplain inundation combined with the reduction in acres of floodplain inundation is expected to result in a reduction of spawning habitat for adult host fish, reduced growth and recruitment in fish host populations, and consequently a reduction in fish hosts available for Chipola slabshell infection (USFWS 2016b, p. 190). However, the WCM is not expected to appreciably change the quantity or quality of water or fish hosts to the extent that it would appreciably diminish the habitat's capability to provide the intended conservation role at present.

Agriculture and Urbanization

Any project or event causing chronic sedimentation degrades the habitat for the Chipola slabshell over the long-term. Uncontrolled access to streams by cattle can result in destruction of riparian vegetation, bank degradation and erosion, and localized sedimentation of stream habitats as does farming to edge of waterbodies. Similarly, sedimentation is expected to occur with the establishment of residences adjacent to streams and the destruction of the vegetated berm to provide water access, as occurs along the Chipola River outside of protected areas. Unpaved roads are constructed primarily of sandy materials and are easily eroded and transported to stream corridors. Stream crossing structures (e.g., culverts, bridges, etc.) have the potential to impact mussels by restricting movement of the host fish and increasing erosion and sedimentation, which can clog the gills of mussels and alter stream morphology, which can change the flow of water and sediments (Aust et al. 2011, p. 129; Roni et al. 2002, p. 5-7; Warren and Pardew 1998, p. 642). Limestone quarries located directly adjacent to the Chipola River mainstem may result in suboptimal conditions for mussels due to increased probability of siltation and instream suspended solids during new construction or increased production, as well as from surface runoff.

Future water withdrawal needs are unlikely to impact the Chipola River. The NWFWMD released the 2018 Water Supply Assessment Update that projects the water supply and consumptive uses for Northwest Florida into the year 2040 (NWFWMD 2018c, entire). The Chipola River flows through Region IV, comprising Calhoun, Holmes, Jackson, Liberty, and Washington counties. The groundwater budget available for Region IV is approximately 1,167 mgd (million gallons per day). In 2020, the projected use is approximately 49.7 mgd and increases to 58.8 mgd in the year 2040. The potential for drought increases the water use budget to 74.5 mgd in the year 2040 and represents about a 5.3% allocation of the regional groundwater budget (NWFWMD 2018c, p. 48 - 55). Due to the water resources available and the projected allocations, the NWFWMD determined that a water supply plan was not recommended for Region IV at this time.

Forestry

Certain silvicultural activities cause erosion, riparian buffer degradation, and increased sedimentation. Forestry practices that involve the harvesting of trees up to the streambank can decrease bank stability, cause direct soil erosion into the stream, and increase runoff with resultant increases in water turbidity and scouring of the streambed (FDCAS 2008, p.3), all of which can create unsuitable or unstable habitat for mussels. Anyone who desires to conduct silviculture activities that are not in compliance with the best management plan must obtain a permit from the appropriate local, state and/or federal government agency prior to conducting the operation. In addition, the maintenance of State water quality standards is required during all silviculture operations (FDCAS 2008, p. 2). Please see Section 4.6.2 for more information regarding forestry best practices.

In 2000, a moratorium prohibiting deadhead logging in Florida was lifted, allowing loggers to retrieve deadhead logs from Florida water bodies upon authorization and according to specific legal and environmental conditions. Deadhead logs are 19th century timbers that sank while in transit and were lost to river bottoms where they were preserved by the cool water and lack of oxygen. Modern day craftsman highly regard the wood that is milled from deadhead logs, which are 10 times more valuable than conventional wood (FDEP 2019, entire). Permits are currently being issued to remove deadhead logs in the Chipola River from reaches known to support populations of at-risk mussel species (USFWS 2003, p. 89). Although no research has documented the effects of deadhead log removal on mussels and their habitat, this activity has the potential to affect their habitat and populations. Deadhead logging impacts may occur directly through disturbance of substrate or indirectly by disrupting the development of stable, fine sediment habitat around woody debris in the Chipola River (Metcalf and Morris 2014, p. 3; Kaesar et al. 2019, p. 667).

3.2 Climate Change

Climate is defined as weather conditions over multiple decades, and climate model projections are generally not designed to capture annual or even decadal variation in climate conditions. Impacts of climate changes can have direct effects or be driven by one or more factors working synergistically as indirect effects on species. These effects may be neutral, positive, or negative and they may change over time. Impacts to species from climate change can lead to changes in geographic range, species composition, and predator/prey interactions (Stys et al. 2017, p 349).

Climate change has already had observable impacts on biodiversity and ecosystems throughout the United States that are expected to continue. Many species are shifting their ranges and changes in the timing of important biological events (such as migration and reproduction) are occurring in response to climate change. Climate change is also aiding the spread of invasive species, and is recognized as a major driver of biodiversity loss and substantial ecological and economic costs globally (Stys et al. 2017, p 349; Jacques et al. 2017, p. 44).

Climate projections are used to capture long-term changes and climate models are developed by comparing current observations and historical changes. Climate models represent our understanding of historical and current climate conditions and are used to project change under future conditions. Climate models have proven remarkably accurate in simulating the climate change we have experienced to date, particularly in the past 60 years or so when we have greater confidence in observations. Today, the largest uncertainty in projecting future climate conditions is the level of greenhouse gas emissions going forward. Longer-term changes in climate will largely be determined by emissions and atmospheric concentrations of carbon dioxide and other longer-lived greenhouse gases (Jacques et al. 2017, p. 31).

In the future, changing climatic conditions may impact Chipola slabshell. The Intergovernmental Panel on Climate Change (IPCC) concluded that warming of the climate system is unequivocal (IPCC 2014, p. 2). The climate in the southeastern United States has warmed about 2 °F (1 °C) from a cool period in the 1960s and 1970s, and is expected to continue to rise (Carter et al. 2018, p. 749). Observed warming since the mid-20th century has been uneven in the Southeast region, with average daily minimum temperatures increasing three times faster than average daily maximum temperatures. The number of extreme rainfall events is increasing. Climate model simulations of future conditions project increases in both temperature and extreme precipitation

(Obeysekera et al., p. 122). Projections for future precipitation trends in the Southeast are less certain than those for temperature, but suggest that overall annual precipitation will decrease, and that tropical storms will occur less frequently, but with more force (more category 4 and 5 hurricanes) than historical averages (Carter et al. 2014, p. 398-399).

3.2.1 Flooding

Tropical storms occur across the range of Chipola slabshell, and they have become more intense during the past 20 years. The wind speeds and rainfall associated with hurricanes are likely to increase as the climate continues to warm (USEPA 2016c, p.1, USEPA 2016d, p.1). Hurricane Michael substantially impacted northwest Florida in October 2018. According to a report by the Florida Forest Service, over 2.8 million acres of forest land were damaged by storm winds. The Chipola River experienced severe impacts, where 75% of upland and bottomland trees were damaged (FFS 2018, p.1, 4 - 5). However, high woody debris loading has likely greatly contributed to the formation of stable, fine sediment habitat in the Lower Chipola River (Kaeser et al. 2019, p. 667), likely resulting in net positive effects of blowdown for Chipola slabshell assuming forest cover regenerates. The increased intensity of hurricanes as well as more frequent high-intensity precipitation events could also increase inland flooding. The precipitation received during heavy storms has increased by 27 percent in the Southeast with the trend for increasingly heavy rainfall events likely to continue into the future (USEPA 2016c, p. 2). With these heavy rainfall events comes flooding, as rivers overtop their banks more frequently, and more water accumulates in low-lying areas that drain slowly. Restoring and preserving flood protection and nutrient reduction capabilities of forested lands along the Chipola River is vital (NWFWMD 2018b, p. 6).

3.2.2 Drought

Long-term climate records suggest that decade-long “mega-droughts” have occurred periodically during the past 700 years in the southeastern US, including in the ACF (Stahle et al., 2007, p. 147). Projections for the ACF watershed indicate that future droughts are likely to be more intense (Yao and Georgakakos 2011, entire). This suggests that while the recently observed droughts in 2006-2008 and 2010-2012 were exceptional based on our recent < 100-year period of record they may not be exceptional compared to historic episodes (Pederson et al., 2012). Gibson et al. (2005) used multiple future climate scenarios, combined with increasing water demand from human users, to predict that future river discharge conditions could include lower high discharge events and lower low flow events. From the 1940s to the 1990s (the majority of the period of record for gages in the ACF), the southeastern US was in a persistent, unusually wet period compared to the previous millennium (Seager et al., 2009, p. 5043). This is the period of time during which most of the reservoir and human development has occurred in the ACF and from which flow assessments are derived. The relative infrequency of severe drought events during this period may provide unrealistic expectations for future conditions.

The duration and severity of droughts may vary within the range of Chipola slabshell. Droughts are likely to be more severe in some locations as periods without rain may be longer and very hot days will be more frequent. Dry spells are expected to be up to twenty days shorter during the cold season in the southern half of Florida, and up to twenty days longer for the same season in Alabama (Keellings and Engstrom 2019, p. 1). While more intense cold season droughts might not be as stressful for slabshell as intensification of droughts during the warm season would be, a cool season drought may limit recharge and storage of water in both natural and anthropogenic reservoirs (Engstrom and Keellings 2018, p. 261; Keellings and Engstrom 2019, p. 3). More frequent or severe droughts (USEPA 2016d, p. 2) may reduce streamflow in some areas. In Alabama, the total amount of water running off into rivers or recharging ground water is likely to decline 2.5 to 5 percent, as increased evaporation offsets the greater rainfall (USEPA 2016c, p. 2). Low flows have decreased in the Southeast US between 1940 and 2019, meaning streams are carrying less water at low-flow than historically (USEPA 2016a, p. 2). Low-flows have not gone below 200 cfs in the Chipola River in the recent past (1986 to 2019; USGS National Water Resources, 2019), but may in the future.

The Chipola River is a spring-fed river with baseflow derived principally from aquifers, and therefore is not as susceptible to drought conditions derived from changes in precipitation patterns as it is to alterations in groundwater withdrawals (See Section 4.1.3). Mussel sites in the Chipola River generally have slopes >20% which helps to limit mussel mortality to < 1% of the local population during low-flow events (USFWS 2016b, p. 125). In addition, Chipola slabshell have been found to occupy areas 1 to 2 meters below the water surface, providing a buffer against the effects of low-flow conditions (USFWS 2016b, p. 129). Even during severe drought conditions in 2007, Cowarts Creek (which joins Marshall Creek to form the Chipola River) did not exhibit signs of mussel mortality (Garner et al. 2009, p. 693). Cowarts Creek retained adequate dissolve oyxgen (6.5 mg/L (81.5% saturation)) and temperature (27 °C), though the flow was sluggish and phytoplankton seemed elevated (Garner et al. 2009, p. 688).

3.3 Invasive Species

An invasive species is not native to the ecosystem it occurs within, and causes harm to the environment, economy or human health. The Asian clam (*Corbicula fluminea*) is a freshwater bivalve that has been introduced into North America. Its prolific reproductive capability has allowed it to quickly spread its range across the continent. The species is believed to compete with native mussels for resources such as food, nutrients, and space (Kraemer 1979, p. 1092, 1094). High densities of Asian clams have been found to negatively affect the survival and growth of juvenile native mussels by disturbance and displacement of young juveniles and possibly through incidental ingestion of glochidia and newly metamorphosed individuals (Strayer 1999a, p. 82). Further, Asian clam populations can grow rapidly and are prone to rapid die-offs (Sousa et al. 2008, p. 90), which can affect native mussels when decomposition depletes the oxygen supply and produces high levels of ammonia (Strayer 1999, p. 82). Dense Asian clam populations may deplete the edible suspended particles as well as deplete the benthic food particles ingested by native juvenile mussels and starve the native bivalves (Strayer 1999a, p. 79, 83). While the possibility of Asian clams out-competing the Chipola slabshell may be a concern in the future, Asian clams have not been shown to be a factor in mussel diversity and abundance in the Chipola River Basin at present based on surveys in areas with extremely high densities (USFWS 2019). Streams with Asian clams should be monitored for the abundance of the invasive species and precautions should be taken to prevent the unintentional spread of the species as a result of human activity.

3.4 Conservation

3.4.1 Regulations

The Chipola slabshell is currently protected under the Endangered Species Act in addition to multiple regulations protecting water quality in the Chipola River. Both federal and state regulations are relevant to the maintenance of water quality where Chipola slabshell occurs. Agencies involved in implementation include The United States Environmental Protection Agency (USEPA), The Florida Department of Environmental Protection, and the Northwest Florida Water Management District (NWFWMD). The Northwest Florida Water Management District works with state and federal agencies and local governments to achieve various conservation goals. The standards of protection for the Chipola River as well as its tributaries and springs are described below.

Water quantity can become limited by agricultural, irrigation, municipal, and industrial withdrawals. Such withdrawals can be exasperated during extreme drought events and periods of low-flow. Groundwater recharge provides water to aquifers and springsheds, and alterations to groundwater removal can alter surface water flow impacting spring flow and available surface water. Florida establishes Minimum Flow Limits (MFLs) to identify the limit at which withdrawals would be significantly harmful to the water resources or ecology of an area. Water reservation is a legal mechanism in Florida that functions to set aside water from consumptive uses for the protection of fish and wildlife or public health and safety (F.S. 373.223). Water reservations and MFLs are both important tools to ensure an adequate supply of water for citizens and environment. There is no known comparable mechanism to protect flows in Alabama. Water reservations were established for the Chipola and Apalachicola rivers in 2006 (F.A.C. 40A-2.223). The magnitude, duration and frequency of observed flows are reserved, essentially in total, for the protection of fish and wildlife of the Chipola River, Apalachicola River, associated floodplains, and Apalachicola Bay. As the Chipola River is presently subject to a water reservation, it is not included in the Northwest Florida Water Management District (NWFWMD) current MFL schedule. Jackson Blue Spring in Marianna, FL, is a first magnitude spring (> 100 cfs) that flows into Spring Creek, a tributary to the Chipola River (Barrios and Chelette 2004, p. 3). Jackson Blue Spring is currently being evaluated for a MFL by the year 2022 and rule adoption in 2023 (NWFWMD 2018b, p.11).

Federal guidelines are in place to minimize alterations to flow regimes. The Service and Department of Environmental Protection (USEPA) proposed instream flow guidelines for protecting riverine ecosystems under a possible interstate water allocation formula between Alabama, Florida, and Georgia for the ACF Basin. Although the three States failed to agree upon an allocation formula and the ACF Compact authorizing their negotiations expired, the Service has applied the instream flow guidelines in consultations with federal agencies on actions affecting the species addressed in this rule. The Service-USEPA guidelines are definitions of measures of flow magnitude, duration, frequency, and seasonality that may serve as thresholds for ‘‘may affect’’ determinations for proposed federal actions that would alter a flow regime (for example, water withdrawals and dam operations). These measures include: monthly 1-day minima; annual low-flow duration; monthly average flow; annual 1-day maximum; annual high-flow duration. Thresholds for these measures are computed from long-term flow records appropriate to the proposed action, such as daily flow records from a stream gage in the action area. The guidelines do not establish a general standard or ‘‘bottom line’’ for flow regime features that are essential to the conservation of Chipola slabshell. At minimum, the Environmental Resource Permit Program within the USEPA regulates the construction, alteration, maintenance, removal, modification and operation of all activities in uplands, wetlands and all other surface waters that alter, divert and change the flow of surface waters. Both state and federal permits may be required to alter wetlands and other surface waters.

Minimum water quality standards have been set by federal agencies both through the Clean Water Act and other initiatives. The Clean Water Act is a federal law that regulates the discharge of pollutants into surface waters, including lakes, rivers, streams, wetlands, and coastal areas. USEPA and FWS and National Marine Fisheries Service (the Services) agreed to a national consultation on the CWA Section 304(a) aquatic life criteria as part of a Memorandum of

Agreement regarding interagency coordination under the CWA and the Act (66 FR 11202). In 2013, the USEPA released new ammonia criteria that included acute and chronic toxicity testing for 13 freshwater mussels, thus leading to an improved understanding of ammonia toxicity and setting a more protective ammonia criteria value for freshwater mussels (USEPA 2013). In 2016, the Florida Department of Environmental Protection (FDEP) adopted the chronic criteria for ammonia as both the acute and chronic values (1.408 mg/L), therefore improving the ammonia standard even further for the conservation of freshwater mussels statewide (USEPA 2016a).

Florida has established water classifications that promote water quality standards that are more stringent than those of the Clean Water Act. The Florida Department of Environmental Protection (FDEP) designates Outstanding Florida Waters (OFWs) under section 403.061(27), F.S. An OFW is defined by FDEP as a waterbody worthy of special protection because of its natural attributes. In general, DEP cannot issue permits for direct discharges to OFWs that would lower ambient (existing) water quality. In most cases, this deters new wastewater discharges directly into an OFW, and requires increased treatment for stormwater discharging directly into an OFW. DEP also may not issue permits for indirect discharges that would significantly degrade a nearby waterbody designated as an OFW. The majority of waterbodies and segments in the range of Chipola slabshell receive regulatory protection through designation as OFWs in addition to protections under their surface water classification as class III waterbodies (Appendix B). OFWs have even more restrictions on nitrogen contamination which uses comparisons to a water quality baseline period set in February 1978 - March 1979. The ammonia concentrations for the baseline period are low for the Chipola River; the maxima concentrations are approximately an order of magnitude less than the level (1.408 mg/L) necessary to fully protect mussels, and have remained low within the Chipola mainstem and its tributaries since (Figure 3-4; USFWS 2016a, p. 1, 3). In addition, the Florida Springs and Aquifer Protection Act of 2016 (Chapter 373, Part VIII, Florida Statutes [F.S.]) established Outstanding Florida Springs (OFSs) that require additional protections to ensure their conservation and restoration, naming Jackson Blue Spring within the Chipola River Basin an OFS in 2016 (Figure 3-5).

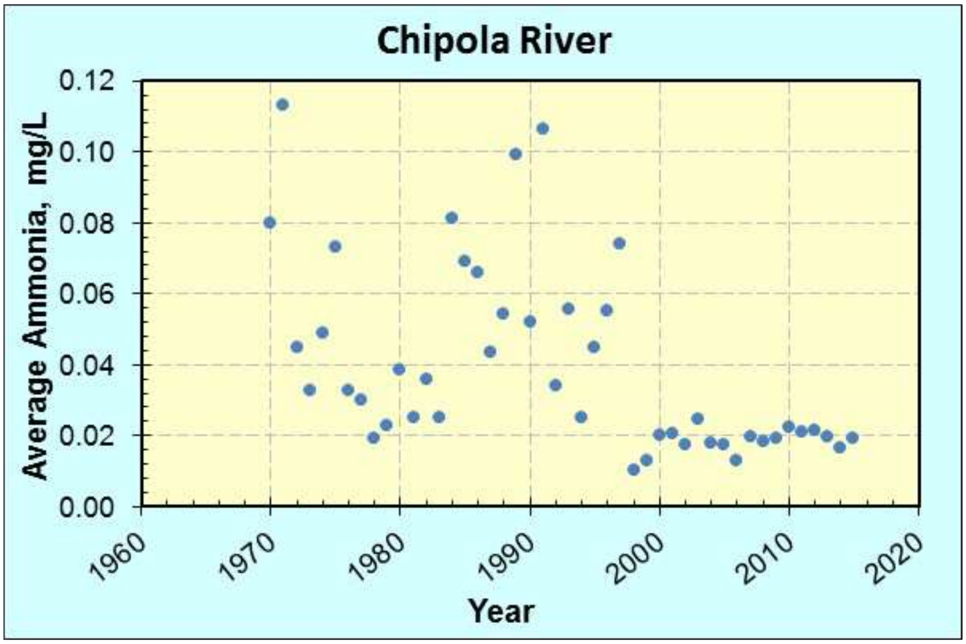


Figure 3-4. Annual average total ammonia concentrations (mg/L) for the Chipola River over the period of record (1970-2015), adapted from USFWS 2016a, p. 3.

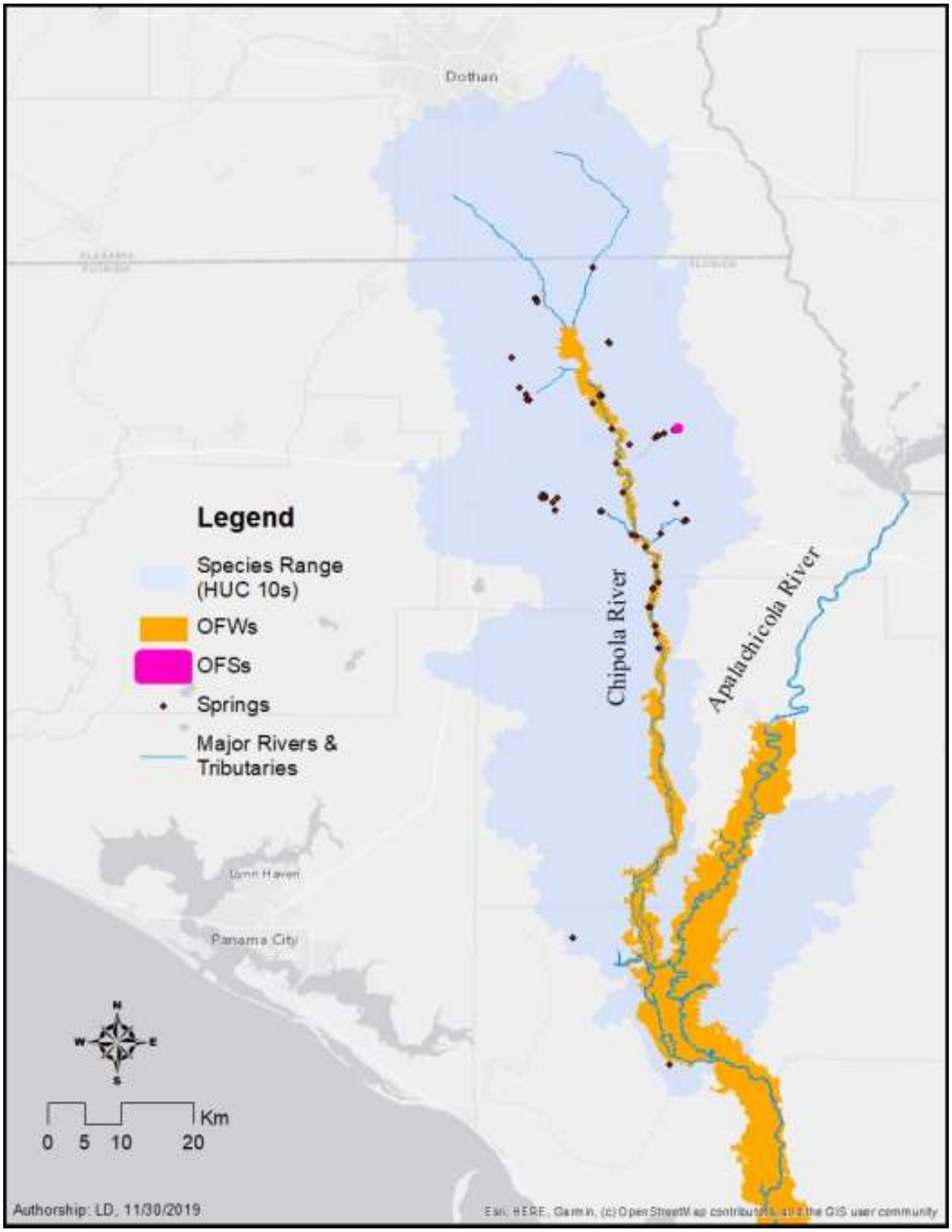


Figure 3-5. Outstanding Florida waters (OFWs) and springs (OFSs) within the range of Chipola slabshell, as defined by FDEP. Jackson Blue Spring is the only OFS within a watershed (HUC 10s) occupied by Chipola slabshell. Springs that are not OFSs are also included here for reference. Other sections of the Apalachicola River are designated as OFWs, but only OFWs at least partially within watersheds occupied by Chipola slabshell are depicted here.

Some waterbodies within the range of Chipola slabshell are listed as impaired (Figure 3-6). Section 303(d) of the Clean Water Act (33 U.S.C. 1251 et seq.) requires states to identify waters that do not fully support their designated use classification, and so are deemed impaired. The most recent assessments within the range of Chipola slabshell were completed by the Florida Department of Environmental Protection and Alabama Department of Environmental Management as of 2018. Impaired water bodies are placed on the state's 303(d) list, and a total maximum daily load (TMDL) must be developed for the pollutant of concern. A TMDL is an estimate of the total load of pollutants that a segment of water can receive without exceeding applicable water quality criteria. There are several reasons why an impaired waterbody may be delisted, including but not limited to: a subsequent assessment determining that a waterbody-parameter is no longer impaired based on current water quality standards, if there has been a TMDL completed for the verified impaired parameter or if a flaw in a previous assessment has been determined.

Impaired waterbodies within watersheds occupied by Chipola slabshell are largely impacted by fecal coliform (Table 3-1). The standards for fecal coliform (e.g., *Escherichia coli*) relate to human health and do not necessarily reflect levels that would be harmful to mussels. While some waters are impaired due to nutrients or organic enrichment, these standards are in place to protect human health (e.g., algal blooms) and do not relate directly to the potential effects of nutrients such as nitrogen on mussels. The numeric nutrient criteria (NNC) and ammonia standard in Florida reflect nutrient impact thresholds for mussels. NNC includes total nitrogen (TN) and total phosphorus (TP) for flowing freshwaters. The TN NNC threshold concentrations are 0.67 mg/L for the Chipola River (Panhandle West), which is well below the newly adopted 1.408 mg/L ammonia concentration in Florida (USFWS 2016a, p. 6). Alabama also has a nitrate/nitrite nitrogen and ammonia standard in addition to other standards that are more representative of the potential harm to mussels than the nutrient or organic enrichment standard, which are no longer used as part of the water quality assessment process (ADEM 2018, pp. 11 – 14). Many of the delisted waterbodies were previously impaired due to elevated mercury levels in fish, which is also a human-health related standard (FDEP 2013, p. ii) that does not reflect levels that would be harmful to mussels. Given the parameters listed under impairment in Table 3-1, and the establishment of TMDLs leading to delisting of waterbodies in Table 3-2, water quality within the range of Chipola slabshell is considered unimpaired in regards to freshwater mussel water quality thresholds.

Table 3-1. Verified list of impaired waters within the range of Chipola slabshell. Data includes waterbody identification number (WBID) or assessment unit ID, the county that at least a portion of the waterbody intersects, relevant parameters and thresholds, and prioritization.

State	County (ies)	WBID/ Unit ID	Water Segment Name	Parameters Assessed	Priority for TMDL Development
Florida	Jackson	51E	Chipola River	Nutrients (Algal Mats)	Medium
Florida	Jackson	52	Cowarts Creek	Fecal Coliform	Medium
Florida	Calhoun, Jackson	569	Tenmile Creek	Fecal Coliform	Low
Florida	Jackson	57	Jordan Bay Drain	Fecal Coliform	Low
Florida	Bay, Calhoun	749	Juniper Creek	Fecal Coliform	Low
Alabama	Houston	AL03130012-0101-100	Limestone Creek	Pathogens (*E. coli*)	Low
Alabama	Houston	AL03130012-0101-410	Cypress Creek	Nutrients*	Low
Alabama	Houston	AL03130012-0101-410	Cypress Creek	Organic enrichment (BOD)*	Low
Alabama	Houston	AL03130012-0202-210	Bruners Gin Creek	Pathogens (*E. coli*)	Low
Alabama	Houston	AL03130012-0203-110	Cowarts Creek	Pathogens (*E. coli*)	Low

* Assessed in 1998. All other parameters assessed within recent assessment cycle (e.g., at least once since 2009)

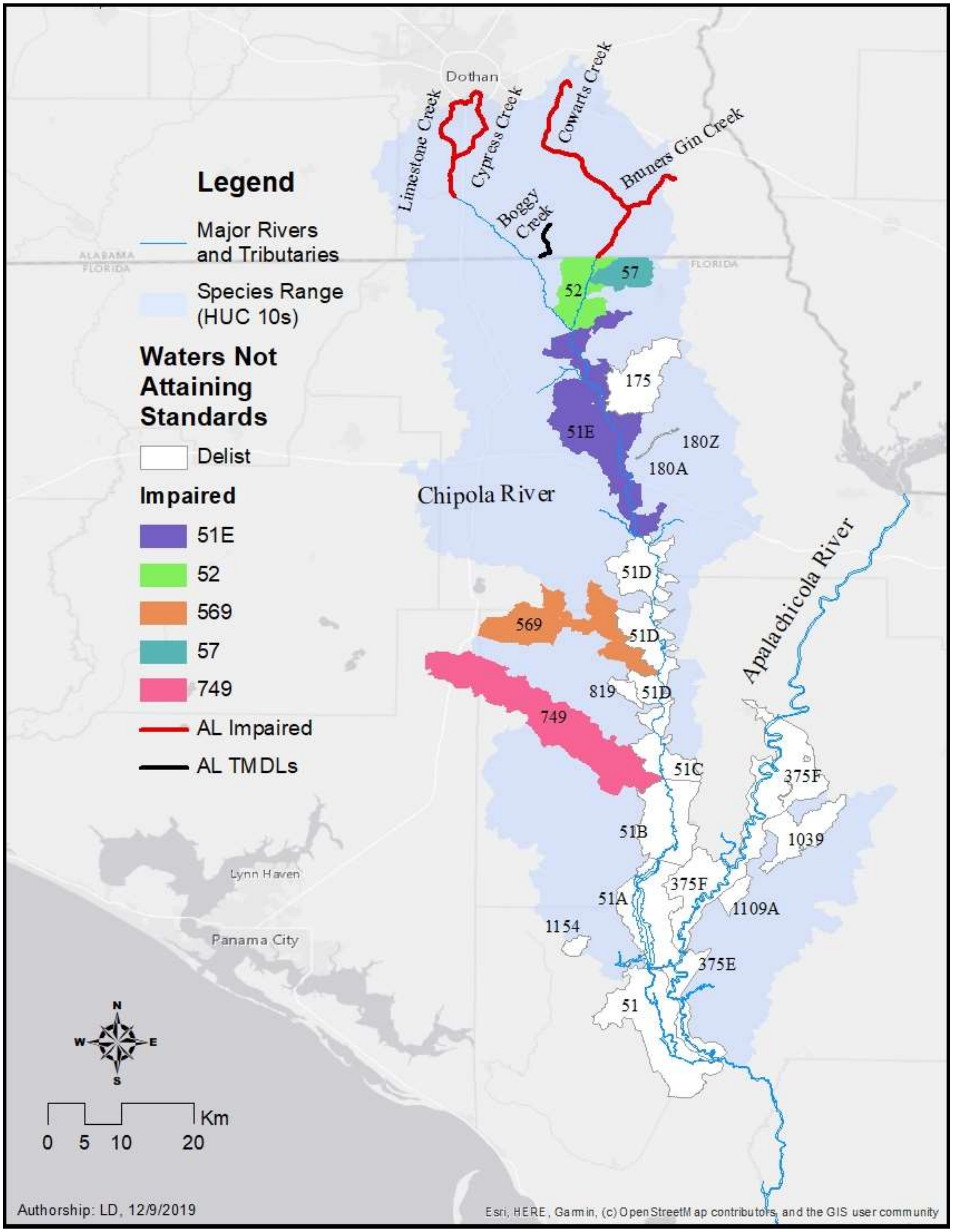


Figure 3-6. Map of waters not attaining standards within the current range of Chipola Slabshell.

Table 3-2. Impaired waters to be delisted within the range of Chipola slabshell. Data presented for these waters includes water body identification number (WBID) or assessment unit ID, the county that at least a portion of the waterbody intersects, relevant parameters, as well as the assessment category.

State	County (ies)	WBID/ Unit ID	Water Segment Name	Parameters Assessed	Integrated FINAL Assessment Category†
Florida	Liberty	1039	Little Gully Creek	Dissolved Oxygen (Percent Saturation)	4a
Florida	Liberty	1039	Little Gully Creek	Nutrients (Chlorophyll-a)	4a
Florida	Liberty	1109A	Equiloxic Creek	Dissolved Oxygen	4c
Florida	Liberty	1109A	Equaloxic Creek	Mercury (in fish tissue)	4a
Florida	Jackson	175	Muddy Branch	Dissolved Oxygen (Percent Saturation)	4d
Florida	Jackson	180A	Merritts Mill Pond	Nutrients (Algal Mats)	4a
Florida	Jackson	180Z	Jackson Blue Spring	Nutrients (Algal Mats)	4a
Florida	Gulf, Liberty	375E	Apalachicola River	Mercury (in fish tissue)	4a
Florida	Calhoun, Liberty	375F	Apalachicola River	Mercury (in fish tissue)	4a
Florida	Gulf	51	Chipola River	Mercury (in fish tissue)	4a
Florida	Calhoun, Gulf	51A	Dead Lake	Mercury (in fish tissue)	4a
Florida	Calhoun	51B	Chipola River	Mercury (in fish tissue)	4a
Florida	Calhoun	51C	Chipola River	Mercury (in fish tissue)	4a
Florida	Calhoun, Jackson	51D	Chipola River	Mercury (in fish tissue)	4a
Florida	Jackson	51E	Chipola River	Mercury (in fish tissue)	4a
Florida	Calhoun	819	Otter Creek	Fecal Coliform	4a
Alabama	Houston	AL03130012-0106-201	Boggy Creek	Organic enrichment (BOD, NBOD)	4a

† EPA's Integrated Report Category:

4a - Impaired for one or more designated uses but does not require TMDL development because a TMDL has already been completed.
4c - Impaired for one or more criteria or designated uses but does not require TMDL development because impairment is not caused by a pollutant.
4d - Waterbody indicates nonattainment of water quality standards, but the Department does not have enough information to determine a causative pollutant; or current data show a potentially adverse trend in nutrients or nutrient response variables; or there are exceedances of stream nutrient thresholds, but the Department does not have enough information to fully assess nonattainment of the stream nutrient standard.

3.4.2 Best Management Practices (BMPs)

Basin Management Action Plans (BMAPs) are the primary mechanism through which TMDLs are implemented in Florida (403.067[7], F.S.). Following the adoption of TMDLs by rule, the best course of action must be determined regarding its implementation. Depending on the pollutant(s) causing the waterbody impairment and the significance of the waterbody, a comprehensive plan may be developed to restore the waterbody. Often this is be accomplished cooperatively with stakeholders by creating a Basin Management Action Plan, referred to as the BMAP. A single BMAP may provide the conceptual plan for the restoration of one or many impaired waterbodies. Given the high water quality standards set for outstanding Florida springs (OFSs) and waterbodies (OFWs), BMAPs are often required to achieve TMDLs for these waters. A BMAP was adopted in 2016 to implement a nutrient TMDL for the Jackson Blue Spring and Merritts Mill Pond (FDEP 2018, entire). Under the Jackson Blue Spring and Merritts Mill Pond Basin Management Action Plan, several Best Management Plans (BMPs) were adopted to improve water quality across a broad area. The BMPs and BMP manuals relevant to the Jackson Blue Spring BMAP are included in Appendix F. Several BMPS or BMP manuals are relevant for projects to reduce nitrogen inputs from agricultural sources, for example. The Basin Management Action Plan for Jackson Blue Spring includes a variety of projects to help limit nitrogen entering into groundwater (FDEP 2018, p. 45). The TMDL restoration target for the spring and pond is 0.35 mg/L of nitrate (monthly average), and it must be achieved within 20 years. BMAPs are not typically developed for bacteria-impaired waters, as fecal coliform impairments result from the cumulative effects of a multitude of potential sources, both natural and anthropogenic (FDEP 2009, p. 32). There is no BMAP for Little Gully Creek (WBID 1039), but Little Gully Creek as all other waterbodies in Table 3-1 and Table 3-2 are incorporated generally within the *Apalachicola River and Bay Surface Water Improvement and Management Plan* (NWFWMD 2017), with the aim of providing a framework for resource management, protection, and restoration using a watershed approach.

Agriculture

In the Jackson Blue Spring BMAP, agricultural sources contribute approximately 92% of the nitrogen load to groundwater (FDEP 2018c, p. 30 – 31; Figure 3-7). Farm fertilizer includes commercial inorganic fertilizer applied to row crops, field crops, pasture, and hay fields. Additional agricultural nitrogen inputs include livestock waste. With crop-specific BMP enrollment or monitoring for farm fertilizer areas, an estimated 93,888 lb-N/yr reduction to groundwater can be achieved. In addition to groundwater reductions from owner-implemented BMPs on fertilized lands, an additional 5,400 lb-N/yr in reductions are estimated from specific stakeholder projects on fertilized lands. This number could increase as more data are collected on the impact of BMPs to groundwater. For all livestock operations, owner-implemented BMPs are expected to achieve a reduction of 5,401 lb-N/yr from owner-implemented BMPs at livestock operations. NWFWMD is also implementing projects to encourage low input agriculture and water quality improvement technologies.

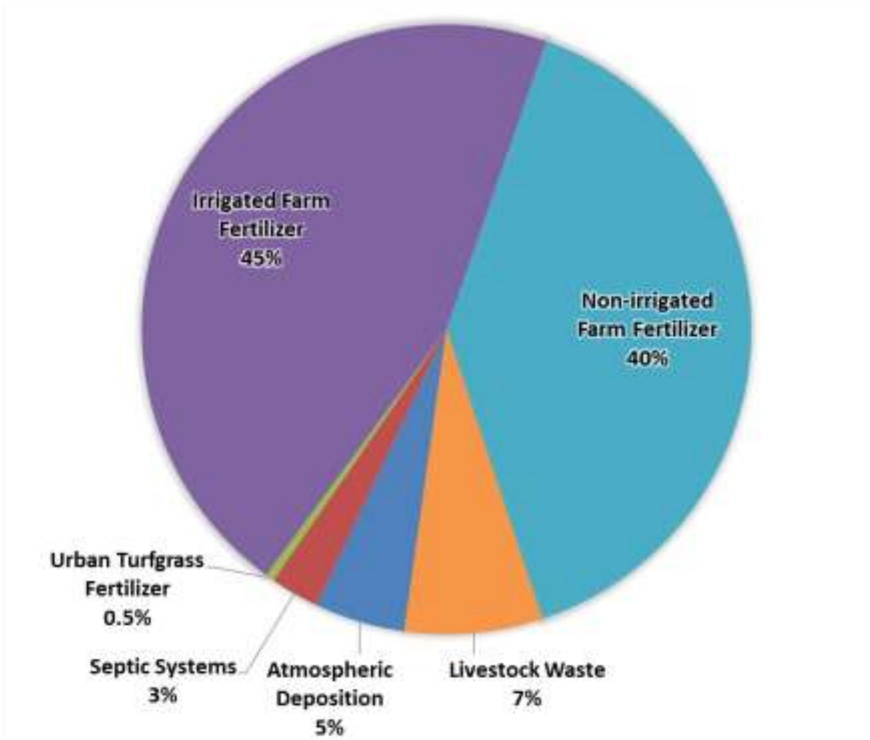


Figure 3-7. Loading to groundwater by source in the Jackson Blue Spring BMAP area (FDEP 2018c, p. 75).

Subsection 403.067, F.S., requires agricultural nonpoint sources in a BMAP area either to implement the applicable FDACS-adopted BMPs, which provides a presumption of compliance with water quality standards, or conduct water quality monitoring prescribed by DEP or NWFWMD that demonstrates compliance with water quality standards. Further, based on the Florida Springs and Aquifer Protection Act, Subsection 373.811(5), F.S., prohibits any new agricultural operations within the PFA that do not implement applicable FDACS BMPs, measures necessary to achieve pollution reduction levels established by DEP, or groundwater monitoring plans approved by a water management district or DEP. Failure to implement BMPs or conduct monitoring that demonstrates compliance with pollutant reductions may result in enforcement action by DEP (s. 403.067(7)(b), F.S.).

Forestry

Florida's Silviculture Best Management Practices (BMP) program originated in 1979. The BMPs apply to all silvicultural operations, and government approval of any variances is required. In general, clearcut harvesting is prohibited within 50 ft (15 m) of an OFW, and harvest may proceed such that 50% of a fully stocked stand is maintained in the remainder of the 200 ft (61 m) primary zone on either side of an OFW (FDACS 2008, p. 1, 4, 7). Guidelines are also provided for culvert installations related to stream crossings in order to minimize alterations to stream flow, the techniques to employ for timber harvesting, pesticide and fertilizer use, and waste disposal, among others (FDACS 2008, p. 28, 31, 34, 36). Compliance monitoring has determined a long-term average of 94% adherence to silviculture BMPs (FDACS 2008, p. 2).

An additional voluntary forestry BMP has been developed to minimize impacts to species at risk. In 2014, the Wildlife Best Management Practices (WBMP) for State Imperiled Species Program was initiated in Florida. The WBMPs were developed to enhance silviculture's contribution to the conservation and management of freshwater aquatic and terrestrial wildlife species in the state. Forest landowners who volunteer for in the WBMP Program and properly implement these practices can help minimize the loss of imperiled species in Florida. Results from compliance monitoring completed in 2017 indicate the overall WBMP compliance rate was 100%. The ownership of the monitoring sites were distributed such that 19% were located on private non-industrial forest lands, 64% on forest industry lands, and 17% on public lands (FDACS 2018, p.4).

Urbanization

Among the promising approaches for correcting current impacts and impairments from urbanized areas are actions to improve the management and treatment of domestic wastewater. There is a high concentration of septic systems within the Chipola River basin (Figure 3-8). Connecting residences and businesses in these areas to centralized wastewater treatment systems has the potential to substantially improve wastewater treatment and reduce loading of nutrients and other pollutants to these waterbodies and to downstream receiving waters (NWFWMD 2017, p. 35). Otherwise, voluntary onsite sewage treatment and disposal systems conversions or enhancements could be effective at limiting nitrogen inputs to groundwater where wastewater treatment facilities are not feasible. The Florida Department of Environmental Protection (FDEP) has created the Septic Upgrade Incentive Program to encourage home-owners to correct conventional septic systems through the addition of nitrogen-reducing enhancements. The program offsets the costs up upgrades and retrofits by providing certified installers and licensed plumbers with up to $10 000 after the installation of approved upgrades within eligible counties. Unfortunately, the range of Chipola slabshell does not currently overlap with the eligible counties, though it may in the future. A funding program in the Chipola River Basin would be designed to prioritize OSTDS where it is most economical and efficient to add nutrient reducing features. Under the BMAP for Jackson Blue Spring, new septic systems on lots less than one acre would be prohibited unless the system includes enhanced treatment of nitrogen or a sewer connection will be available within five years (FDEP 2018c, p. 12).

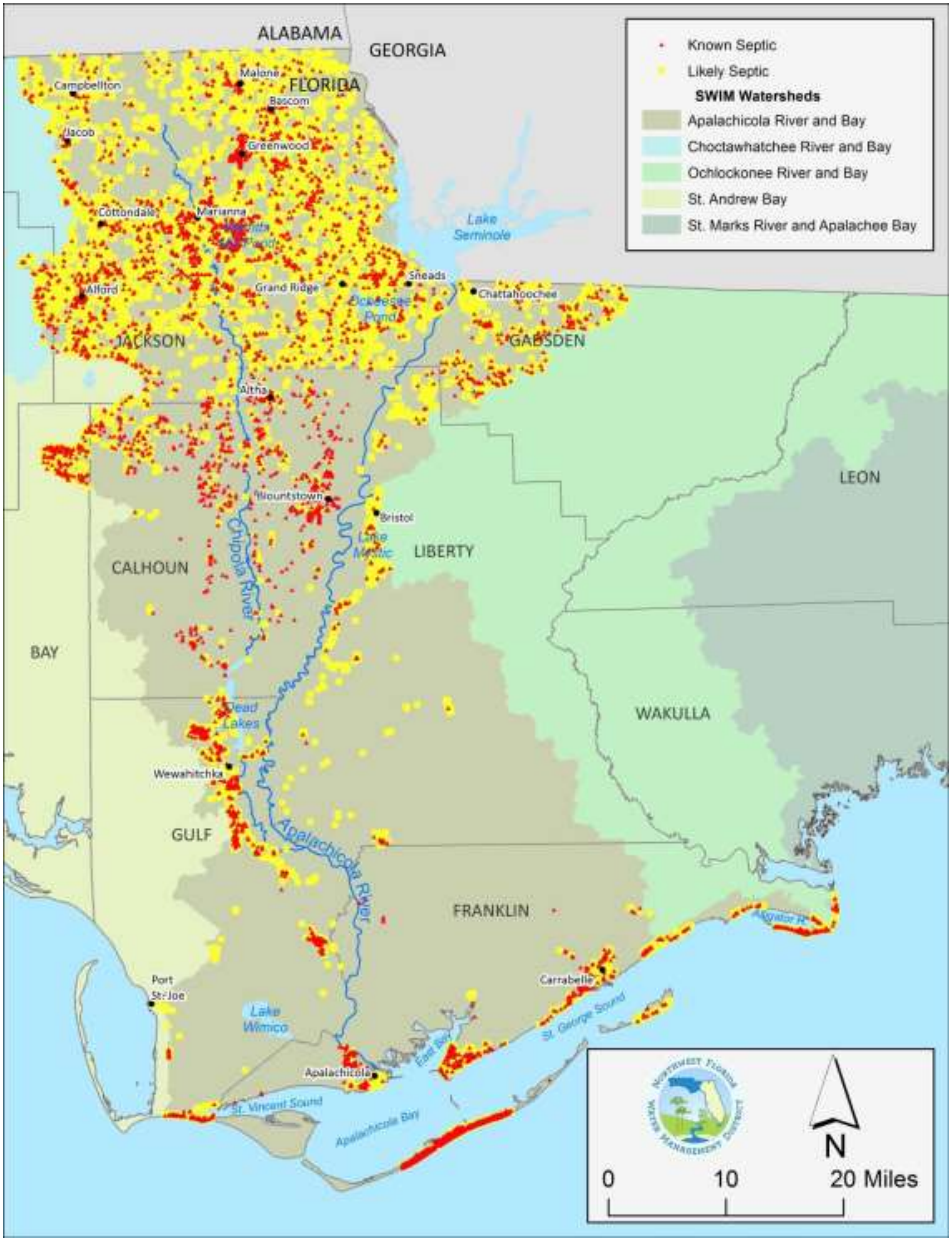


Figure 3-8. Septic Systems in the Apalachicola River and Bay Watershed, from NWFWMD 2017, p. 24.

3.4.3 Streambank Restoration

The presence of multiple at-risk species has provided the impetus for the implementation of restoration projects within the range of Chipola slabshell. There are six federally threatened and endangered mussels species that occur within the Chipola River: oval pigtoe (*Pleurobema pyriforme),* fat three-ridge (*Amblema neslerii),* Chipola slabshell, Gulf moccasinshell (*Medionidus penicillatus),* purple bankclimber (*Elliptoideus sloatianus)*, and shinyrayed pocketbook (*Hamiota subangulata)*. The Chipola River is also a managed resource for striped bass (*Morone saxatilis*) and the unique shoal bass (*Micropterus cataractae)* fishery. Other threatened and endangered species include: Amphibians (n =1), reptiles (n = 2), fish (n =1), birds (n = 5), mammals (n = 2), and plants (n =3). Endangered and threatened species under serious threat from habitat loss, degradation and fragmentation have been documented and a watershed based plan of action has been developed and initiated for their recovery (USFWS 2014, p. 11).

The shoal bass is recognized as an umbrella species, providing many opportunities for collaborative habitat restoration efforts that are also beneficial for Chipola slabshell. Projects in the Chipola Basin have been implemented through the Service Partners program, National Fish and Wildlife Foundation (NFWF), Southeast Aquatic Resources Partnership (SARP) and their program The National Black Bass Initiative (NBBI), and the Florida Fish and Wildlife Conservation Commission (FWC), among others. An umbrella species is selected for making conservation-related decisions, typically because protecting these species indirectly protects the many other species that make up the ecological community of its habitat (Roberge and Angelstam 2004, p. 77). These projects address specific threats identified for shoal bass and other focal aquatic species through the Service's Chipola River Watershed Threats Assessment (USFWS 2014, p. 12). Conservation actions implemented by these networks promote the restored function of spring, riparian and stream systems, and emphasize the conservation of native aquatic communities and supporting habitats.

To guide project prioritization, the Service conducted a basin threats assessment for the Chipola River and analyzed 141 unpaved road crossings, point sources, and fish passage barriers to identify and reduce sedimentation risks to aquatic life (USFWS 2011, entire; Figure 3-9). 85 crossings were eliminated from the assessment for reasons including the lack of a stream or water body to convey sediment at the crossing, the crossing functioning as a cross drain structure rather than stream crossing structure, crossings were on private lands, or the crossings' roadways were paved prior to this survey. All unpaved road-stream crossing sites in the Chipola watershed were evaluated for risks of sedimentation using the Sedimentation Risk Index (SRI), and were then ranked into narrative categories of erosion risk potential. Of those crossings scored, 1% were "excellent" and least impacted, 28% were "good," 56% were "fair," 15% were “poor.” No sites were rated as “very poor.” Ranked sites were prioritized for subsequent restoration practices, with lowest SRI scores reflecting the highest risk of erosion potential, and proximity to sites of listed species and their habitat.

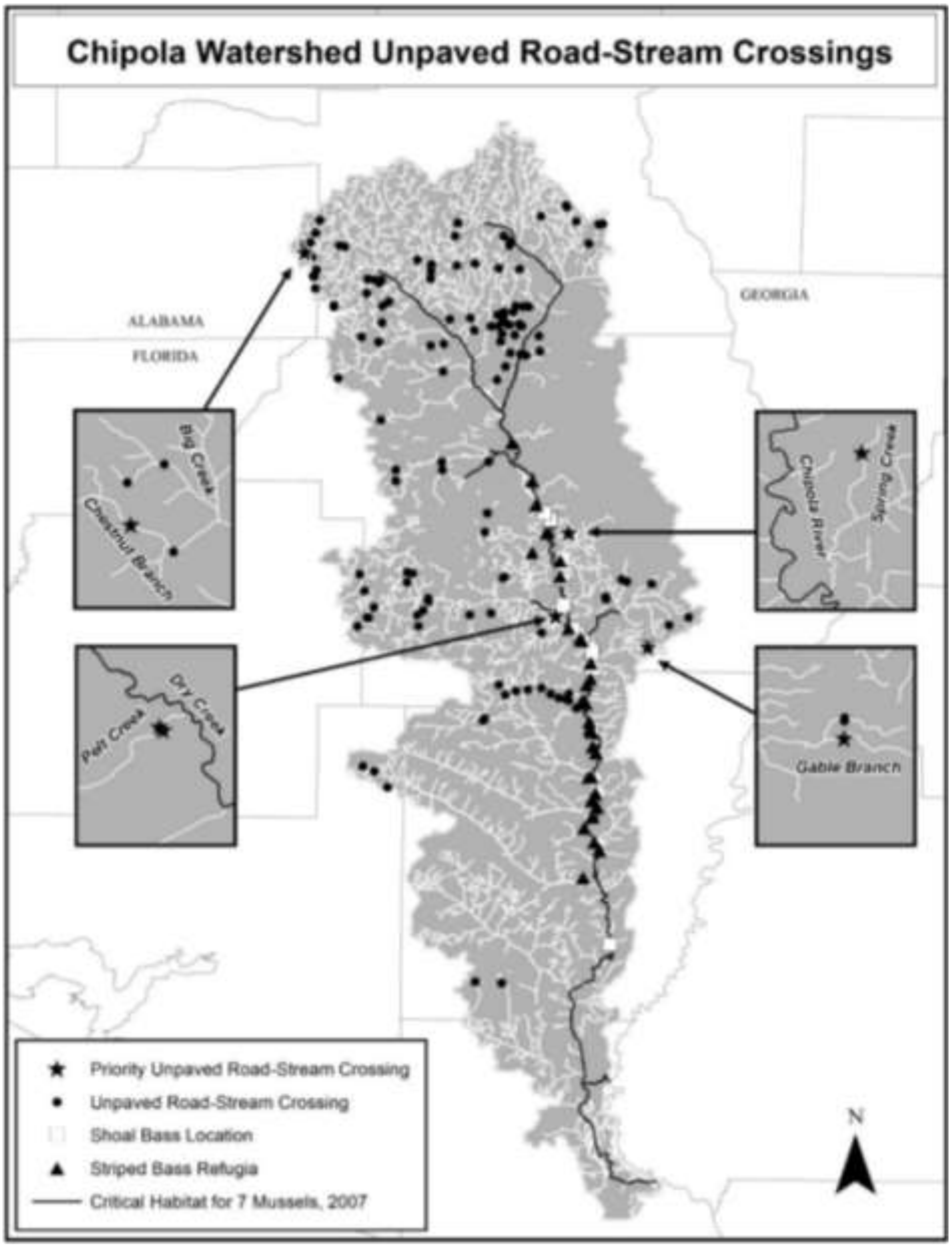


Figure 3-9. All assessed and priority road-stream crossing locations within the Chipola watershed. (USFWS 2011, p. 16).

The Service began restoration efforts on the Chipola in 2013 through a partnership with FWC. Projects were implemented at a private landowner's farm near Marianna, FL that included assistance for the purchase of fencing to exclude cattle from the riparian zones and springs, as well as providing alternative water sources cattle. Culvert replacement also occurred at this site to allow fish passage. The restoration of a channelized tributary also occurred in the same project area.

Subsequent projects have focused on several threats and unpaved stream crossings in the Alabama portion of the headwater streams of the Chipola River (Figure 3-9). In 2014-2015, three projects in collaboration with FWC funded by NFWF were initiated in Geneva County, AL. The first served to stabilize roughly 1 mile (1.6 km) of unpaved road adjacent to Chestnut Branch to reduce approximately 113.41 m^3 of annual soil discharge. A second road stabilization project at Big Creek reduced 80.0 m^3 of annual soil discharge. The third project in Geneva County erected 4,000 linear feet (1.2 km) of streambank fencing and planted trees in the riparian zone to reduce fecal coliform and sedimentation of a headwater stream that feeds into Big Creek. The Service, along with its partners, have successfully restored (>5 miles or 8 km of stream) in the Chipola Basin and continue to implement stream restoration projects (i.e., bank stabilization, solar wells, livestock exclusion fencing, riparian restoration, low-water crossings, and reshaping of spring-fed tributaries) to reduce sediment inputs.

3.4.4 Protected Lands

In total, 15,133 acres of the 800,042 total acres within the Chipola River Basin are protected, with additional protection within the Apalachicola River Basin. Protecting and restoring watershed resources is a shared responsibility on the part of numerous stakeholders, including local governments, state and federal agencies, private businesses, and the public. Federal protected lands occur within the Chipola Experimental Forest in Calhoun County. The NWFWMD owns the majority of state lands, with just over 9,000 acres in the Chipola River Basin and an additional 810 acres in conservation easements (Figure 3-10; NWFWMD 2018b, p.22). A large portion of this area was purchased using Florida Forever program funds, which also supports activities including water resource development, stormwater management projects, water body restoration, recreation facilities, public access improvements, and removing invasive plants, among others (NWFWMD 2018b, p. 1). In general, the Chipola River Basin has been identified as part of the Forest Restoration Acquisition Area within the Florida Forever 2018 Workplan, because of the heavy damaged to trees in the drainage during Hurricane Michael and the potential impacts to water quality and quantity that could occur if these areas to not return to forested land cover (NWFWMD 2018a, p. 6). Areas targeted for acquisition through Florida Forever include all lands along the Chipola River, the Spring Lake Spring Group area containing many springs and tributaries, and the area around Jackson Blue Spring due to its large contribution to groundwater in the Chipola River Basin (NWFWMD 2018b, p. 22). Other lands protected by the State of Florida include Florida Caverns State Park, and Judges Cave Wildlife and Environmental Area, and the Pittman Property (Table 3-3). The Chipola Experimental Forest is under federal protection, with the remainder of parcels managed at the local level save for one private parcel managed by The Nature Conservancy. The large majority of protected areas are adjacent to the Chipola River (12 145 acres).

The southern portion of the species range is extensively protected, while the northern extent of the range is not. Within the Apalachicola River Basin, portions of the Apalachicola National Forest (federal), Apalachicola River Water Management Area (state), Apalachicola Savannah Research Natural Area (federal), and Apalachicola River Wildlife and Environmental Area (state) provide protection for the majority of the watershed area that contains the southernmost slabshell records within the Chipola Cutoff, Lower Chipola, and the Apalachicola River. Within Alabama, no lands within the watersheds occupied by Chipola slabshell are known to be protected by federal, state or private agencies.

Table 3-3. Protected lands within the Chipola River Basin, adapted from FDEP 2018, p. 35 and NWFWMD 2017, p. G1-8 and FNAI 2019.

Conservation Land	**Managing Agency**	**Level**	**County (ies)**	**Acres**
Chipola Experimental Forest	US Dept. of Agriculture, Forest Service	Federal	Calhoun	911
Upper Chipola River Water Management Area	NWFWMD	State	Calhoun, Jackson	9094
Florida Caverns State Park	FDEP, Div. of Recreation and Parks	State	Jackson	1,268
Judges Cave Wildlife and Environmental Area	FL Fish and Wildlife Conservation Commission	State	Jackson	36
Pittman Property (acquisition underway)	NWFWMD	State	Jackson	167
Dead Lake Park	Gulf County	Local	Gulf	83
Chipola River Greenway	Jackson County	Local	Jackson	292
Marianna Greenway	City of Marianna	Local	Jackson	35
Eastshore Property	Jackson County	Local	Jackson	36
Jackson County Blue Springs and Merritts Mill Pond	Jackson County	Local	Jackson	262
Blue Springs Recreation Area	Jackson County	Local	Jackson	2085
Calhoun Spigelia Preserve	The Nature Conservancy	Private	Calhoun	32
Gaskin et al. Conservation Easement	NWFWMD	Private	Gulf	780
Juniper Headwaters Preserve	NWFWMD & Bay County	Local	Bay	40
Rock Hill Preserve	The Nature Conservancy	Private	Washington	12
Total				***15,133***

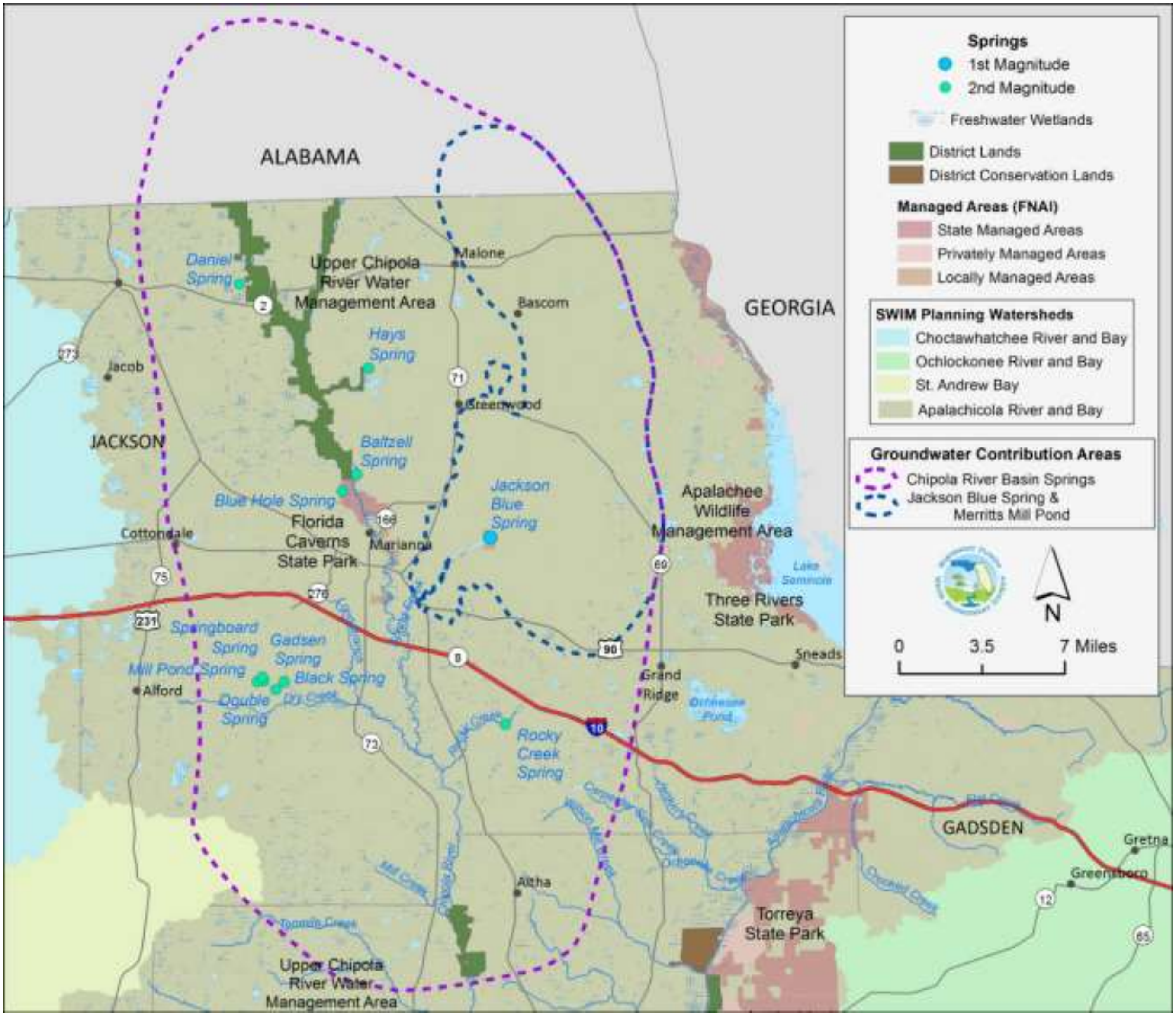


Figure 3-10. Protected areas of the upper Chipola River Basin, from NWFWMD 2017, p. 10

CHAPTER 4 – CURRENT CONDITION

Under the 3Rs framework, the population is the unit of resiliency, which is then scaled up to redundancy and representation at the species scale, appropriately defining and delineating populations is a crucial step to assess species viability. After delineating subpopulations (or management units) within the single Chipola slabshell population, we then assessed resiliency as described in the following sections by synthesizing the best available information about current population and habitat conditions. We also describe our approach to assess current redundancy and representation for Chipola slabshell.

4.1 Historical and Recent Distribution

The Chipola slabshell was originally known from the main stem of the Chipola River and several large tributaries. Our discussion of the historical distribution of Chipola slabshell includes all records 20 years or older (e.g., < 1999) from the date of this status assessment. The type locality is Chipola River, Marianna, Jackson County, Florida (Walker 1905, P. 135). In 1956, Clench and Turner collected specimens in Jackson County, FL at Big Creek, Reedy Creek, and the Chipola River NE of Marianna, FL and they collected specimens in four main stem Chipola River locations in Calhoun County, FL noting the species typically occurred at low densities though could be locally abundant (Clench and Turner 1956, p. 176). In addition to these localities, Brim Box and Williams (2000, p. 36) located a single museum specimen collected from Howards Mill Creek in 1968. Howards Mill Creek is a Chattahoochee River tributary in southeastern Alabama. Brim Box and Williams (2000, p. 37) surveyed the site in 1994 but Chipola slabshell was not encountered. The spatial accuracy of the Howards Mill Creek collection site is questionable, and the lack of other specimens from the nearby Chattahoochee River and its tributaries precludes extending the historical range beyond the Chipola River drainage (Figure 4-1).

Currently, the Chipola slabshell is widespread within its range and common at some localities. Our discussion of the recent distribution of Chipola slabshell includes all records (dead, live, shell) within 20 years of this status assessment (e.g., ≥ 1999). We chose this timeframe for two reasons: firstly because it's within the lifespan of Chipola slabshell and secondly because the entire historical range of the Chipola slabshell as well as adjacent areas have been surveyed during this period. The comparison between historical and recent distributions depicts an expansion north, south and east of the species previously known range (Figure 4-1). New sites were recorded east within the Chipola Cutoff and north into the Apalachicola River in the River Styx HUC 10, as well as south along the Chipola River mainstem within the Dead Lake HUC 10 (Figure 4-1). Chipola Slabshell was also documented as extant in Alabama within the Big Creek (Marshall Creek HUC 10) and Cowarts Creek (Cowart Creek HUC 10) tributaries of Chipola

River (Figure 4-1; Garner et al. 2009, entire). Chipola slabshell had not been reported from Alabama reaches of the Chipola drainage since 1916 (Brim Box and Williams, 2000, p. 36).

A lack of consistent survey methods across observers and through time limits the discussion of abundance trends for Chipola slabshell to presence in a given area. Historical data from 1991 or earlier is sparse, with 32 spatially explicit slabshell records compared to 138 collected recently from 2005 onward (USFWS 2019). Given the low historical sample size, the trend in Chipola slabshell presence (at least one individual documented) can be assessed with higher certainty at larger spatial scales (e.g., watershed: region drained by a river, river system, or other body of water) compared to smaller ones (e.g., reach: the length of a channel that is uniform with respect to discharge, depth, area, and slope). While the limited historical data may not have documented every stream reach where Chipola slabshell was present, it is likely that presence somewhere within a watershed would have been detected.

Chipola slabshell has exhibited an increase in occupancy over time, although the reliability of this estimate varies with spatial scale. Watershed and subwatershed-scale estimates are more reliable than stream-scale metrics given the area under consideration. At the watershed (HUC 10) and subwatershed (HUC 12) scale, Chipola slabshell has been found within the River Styx HUC 10 where the species had not been documented historically, with seven additional HUC 12s exhibiting occupancy (Table 4-1). Of all available habitat (Appendix E) comprised of 4^{th} order or larger streams within HUC 10s currently occupied by Chipola slabshell, 49 unique reaches (111.6 km) are occupied according to recent surveys; historically, 15 were occupied (Table 4-1). Given the short dispersal distance for Chipola slabshell associated with small host fish home ranges, the best scale for measuring a change in occupancy is likely the stream reach. We also assessed recent occupancy compared to availability of habitat according to stream reach length. Slabshells currently occupy 28% of the length of potentially available stream reaches (111.6 km of 404.6 total), where it historically occupied 11% (46.1 km). Assessing the extent of occupancy in this manner assumes all 4^{th} order or larger reaches included in the analysis contain suitable habitat which is likely not the case. In general, Chipola slabshell occupancy has increased at both small and large scales compared to historical estimates, with recent data suggesting a robust distribution within the range.

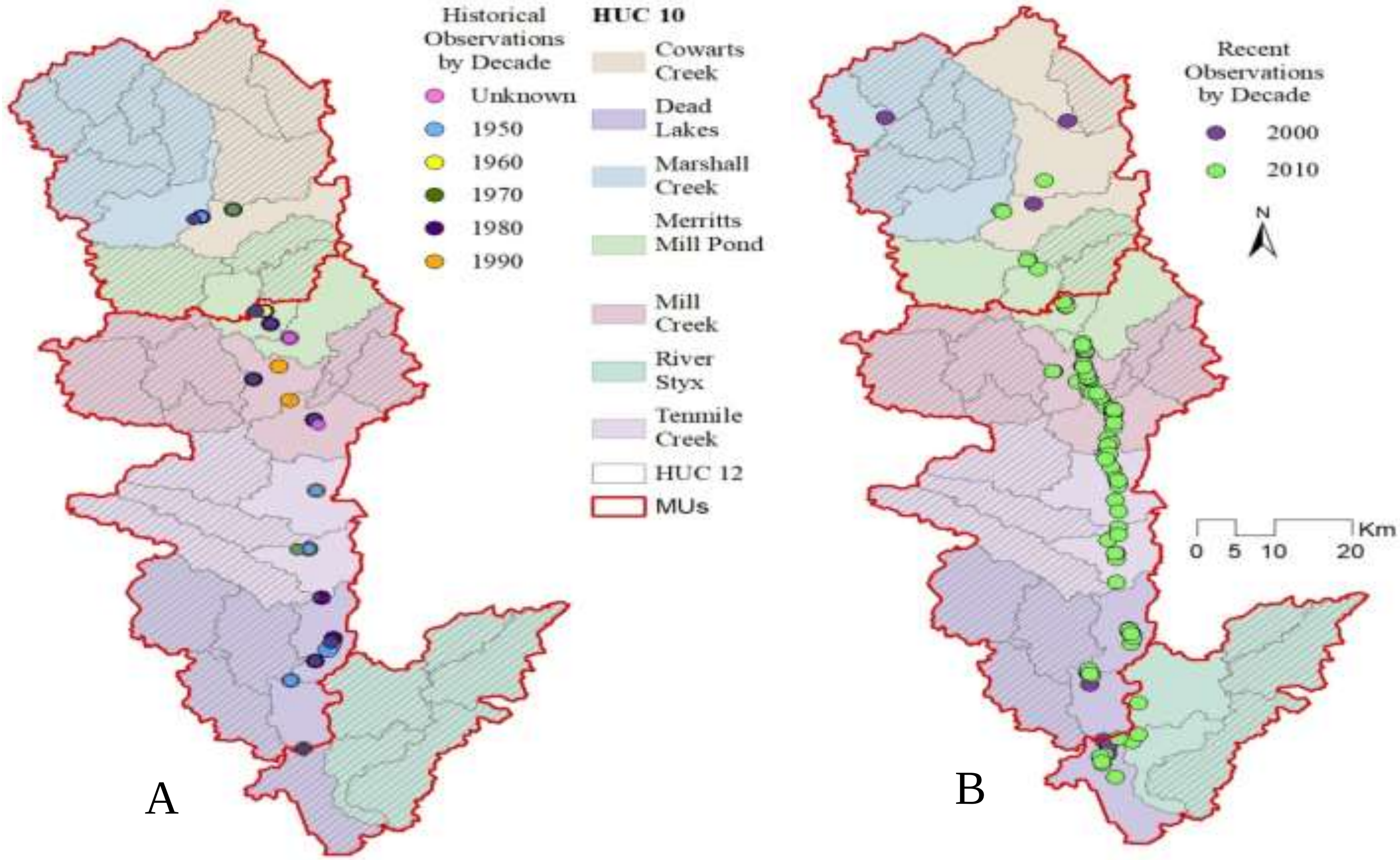


Figure 4-1. Historical (A) and current (B) distribution of the Chipola slabshell. HUC 10 watersheds are included to highlight distribution patterns, with hatched HUC 12 subwatersheds indicating presumably unoccupied areas within each HUC 10 watershed. Three management units (MUs 1- 3; south to north) are also included in red, and these are described in more detail in Section 4.2.

Table 4-1. Change in occupancy across the entire range of Chipola slabshell, using multiple scales of analysis. Historical data may not have documented every stream reach where Chipola slabshell was present, but detection within a larger area (e.g., watershed) is more likely to have occurred.

Analysis Unit	**Chipola Slabshell Occupancy**		
	Historical (≤ 1991)	**Recent (≥2005)**	**Increase (%)**
HUC 10	6	7	16.6
HUC 12	10	17	70.0
Reach Length (km)	46.1	111.6	142.1

4.2 Delineating Sub-populations

Information on the genetic diversity of Chipola slabshell is extremely limited. The exchange of genetic material must occur at close distances, with males fertilizing adjacent downstream females. The dispersal of juveniles is an important factor in determining which individuals might be linked through gene flow for delineating populations. The dispersal distances for freshwater mussels are largely dictated by their host fish. Home range sizes and movements for the known primary host fishes for Chipola slabshell, bluegill and redbreast sunfish, indicate limited movements and dispersal capacity of hosts. Bluegill and redbreast sunfish are considered common throughout the range of Chipola slabshell, suggesting good dispersal connectivity, even if each dispersal event is restricted in extent. Given that Chipola slabshell presence is not as ubiquitous as its host fish, it is likely that another important factor, habitat connectivity, limits the distribution of Chipola slabshell. Habitat (e.g., substrate characteristics that support the formation of mussel beds) could be naturally patchy, or fragmented for a variety of reasons discussed in Chapter 3. Anthropogenic sources of fragmentation include urbanization, land use change, and waterway alterations (e.g., channelization). Regardless of the cause, connectivity was used to delineate sub-populations of Chipola slabshell.

The Chipola slabshell was delineated into three sub-populations within the amended recovery criteria (USFWS 2019b, p. 4) to account for the two natural breaks in connectivity at Dead Lake and the Chipola sink at Florida Caverns State Park. Although these breaks do not prevent dispersal of infected host fish between sub-populations of the Chipola slabshell, we delineated the sub-populations by examining the potential barriers to dispersal and or habitat suitability to genetic exchange. Since our knowledge of the level of genetic diversity is limited, it is possible sub-populations exhibit some natural variation in genetic diversity.

Within each sub-population/MU, we further defined MUs based on HUC 10 watersheds. Where watersheds did not correspond to the breaks in connectivity that define sub-populations/ MUs, HUC 12 sub-watersheds were utilized to better delineate the MU. HUC 10s are composed of many HUC 12 sub-watersheds, which in turn are composed of many catchments. This approach was used on a few occasions. The southern-most HUC 12 of the Dead Lake HUC 10 was incorporated within MU 1. The Merritts Mill Pond HUC 10 was split into Northern and Southern portions, with the divide occurring within the Carters Mill Branch (31300120304) HUC 12 along catchment boundaries (Table 4-2).

Table 4-2. Sub-populations or management units of Chipola slabshell, with their respective watershed (HUC 10) and subwatershed (HUC 12) analysis units.

Management Unit (MU)	Analysis Unit – HUC 10s (ID)	HUC 12s (ID)
1	River Styx (313001106)	All associated HUC 12s, with the inclusion of Douglas Slough (31300120606)
2	Merritts Mill Pond –South (313001203)	Only Merritts Mill Pond (31300120305) and the southern portion of Carters Mill Branch (31300120304)
	Mill Creek (313001204)	All associated HUC 12s
	Tenmile Creek (313001205)	All associated HUC 12s
	Dead Lake (313001206)	All associated HUC 12s except Douglas Slough (31300120606)
3	Marshall Creek (313001201)	All associated HUC 12s
	Cowarts Creek (313001202)	All associated HUC 12s
	Merritts Mill Pond –North (313001203)	Only Hayes Spring Run (31300120301), Waddells Mill Creek (31300120302), Muddy Branch- Chipola River (31300120303), and the northern portion of Carters Mill Branch (31300120304)

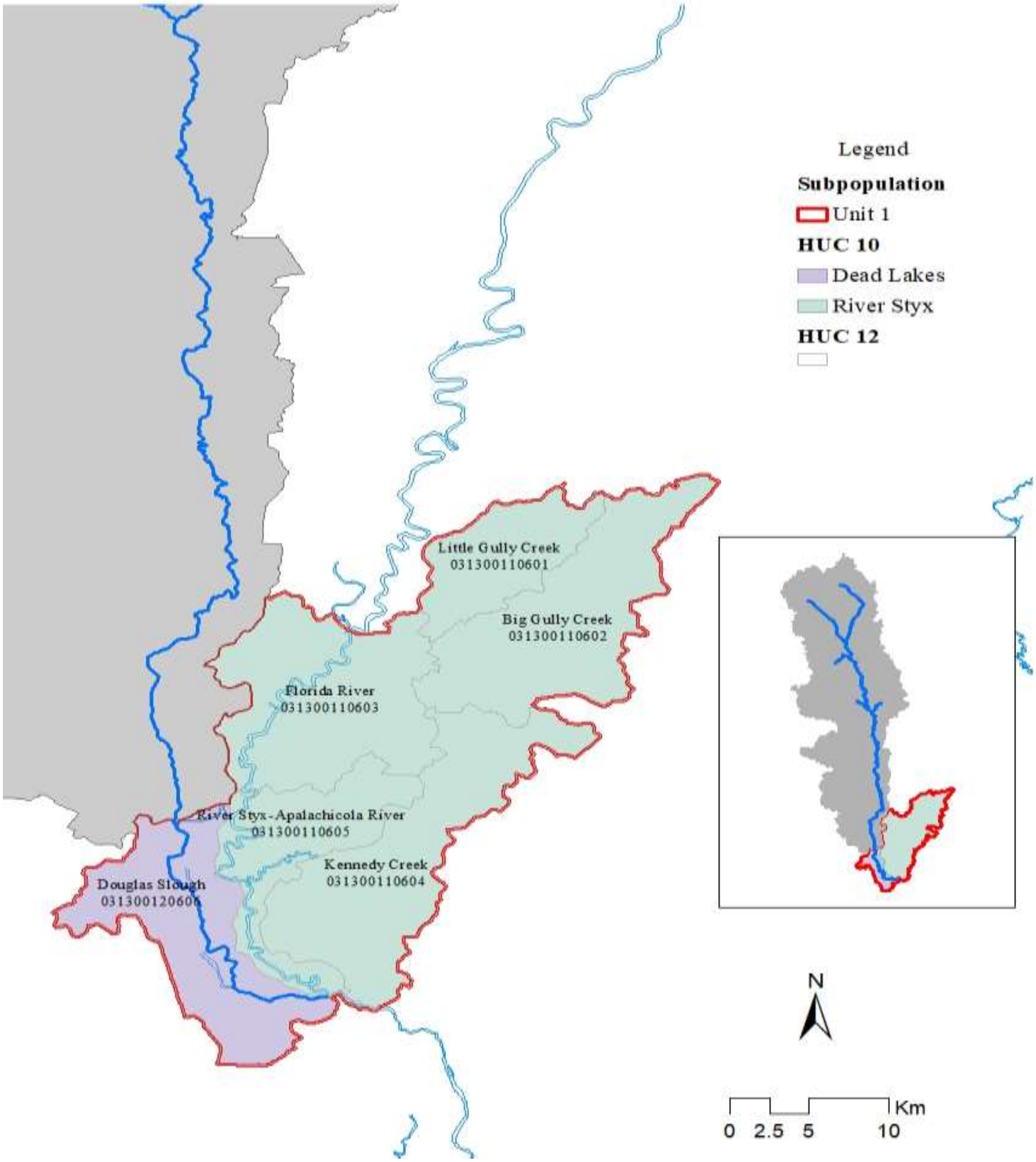


Figure 4-2. Chipola slabshell sub-population unit one (MU 1). Critical habitat is included in the inset for reference.

Moving from downstream (south) to upstream (north), the first natural break in connectivity for Chipola slabshell occurs at Dead Lake. Recent mussel surveys completed by the Service that occurred within Dead Lake have documented very low or absent mussel fauna in Dead Lake (2014 – present; USFWS 2019a). The absence of Chipola slabshell in Dead Lake is likely the result of a distance of 3 to 4 miles (5 to 6 km) between suitable mussel survey sites that support mussel fauna (USFWS 2019a). The lack of mussel fauna can be attributed to the accumulation of organic debris and detritus that is unstable habitat for freshwater mussels, which is not conducive to the habitat requirement of a stable environment (USFWS 2019b, p. 6). Although there is no barrier preventing host fish movement, the result of the unstable habitat in Dead Lake could prevent colonization of juveniles from recently transformed Chipola slabshells that were shed from host fish in Dead Lake, given the limited home range of the fish. Therefore, Dead Lake creates a natural break between sub-population unit 1 (Table 4-2) and sub-population unit 2 (Figure 4-3).

Continuing upstream from Dead Lake, the second natural break is the sink of the Chipola River. Upstream from Marianna, FL is Florida Caverns State Park. There is a natural sink where the Chipola River travels underground for 1/4 mile (1/2 km) and resurfaces to form the main stem Chipola River. During high flows the Chipola River can overwhelm the sink and inundate the floodplain, which may disperse host fish from upstream to downstream habitats. In addition, a small channel has been created that provides overland water flow to bypass the sink. However, it is unlikely that host fish that have restricted home ranges would travel through underground caverns to disperse mussels, and the substrate suitability of the artificial channel for juvenile slabshells is likely limited. Therefore, the sink delineates sub-population unit 2 (Figure 4-3) and sub-population unit 3 (Figure 4-4).

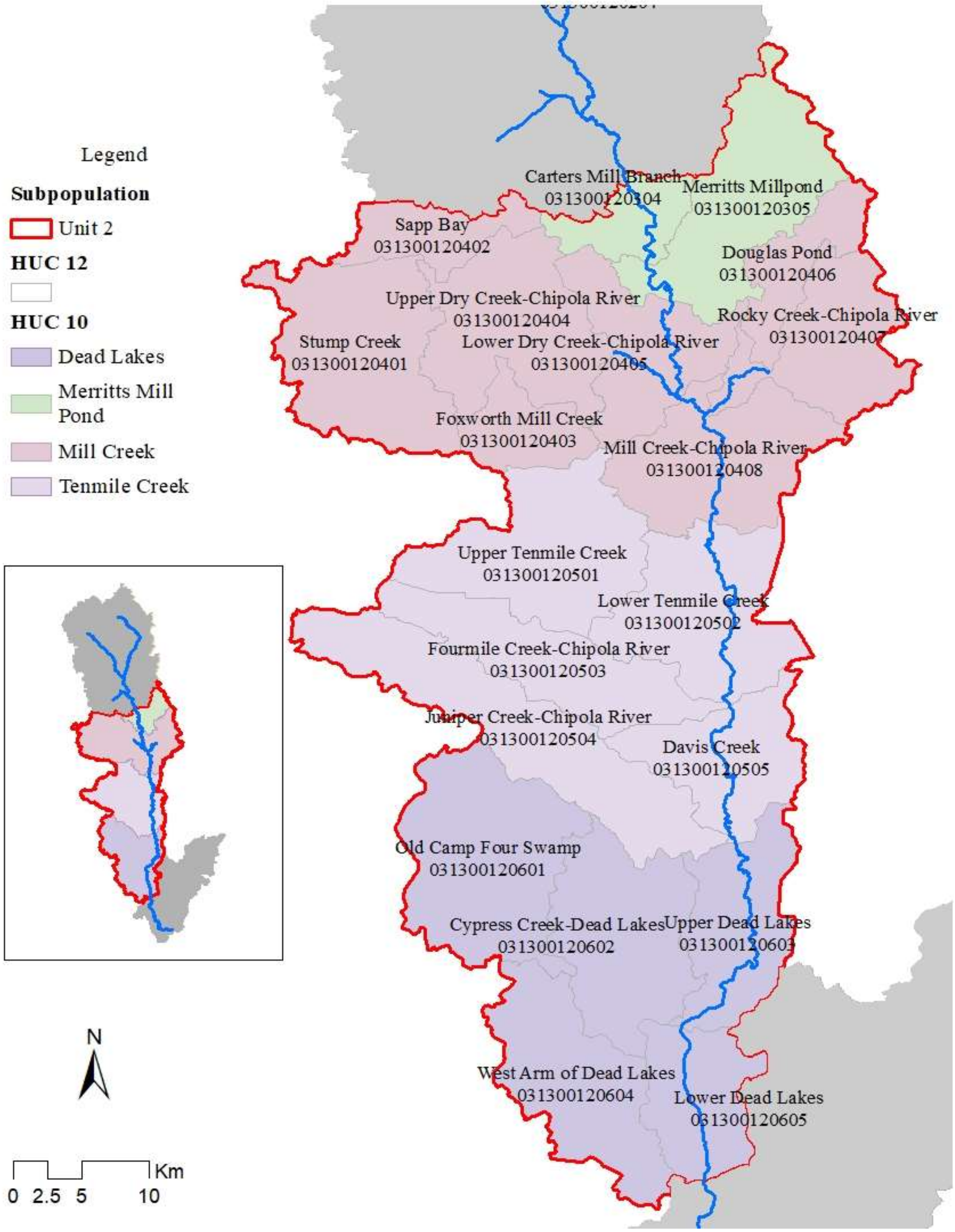


Figure 4-3. Chipola slabshell sub-population unit two (MU 2). Critical habitat is included in the inset for reference.

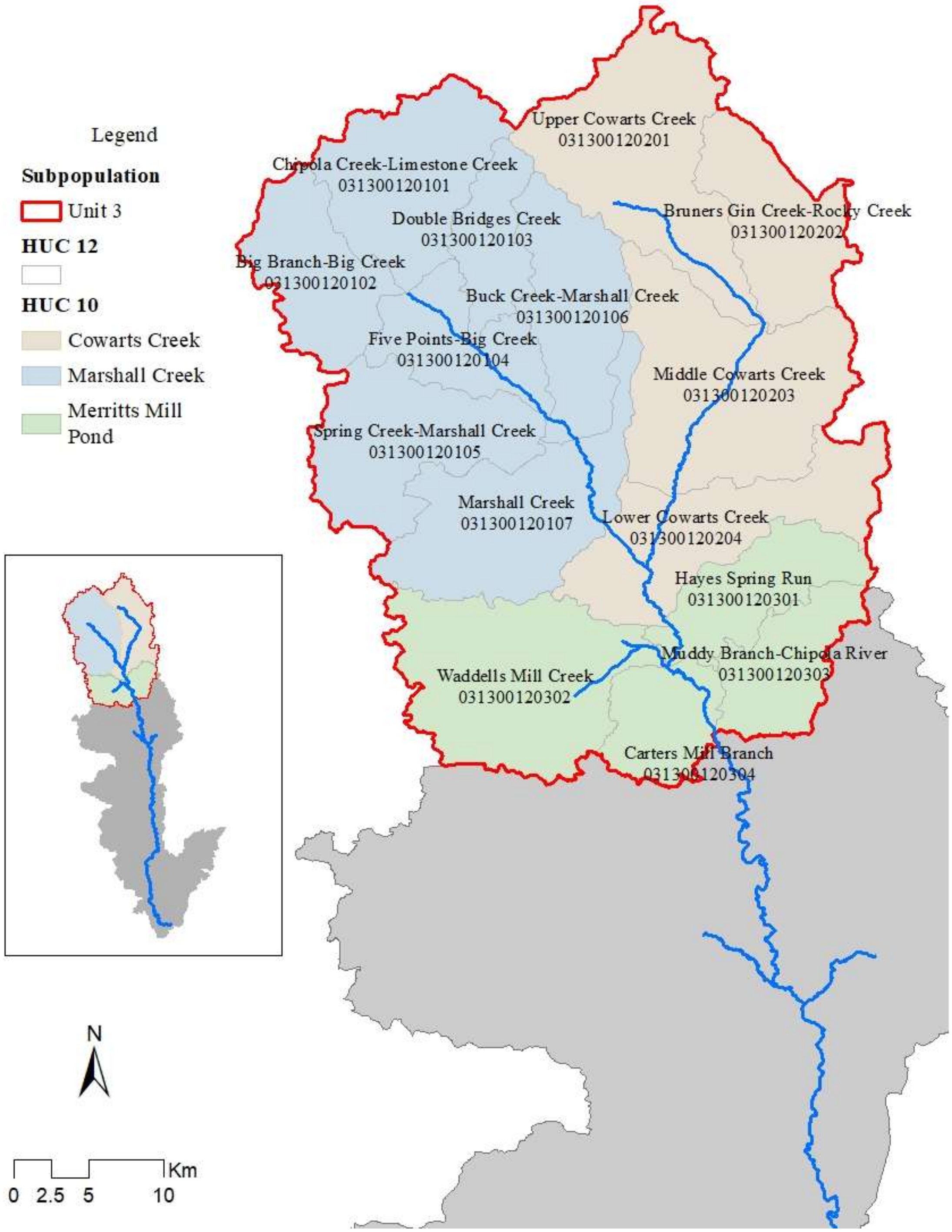


Figure 4-4. Chipola slabshell sub-population unit three (MU 3). Critical habitat is included in the inset for reference.

4.2.1 Subpopulation Description

Management Units and their HUC 10 watersheds are listed below, with HUC 10s listed from north to south within each respective MU. A description of conditions in each watershed that are relevant for the assessment of resilience is included. Resilience factors are discussed further in Section 4.4

1) MU1: River Styx & Douglas Slough— The majority of this HUC 10 is protected (57 %). Wetlands are abundant throughout the watershed in both protected and privately owned lands. The west bank of the Chipola River in the northern part of the watershed is vulnerable to development, especially adjacent to Wewahitchka, FL, where residential development has removed the majority of the riparian buffer. It is possible that the watershed is more widely occupied than is currently known, as records from the edge of the range are between seven and ten years old. The southernmost record is from 2010, and the record furthest north within the Apalachicola River is from 2013.

2) MU 2: Merritts Mill Pond, South –1211 of 40092 acres (3%) of this watershed is protected, concentrated along but not fully encompassing the Chipola River mainstem. Sections of unprotected mainstem directly border the city of Marianna. There are currently no recent records directly adjacent to, or 7 km downstream of Marianna. There are no recent records for slabshell in Spring Creek where it is known from a historical record; The Merritt's Mill Pond Dam has reduced stream connectivity, though the lower portion of the creek is unimpaired, retaining flow with the Chipola River. Slabshell were recently (2015) found near the confluence of Spring Creek and the Chipola River, verifying slabshell presence in the immediate vicinity to help facilitate colonization of the creek. The waters have been listed as impaired due to nutrients (WBID 51E), and water quality testing by USFWS found the greatest aquatic life risk score in this region (site 4; Hemming et al. 2007, p. 48), though Florida water quality standards were not violated during testing. The priority for TMDL development is medium (TMDL should be created in 5 to 10 years from the listing date (2013)), meaning nutrient impacts should be mitigated by 2040. Towards this goal, the Apalachicola River and Bay SWIM Plan includes Marianna as a target of its stormwater planning and retrofit priority project (NWFWMD 2017, p. 43-44). The existing BMAP for Merritts Mill Pond and Jackson Blue Spring should help alleviate water quality concerns in Spring Creek, and a minimum flow limit (MFL) is being evaluated for 2023 to protect water quantity for the creek.

3) MU 2: Mill Creek—12 acres is protected by The Nature Conservancy's Rock Hill Preserve on the far western edge of the watershed, but none of the Chipola River mainstem is protected under federal, state, local or private stewardship. The east bank of the Chipola River is particularly vulnerable given this is where present development and agriculture is concentrated, limiting the riparian buffer here. There are two limestone quarries directly adjacent to the Chipola mainstem in this watershed. At this time, it is unclear if the active quarries are impacting habitat; live slabshell records have been obtained in the area as recently as 2015. This watershed is well sampled, with slabshell occurring consistently throughout the Chipola River mainstem as well as the lower portions of Dry Creek within the designated critical habitat. The 2014 record from approximately 25 m upstream of the highway 73 bridge on Dry Creek found numerous dead oval pigtoe and shinyrayed pocketbook as well as one dead slabshell, suggesting pesticide runoff as a possibility for the mortalities as the site conditions were otherwise excellent (USFWS 2019a). Records closer to the confluence with the Chipola River state there were too many *Elliptio pullata* (gulf spike, a common mussel) to collect Chipola slabshell, though the presence of one live slabshell was recorded (USFWS 2019). Part of the watershed is listed as impaired for nutrients (WBID 51E), but a TMDL is under development and should be implemented in the next five years. Water quality in Dry Creek is not additionally protected as an OFW and is not subject to a water reservation or MFL, but water usage for Northwest Florida is not expected to outpace supply by 2040, accounting for the potential of drought increases with climate change (NWFWMD 2018c, p. 51, 54).

4) MU 2: Tenmile Creek— 2328 of 140266 acres (1.7 %) are protected, over half of which is along the Chipola River mainstem; however the majority of the river remains unprotected. Residential developments occur in unprotected areas along the mainstem and have resulted in removal of the riparian buffer adjacent to the channel. Abundance is high in the Upper Chipola River Water Management Area and in the southern portion of the watershed, but at least some of the records are qualitative estimates. Slabshell records within the watershed occur throughout the historical distribution. While the mainstem of the Chipola River is not impaired, Tenmile Creek (WBID 569) and Juniper Creek (WBID 749) contain elevated fecal coliforms which is a human health parameter that could be related to sedimentation. TMDL prioritization is low, meaning it will be completed by 2028 or sooner (within 10 years of verification). The water quality impairments in the watershed could also result in increased sedimentation if the coliforms are found to originate from cattle accessing streams. Residences have severely reduced or completely removed the riparian buffer

in some areas, likely leading to elevated sedimentation (e.g., confluence of Tenmile Creek and Chipola River).

5) MU 2: Dead Lake— 895 of 130,102 acres (0.7%) in the watershed is protected, largely within the privately owned Gaskin Conservation Easement on the west bank of Dead Lake. However, anthropogenic land uses are concentrated along the Chipola River. Records are not evenly distributed within watershed, but they are largely clustered in the locations where specimens were recorded historically. Dead Lake has been noted to contain unsuitable habitat for slabshell, though records occur at in the braided channels of the Chipola River that feed into the lake. Records at the mouth of Flat Creek in the northern braided channel region of Dead Lake suggest that slabshell may currently occupy the lower segments of the creek or could disperse into it in the near future. There are no listed waterbody impairments in this watershed, and flows are protected under OFW and water reservation. One historic record occurs in an area where residences have reduced or completely removed the riparian buffer, likely leading to elevated sedimentation. The poor quality of habitat (scour, clay) near residential developments south of the highway 71 Chipola River crossing was noted during 2018 surveys (USFWS 2019a).

6) MU 3: Marshall Creek— 2344 of 136254 acres (1.7%) are protected and expected to remain so, encompassing the lower reaches of Marshall Creek within Florida. The city of Dothan, AL, occurs in the northern portion of the watershed. There is currently some residential development in upstream tributaries, but not along occupied creeks. The species distribution in the watershed is consistent with historical records; the site for Marshall's Creek from 1954 was confirmed to be occupied in 2018. A new record for Big Creek was also obtained, extending the species known range (Garber et al. 2009, p. 691). The distance between these records is considerable, at approximately 22 km. Slabshell may occur along Marshall Creek connecting the records within the watershed, but these intermediate occurrences have not been documented to date. The watershed contains impairments for fecal coliform (WBID 52, Limestone Creek) nutrients, and organic enrichment (Cypress Creek). If the water impairments are related to cattle, there may be sedimentation occurring from cattle movement. TMDL prioritization for Florida is low, meaning the TMDL for WBID 52 will be completed by 2028 or sooner (within 10 years of verification). TMDLs for the Alabama portion of the waterbody are prioritized for the 2016-2022 period for Cypress Creek, but will occur after this period for Limestone Creek. However, Big Creek was 25.2 °C with fairly high dissolved oxygen (6.85 mg/L; 88.1% saturation) during a severe drought in 2007 (Garner et al. 2009, p. 693).

7) MU 3: Cowarts Creek— 3291 of 115367 acres (2.6%) are protected and expected to remain so, encompassing the northern extent of the Chipola River as well as the lower reaches of Marshall Creek as well as Cowart's Creek upstream to the Alabama-Florida state boundary. Riparian buffers are largely intact, with no noticeable residential development along the Chipola River or its tributaries; urban areas are concentrated at the northern edge of the watershed along highway 84. Most records included in the resiliency assessment were from over a decade ago, and the most recent records for the watershed include 1 live and 1 dead slabshell in Cowart's Creek in 2018, and 3 live and 1 dead in the lower reaches of Marshall Creek (USFWS 2019). The species distribution is consistent with the historical range in the watershed (Garner et al. 2009, p. 691). 2006 surveying occurred during an exceptionally intense summer drought, and few mortalities were noted (Garner et al. 2009, p. 693). Only the Chipola River mainstem is protected as an OFW in addition to the existing water reservation. The area contains impairments for fecal coliform in multiple stream reaches (WBID 52, 57, Bruners Gin Creek, and Cowarts Creek), which may be associated with cattle accessing streams. TMDL prioritization for Florida is low, meaning TMDLS for WBID 52 and 57 will be completed by 2028 or sooner (within 10 years of verification). TMDLs for the Alabama portion of the watershed are not prioritized for the 2016-2022 period, so will be developed and implemented sometime after. Cowarts Creek was noted to be sluggish and warm (temp and DO were 27 C and 6.5 mg/L, respectively) during a severe summer drought in 2007 (Garner et al. 2009, p. 693). Cowarts Creek was noted to be turbid during the 2006 summer drought (Garner et al. 2009, p. 693).

8) MU 3: Merritts Mill Pond, North – 3072 of 73,700 acres (4%) are protected, encompassing almost all of the Chipola River mainstem in this watershed, the portion of Waddell's Mill Creek occupied by slabshell, and the majority of Hays Spring Run. Dead juvenile and adult slabshell as well as large amounts of unidentified mussel shell were found in Waddell's Mill Creek in 2019 suggesting occupancy within the area. No records have ever been obtained from Baker's Creek directly upstream, though it is identified as critical habitat. Only two live individuals have been recorded from the watershed, but the degree of survey effort is uncertain. 2019 surveys indicate access was difficult due to blowdown from Hurricane Michael. It is likely that abundance and distribution in the area is greater than historically known or currently documented. The limited riparian buffer between agricultural lands and creeks in the area promotes nutrient and contaminant transfer to the Chipola River. Part of the watershed is listed as impaired for nutrients (WBID 51E), but a TMDL is under

development and should be implemented by 2023. Water quality in Waddell's Mill Creek is not an OFW and is not subject to a water reservation or MFL. There are possible sedimentation or agricultural runoff impacts at the Waddell Creek slabshell record given the presence of a bridge, minimal riparian buffer, and the lack of live individuals in the dataset (USFWS 2019).

4.3 Representation

Chipola slabshell is a narrow endemic known to occur only within the Chipola River and adjacent reaches of the Apalachicola River. Representation refers to the breadth of genetic and environmental diversity within and among populations that contributes to the ability of the species to respond and adapt to changing environmental conditions over time. Maintaining resilient populations across the range of variation within the species will increase the amount of variation within the species on which natural selection can act, increasing the chances that the species will persist in a changing world. However, there is currently no evidence to support delineating multiple representative units for this species.

4.4 Current Resiliency and Redundancy Approach

The single population of Chipola slabshell largely occurs within a single basin, but variation in the factors important for viability can occur at finer scale. Because the river basin is at a very coarse scale to consider influences on viability, HUC 10 watersheds and HUC 12 subwatersheds were utilized as the analysis units for assessing resiliency. These analysis units are grouped into management units (MUs) that correspond to the 3 sub-populations. Note that an MU may be made up of one or more HUC10 watersheds or HUC 12 sub-watersheds, depending on the MU boundaries. HUC 10 watersheds encompass immediate habitat and its surrounding landscape, and were identified by species experts as the scale most appropriate for analyzing resiliency for the congener yellow lance, *Elliptio lanceolata* (USFWS 2017, p. 21). Given the hierarchical nature of the relationship between HUC 10s, MUs, and the population/species, we first consider resiliency at the HUC 10 level, then scale up to MUs. Ultimately, MU resiliency will lead to inferences at the species level, which in the case of Chipola slabshell is composed of a single population. Redundancy at the species level was assessed using a count of watersheds demonstrating resiliency within and among MUs.

The magnitude and scale of potential impacts to Chipola slabshell or its habitat by a given threat are described using a condition category scale. Each watershed was rated as currently being in poor, fair, good or excellent condition for each of the resiliency factors.

Condition categories generally reflected viability; excellent conditions indicate increasing abundance/occupancy and suitable habitat, good conditions indicate stable population and habitat factors but not necessarily increasing trends, fair conditions indicate verified survival but potential population decline, poor conditions reflect limited information on survival and probable decline, and Ø conditions indicate no survival. In the following discussion of the factors that were used to determine resilience, as well as the factors that were not ultimately used, it must be emphasized that this species has not been extensively studied, and quantitative data on habitat needs and population dynamics are not available. There is great uncertainty in precisely how these factors influence Chipola slabshell population resilience, and experts were consulted to guide the assessment. Condition factors for Chipola slabshell included two population factors (occupancy, and abundance/recruitment) and two habitat factors (sedimentation, canopy) based on influences on viability and data availability discussed in Chapter 3. A description of the ranking process for the condition of each resilience factor is described in the following sections.

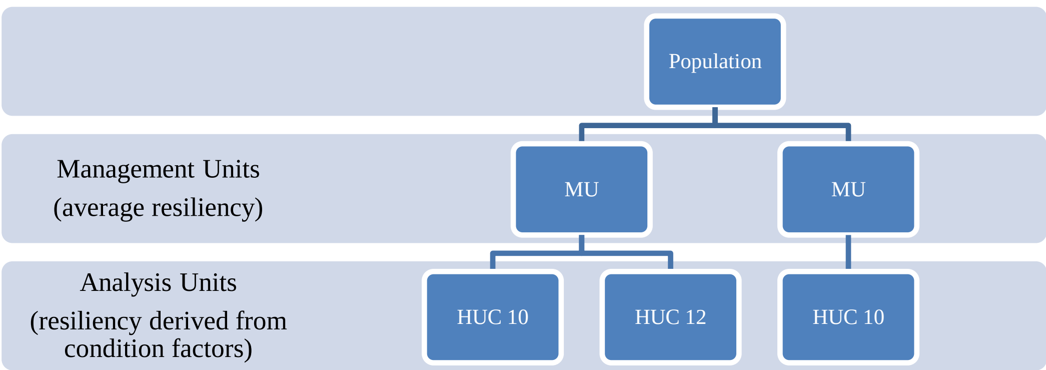


Figure 4-5. Resiliency assessment hierarchy. For Chipola slabshell, resiliency is measured at the analysis unit and scaled to the management unit. Redundancy is measured at the species level using a count of resilient MUs and watersheds.

4.4.1 Population Factors

To assess the distribution, occupation, abundance, and recruitment of Chipola slabshell MUs, we first assigned a status category of extant or extirpated to each MU. Slabshells were considered extant if a live individual or fresh dead specimen was collected recently (since 2005). Given the longevity of the species, and the timing and frequency of mussel surveys conducted throughout the species' range, collections or observations of live individuals or fresh dead specimens since 2005 likely indicates the continued presence of a species within a river or stream. Second, for extant MUs, we determined the extent of occupation within each HUC 10 so that changes could be evaluated through time. Because of inconsistency in survey efforts, estimated abundance was based on count numbers of the species summarized from inventory data. The population condition factors are described in more detail below.

Occupancy

All three MUs, or subpopulations, of Chipola are currently extant. To examine shifts in occupancy, the distribution of Chipola slabshell within the subwatersheds (HUC 12) of HUC 10 watersheds was examined. While stream reach is the most precise measure of occurrence, sparse historical data might provide an overly optimistic assessment of occupancy as survey efforts have drastically increased in the recent past. Historical surveys are sparse, utilize inconsistent methods, and are often not range-wide. When surveys were conducted, they typically involved tactile or visual (snorkel, or surface air-supply systems in deeper (> 4 ft) waters) methods to detect mussels. Most recent surveys involved timed searches where species were identified and counted. In our discussion of past and current distribution (see Section 4.1), the subwatershed or watershed scale provide an estimate of occupancy for Chipola slabshell more reliably between the historical and recent period than stream reach metrics, as the area under consideration is much larger and has likely been sampled in both time periods. We therefore assess occupancy as the change in the proportion of occupied HUC 12s within the HUC 10 watersheds that compose MUs.

The occupancy of a watershed was verified if a live individual or fresh dead specimen was collected during surveys conducted from 2005 to 2019 (within the last 20 years). The entire extent of the known Chipola slabshell range was surveyed at least once within this timeframe in addition to coinciding well with the estimated lifespan for the species. For watersheds that have not received consistent survey effort (e.g., headwaters), it is difficult to determine whether a lack of occurrence since 2005 relative to pre-2005 reflects a lack of sampling or a decline in abundance or distribution. Regardless, documenting newly occupied HUC 12s within each HUC 10 can help quantify a possible range expansion through dispersal of juveniles. Chipola slabshell presence was compiled from surveys completed by the Service, USGS, and state agencies (USFWS 2019).

We determined cut-offs related to occupancy in order to define condition categories for this population factor. These thresholds were set according to species biology of closely related at-risk species, yellow lance, but utilized a more conservative approach (USFWS 2017, p. 35). Chipola slabshell likely has fecundity similar to other *Elliptio* spp., maintaining a consistent, low-level of reproductive success. If there was evidence of both consistent and new occupation of HUC 12s by Chipola slabshell, we defined HUC 10s exhibiting both of these characters as being in excellent condition. Good condition HUC 10s were those that maintained a consistent slabshell presence through time, but without an expansion to new HUC 12s in the recent past. We considered a decline in occupancy of HUC 12s less than 50 percent to reflect fair conditions for Chipola slabshell. A decline in occupancy of HUC 12s of 50 percent or more indicated poor conditions for Chipola slabshell (Table 4-3). The occupation of HUC 12s within management units (MUs), and the difference between historical (> 20 years) and recent (≤ 20 years) data was then compiled from Section 4.1, and each HUC 10 was assigned to a condition category (Table 4-4).

Table 4-3. Chipola slabshell occupancy metrics used to create condition categories for the assessment of current resiliency.

Condition Category	Evidence of Occupancy
Excellent	Consistent occupation in addition to newly occupied HUC 12s in a given HUC 10 within the last 20 years compared to historical records.
Good	Consistent occupancy of all HUC 12s in a given HUC 10 over the last 20 years compared to historical records.
Fair	<50 % Decreased occupancy of HUC 12s in a given HUC 10 within the last 20 years compared to historical records.
Poor	≥50 % Decreased occupancy of HUC 12s in a given HUC 10 within the last 20 years compared to historical records.
Ø	Complete loss of occupancy in a given HUC 10 within the last 20 years compared to historical records.

Table 4-4. Change in occupation of HUC 10s within management units (MUs), and the relation to Chipola slabshell condition.

MU	HUC 10	Occupied HUC 12s	Condition
1	River Styx & Douglas Slough	Increase	Excellent
2	Merritts Mill Pond –South	Stable	Good
	Mill Creek	Stable	Good
	Tenmile Creek	Stable	Good
	Dead Lake	Stable	Good
3	Marshall Creek	Increase	Excellent
	Cowarts Creek	Increase	Excellent
	Merritts Mill Pond –North	Increase	Excellent

Abundance and Recruitment

During stream surveys mussel abundance was recorded as either present, a local population estimate, or an actual count of the number of mussels observed in the survey location (e.g., density in a mussel bed). For most surveys, quantitative measures of density were not available and qualitative approximations were only sporadically documented. More recently, surveyors have recorded the number of live individuals or dead shells observed at a location. Recent surveys have documented many Chipola slabshell records and reinforced the idea that slabshells occur at relatively low densities. From 2005 to present (n =138), 53% of observations (live, dead or shell) yielded five or fewer individuals; very few observations (n = 10) contained more than 40 individuals (Figure 4-6; USFWS 2019).

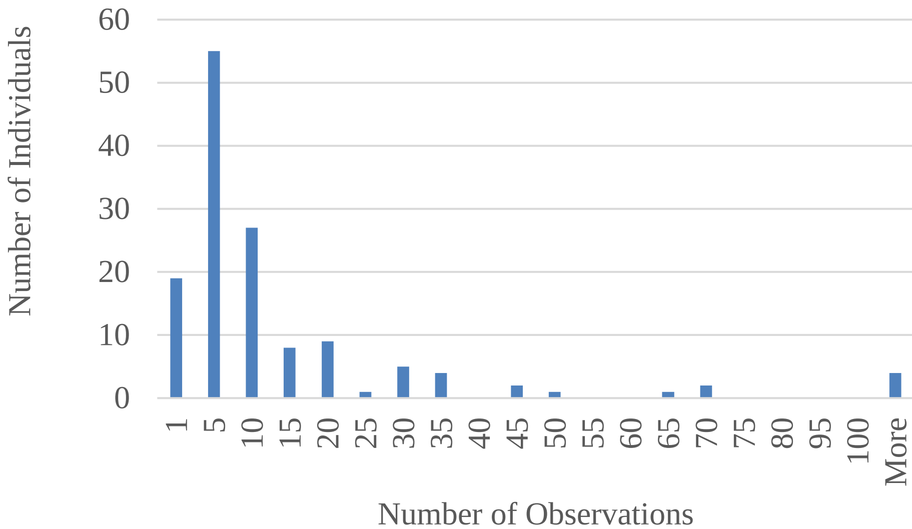


Figure 4-6. Abundance of Chipola slabshell for a given observation/record during recent field surveys (2005 to 2019; USFWS 2019).

Recent (≥ 2005) but preliminary population estimates are available for the smaller MUs in the Chipola slabshell range. MU 3 is estimated to contain at least 298 slabshell within Cowarts Creek, but that is based on extrapolations from three individuals at one site (Garner et al. 2006, p. 7). Priester (2008, p. 55) found a total of 13 individuals from 2006 and 2007 surveys in the Cowarts Creek area within MU 3. Elsewhere, sampling completed by Priester documented at least 66 live individuals in MU 1 between 2005 and 2007 (pp. 53 - 54). MU 1 was estimated to contain 2,645 slabshell in 2011-2012, but this estimate was based on only 10 individuals collected at two sites (USFWS 2016b, p. 129). Slabshell are known to be abundant within MU 2 which may be a factor of its size and greater survey effort. Within MU 2, Priester (2008, p. 54 –

56) found 84 live individuals in Mill Creek HUC 10; more recent surveys have confirmed an abundance of individuals in MU 2. We utilized both the cumulative record of the total number of live individuals and dead shells observed within a HUC 10 watershed in recent surveys ($\geq$ 2005) and subpopulation estimates (when reliable) to provide an approximate estimate of abundance within watersheds. This information is summarized in Table 4-6.

While measures of slabshell abundance reflect past influences on resiliency, recent recruitment reflects where the population may be headed. For example, dense mussel beds containing older/senescing (i.e., less-reproductive) individuals may be more susceptible to extirpation because they have few young individuals to sustain the population into the future. Conversely, less dense mussel beds containing many young and/or gravid individuals may be likely to grow denser, thus sustaining the population into the future. Sampling methods used to estimate reproduction involved repeatedly capturing small-sized individuals near the low end of the detectable size range (< 35 mm) and capturing gravid females during the reproductively active time of year. We do not have length-at-age data for Chipola slabshell from which to infer the age of these mussels, however, presence of smaller individuals and a variety of shell sizes within recent ($\geq$ 2005) surveys likely indicates that Chipola slabshell are reproducing.

Trends in abundance or recruitment estimates cannot be determined, but Chipola slabshell has demonstrated recent successful reproduction. Information on individual length is unavailable prior to 1991 (USFWS 2019). During the 1991 status survey, 33 sites within the historical range of this species on the Chipola River were sampled, including 12 of 16 (75 percent) known historical sites (63 FR 12664). Live individuals were found at five sites (15 percent), including one historical site. An average of 3.7 live individuals was found per site. No live specimens appeared to be juveniles, as the smallest live individual was 47 mm (1.9 in) in length. However, more recent surveys have documented recruitment in all MUs. Within MU 3, at least one smaller individual (44 mm) was encountered in Cowarts Creek and estimated to be 6 years of age, supporting recent reproduction within MU 3 (Garner et al. 2009, p. 693). In the quantitative survey by Gangloff within MU 1, slabshell lengths ranged from 22.1 to 56.4 mm; and individuals from the boat ramp basin of MU 2 ranged from 31.0 to 60.5 mm (USFWS 2016b, p. 129). Priester (2008, p. 22, 30) measured 154 slabshells across all three MUs and observed a variety of shell sizes which strongly suggests recruitment and a good abundance of individuals of different age classes throughout the range of Chipola slabshell (Figure 4-7). While Priester's data can't be linked to specific MUs, it does provide insight into recruitment at the population/species level. Since abundance estimates did not account for detection probability, the approximate abundances should be considered conservative. Pandolfo (2014, p.46) estimated the detection probability for *Elliptio* species to be 0.42, which may be a good approximation for the difficulty of detection for Chipola slabshell. Chipola slabshell may have been present but not detected during some surveys, and we did not use an estimate of detection probability to account for these occasions. It should be noted that records of reproduction/recruitment were not often documented during Chipola slabshell surveys; thus, this information is incorporated when available as additional supporting evidence for assigning the condition category for a particular MU.

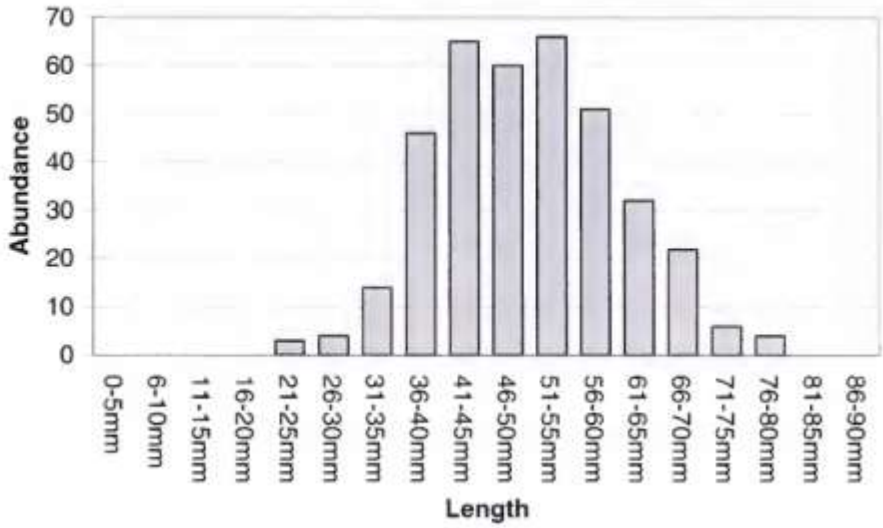


Figure 4-7. Population distribution of Chipola slabshell by length (n= 154; Priester 2008, p. 30).

We considered excellent condition to be present when more than 100 individuals (live) reported from a given HUC 10 within an MU during a recent ($\geq$ 2005) sampling event; or an recent abundance estimate is available for the subpopulation and identifies densities sufficiently high to suggest a healthy population (e.g., multiple age classes and evidence of ongoing recruitment). Good condition is indicated by 10-100 individuals (live or dead) ever reported from a given HUC 10 within an MU or some quantitative information available for a subpopulation estimate that indicates detectable population density and more than one age class represented. Fair conditions occur when less than 10 individuals have been reported in recent surveys, with the subpopulation potentially represented only by older individuals with limited recruitment. Poor conditions occur when no live individuals have been reported, and Ø is indicated by a complete lack of recent Chipola slabshell records (Table 4-5).

Table 4-5. Chipola slabshell abundance and recruitment metrics used to create condition categories for the assessment of current resiliency.

Condition Category	Abundance and Recruitment
Excellent	Abundant in collections or surveys. More than 100 individuals (live) reported from the HUC 10 during a given sampling event; or an abundance estimate is available for the subpopulation and identifies densities sufficiently high to suggest a healthy population (e.g., likely ongoing recruitment).
Good	Occasional to common in collections or surveys. 10-100 individuals (live or dead) reported from the HUC 10; or some quantitative information available for a subpopulation estimate that indicates detectable population density and more than one age class represented.
Fair	Rare in collections or surveys. Less than 10 individuals (live or dead) reported from the HUC 10; usually qualitative collections of varying effort; not enough information available to generate a subpopulation estimate; subpopulation potentially represented only by older individuals with limited recruitment
Poor	Only shells or fresh dead observed (no live); population reduction likely not offset by recruitment
Ø	No records

It should be noted that some MUs contain low abundance and few records. For example, MU 3 is represented by collections of very few individuals in any given year and are categorized as small population size. It is difficult to make inferences about the current and future condition of MU 3. Although there is uncertainty in the status of all MUs, it was our goal to be as inclusive as possible regarding the current condition of the species, so these small populations were included for the purposes of this SSA. Increased survey efforts with more focus on limited detection population modelling may better inform the analysis.

Table 4-6. Estimates of abundance and evidence of reproduction during recent ($\geq$ 2005) surveys for Chipola slabshell within HUC 10s and their respective management units (MUs).

MU	HUC 10	Abundance and Recruitment (USFWS 2019)	Condition
1	River Styx & Douglas Slough	Live: 172 (80 in a single smple; 2006), Dead: 43, Shell: 0 Total estimate: 2,645 (preliminary, not used for condition) Evidence of recruitment (size classes): yes in 2011 (range 22 to 56 mm)	Good
2	Merritts Mill Pond –South	Live: 31 (10 in a single sample; 2019), Dead: 17, Shell: 5 Total estimate: N/A Evidence of recruitment (size classes): yes in 2019 (n = 12, range 45 to 80 mm)	Good
	Mill Creek	Live: 605 (212 in a single sample; 2015), Dead: 64, Shell: 1 Total estimate: N/A Evidence of recruitment (size classes): yes in 2019 (n = 25, range 33 to 82 mm)	Excellent
	Tenmile Creek	Live: 604 (128 in a single sample; 2017), Dead: 132, Shell: 0 Total estimate: N/A Evidence of recruitment (size classes): no	Excellent
	Dead Lake	Live: 126 (65 in a single sample; 2018), Dead: 8, Shell: 0 Total estimate: N/A Evidence of recruitment (size classes): no	Good
3	Marshall Creek	Live: 7 (3 in a single sample; 2019) Dead: 3 Shell: 0 Total estimate: N/A Evidence of recruitment (size classes): no	Fair
	Cowarts Creek	Live: 14 (9 in a single sample; 2007), Dead: 2, Shell: 0 Total estimate: 298 (preliminary, not used for condition) Evidence of recruitment (size classes): yes in 2019 (n = 5, range 44 to 76)	Good
	Merritts Mill Pond –North	Live: 2 (2 in a single sample; 2019), Dead: 3, Shell: 0 Total estimate: N/A Evidence of recruitment (size classes): yes in 2019 (n = 2, range 33 to 45 mm)	Fair

4.4.2 Habitat Factors

We considered two habitat condition factors as part of the Chipola slabshell resiliency assessment. Potential threats to Chipola slabshell or its habitat were categorized in terms of magnitude and immediacy based on the best available information in literature or other sources, such as the Southeast Aquatic Resources Partnership (SARP). By working with partners, SARP has identified the primary threats to aquatic habitat within the ACF basin, of which the Chipola River is a part. The SARP threats assessment includes sedimentation, which has been identified as an important factor influencing Chipola slabshell viability via habitat destruction and modification. The SARP sedimentation index was calculated at the catchment scale (smallest watershed level defined by stream segments), and then averaged to derive estimates for the HUC10s of each MU. SARP ranked their sedimentation index as a relative index within the Chipola drainage (Table 4-7). While the sedimentation index considers non-native land cover, we also assessed the proportion of riparian area with at least 50 percent canopy cover (Table 4-9). We assessed canopy cover as a condition factor indicative of water quality, with canopy cover limiting the spread of contaminants as well as sediment and nutrients from developed areas into streams occupied by slabshell. The delivery of run-off of any sort into streams is mitigated by a riparian buffer, of which canopy cover is a surrogate measure. In addition, sedimentation and canopy cover could change in the future through land use change to either improve or decrease Chipola slabshell condition.

Sedimentation Index

Sedimentation is a common threat to aquatic ecosystems across many basins in the southeast. Sources of sediment include unpaved road crossings, impervious surfaces and agriculture practices, transmission line intersections, and more. To identify where this threat is greatest, sources of sedimentation within each catchment were identified (e.g., road crossings, transmission lines, soil loss potential, non-native land cover), summarized, and converted to a rank from 0 to 1 for each sedimentation component. When available, data was binned based on varying condition levels when justified in literature. Otherwise, the component indicators (i) were ranked using a linear value function defined as: i = (n-min)/(max-min), where n is the raw value of the given indicator. Some of the components are those that can be targeted and addressed, such as road crossings and transmission lines. All four components were weighted equally (25%) and added together to produce an index for sedimentation condition. One metric (soil loss potential) was binned prior to the creation of the index, imposing a three-part structure on the data. We utilized Jenks natural break classification both to reflect existing data clustering, and to identify another break in the data where consistently excellent conditions were present (Table 4-7).

Table 4-7. The SARP sedimentation index used to create Chipola slabshell condition categories for the assessment of current resiliency.

Condition Category	Sedimentation Index
Excellent	0 – 0.08: characterized by minimal density of road crossings, transmission lines, non-natural land cover; low soil loss potential
Good	0.09 – 0.23: characterized by low density of road crossings, transmission lines, and non-natural land cover; low soil loss potential
Fair	0.24 – 0.36: characterized by moderate density of road crossings, transmission lines, and non-natural land cover; moderate soil loss potential
Poor	> 0.37: characterized by maximal density of road crossings, transmission lines, and non-natural land cover; moderate to high soil loss potential

Soil Loss Potential

One well known mechanism of determining the potential for soil loss/erosion across a spatial scale is employing the Revised Universal Soil Loss Equation, or RUSLE. This equation takes multiple spatial layers and combines them to create one layer, determining where the most erosion could occur. The RUSLE equation is: A=R*K*LS*C*P, where A is the average annual soil loss in tons per acre per year; R is the rainfall/runoff intensity; K is the soil erodibility; LS is the hillslope length and steepness; C is the cover and management; and P is the support practice. In 2014, the USGS released a report detailing a classification of streams for the ACF river basin. During this study, a RUSLE dataset was created that combined data from many sources including the NLCD from the year 2001 (Elliott et al. 2014, p. 32). In the future, an updated RUSLE dataset using the latest NLCD would be useful for inclusion in this SSA.

The RUSLE dataset was obtained from USGS and the average was calculated for each catchment. This indicator was then ranked from 0 to 1 with 1 indicating a higher erodibility of soil. Data was binned into low medium and high values as justified by USGS (Elliott et al. 2014, p. 39):

- 0-0.25 tons/acre/year = low (0),
- 0.25 to 1 tons/acre/year = medium (0.5),
- and > 1 tons/acre/year = high (1)

Erosion rates of 0–0.25 tons/acre/year (0–0.02 mm/yr) were assigned as “low” and are characteristic of eastern forests and stable continental cratons in natural settings and within the low range of conservation agricultural practices. A medium class was assigned to erosion rates of 0.25–1 tons/acre/year (0.02–0.08 mm/yr) within the range of eastern forests, moderate gradient hillslopes, and conservation agriculture. A high class was assigned to erosion rates greater than 1 ton/acre/year (0.08 mm/yr). For context, soil erosion for the Apalachicola-Chattahoochee-Flint River Basin ranged from 0 to 200 tons per acre per year (tons/acre/year), equivalent to denudation rates of 0–15 millimeters per year (Elliott et al. 2014, p. 39). Within the range of Chipola slabshell, potential soil loss ranged from 0.003 to 5.94 tons/acre/year.

Road Crossings

SARP has been collecting road crossing data across the Southeast as a part of its Southeast Aquatic Connectivity Program. In order to mitigate sedimentation from road crossings, the catchments with the most road crossings per square kilometer were identified. Road crossing data was created by the USGS, by intersecting the NHDplus medium resolution hydrography and the Tiger 2017 line road dataset. USGS also worked to eliminate duplicate crossings and incorporate additional road data when available from agencies such as the US Forest Service. In addition, SARP supplemented this dataset of crossings with unpaved road crossings in the Chipola basin collected by the USFWS Panama City Field Office. The density of these road crossings (number/ square kilometer) was calculated for each catchment and ranked from 0-1 using a linear value function, with one indicating a higher density of crossings in catchment. The density of road crossings ranged from 7 to 0 per km^2 within the drainage.

Transmission Lines

Utility transmission lines often intersect streams and are relatively unbuffered or unforested, causing erosion and sediment input into streams. Southern Company (a gas and electric utility holding company based in the southern United States) provided transmission line and stream intersection points for the ACF basin. SARP identified additional transmission lines via aerial maps when possible. The density of intersection points (per square km) was calculated for each catchment. This indicator was then ranked from 0 to 1 using a linear value function, with 1 indicating a higher density of transmission lines per square kilometer. The density of transmission lines range from 0 - 3/km^2 within the drainage.

Non-natural Land Cover

Non-natural land cover is a contributor to sedimentation within aquatic ecosystems, specifically unregulated agriculture practices and impervious surfaces. The 2017 USDA cropscape dataset was used to calculate the percentage of the catchment that contained non-natural land cover. This indicator was then ranked from 0 to 1 using a linear value function, with 1 indicating a higher percent non-natural land cover. Non-natural land cover ranged from 0 to 100% within the drainage. The combined sedimentation index included in Table 4-8, below.

Table 4-8. Sedimentation Index for HUC 10s within management units (MUs), and the relation to Chipola slabshell condition.

MU	HUC 10	Sedimentation Index	Condition
1	River Styx & Douglas Slough	0.01	Excellent
2	Merritts Mill Pond –South	0.17	Good
	Mill Creek	0.15	Good
	Tenmile Creek	0.08	Excellent
	Dead Lake	0.01	Excellent
3	Marshall Creek	0.32	Fair
	Cowarts Creek	0.34	Fair
	Merritts Mill Pond –North	0.20	Good

<u>Canopy</u>

Canopy cover within 60 meters of Chipola slabshell streams was used as a proxy of water quality, as forested riparian areas buffer streams from pollutants. Canopy cover ≥ 50 percent within 200 feet (60 m) of streams was considered suitable based on buffer width and stand metrics provided by the Florida Silviculture Best Management Plan. While no amount of harvesting is permitted within 50 feet (15 m) of OFWs, selective harvest up to 50 percent of a fully stocked stand is permitted (FDCAS 2008, p. 4). These guidelines are considered protective of water quality by reducing or eliminating land use related inputs of nutrients, debris, and chemicals that can adversely affect aquatic communities.

We assessed the portion of riparian area with 50 percent or greater canopy coverage. We estimated that poor conditions were present if less than half of the area assessed met the threshold of 50 percent canopy, that ¾ to half of the area assessed would need to meet the minimum canopy threshold of 50 percent for Chipola slabshell to be in fair condition, with good conditions present when up to 90 percent of the area met threshold canopy values, and excellent conditions occurring when threshold canopy values were met in more than 90 percent of the area examined (Table 4-9). The approach for assessing the riparian area canopy cover is described below.

Table 4-9. Canopy metrics used to create condition categories for Chipola slabshell to be used in the assessment of current resiliency.

Condition Category	Canopy
Excellent	> 90 percent of buffer has ≥ 50 percent canopy cover
Good	76 to 90 percent of buffer has ≥ 50 percent canopy cover
Fair	50 to 75 percent of buffer has ≥ 50 percent canopy cover
Poor	< 50 percent of buffer has ≥ 50 percent canopy cover

We calculated suitable canopy cover within 60 m of streams for each recent slabshell record (within the last 20 years) using the 2016 National Land Cover Database Tree Canopy dataset. It is likely that bottomland canopy coverage has been reduced following Hurricane Michael in 2018, given that 75% of trees were damaged in these areas (FFS 2018, p.4). However, it is difficult to know exactly how this translates to canopy coverage. We calculated the percent of the 60-m buffer with suitable canopy cover along stream reaches at two spatial extents. First, we examined stream reaches between recent occurrences (> 2005) of Chipola slabshell and up to 3 km upstream from recent slabshell records. If the main channel containing slabshell split into two tributaries of equal stream order, we assessed canopy cover up to 3 km upstream of slabshell records along both tributaries. We included upstream reaches because conditions there influence sediment and water quality downstream. It is unknown exactly how far downstream sediments may settle or contaminants may travel. Three km was chosen as the upper extent to be consistent with distances typically considered during Section 7 consultations for the species. The second spatial extent included all tributaries upstream of recent records within the HUC 10 (not including those reaches included in the first extent so as not to double count them). We calculated the percent of suitable canopy cover at both spatial extents, and calculated a weighted average canopy cover where canopy cover within 3 km upstream of slabshell records was weighted twice as high as canopy cover on other upstream tributaries, under the assumption that mussels and their habitat are more directly impacted by canopy conditions nearby than those far away. The condition of this factor for each HUC 10 was classified based on the weighted average of suitable canopy cover (Table 4-10).

Table 4-10. Percent (%) of suitable canopy cover within a 200-ft stream buffer at two spatial extents, and a weighted average of the two extents and how this related to Chipola slabshell condition.

MU	HUC 10s	Between Records and 3 km Upstream	All Other Upstream Tributaries in HUC 10	Weighted Average	Condition
1	River Styx & Douglas Slough	94	89	92	Excellent
2	Merritts Mill Pond –South	94	86	91	Excellent
	Mill Creek	94	82	90	Good
	Tenmile Creek	90	89	90	Good
	Dead Lake	85	92	87	Good
3	Marshall Creek	96	75	89	Good
	Cowarts Creek	99	68	89	Good
	Merritts Mill Pond –North	99	89	96	Excellent

4.4.3 Resiliency Scoring

Each watershed was rated as currently being in one of four condition categories for each of the resiliency factors: poor, fair, good or excellent. While extirpated (Ø) was included as a possible condition for population factors, no analysis units (e.g., HUC 10s) were ranked as such in the current condition. The four condition categories were then converted to numerical ranks 1, 2, 3, and 4, respectively. We then calculated a weighted average of the factor scores to generate an overall resiliency score. A weighted average is a calculation that takes into account the varying degrees of importance of the numbers in a data set. The weighted average factor score is the sum of weights times scores divided by the sum of the weights.

All four factors had an equal baseline weight of 0.25 in the weighted average (summing to 1), and some weights were adjusted based on factor-specific characteristics identified by experts (Appendix G). Experts noted that Chipola slabshell may be able to tolerate sedimentation better than most other unionids. Occupation is important as abundance and recruitment can fluctuate greatly from year to year. Occupancy is useful for understanding long-term spatial patterns which can relate to resiliency, while abundance and reproduction are more direct metrics of a population's resiliency. We used the average weight assigned by experts to derive the weights for the four resiliency factors. The final weights for all factors were:

Occupancy: 0.296
Abundance and Recruitment: 0.304
Sedimentation Index: 0.178
Canopy: 0.222

The total weight for all population factors (0.6) was not equal to the total weight for all habitat factors (0.4) meaning that the final resiliency score for each MU was determined more by population than habitat conditions. A summary of all criteria and weights for resiliency factors is shown in Table 4-11. The weighted average of resiliency factor values was converted to population resiliency from the numerical ranks as follows:

Very Low Resiliency: < 2.5 weighted average of resiliency factors
Low Resiliency: 2.5 – 3.0 weighted average of resiliency factors
Moderate Resiliency: > 3 – 3.5 weighted average of resiliency factors
High Resiliency: >3.5 weighted average of resiliency factors

Resiliency was first calculated for each HUC 10, then scaled up to the respective MU by averaging the scores from all HUC 10s in that MU. Generally speaking, MUs with high and moderate resiliency were considered to exhibit resiliency, with low and very low resiliency scores not exhibiting such characteristics. Very low resiliency HUC 10s and MUs do not demonstrate resiliency and may be in immediate danger of extirpation. Summaries of the eight HUC 10s, their associated MUs, and resiliency ranks are provided in the following section.

Table 4-11. Summary of condition categories, resiliency factors, and weights used to assess current resiliency for Chipola slabshell.

Condition Category	**Population Factors (since 2005)**		**Habitat Factors**	
	Occupancy	**Abundance & Recruitment**	**Sedimentation Index**	**Canopy**
Factor Metric	*Proportion of occupied HUC 12s within a HUC 10*	*# Individuals and evidence of reproduction*	*a) Density of road crossings and transmission lines, percent non-natural cover, and b) soil loss potential*	*% 200-ft buffer with ≥ 50% canopy cover within assessed stream length*
Excellent	Consistent occupation in addition to newly occupied	> 100 (live) during a given sampling event; suggests a healthy population (e.g., likely ongoing recruitment).	0 – 0.08: a) minimal; b) low	> 90
Good	Consistent occupancy	10-100 (live or dead); more than one age class represented	0.09 – 0.23: a & b) low	76 to 90
Fair	<50 % Decreased occupancy	< 10 individuals (live or dead); potentially represented only by older individuals with limited recruitment	0.24 – 0.36: a & b) moderate	50 to 75
Poor	≥50 % Decreased occupancy	Only dead observed; population reduction likely not offset by recruitment	0.37 – 0.76: a) maximal; b) moderate to high	< 50
Ø	No occupancy in HUC 10	No records	N/A	N/A
Weight	***0.296***	***0.304***	***0.178***	***0.222***

4.5 Current Resiliency and Redundancy

There are currently two management units (MUs) that demonstrate resiliency and one that does not (Table 4-12), with an apparent north-south gradient in degree of resiliency (Figure 4-8). Of the resilient populations, MU 1 exhibited high resiliency, even though the abundance metric was ranked as good and not excellent. This MU had excellent canopy and sedimentation condition, which is a product of the low soil loss potential, limited development, and high proportion of protected land (57%) concentrated in riparian areas within the MU. In addition, MU 1 exhibits excellent occupancy; new records (> 2005) for the River Styx HUC 10 have been obtained where none were previously known in this watershed. The River Styx is part of the Apalachicola River Basin and the lack of historical data here likely represents true absence, as the Appalachicola River has been a target for mussel surveying since at least 1991 (USFWS 2019).

MU 2 was evaluated as having moderate resiliency. MU 2 contains the majority of slabshell records, partly because this area of the species range has been the most extensively surveyed, but also because MU 2 contains the majority of the Chipola mainstem length. Both the Mill Creek and Tenmile Creek HUC 10s had excellent abundance, with the trend for occupation, relative sedimentation risk and the riparian canopy cover in MU 2 supporting the idea that slabshells in the MU are stable and reproducing. Lower population estimates at Merritt's Mill Pond- South and Dead Lake HUC 10 could be due to a variety of limitations. Many shells and excellent habitat were noted at Merritt's Pond - South, but access to survey in 2019 was limited by Hurricane Michael storm debris. The region of Merritt's Mill Pond downstream of Marianna, FL, does not contain many slabshell records, which may be related to either a lack of sampling, difficulty in detection, or limited habitat suitability in this region. The Dead Lake HUC 10 contains slabshells in the northern section of Dead Lake which features braided channels with suitable substrate. But the remainder of the watershed is occupied by Dead Lake, which does not contain slabshell habitat.

MU 3 is does not have resiliency. This MU is characterized by the headwaters of the Chipola River, representing natural conditions that are likely marginal for Chipola slabshell and so abundance would not be expected be high. The combination of very few records, higher natural potential soil loss, non-native land cover, and areas of limited riparian canopy limit slabshell resiliency in MU 3. While the occupation trend is positive, abundance estimates do not suggest that mussels in this MU would persist following stochastic events such as high flow events, droughts, pollutant discharge, and sediment pulses.

In general, the majority of the Chipola slabshell population exhibits resiliency at present. Most of the population is not currently at risk from habitat modification. The high degree of land protection afforded to the existing population has created multiple management units where Chipola slabshell are buffered by forested public lands, protecting water quality and ensuring the viability of the population and species as a whole.

Table 4-12. Summary of current resiliency for Chipola slabshell management units (MUs).

MU	HUC 10s	Population Factors		Habitat Factors		Watershed Score	Overall MU Resiliency
		Occupancy	Abundance & Reproduction	Sedimentation Index	Canopy		
1	River Styx & Douglas Slough	Excellent	Good	Excellent	Excellent	High (3.7)	**High (3.7)**
2	Merritts Mill Pond –South	Good	Good	Good	Excellent	Moderate (3.2)	**Moderate (3.3)**
	Mill Creek	Good	Excellent	Good	Good	Moderate (3.3)	
	Tenmile Creek	Good	Excellent	Excellent	Good	High (3.5)	
	Dead Lake	Good	Good	Excellent	Good	Moderate (3.2)	
3	Marshall Creek	Excellent	Fair	Fair	Good	Low (2.8)	**Low (3.0)**
	Cowarts Creek	Excellent	Good	Fair	Good	Moderate (3.1)	
	Merritts Mill Pond –North	Excellent	Fair	Good	Excellent	Moderate (3.2)	

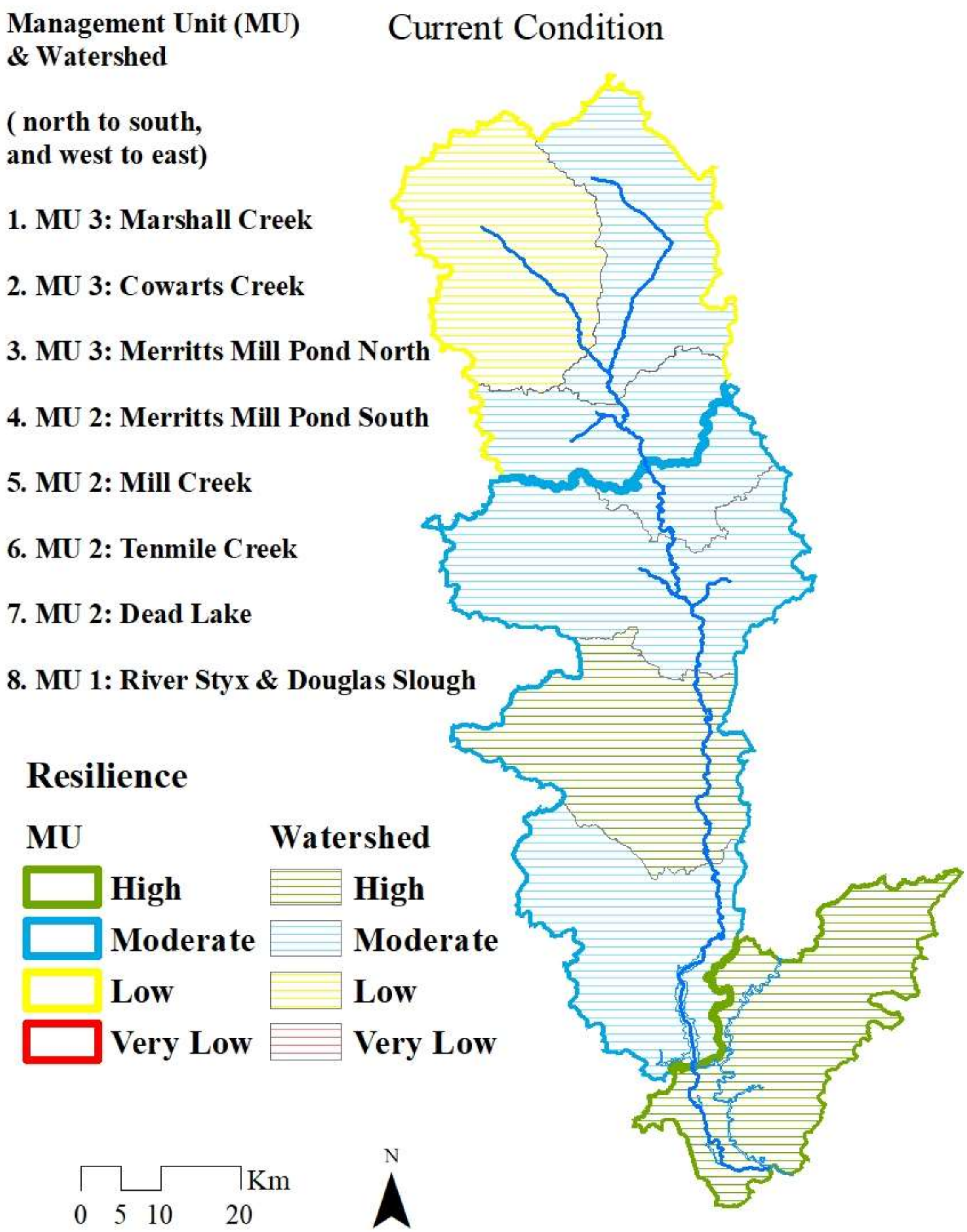


Figure 4-8. Current Chipola slabshell watershed and management unit (MU) resiliency.

To measure redundancy, we examined the number and distribution of resilient watersheds within Chipola slabshell management units (sub-populations). Species that have resilient populations spread throughout their historical range are less susceptible to extinction (Carroll et al. 2010, entire). Although the Chipola slabshell is a narrow range endemic, the current occupancy of the entire range is evident. High redundancy for Chipola slabshell is defined as multiple resilient MUs distributed throughout the species' historical range. The sub-populations/MUs meet the maximum species-level redundancy possible, although the resiliency of MU 3 is low and could be improved through further restoration activities to minimize sedimentation and maximize canopy cover. MU 3 is still considered to be contributing to high redundancy, as the portion of Marshall Creek historically occupied is contained within, or directly adjacent to, the boundary of the Cowart's Creek watershed which is considered resilient. There is limited information pertaining to genetic variation, but what environmental diversity there is (e.g., a general north-south gradient with headwater streams in MU 3, mainstem of the Chipola River in MU 2, and the Apalachicola River in MU 1) is currently occupied. In some cases records occur in newly occupied areas compared to historical records (e.g., Apalchicola River in River Styx HUC 10) or the recent past (e.g., rediscovery of slabshell in Cowarts Creek HUC 10 and Marshall Creek HUC 10). Therefore the risk of a catastrophic event that would affect the entire range of the species is reduced compared to the historical range. This concludes our assessment of the current condition of the species. The current condition serves as a description of the present state of the species as well as a baseline to compare against plausible future conditions, which are the subject of the next section of this report.

CHAPTER 5 – FUTURE CONDITION

Thus far, we have considered Chipola slabshell life history characteristics (Chapter 1), the habitat and demographic requisites needed for viability (Chapters 2 and 3), and have estimated the current condition of those needs through the lens of the 3Rs (Chapters 4). Next, we forecast Chipola slabshell future conditions, in terms of resiliency, representation, and redundancy to describe the future viability of Chipola slabshell.

The main factor influencing the viability of Chipola slabshell is habitat degradation or loss through land use change (e.g., urbanization, agriculture). Land use change can lead to direct impacts on viability through increases in sedimentation and contaminants within waters occupied by Chipola slabshell. Unfortunately, predicting future stream-channel conditions with respect to sedimentation in the ACF remains a challenge, and the ongoing remobilization of sediments would be difficult to separate from the cumulative effects of climate and land-use change (Elliott et al. 2014, p. 66). An increase in the contaminant load from incompatible land uses is expected to continue into the future to varying degrees, depending on a combination of factors including the impacts of climate change across the landscape, with habitat degradation or loss likely to be more significant in some MUs compared to others. We attempted to discern this variance by using the best available information on management plans and conservation projects, while also analyzing spatially-explicit models of future land use and climate change (e.g., SRES/RCP models) as indicators of associated water quality conditions.

We assessed the future condition of Chipola slabshell under three plausible future scenarios. The scenarios incorporated a range of conditions associated with climate and land use change, including a Lower Range, Moderate, and Higher Range Scenario. These three scenarios forecast slabshell viability over a 20 and 40-year projection period representing approximately two generations for each period. We concentrated on this duration because the species is relatively long-lived (15 to 20 years), it has relatively low fecundity (see section 3.1, above), and climate change or land use effects could become limiting within the timeframe. However, where possible we include model data at decadal timeframes in order to assess these trends.

5.1 Approach to Constructing in Future Scenarios

We identified the main drivers of change for the future scenario analyses to be human population growth and subsequent urbanization and land use change. Land use change may have synergistic effects with climate change, so several common climate projections are considered in the assessment of future condition. Species and ecosystems are impacted by the habitat degradation and loss associated with population growth, including impacts to water pollution, local climate conditions, and disturbance dynamics.

5.1.1 Population Growth and Land Use Change

According to the United States Census, the human population in the southern US has grown at an average annual rate of 37.7% since 2010 (US Census 2020, pp. 1-2), by far the most rapidly growing region in the country. Florida’s 2070 population will be an estimated 33,721,828, an increase of 15 million residents from 2010 (Carr and Zwick 2016, p.4). The total state lands acreage could see a change in developed areas from 6,275,000 acres to 11,648,000 acres, an increase of 15.6%, by the year 2070 (Carr and Zwick 2016, p.15). As of 2017, there were an estimated 1.45 million permanent residents in northwest Florida (NWFWMD 2018b, p.3). The 2070 population model for the Panhandle will remain the least developed area for the State of Florida, increasing the population by 703,090 residents to 2,110,976 (Carr and Zwick 2016, p. 5), and the three counties in the Chipola Basin in Florida remain predomantly rural. The projections for the counties surrounding the Chipola River from 2010 to 2045 are presented in Table 5-1.

Table 5-1. Chipola Basin projected population change, adapted from NWFWMD 2018b, p.3.

Counties	2010	2045	% change
Jackson	49,746	52,800	4.72
Calhoun	14,625	17,300	15.33
Gulf	15,863	18,500	13.52

To assess the impacts to Chipola slabshell of future land use change and its possible interaction with climate, we utilized the FOREcasting SCEnarios of land-use (FORE-SCE) model (Sohl et al. 2014). The USGS's FORE-SCE model projections are used for a wide variety of purposes, including analyses of the effects of landscape change on biodiversity, water quality, and regional weather and climate Scenarios were modeled for 2006 to 2100, corresponding to major scenario storylines from the Intergovernmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (SRES). The 1992 to 2005 period was considered the historical baseline, with datasets such as the National Land Cover Database (NLCD), USGS Land Cover Trends, and US Department of Agriculture's Census of Agriculture used to guide the recreation of historical land cover for this period. The global IPCC SRES (e.g., A1B, A2, and B1 scenarios) were downscaled to ecoregions in the conterminous United States, with the USGS Forecasting Scenarios of land use (FORE-SCE) model used to produce landscape projections at decadal intervals consistent with the IPCC SRES (Figure 5-1). The different land-use scenarios focused on socioeconomic impacts on anthropogenic land use (demographics, energy use, agricultural economics, and other socioeconomic considerations).

We utilized the FORE-SCE dataset to assess future land use change, as it is inclusive of various forms of potential land use change (Appendix I), where other commonly used land use change datasets focus mainly on urbanization that may be overestimated in rural landscapes (e.g., SLEUTH; Appendix H) or only project out to the maximum timeframe of our analysis and not cover the range of Chipola slabshell (e.g., Florida 2070). The SLEUTH (Slope, Land use, Excluded area, Urban area, Transportation, Hillside area) model, which simulates patterns of urban expansion that are consistent with spatial observations of past urban growth and transportation networks, including the sprawling, fragmented, "leapfrog" development that has been the dominant form of development in the Southeast (Terando et al. 2014, p.2). However, the FORE-SCE SRES projections are spatially explicit and thematically more detailed than most comparable regional- or national-scale land-use and land-cover projections, resulting in an improved ability to inform ecological applications (Sohl, et al. 2014, p. 1033). For future scenario predictions, we considered the more "extreme" land use projections under SRES A2 and B1 for the Higher and Low Range Scenarios, respectively. The A1B projection was used to evaluate land use under an intermediate climate and socioeconomic future for the Moderate

Range Scenario; A1B projects a future with very rapid economic growth (similar to A2), low population growth and rapid introduction of new and more efficient technology. In this world, people pursue personal wealth rather than environmental quality. (IPCC 2000, p. 4 -5). The SRES A2 projection of the Higher Range Scenario assumes a continuously increasing global population where economic development is primarily regionally oriented and per capita economic growth and technological change are more fragmented and slower than in other land use projections. The SRES B1 projection used in the Lower Range Scenario describes a convergent world with the same global population as A1B that peaks in midcentury and declines thereafter, but with rapid changes in economic structures toward a service and information economy and the introduction of clean and resource-efficient technologies (Figure 5-1).

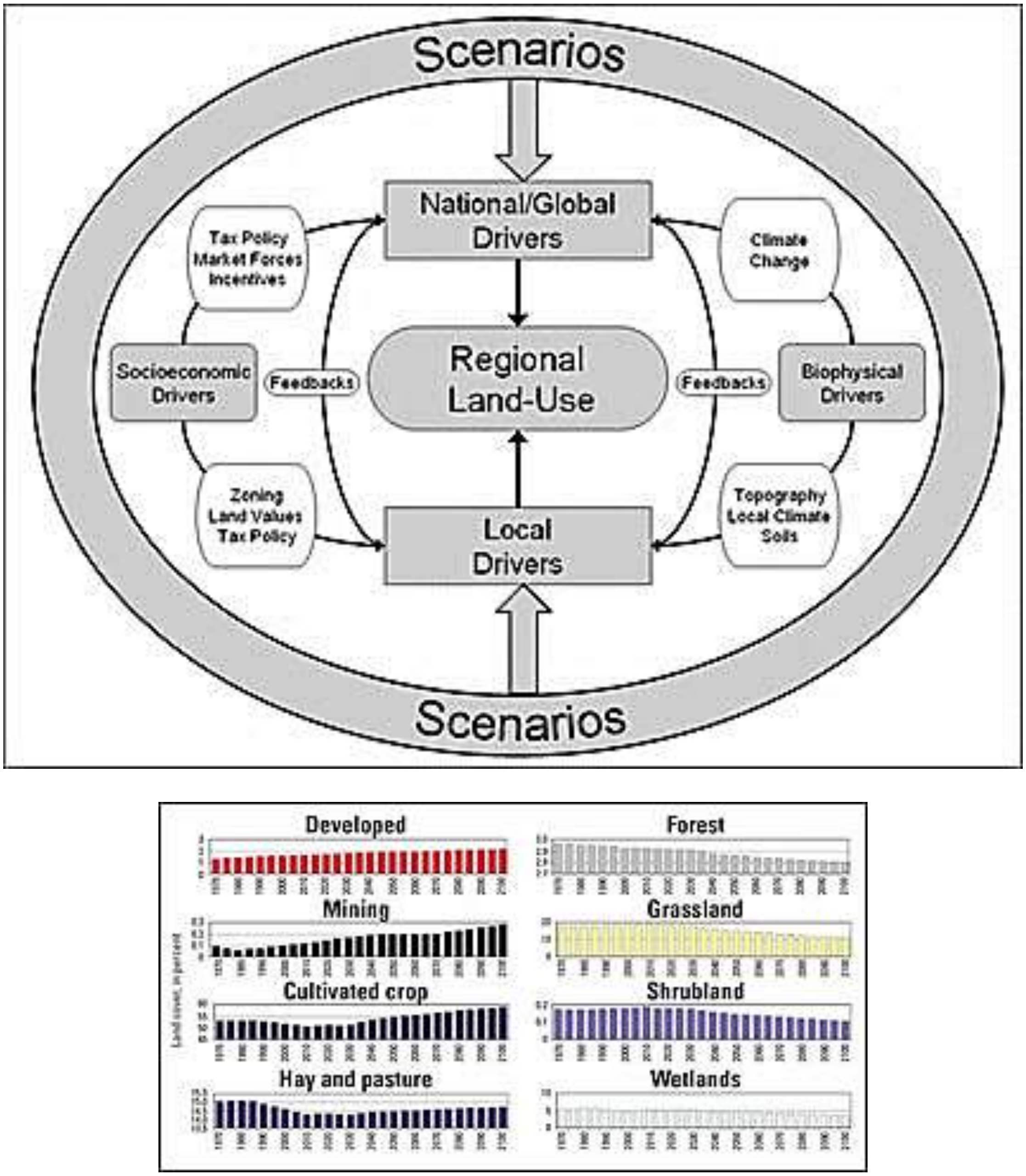


Figure 5-1. FOREcasting SCEnarios of Land-use Change (FORE-SCE) modeling framework to provide spatially explicit projections of future land-use and land-cover change. FORE-SCE provides land-cover coverage for 17 land cover classes consistent with the National Land Cover Database, at decadal intervals.

5.1.2 Changes in Climate-associated Factors

In order to predict future changes in climate, scientists rely on climate model simulations that are driven by assumptions about future human population growth, changes in energy generation and land use, socio-economic development, and technology change. The IPCC's Fifth Assessment Report (AR5), published in 2014, presents the most recent climate findings based on a set of scenarios that use Representative Concentration Pathways (RCPs). The RCPs are representative of several different scenarios that have similar greenhouse gas emissions characteristics on a time-dependent trajectory to reach a certain projected outcome (Wayne 2013, p.1). There are four RCPs, identified by the amount of radiative forcing (i.e., the change in energy in the atmosphere due to greenhouse gases) reached by 2100: one high pathway (RCP 8.5); two intermediate stabilization pathways (RCP 6.0 and RCP 4.5); and one low trajectory pathway (RCP 2.6 or RCP 3PD) (Wayne 2013, p.11). RCP 8.5 assumes that emissions would be more or less unabated due to a lack of climate-change reversal policies (Wayne 2013, p.15). For RCP 4.5 and RCP 6.0, emissions are assumed to be relatively stable throughout the century, however RCP 6.0 does not incorporate climate-reversal policies into forecasts, while RCP4.5 incorporates a number of climate policies into forecasts (Wayne 2013, p.15).

When comparing to the climate component of the FORE-SCE model (SRES scenarios A2, A1B, and B1), RCP 8.5 and SRES A2 are similar, particularly at late century, and RCP 4.5 and SRES B1 are similar throughout the future. One of the main differences between RCP and SRES models is that RCPs start with atmospheric concentrations of greenhouse gases rather than socioeconomic processes. Although the SRES projections are not used widely today, these two approaches (SRES or RCP) are not inconsistent. Rather, they both present plausible and consistent pictures of how future human activities may affect climate (Figure 5-2).

Despite the recognition of potential climate effects on ecosystem processes, there is uncertainty about what the exact climate future for the Southeastern US will be and how the ecosystems and species in this region will respond. The greatest threat from climate change may come from synergistic effects. That is, factors associated with a changing climate may act as risk multipliers by increasing the risk and severity of more imminent threats, especially for rivers in wide flood plains where stream channels have room to migrate (Elliot et al. 2014, p. 67 -68). As a result, impacts from land use change might be exacerbated under even a mild to moderate climate future.

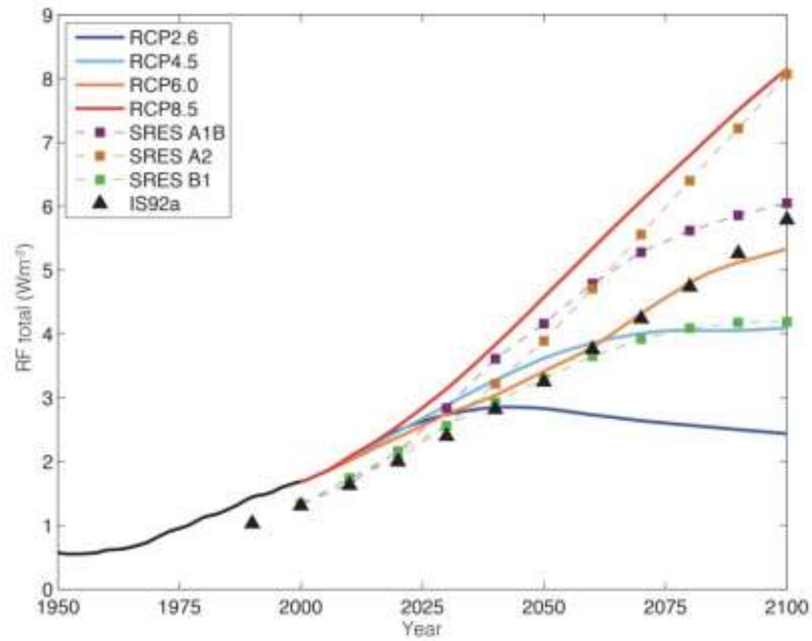


Figure 5-2. Historical and projected future anthropogenic radiative forcing (RF; the change in energy in the atmosphere due to greenhouse gases) under different scenarios, relative to the preindustrial period (about 1765) (Cubasch et al. 2013, p. 146).

We considered the "extreme" climate future under RCP 8.5/SRES A2 in combination for an upper range, RCP 4.5/ SRES B1 as lower range, and RCP 6.0/SRES A1B as a middle range for possible future conditions. Regardless of a higher or lower-range emissions climate future, systematic changes are expected to be realized to varying degrees in the Southeastern US within the range of Chipola slabshell (e.g., Alder and Hostetler 2013; Appendix J, Carter et al. 2018, LaFontaine et al. 2019) with strong implications for resiliency, including more frequent drought (Figure 5-3) and reduction in baseflow (Figure 5-4).

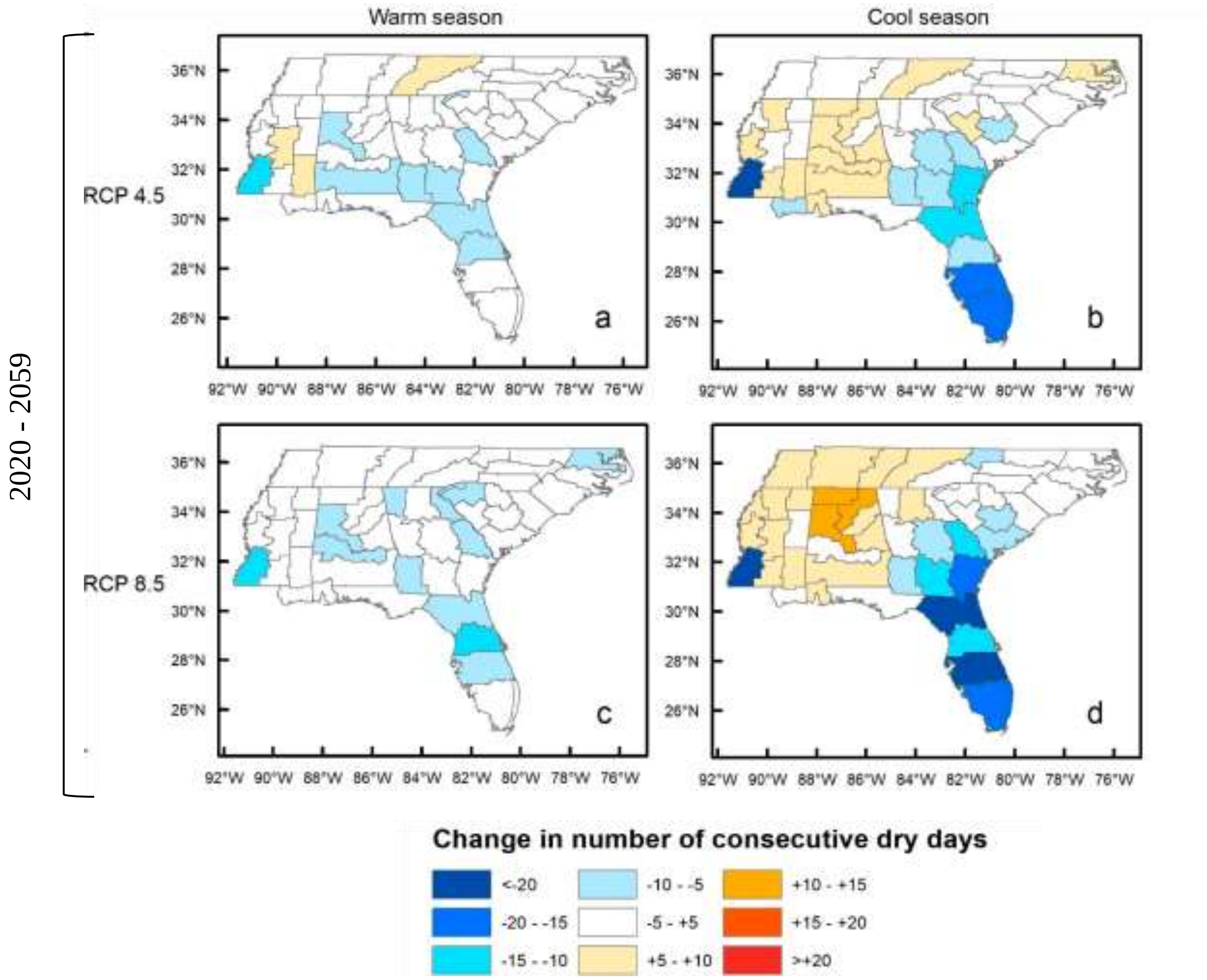


Figure 5-3. Absolute changes in length of 20-year return period consecutive dry days in downscaled CMIP5 models for future periods versus observations (Keellings and Engstrom 2019, p. 6). Warm season estimates are shown in (a,c), and cold season estimates are shown in (b,d). The future period ranges from 2020 to 2059, with both RCP 4.5 and 8.5 used to assess potential future outcomes.

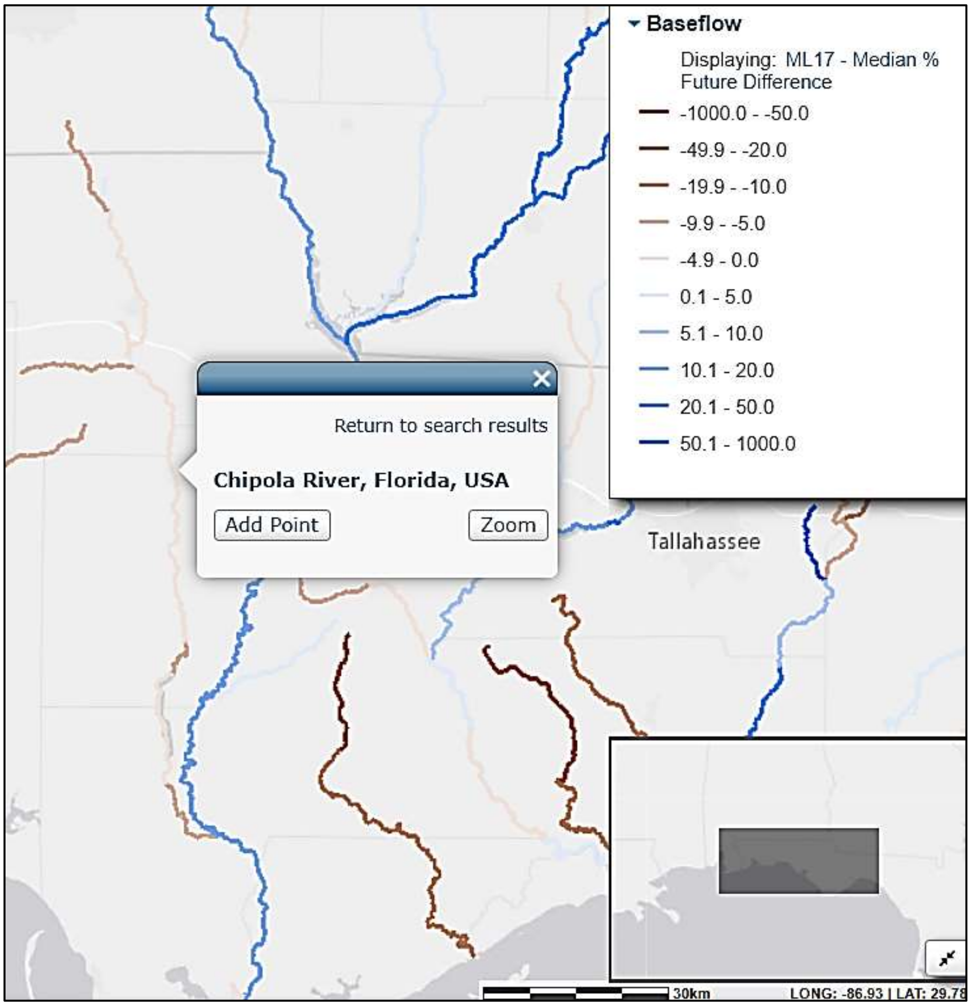


Figure 5-4. Future percent difference from historical conditions for baseflow within stream segments (LaFontaine et al. 2019). Future conditions were modelled for the period 2045-2075, and historical conditions are derived from the period 1952-2005. Values are expressed as the percent difference based on a median of 45 future scenarios including 4 RCP pathways (2.6, 4.5, 6.0, and 8.5.

5.1.3 Conservation Management

Current levels of conservation management as discussed in Section 3.4 were assumed to be constant across all scenarios unless commitment of specific actions are currently, or will be imminently, in place. Areas of the Chipola River mainstem that are not protected currently (e.g. MU 2) have been prioritized for purchase or easements through Florida Forever funds, which will likely help mitigate reductions in riparian canopy cover. Much of the riparian cover is classified as wooded or herbaceous wetland and the area occupied by these cover types does not change with time, even though woody wetland extent declines substantially in the A1B and A2 projections elsewhere in the USA due to land-use conversion (Stohl et al. 2014, p. 1025). In 2018, the impact of Hurricane Michael to the riparian tree cover in the Chipola River was extensive. However, most of the downed trees tended to be pine trees and many other riparian trees remain to provide some riparian cover. The additional woody debris may reduce overall shear stress in the river and provide additional refugia and stabilization of sediments for freshwater mussels (Metcalf and Morris, p. 4 – 5).

5.2 Future Resiliency and Redundancy Assessment

Resiliency and redundancy scoring was completed as in Section 4.5. The resiliency of MUs (scaled up from watershed rankings) included high, moderate, low and very low. High resiliency MUs were defined as those with high or moderate resiliency at the end of a given projection period (20 or 40 years in the future). Projections of Chipola slabshell resiliency and redundancy were forecasted using a 40-year maximum projection. This projection was chosen to represent a time frame during which the effects of management actions can be implemented and realized on the landscape, climate change effects may become apparent, and it is also a reasonable time frame (including approximately 4-5 generations) for the species to respond to potential changes on the landscape. Resilient MUs are expected to persist to the end of the projection period, and have the ability to withstand stochastic events. MUs with moderate resiliency were defined as having lower resiliency than those with high resiliency but are still expected to persist through the projection period. MUs with moderate resiliency have lower abundances and reduced recruitment than resilient MUs. Finally, those MUs with low resiliency may not be able to withstand stochastic events. As a result, low resiliency MUs were predicted to be much less likely to persist through the projection period, and therefore are not considered resilient. Very low resiliency equates to possible extirpation; see Table 5-2 for definitions. Resilient watersheds (high or moderate resiliency) at the end of the projection period were counted to give an estimate of redundancy.

Table 5-2. Overview of condition categories reflecting possible changes in occupancy, abundance, sediment, and canopy used to determine the overall projected future conditions of Chipola slabshell.

Future Resiliency Category	Description
High	These are sizable populations expected to be distributed over a significant and more or less contiguous length of stream, and likely to demonstrate recruitment. Connectivity among populations is maintained or improved. Water quality meets designated uses and contiguous reaches with clean, firm sand without excessive silt are predominant. Habitats are optimal for reproduction and recruitment, and multiple age classes are represented in surveys. Minimal change in forested riparian area is expected given protected status or low urbanization. These populations are expected to persist during the projection period (20 or 40 years) and withstand stochastic events.
Moderate	Populations are restricted in distribution with potentially limited levels of recruitment. Firm sand substrate free of excessive silt is maintained, and natural flow regimes persist in currently occupied rivers and streams. Lowered water quality and habitat degradation may occur but not at a level that negatively affects both the density and extent of mussel distribution. Some change in forested riparian area is expected given protected status. Resiliency is less than under high conditions, but the majority of slabshell records expected to persist beyond the projection period (20 or 40 years); however, loss of smaller tributary populations is possible. Populations are smaller and less dense than the high condition category.
Low	Populations are small, highly restricted in distribution, and likely not resilient, but may still be observable in low numbers. Best available information indicates little or no evidence of recruitment, and loss of mussel habitat or water quality degradation, within the formerly occupied river or stream reach, has been measured or observed. The forested riparian area is vulnerable to reduction given protected status. These populations have low resiliency, are not likely to withstand stochastic events, and are the least likely to persist past the projection period (20 or 40 years).
Very Low	Populations are expected to no longer occur in a given area within the projection period (20 or 40 years). No recruitment is observed, indicating reproduction is no longer occurring. The forested riparian area is vulnerable to extensive reduction given protected status. Contiguous mussel habitat with clean, silt-free substrates have been lost or are covered in sediment. Water quantity or quality limits colonization potential. Population sizes may be below detectable levels despite consistent survey efforts within formerly occupied range, or may only be represented by highly isolated, or older, non-recruiting individuals.

5.3 Description of Future Scenario Results

We project future resiliency as in the current condition, by assessing resiliency within HUC 10s, and scaling up to MU and species-level resiliency and redundancy. For example, future occupancy is assessed in reference to historical occupancy conditions (< 2005). The factors that influence resiliency in the species (e.g. occupancy, abundance, sediment, canopy) either change as minimally as can be expected from the current condition (Low Range Scenario), or worsen to a moderate (Moderate Range Scenario) or greater degree (Higher Range Scenario) based on potential future climate and land use and their impacts on water quality and quantity (Table 5-3). The data used to inform the future condition scenarios for each Chipola slabshell watershed are described further below, and detailed at the watershed level when possible.

Three scenarios were used to characterize the uncertainty regarding plausible futures for the Chipola slabshell. Resiliency and redundancy were forecasted for each scenario using each of three possible climate futures coupled with the associated land use change from FORE-SCE models and assumptions about conservation management. The expected future resiliency of each MU was forecasted based on events that were projected to occur under each scenario. All scenarios assumed that current conservation efforts (See Section 3.4) would remain in place but that no new actions would be taken. As with current condition estimates, estimates were made at the lowest hierarchical level (HUC 10s and MUs) and were then scaled up to the population level. Management Units and their HUC 10 watersheds are listed from north to south within each respective MU.

Table 5-3. Summary of future scenarios for Chipola slabshell.

Scenario	Climate	Urbanization	Agriculture & Forestry	Water Quality & Quantity	Species Occupancy & Abundance	Sedimentation & Canopy
Lower Range: Current conservation efforts with low range climate and land use change models	Moderate- Low Climate Future (RCP 4.5): some climate change effects experienced; certain areas impacted more than others by heat and drought (RCP 4.5)	B1: lower than other scenarios due to drop in population growth mid-century and a focus on ''smart'' urban growth	B1: Agricultural lands (cropland and hay/pasture) often decrease modestly, as there is a tendency for cropland to increase and pasture to decrease	Slightly increased impacts through time tempered by utilizing improved technologies and successful implementation of protection projects and strategies	Stable to improved condition, but reduction in condition may occur depending on local land use trends and flow limitations	Existing resources targeted to highest priority riparian buffer acquisition and restoration to maintain water quality
Moderate Range: Current conservation efforts with moderate to high range climate and land use change models	Moderate Climate Future (RCP 6): some climate change effects experienced; some areas impacted more than others by heat and drought	A1B: high rate of urban increase, population that peaks in mid-century and declines thereafter	A1B: strongest rates of forest cutting. Agricultural lands (cropland and hay/pasture) increase considerably, but less than A2	Increase in impacts not fully mitigated by continued levels of regulation, protection, and technology	Selective declines in condition; protection and restoration efforts may act to offset impacts in some locations. Possible impacts from low flows in some areas	Water quality impacts outpacing targeted riparian buffer acquisition and restoration in some locations given existing resources
Higher Range: Current conservation efforts with higher range climate and land use change models	Moderate to Worse Climate Future (RCP 8.5): exacerbated effects of climate change related to heat and drought	A2: highest rate of urban increase, high economic growth, very high population growth	A2: Agricultural lands (cropland and hay/pasture) increase substantially	Declining water quality and quantity in many areas resulting from increased impacts and water management	Synergistic impacts on landscape result in declines that are unlikely to be offset in most locations. Probable impacts from low flows in some areas.	Degraded instream and riparian habitat conditions in many locations regardless of targeted riparian buffer acquisition and restoration

5.3.1 Lower Range Scenario

Under this scenario, climate and land use change proceed according to low range models, and current conservation efforts involving riparian restoration and land protection are continued to largely mitigate negative effects.

Under the Lower Range Scenario, factors that currently influence Chipola slabshell were assumed to remain as consistent as possible over the 20 and 40-year assessment period. The FORE SCE land use projection evaluated in this scenario (B1) includes the same global population that peaks in midcentury and declines thereafter as in the Moderate Range Scenario, but with the introduction of clean and resource-efficient technologies. The trajectory of such a future corresponds well with Climate Change Model RCP 4.5. The area of new urban lands is low in this scenario due to a focus on environmentally friendly lifestyles (Sohl et al. 2014, p. 1021). Effects of climate change are expected to be moderate to low, with increased risk of impacts from droughts and low baseflow (IPCC 2013, p.7) after 2040 within the Alabama portion of the range (Keellings and Engstrom 2019, p. 6; Figure 5-3). Because water quality, flow, and habitat impacts are predicted to be less severe in this scenario as compared to others, it is expected that the species will have a neutral or slightly positive response. Below, we describe how resiliency factors are expected to change for each MU and the watersheds that comprise them within the Lower Range Scenario (Table 5-8). A summary of the expected change in condition rank for each resilience factor is contained within Table 5-8.

Table 5-4. Change in condition rank for Chipola slabshell resilience factors under the Lower Range Scenario for the entire species range. Population and habitat factors are evaluated in both a 20-year and 40-year projection. Time periods with (-) indicate no change, otherwise the condition may increase or decrease by one rank compared to the current condition.

MU	HUC 10s	Population Factors (20/40)		Habitat Factors (20/40)	
		Occupancy	Abundance & Reproduction	Sedimentation	Canopy
1	River Styx & Douglas Slough	- / -	- / Increase	- / -	- / -
2	Merritts Mill Pond –South	- / -	- / -	- / -	- / -
	Mill Creek	- / -	- / -	- / -	- / -
	Tenmile Creek	- / -	- / -	- / Increase	- / Increase
	Dead Lake	- / -	- / -	- / -	- / -
3	Marshall Creek	- / -	- / -	- / -	- / -
	Cowarts Creek	- / -	- / -	- / -	- / -
	Merritts Mill Pond –North	- / -	- / -	- / -	- / -

5.3.1.1 Management Unit 1 (Table 5-5)

1) River Styx & Douglas Slough
   i) Land Use & Cover—The anthropogenic land uses (urban, mining, agriculture, silviculture) decrease slightly to 4 % in 2040 and to 4.4 % in 2060, from a value of 4.8 % in 2020. The remainder of the landcover is natural (forest, wetland, water, or barren).
   ii) Water Quality and Quantity—No expected decreases in water quality given minimal climate and land change. Droughts are not expected to be impactful when combined with decreased flows from the Woodruff Dam on the Apalachicola River, however there may be a minor decrease in baseflow in the Lower Chipola after 2040 (LaFontaine et al. 2019) that is not impactful under this scenario. There was minimal evidence of Chipola slabshell mortality at flows above 5,000 cfs during surveys of the Cutoff during 2006, and no mortality was reported in the Chipola River in 2006 or 2007. In addition, none were found exposed or dead in any of the recent low water events occurring in 2010 or 2011, even when flows were less than 5,000 cfs in 2011, although a mortality of 53 slabshell was anticipated (USFWS 2016b, p. 129).
   iii) Species Occupancy and Abundance— No change in 20 years, abundance increases by one rank in 40 years compared to current condition. It is likely that individuals will continue to expand to occupy available habitat in the watershed (Appendix E) given the expansion into this watershed in the recent past (e.g. further north within the Apalachicola River, further east into Big Gully Creek subwatershed (HUC 12: 31300110603) and extensive protected area. However, occupation is already ranked as excellent. The watershed is anticipated to experience an increase in abundance even with occasional mortality from the synergistic effects of drought and water management activities.
   iv) Sedimentation and Canopy— No change from current condition. Sedimentation is not expected to impact Chipola slabshell beyond that seen in the current condition by 2040 or 2060.

Table 5-5. Change in condition rank for Chipola slabshell resilience factors under the Lower Range Scenario. Population and habitat factors are evaluated for MU 1 in both a 20-year and 40-year projection. Time periods with (-) indicate no change, otherwise the condition may increase or decrease by one rank compared to the current condition.

MU	**HUC 10s**	**Population Factors (20/40)**		**Habitat Factors (20/40)**	
		Occupancy	**Abundance**	**Sedimentation**	**Canopy**
1	River Styx & Douglas Slough	- / -	- / Increase	- / -	- / -

5.3.1.2 Management Unit 2 (Table 5-6)

2) Merritts Mill Pond –South
    i) Land Use & Cover—Urbanized area increases from 3.7 to 4.9% by 2060, with a corresponding decrease in agricultural and forested lands.
    ii) Water Quality and Quantity—Positive trajectory for water quality from TMDL development and implementation (ETA 2023). Water flows are protected from consumptive uses by water reservation (legal protection, and a minimum flow limit will be evaluated in 2023. Climate change is not expected to reduce water quality or quantity for Chipola slabshell within 40 years.
    iii) Species Occupancy and Abundance— No change from current condition. Occupancy is likely to remain unchanged into 2060, but abundance is vulnerable to the expansion of Marianna into unprotected riparian habitat after 2040, following a period of rebuilding from Hurricane Michael in 2018. The expansion of Marianna into riparian areas by 2060 is not expected to occur in this scenario, as smart urban development is assumed.
    iv) Sedimentation and Canopy— No change from current condition. While current protected areas do not fully encompass the Chipola River mainstem adjacent to Marianna, impacts that would reduce these resilience factors for Chipola slabshell are not expected in this scenario. Additional areas targeted for acquisition (besides the Chipola mainstem; see Section 3.4.4) within the watershed include the Spring Lake Spring Group and the area around Jackson Blue Spring within the center of Jackson County (NWFWMD 2018b, p. 22).

3) Mill Creek
    i) Land Use & Cover—Land use change is expected to shift slightly toward natural cover in this scenario. Urbanized area remains largely stable, increasing from 0.8% to 0.9% in 2040 and 2060, while agricultural lands decrease slightly from current levels (24.8 to 23.1% by 2060) corresponding to a 2% increase in forested area by 2060 Most of the increase in forested area occurs by 2040 (1.5%).
    ii) Water Quality and Quantity—Likely to be maintained as in the current condition given the land use trends, but vulnerable due to lack of protected area.
    iii) Species Occupancy and Abundance—No change from current condition. Possible future expansion upstream along Dry Creek, as the 2014 record is on the edge of a subwatershed (HUC 12) boundary which were used to delimit occupancy units. However, expansion is not assumed.
    iv) Sedimentation and Canopy— Increase by one rank in 20 years compared to current condition. Given the positive change in land use, sedimentation condition may increase to excellent by 2060 with the reduction in agricultural area and increase in forested area. The current canopy condition is on the verge of excellent rank. By 2040, canopy condition is expected to increase one rank to excellent. The increase in forest cover is assumed to occur within riparian zones, given the desire to maintain and restore wetlands under the environmentally friendly landuse projection used in

this scenario (Sohl et al. 2014, p. 1022), the tendency for the riparian zone to be comprised of wooded wetland, and the prioritization of funds for acquisition of riparian areas (NWFWMD 2018b, p. 22).

4) Tenmile Creek
   i) Land Use & Cover—Natural landcover increases, with a portion of agricultural and silviculture area converting to forest. By 2060, 87% of the watershed is forested or wetland, an increase of 5% from 2020. The majority of the increase in forested area occurs by 2040 (increase of 3.7%). The proportion of urbanized land remained constant through time.
   ii) Water Quality and Quantity— Likely to be maintained as in the current condition given the land use trends, but vulnerable due to minimal protected area.
   iii) Species Occupancy and Abundance—No change from current condition.
   iv) Sedimentation and Canopy—Canopy increases by one rank in 20 years compared to current condition. Sedimentation condition is already excellent and cannot increase further. The current canopy condition is on the verge of excellent rank. By 2040, canopy condition is expected to increase one rank to excellent. The increase in forest cover is assumed to occur within riparian zones, given the desire to maintain and restore wetlands under the environmentally friendly landuse projection used in this scenario (Sohl et al. 2014, p. 1022), the tendency for the riparian zone to be comprised of wooded wetland, and the prioritization of funds for acquisition of riparian areas (NWFWMD 2018b, p. 22).

5) Dead Lake
   i) Land Use & Cover—Land cover change is minimal, with a slight decrease in agriculture area from 5 to 4.4% in 2040 and 4.8% in 2060, and a minor increase in urbanized area by 2060 (0.2%). The proportion of natural cover (forests, wetlands) remains essentially unchanged.
   ii) Water Quality and Quantity—Likely to be maintained as in the current condition given the land use trends, but vulnerable due to little protected area.
   iii) Species Occupancy and Abundance—No change from current condition.
   iv) Sedimentation and Canopy— No change from current condition. Given the positive change in land use, sedimentation condition is not anticipated to change from current levels though some mainstem segments are vulnerable to further residential development.

Table 5-6. Change in condition rank for Chipola slabshell resilience factors under the Lower Range Scenario. Population and habitat factors are evaluated for MU 2 in both a 20-year and 40-year projection. Time periods with (-) indicate no change, otherwise the condition may increase or decrease by one rank compared to the current condition.

MU	HUC 10s	Population Factors (20/40)		Habitat Factors (20/40)	
		Occupancy	Abundance	Sedimentation	Canopy
2	Merritts Mill Pond –South	- / -	- / -	- / -	- / -
	Mill Creek	- / -	- / -	Increase / -	Increase / -
	Tenmile Creek	- / -	- / -	- / -	Increase / -
	Dead Lake	- / -	- / -	- / -	- / -

5.3.1.3 Management Unit 3 (Table 5-7)

6) Marshall Creek
   i) Land Use & Cover—Agriculture area decreases slightly in this scenario, from 48.8 to 43.2 by 2060, with the percentage of urbanized areas increasing from 2.5 to 4.7 %. Forested area increases 3.1%, from 30.1 to 33.1% by 2060.
   ii) Water Quality and Quantity—Fecal coliform impairments are not necessarily reducing water quality for Chipola slabshell. Water flows are well supported by ground water contributions from springs during drought (Garner et al. 2009, p. 693). Low flows are not expected to impact slabshell in this scenario. The watershed is vulnerable given the minimal protected area and relatively high agricultural area.
   iii) Species Occupancy and Abundance— No change from current condition. The 2007 record on Big Creek is not known to be well connected to other records in the watershed. This record may be lost in the future, reducing occupancy to the historic distribution which is represented by records from 2018 and 2019. However, we believe it will persist in the present scenario. Newly occupied subwatersheds are maintained into the future, given the land use trend of lowered agricultural and increased forested area.
   iv) Sedimentation and Canopy— No change from current condition. Positive land use trends maintain current conditions. No improvement in condition is seen as the capacity for the protection of riparian areas in Alabama is unknown, and riparian area in Florida is already protected.

7) Cowarts Creek
   i) Land Use & Cover—Agriculture area decreases slightly in this scenario, from 52.6 to 47.5 by 2060, with the percentage of urbanized areas increasing from 1 to 2 %. Forests increase by 3.9%, from 29 to 32.9 % by 2060, with most of this increase (2.5%) occurring by 2040.
   ii) Water Quality and Quantity—Fecal coliform impairments are not necessarily reducing water quality for Chipola slabshell. Water flows are fairly well supported by

ground water contributions from springs during drought (Garner et al. 2009, p. 693). Low flows are not expected to impact slabshell in this scenario. The watershed is vulnerable given the minimal protected area and relatively high agricultural area compared to other watersheds in MUs 1 and 2.

iii) Species Occupancy and Abundance— No change from current condition. Newly occupied subwatersheds are maintained into the future, given the land use trend of lowered agricultural and increased forested area.

iv) Sedimentation and Canopy— No change from current condition. There is a risk of sediment impacts if fecal coliform impairment is from cattle accessing waterbodies. However, positive land use trends maintain current conditions. No improvement in condition is seen as the capacity for the protection of riparian areas in Alabama is unknown.

8) Merritts Mill Pond –North

i) Land Use & Cover—Agriculture area decreases slightly in this scenario, from 41.1 to 40.3 by 2060, with the percentage of urbanized areas increasing from 2 to 2.7%. Forested area remains largely unchanged through 2060, at 41.8%.

ii) Water Quality and Quantity—Positive trajectory for water quality from TMDL development and implementation (WBID 51 E). Water flows are protected from consumptive uses by water reservation (legal protection).

iii) Species Occupancy and Abundance— No change from current condition. Survey access was noted to be limited due to downed trees in 2018. While additional records may be found that connect the currently clustered distribution, this is not assumed.

iv) Sedimentation and Canopy— No change from current condition. Land cover trends suggest sedimentation should not increase in the future, but also not decrease. The riparian buffer is largely protected and already ranked as excellent.

Table 5-7. Change in condition rank for Chipola slabshell resilience factors under the Lower Range Scenario. Population and habitat factors are evaluated for MU 3 in both a 20-year and 40-year projection. Time periods with (-) indicate no change, otherwise the condition may increase or decrease by one rank compared to the current condition.

MU	HUC 10s	Population Factors (20/40)		Habitat Factors (20/40)	
		Occupancy	**Abundance**	**Sedimentation**	**Canopy**
3	Marshall Creek	- / -	- / -	- / -	- / -
	Cowarts Creek	- / -	- / -	- / -	- / -
	Merritts Mill Pond – North	- / -	- / -	- / -	- / -

Table 5-8. Summary of future resiliency for Chipola slabshell management units (MUs) in the Lower Range Scenario at the end of the 20 and 40-year projection. Where condition ranks differ between projections, ranks for each projection are included. The final watershed score and MU resiliency are summarized separately for each projection.

MU	HUC 10s	Population Factors		Habitat Factors		20-year projection		40-year projection	
		Occupancy	Abundance	Sedimentation	Canopy	Watershed Score	Overall MU Resiliency	Watershed Score	Overall MU Resiliency
1	River Styx & Douglas Slough	Excellent	20: Good 40:Excellent	Excellent	Excellent	High (3.7)	**High (3.7)**	High (4)	**High (4)**
2	Merritts Mill Pond –South	Good	Good	Good	Excellent	Moderate (3.2)	**Moderate (3.5)**	Moderate (3.2)	**Moderate (3.5)**
	Mill Creek	Good	Excellent	Excellent	Excellent	High (3.7)		High (3.7)	
	Tenmile Creek	Good	Excellent	Excellent	Excellent	High (3.7)		High (3.7)	
	Dead Lake	Good	Good	Excellent	Good	Moderate (3.2)		Moderate (3.2)	
3	Marshall Creek	Excellent	Fair	Fair	Good	Low (2.8)	**Low (3.0)**	Low (2.8)	**Low (3.0)**
	Cowarts Creek	Excellent	Good	Fair	Good	Moderate (3.1)		Moderate (3.1)	
	Merritts Mill Pond –North	Excellent	Fair	Good	Excellent	Moderate (3.2)		Moderate (3.2)	

5.3.2 Moderate Range Scenario

Under this scenario, climate and land use change proceed according to moderate to high models, and current conservation efforts involving riparian restoration and land protection limit impacts in some locations.

Under the Moderate Range Scenario, factors that currently influence Chipola slabshell are more likely to be negatively influenced over the 20 and 40-year assessment period. The FORE SCE land use projection evaluated in this scenario (A1B) includes the same global population that peaks in midcentury and declines thereafter as in the Lower Range Scenario, but with a balance between fossil and non-fossil energy sources. The trajectory of such a future corresponds well with Climate Change Model RCP 6. Urban development is not focused on smart urban growth as in the Lower Range Scenario, but is not as high as that seen in the economically focused Higher Range Scenario (A2) projection (Sohl et al. 2014, p. 1021). Very high economic growth in the A1B projection resulted in high demand for forest products and the strongest rates of forest cutting. High energy demands and high technological innovation in the A1B scenario also resulted in the assumption of high use of biofuels, including cellulosic biofuels that impacted forest harvest (Sohl et al. 2014, p. 1022). However, given the Florida Silviculture Best Management Practices (Sections 3.4.2), forest cover should be harvested in a way that is protective of aquatic life within the majority of the species range. Agricultural lands (cropland and hay/pasture) typically increased less than in the Higher Range Scenario. Effects of climate change are expected to be moderate to high, resulting in some increased impacts from droughts and reduced baseflow after 2040 within the Alabama portion of the range (Keellings and Engstrom 2019, p. 6; Figure 5-3, La Fontaine et al. 2019; Figure 5-4). Because water quality, flow, and habitat impacts are likely to occur in this scenario, it is expected that the species will have a neutral or slightly negative response. Synergistic effects may occur outside of protected areas. Below we describe how resiliency factors are expected to change for each MU and the watersheds that comprise them within the Moderate Range Scenario (Table 5-13). A summary of the expected change in condition rank for each resilience factor is contained within Table 5-9.

Table 5-9. Change in condition rank for Chipola slabshell resilience factors under the Moderate Range Scenario for the entire species range. Population and habitat factors are evaluated in both a 20-year and 40-year projection. Time periods with (-) indicate no change, otherwise the condition may increase or decrease by one rank compared to the current condition.

MU	HUC 10s	Population Factors (20/40)		Habitat Factors (20/40)	
		Occupancy	Abundance	Sedimentation	Canopy
1	River Styx & Douglas Slough	- / -	- / -	- / -	- / -
2	Merritts Mill Pond –South	- / -	- / Decrease	- / Decrease	-/ Decrease
	Mill Creek	- / -	- / -	- / -	- / -
	Tenmile Creek	- / -	- / -	- / -	- / -
	Dead Lake	- / -	- / -	- / -	- / -
3	Marshall Creek	Decrease /-	Decrease /-	Decrease /-	Decrease / -
	Cowarts Creek	Decrease /-	Decrease /-	Decrease /-	Decrease /-
	Merritts Mill Pond –North	Decrease /-	- / -	- / -	- / -

5.3.2.1 Management Unit 1 (Table 5-10)

1) River Styx & Douglas Slough
    i) Land Use & Cover—The anthropogenic land uses (urban, mining, agriculture, silviculture) increase slightly to 7.5% by 2060, from a value of 4.8 % in 2020. The majority of this growth is agricultural. The majority of the landcover (92.5%) is natural (forest, wetland, water, or barren).
    ii) Water Quality and Quantity—Droughts may be impactful when combined with decreased flows from the Woodruff Dam on the Apalachicola River. Low-flow mortality was observed in 2014 when flow was 4500 cfs. It is estimated that these low flow conditions could lead to mortality in 2% of Chipola slabshell subpopulation in MU 1. However, the magnitude of this effect is currently unknown (USFWS 2016b, p. 186). It is assumed that these effects are minimal in the current scenario.
    iii) Species Occupancy and Abundance— No change from current condition. It is likely that individuals will continue to expand to occupy all available habitat in the watershed (Appendix E). However, the occasional mortality from the synergistic effects of reduced baseflow (LaFontaine et al. 2019) and water management activities could limit the growth rate, and the most marginal habitats (shallow waters in side channels) may not be consistently occupied. Records adjacent to Wewahitchka are vulnerable to expansion of the city.
    iv) Sedimentation and Canopy— No change from current condition. The coverage of woody and herbaceous wetlands was maintained at 2020 levels through 2060. Wetlands are abundant throughout the watershed in both protected and privately owned lands, and compose the majority of the riparian buffer. The degree of urbanization experienced is unlikely to greatly increase sedimentation by 2040 or

2060.

Table 5-10. Change in condition rank for Chipola slabshell resilience factors under the Moderate Range Scenario. Population and habitat factors are evaluated for MU 1 in both a 20-year and 40-year projection. Time periods with (-) indicate no change, otherwise the condition may increase or decrease by one rank compared to the current condition.

MU	HUC 10s	Population Factors (20/40)		Habitat Factors (20/40)	
		Occupancy	Abundance	Sedimentation	Canopy
1	River Styx & Douglas Slough	- / -	- / -	- / -	- / -

5.3.2.2 Management Unit 2 (Table 5-11)

2) Merritts Mill Pond –South
   i) Land Use & Cover—Urbanized area increases from 4.0 to 7.8% by 2060, with a corresponding decrease in forested lands. Agricultural area does not increase substantially.
   ii) Water Quality and Quantity—A TMDL related to nutrient impairment should be developed by 2023 or sooner. Water flows are protected from consumptive uses by water reservation (legal protection). Expansion of Marianna toward the Chipola River could offset these protections for records adjacent to the city.
   iii) Species Occupancy and Abundance— Unchanged in 2040, abundance reduced by 2060 compared to current condition. Occupancy is likely to remain unchanged into 2060 given existing water protections and minimal agricultural expansion. At least fresh dead specimens are expected to be found adjacent to the city to maintain occupation here, but a reduction in local habitat quality (e.g. bank stability) adjacent to the city will likely lead to a reduction in abundance for the nearby records by 2060 following a period of rebuilding from Hurricane Michael.
   iv) Sedimentation and Canopy—Unchanged in 2040, reduced by 2060 compared to current condition. Current protected areas do not fully encompass the Chipola River mainstem adjacent to Marianna. Increased human presence and impervious surfaces associated with the likely expansion of Marianna towards the Chipola River is likely to reduce sedimentation rank compared to the current condition by 2060. The current canopy condition is marginally excellent, so a reduction in this condition factor by 2060 is likely to occur with urbanization in this scenario.

3) Mill Creek
   i) Land Use & Cover—Land use is expected to shift slightly toward anthropogenic cover until 2060, when there is a temporary decrease. Urbanized area remains largely stable, increasing from 0.8% to 0.9% in 20 and 40-year future projections, while agricultural lands increase slightly from current levels (25.4 to 25.7% by 2040) with

a slight decrease in forested areas by 2040.

ii) Water Quality and Quantity— No change from current condition. Likely to be maintained as in the current condition given the land use trends, but vulnerable due to lack of protection.

iii) Species Occupancy and Abundance—No change from current condition. Possible future population expansion upstream along Dry Creek, as the 2014 record is on the edge of a subwatershed (HUC 12) boundary which were used to delimit occupancy units. However, this expansion is not assumed.

iv) Sedimentation and Canopy— No change from current condition.

4) Tenmile Creek

i) Land Use & Cover—In general, forest cover oscillates with agriculture and silviculture activity through time. A temporary reduction in agriculture and silviculture area is associated with a surge in forested area (60.8% in 2040 to 68.9% in 2060), which is reduced again by silviculture and agriculture returning to levels comparable to 2020 by 2070. However, the general trend is for slight agricultural growth (from 13.6 to 14.5 % by 2070) and increased silvicultural area (from 7.3 to 9.4% by 2070), associated with a reduction in forest extent (59.9 to 57% by 2070). Urbanized area stays constant at 0.6%.

ii) Water Quality and Quantity—Likely to be maintained as in the current condition given the minimal increase in agriculture and urbanization. The riparian zone is vulnerable due to minimal protected area within the watershed, but silviculture-based development should help maintain 50% canopy cover within 60 m (200 ft) of the Chipola and Apalachicola Rivers, given adherence to best management practices (see Section 3.4.2). In addition, wetland area is not expected to change through time, and this cover type comprises the majority of the 60-m riparian buffer.

iii) Species Occupancy and Abundance—No change from current condition.

iv) Sedimentation and Canopy— No change from current condition.

5) Dead Lake

i) Land Use & Cover—Agriculture area increases from 6.5 to 13.1 % in 2060, with a minor increase in urbanized area by 2060 (0.2%). The proportion of forested area decreases from 58 to 50 % in conjunction with an increase in silviculture.

ii) Water Quality and Quantity—Likely to be maintained as in the current condition given minimal urbanization. The woody wetland of the riparian zone limits alteration, as this cover type is not reduced within the land use projection for this scenario. Instead, forested lands elsewhere in the watershed are converted to agriculture. The riparian zone remains vulnerable due to limited protected area. As elsewhere along the Chipola mainstem, water flows are protected from consumptive uses by water reservation (legal protection). Baseflow north of Dead Lake may be reduced by 5 to 9.9 % after 2040 (LaFontaine et al. 2019), but this reduction is not anticipated to be impactful to Chipola slabshell.

iii) Species Occupancy and Abundance—No change from current condition.

iv) Sedimentation and Canopy— No change from current condition. Condition is not anticipated to change from current levels though mainstem segments are vulnerable to residential development.

Table 5-11. Change in condition rank for Chipola slabshell resilience factors under the Moderate Range Scenario. Population and habitat factors are evaluated for MU 2 in both a 20-year and 40-year projection. Time periods with (-) indicate no change, otherwise the condition may increase or decrease by one rank compared to the current condition.

MU	**HUC 10s**	**Population Factors (20/40)**		**Habitat Factors (20/40)**	
		Occupancy	**Abundance**	**Sedimentation**	**Canopy**
2	Merritts Mill Pond –South	- / -	- / Decrease	- / Decrease	- / Decrease
	Mill Creek	- / -	- / -	- / -	- / -
	Tenmile Creek	- / -	- / -	- / -	- / -
	Dead Lake	- / -	- / -	- / -	- / -

5.3.2.3 Management Unit 3 (Table 5-12)

6) Marshall Creek
   i) Land Use & Cover— Agriculture area remains fairly constant in this scenario, ranging from 50.3 in 2020 to 43.2 % by 2060, but returning to 52.3 % by 2070. The percentage of urbanized area increases from 3.1 (2020) to 4.7 % in 2060, but is projected to be higher in both 2040 (5.2%) and 2070 (7.4%). Forests generally decrease from 27.2 to 20.2% by 2070, with a momentary increase to 33.1 % in 2060.
   ii) Water Quality and Quantity— The watershed is vulnerable given the minimal protected area within Alabama and the relatively high agricultural area within the watershed which influences ground water quality. The watershed contains impairments for fecal coliform, nutrients, and organic enrichment with TMDLs set to be completed by 2028 or sooner in Florida but have no estimated date for completion within Alabama. Water flows are currently well supported by ground water contributions from springs during drought (Garner et al. 2009, p. 693), but the anticipated increase in drought and reduction in baseflow in the northern part of the Chipola slabshell range are expected to impact slabshell in the future within this scenario. The watershed is vulnerable given the minimal protected area within Alabama and the relatively high agricultural and the negative relationship with ground water quality.
   iii) Species Occupancy and Abundance— Decrease by one rank in 20 years compared to current condition. The trend in increased anthropogenic cover is consistent through 2040, but uncertain by 2060. A decrease in occupancy and abundance is expected to occur in the near future, but these factors will not necessarily decrease another rank by 2060. The 2007 record on Big Creek is not known to be well connected to other records in the watershed. Urbanized areas near Dothan are expected to extend toward

this record. The Big Creek record is projected to be lost by 2040, reducing occupancy to the historic distribution. Slabshell records become difficult to relocate with an increase in dead individuals outside of protected areas, reducing the abundance rank.

iv) Sedimentation and Canopy— Decrease by one rank in 20 years compared to current condition. Sediment and canopy impacts occur in unprotected riparian areas, with forest cover exhibiting a decline in condition by 2040 that may not decrease further by 2060. A decrease in canopy condition rank in the near future is expected given the trend in agricultural and urban development and expected loss of forest area. A reduction in canopy condition is especially likely given the minimal forested area within the watershed in general and minimal extent of wooded wetland (which largely remains unchanged in area through time) within the riparian zone of Marshall Creek.

7) Cowarts Creek

i) Land Use & Cover—Agriculture area increases slightly in this scenario, from 54.1 to 56.4 by 2070, with a low in 2060 of 47.5 %. The percentage of urbanized areas increases from 1.1 to 2 % by 2060. Forests decreases from 26.5 to 20.4% by 2070, with a momentary increase to 32.9 % in 2060.

ii) Water Quality and Quantity—Fecal coliform impairments are not necessarily reducing water quality for Chipola slabshell. TMDL development is set for 2028 or sooner in Florida, but there is currently no date set for a TMDL in Alabama. Water flows are currently well supported by ground water contributions from springs during drought (Garner et al. 2009, p. 693), but the anticipated increase in drought and reduction in baseflow in the northern part of the Chipola slabshell range are expected to impact slabshell in the future within this scenario. The watershed is vulnerable given the minimal protected area within Alabama and the relatively high agricultural and the negative relationship with ground water quality.

iii) Species Occupancy and Abundance— Decrease by one rank in 20 years compared to current condition. The trend in increased anthropogenic cover is consistent through 2040, but uncertain by 2060. A decrease in occupancy and abundance is expected to occur in the near future, but these factors will not necessarily decrease another rank by 2060. Newly occupied subwatersheds (Middle Cowarts Creek: 031300120203, Upper Cowarts Creek: 031300120201) are lost by 2040, reducing the distribution to protected areas within the historical distribution is the Lower Cowarts Creek subwatershed (031300120204). Records become difficult to relocate with an increase in dead individuals within protected areas. Although reduced, abundance is higher than the Marshall Creek watershed as there are more slabshell records in the Cowarts Creek watershed.

iv) Sedimentation and Canopy— Decrease by one rank in 20 years compared to current condition. Sediment and canopy impacts occur in unprotected riparian areas, with forest cover exhibiting a decline in condition by 2040 that may not decrease further by 2060. A decrease in canopy condition rank in the near future is expected given the trend in agricultural and urban development and expected loss of forest area. A reduction in canopy condition is especially likely given the minimal forested area within the watershed in general and minimal extent of wooded wetland (which largely remains unchanged in area through time) within the riparian zone of Cowarts Creek.

8) Merritts Mill Pond –North
   i) Land Use & Cover—Agriculture area increases slightly in this scenario, from 41.6 to 45.4 by 2070, with a momentary decrease to 40.3% in 2060. Urbanized area increases from 2.4 to 2.7 % in 2060, but peaks at 3.2% in 2050 and increases to 3.3% in 2070. Forests decrease from 39.2 to 32.3% in 2070, with a peak of 41.8% in 2060.
   ii) Water Quality and Quantity—A TMDL related to nutrient impairment for the Chipola River should be completed by 2023 or sooner. Water flows are protected from consumptive uses by water reservation (legal protection) except for those in Waddells Mill Creek.
   iii) Species Occupancy and Abundance— Occupancy decrease by one rank in 20 years compared to current condition. A decrease in occupancy is expected to occur in the near future. The trend in increased anthropogenic cover is consistent through 2040, but uncertain by 2060. The newly occupied area in the Waddells Mill Creek subwatershed (031300120302) is expected to be lost by 2040, as only fresh dead individuals were recorded in 2019; current habitat conditions are likely poor (record is adjacent to a road and agriculture) and expected to worsen with the trend in land use change. There were no records from this subwatershed historically, and so occupancy is reduced a rank to good. Slabshell likely remain in the Chipola River mainstem which is protected, so abundance condition rank is not expected to decrease.
   iv) Sedimentation and Canopy— No change from current condition. The riparian buffer of the Chipola River is largely protected.

Table 5-12. Change in condition rank for Chipola slabshell resilience factors under the Moderate Range Scenario. Population and habitat factors are evaluated for MU 3 in both a 20-year and 40-year projection. Time periods with (-) indicate no change, otherwise the condition may increase or decrease by one rank compared to the current condition.

MU	**HUC 10s**	**Population Factors (20/40)**		**Habitat Factors (20/40)**	
		Occupancy	**Abundance**	**Sedimentation**	**Canopy**
3	Marshall Creek	Decrease /-	Decrease /-	Decrease /-	Decrease /-
	Cowarts Creek	Decrease /-	Decrease /-	Decrease /-	Decrease /-
	Merritts Mill Pond – North	Decrease / -	- / -	- / -	- / -

Table 5-13. Summary of future resiliency for Chipola slabshell management units (MUs) in the Moderate Range Scenario at the end of the 20 and 40-year projection. Where condition ranks differ between projections, ranks for each projection are included. The final watershed score and MU resiliency are summarized separately for each projection.

MU	HUC 10s	Population Factors		Habitat Factors		20-year projection		40-year projection	
		Occupancy	Abundance	Sedimentation	Canopy	Watershed Score (20)	Overall MU Resiliency (20)	Watershed Score (40)	Overall MU Resiliency (40)
1	River Styx & Douglas Slough	Excellent	Good	Excellent	Excellent	High (3.7)	**High (3.7)**	High (3.7)	**High (3.7)**
2	Merritts Mill Pond –South	Good	20: Good 40: Fair	20: Good 40: Fair	20: Excellent 40: Good	Moderate (3.2)	**Moderate (3.3)**	Low (2.5)	**Moderate (3.2)**
	Mill Creek	Good	Excellent	Good	Good	Moderate (3.3)		Moderate (3.3)	
	Tenmile Creek	Good	Excellent	Excellent	Good	High (3.5)		High (3.5)	
	Dead Lake	Good	Good	Excellent	Good	Moderate (3.2)		Moderate (3.3)	
3	Marshall Creek	Good	Poor	Poor	Fair	Very Low (1.8)	**Very Low (2.3)**	Very Low (1.8)	**Very Low (2.3)**
	Cowarts Creek	Good	Fair	Poor	Fair	Very Low (2.1)		Very Low (2.1)	
	Merritts Mill Pond –North	Good	Fair	Good	Excellent	Low (2.9)		Low (2.9)	

5.3.3 Higher Range Scenario

Under this scenario, climate and land use change proceed according to higher range models, and current conservation efforts involving riparian restoration and land protection are less successful at limiting impacts given existing resources.

Under the Higher Range Scenario, factors that currently influence Chipola slabshell are most likely to be negatively influenced over the 20 and 40-year assessment period. The FORE SCE land use projection evaluated in this scenario (A2) includes a continuously increasing population, but technological change is more fragmented and slower than in other scenarios. The trajectory of such a future corresponds well with Climate Change Model RCP 8.5. Urban development is the highest of the three scenarios because of the economic focus of the A2 projection (Sohl et al. 2014, p. 1021). Agricultural lands (cropland and hay/pasture) increase substantially. Effects of climate change are expected to be moderate to high, resulting in some increased impacts from droughts after 2040 within the Alabama portion of the range, including drought and reduced baseflow (Keellings and Engstrom 2019, p. 6, LaFontaine et al. 2019). Because water quality, flow, and habitat impacts are likely to occur in this scenario, it is expected that the species will have a neutral or negative response. Synergistic effects may occur outside of protected areas. Below we describe how resiliency factors are expected to change for each MU and the watersheds that comprise them within the Higher Range Scenario (Table 5-18).A summary of the expected change in condition rank for each resilience factor is contained within Table 5-14.

Table 5-14. Change in condition rank for Chipola slabshell resilience factors under the Higher Range Scenario for the entire species range. Population and habitat factors are evaluated in both a 20-year and 40-year projection. Time periods with (-) indicate no change, otherwise the condition may increase or decrease by one rank compared to the current condition.

MU	HUC 10s	Population Factors (20/40)		Habitat Factors (20/40)	
		Occupancy	Abundance & Reproduction	Sedimentation	Canopy
1	River Styx & Douglas Slough	- / -	- / Decrease	- / -	- / -
2	Merritts Mill Pond –South	- / Decrease	- / Decrease	- / Decrease	- / Decrease
	Mill Creek	- / Decrease	- / -	- / -	- / -
	Tenmile Creek	- / -	- / -	- / -	- / -
	Dead Lake	- / -	- / -	- / -	- / -
3	Marshall Creek	Decrease /-	Decrease /-	Decrease /-	Decrease / -
	Cowarts Creek	Decrease /-	Decrease /-	Decrease /-	Decrease /-
	Merritts Mill Pond –North	Decrease /-	- / Decrease	- / -	- / -

<u>*5.3.3.1 Management Unit 1 (Table 5-15)*</u>

1) River Styx & Douglas Slough
    i) Land Use & Cover—The anthropogenic land uses (urban, mining, agriculture, silviculture) increase slightly to 6.1% by 2060, from 4.7% in 2020. The majority of this growth is agricultural outside of protected areas. The remainder of the landcover (93.9%) in 2060 is natural (forest, wetland, water, or barren).
    ii) Water Quality and Quantity—Droughts may be impactful when combined with decreased flows from the Woodruff Dam on the Apalachicola River. Low-flow mortality was observed in 2014 when flow was 4500 cfs. It is estimated that these low flow conditions could lead to mortality in 2% of Chipola slabshell subpopulation in MU 1. Additionally, Chipola slabshell may experience harm through reduced recruitment. However, the magnitude of this effect is currently unknown (USFWS 2016b, p. 186).
    iii) Species Occupancy and Abundance—Decrease in abundance after 40 years compared to current condition. The records adjacent to Wewahitchka are vulnerable from development of the city into unprotected riparian zone. Occasional mortality from the synergistic effects of drought, reduced baseflow in the southern portion of the Lower Chipola River from climate change, and water management activities could result in a reduction in abundance condition by 2060, though occupation is not expected to decrease.
    iv) Sedimentation and Canopy—Unchanged from current condition. The riparian zone is largely protected. The degree of urbanization experienced is unlikely to decrease condition by 2040 or 2060.

Table 5-15. Change in condition rank for Chipola slabshell resilience factors under the Higher Range Scenario. Population and habitat factors are evaluated for MU 1 in both a 20-year and 40-year projection (20/40). Time periods with (-) indicate no change, otherwise the condition may increase or decrease by one rank compared to the current condition.

MU	HUC 10s	Population Factors (20/40)		Habitat Factors (20/40)	
		Occupancy	Abundance	Sedimentation	Canopy
1	River Styx & Douglas Slough	- / -	- / Decrease	- / -	- / -

5.3.3.2 Management Unit 2 (Table 5-16)

2) Merritts Mill Pond –South
   i) Land Use & Cover—Urbanized area increases steadily from 3.9 to 7.7% by 2060, and agriculture increases from 36.8 to 41.4 % by 2060, with most of this increase occurring after 2040. The area of silvicultural oscillates slightly through time. In general, the increase in anthropogenic cover corresponds with a decrease in forested lands, which decrease from 47.7 % in 2020 to 38.3 % in 2060.
   ii) Water Quality and Quantity—A TMDL related to nutrient impairment should be completed by 2023 or sooner, however the marked increase in agricultural land after 2040 could result in impairment again in the near future. Water flows are protected from consumptive uses by water reservation (legal protection).
   iii) Species Occupancy and Abundance— Unchanged in 2040, reduced by 2060 compared to current condition. Expansion of the Marianna into unprotected riparian habitat is assumed. A reduction in local habitat quality (e.g. bank stability) adjacent to the city will likely lead to a reduction in abundance by 2060 following a period of rebuilding from Hurricane Michael. An increase in agricultural area in the watershed may exacerbate the change in condition in records near Marianna through a decrease in water quality. Abundance condition is reduced, such that no live or fresh dead individuals encountered adjacent to Marianna. Only live records in the Merritts Millpond (031300120305) HUC 12 subwatershed remain, with slabshell effectively extirpated from the portion of the Carters Mill Branch (031300120304) subwatershed within MU 2 that contains Marianna. Occupancy is reduced to 50% of the HUC 12 subwatersheds that were occupied historically within the Merritts Mill Pond HUC 10 watershed, resulting in a condition rank decrease to poor.
   iv) Sedimentation and Canopy— Unchanged in 2040, reduced by 2060 compared to current condition. Current protected areas do not fully encompass the Chipola River mainstem adjacent to Marianna. Increased human presence and impervious surfaces associated with the anticipated expansion of Marianna towards the Chipola River and increased agricultural area after 2040 is likely to reduce sedimentation rank by 2060. The current canopy condition is marginally excellent, so a reduction in this condition

factor by 2060 is likely to occur with the loss of forest cover in this scenario.

3) Mill Creek
   i) Land Use & Cover—Land use is expected to shift toward anthropogenic cover. Urbanized area remains largely stable, increasing from 0.8% to 1 % in 40-year future projections, while agricultural lands increase from current levels (27.6 to 31.7% by 2060) with a decrease in forested areas from 55.4 to 50 % in 2060.
   ii) Water Quality and Quantity—A TMDL is under development related to nutrient impairments within the Chipola River mainstem, and is expected to be completed by 2024 or sooner. Water quality is likely to be maintained in the Chipola River mainstem as in the current condition given the minimal land use change, but is vulnerable due to lack of land protection and the increase in agricultural area. Water quality in Dry Creek in not protected as an OFW, and no water reservation protecting flow is in place for the creek. A reduction in baseflow for Dry Creek is expected after 2040 (LaFontaine et al. 2019).
   iii) Species Occupancy and Abundance—A reduction in occupancy is expected by 2060 compared to the current condition. It is anticipated that occupation of Dry Creek will not be maintained given the increasingly unfavorable conditions associated with climate change (e.g. baseflow). Recent records confirm one living and one dead specimen in Dry creek, with pesticide mortality a concern (USFWS 2019). A reduction in flow may not be an issue in itself, but could have synergistic effects with water quality in the future. The mainstem is not expected to be as impacted by climate-associated changes in baseflow, and is projected to retain abundant slabshell records without a change in abundance condition.
   iv) Sedimentation and Canopy—No change from current condition. Land use conversion is low, though protected riparian area is minimal and the Chipola River mainstem is vulnerable to development.

4) Tenmile Creek
   i) Land Use & Cover—Forested area decreases with agricultural conversion. Forest decreases from 58.5 % in 2020 to 53.6 % in 2060. Agricultural area increases from 17.1 to 22.6 % by 2060. Urban area remains constant at 0.6 %. The extensive woody wetland of the riparian zone in the southern region of the watershed helps to limit development (this cover type is not expected to change), but the riparian zone is vulnerable due to minimal protected area.
   ii) Water Quality and Quantity—Likely to be maintained as in the current condition given the minimal increase in agriculture and urbanized area, as well as the existing OFW status and water reservation that is in place for the Chipola River. TMDLs for fecal coliforms are under development for Tenmile and Juniper Creek, and should be in place by 2028 or sooner.
   iii) Species Occupancy and Abundance—No change compared to the current condition. Records are well distributed and fairly numerous within the mainstem and do not (currently or historically) occur in the adjacent creeks.

iv) Sedimentation and Canopy— No change compared to the current condition. Given the minimal change in land use, sedimentation condition is not anticipated to change from current levels. Canopy is vulnerable to development but the riparian zone is primarily composed of wooded wetland which is expected to be conserved through time.

5) Dead Lake

i) Land Use & Cover—Agriculture area increases from 7.5 to 9.6 % by 2060, with a minor increase in urbanized area by 2060 (0.2%). The proportion of forested area decreases from 56.7 to 54.2 %.

ii) Water Quality and Quantity—No change compared to the current condition. Land use change is minimal. The Chipola River mainstem is vulnerable due to sparse protected lands. Water flows are protected from consumptive uses by water reservation (legal protection), but baseflow immediately north of Dead Lake may be decreased between 5 and 9.9% after 2040, based on the median of future climate change scenarios (Fontaine et al. 2019).

iii) Species Occupancy and Abundance—No change compared to current condition. Although some reduction in baseflow is anticipated, the most extensive reductions would only effect a currently poor record that contained one live individual in 2018 where the substrate was noted to be poor (USFWS 2019). Abundance and occupancy are unlikely to be impacted by the slight change in land cover.

iv) Sedimentation and Canopy— No change compared to current condition. Some mainstem segments are vulnerable to residential development, but land use change is minimal. Woody wetland cover does not change through time, and this cover type is extensive within the riparian zone, helping to retain canopy cover in at least the northern portion of the watershed where the floodplain is broadest.

Table 5-16. Change in condition rank for Chipola slabshell resilience factors under the Higher Range Scenario. Population and habitat factors are evaluated for MU 2 in both a 20-year and 40-year projection. Time periods with (-) indicate no change, otherwise the condition may increase or decrease by one rank compared to the current condition.

MU	**HUC 10s**	**Population Factors (20/40)**		**Habitat Factors (20/40)**	
		Occupancy	**Abundance**	**Sedimentation**	**Canopy**
2	Merritts Mill Pond –South	- / Decrease	- / Decrease	- / Decrease	-/ Decrease
	Mill Creek	- / Decrease	- / -	- / -	- / -
	Tenmile Creek	- / -	- / -	- / -	- / -
	Dead Lake	- / -	- / -	- / -	- / -

5.3.3.3 Management Unit 3 (Table 5-17)

6) Marshall Creek

i) Land Use & Cover—Agriculture area increases slightly in this scenario, from 52.7 in

2020 to 53.1% by 2040 and 55.4 % by 2060. Urbanized areas increase from 2.7 (2020) to 4.2 % by 2040 and 5.9 % by 2060. Forests generally decrease from 25.5 to 23.8% in 2040, and 19.4% by 2060. Wooded and herbaceous wetland area is not projected to change in the future, but wetland extent is minimal within the watershed (8.3%). The watershed has minimal protected area which occurs only in Florida, and relatively high agricultural area.

ii) Water Quality and Quantity—Fecal coliform impairments are not necessarily reducing water quality for Chipola slabshell. Water flows are supported by ground water contributions from springs during drought (Garner et al. 2009, p. 693), but synergistic effects of land use change, extreme low flows, and a reduction in baseflow are expected to impact slabshell as early as 2040 in this scenario.

iii) Species Occupancy and Abundance— Decrease by one rank in 20 years compared to current condition. The 2007 record on Big Creek within the Big Branch-Big Creek subwatershed (031300120102) is not known to be well connected to the other recent record in the watershed. Urbanized areas near Dothan are expected to extend toward the Big Creek record. The Big Creek record is projected to be lost by 2040, reducing occupancy to the historic distribution. The other record in the watershed occurs within the Marshall Creek subwatershed (31300120107), which begins north of the highway 2 bridge and is within protected lands. This record is not expected to be lost with the reduction in baseflow, however slabshell become difficult to relocate in the near future with an increase in dead individuals, reducing the abundance rank to poor by 2040. If this record was lost in conjunction with the Big Creek record, slabshell would be extirpated from the watershed based on existing records. This watershed is vulnerable to extirpation by 2060 given the sparsity of records.

iv) Sedimentation and Canopy— Decrease by one rank in 20 years compared to current condition. Sediment and canopy impacts occur in unprotected riparian areas, with forest cover exhibiting a decline in condition by 2040. A decrease in canopy condition rank in the near future is expected given the trend in agricultural and urban development and expected loss of forest area. A reduction in canopy condition in the riparian zone is especially likely given the minimal forested area within the watershed and minimal wooded wetland area within the riparian zone of Marshall Creek.

7) Cowarts Creek

i) Land Use & Cover—Agriculture area increases in this scenario, from 55.9 to 58.9% by 2060. The percentage of urbanized areas increases from 1.1 to 1.9% in 2040 and 2.8 % by 2060. Forests decrease from 25.5 to 23.8% by 2040 and 20.2% by 2060. The watershed has minimal protected area and relatively high agricultural area. 15.8% of the watershed is wetland, and remains unchanged through time.

ii) Water Quality and Quantity—Fecal coliform impairments are not necessarily reducing water quality for Chipola slabshell. Water flows are currently fairly well supported by ground water contributions from springs during drought (Garner et al. 2009, p. 693), but synergistic effects of land use change, extreme low flows, and a reduction in baseflow are expected to impact slabshell as early as 2040 in this scenario.

iii) Species Occupancy and Abundance— Decrease by one rank in 20 years compared to current condition, with abundance reduced further by 2060. Records from newly occupied subwatersheds (Middle Cowarts Creek: 031300120203, Upper Cowarts Creek: 031300120201) are lost by 2040, reducing the distribution to the historical range within protected areas of the Lower Cowarts Creek subwatershed (031300120204). Therefore, occupation is reduced a rank to good. Records become difficult to relocate with an increase in dead individuals in protected areas, lowering the abundance rank by one in 2040. Although reduced, abundance is higher than the Marshall Creek watershed as there are more slabshell records in the Cowarts Creek watershed; however, this watershed is noted to be vulnerable to extirpation by 2060 given the sparsity of records, and abundance is reduced another rank to poor by 2060.

iv) Sedimentation and Canopy— Decrease by one rank in 20 years compared to current condition. Sediment and canopy impacts occur in unprotected riparian areas, with forest cover exhibiting a decline in condition by 2040 that may not decrease further by 2060. A decrease in canopy condition rank in the near future is expected given the trend in agricultural and urban development and expected loss of forest area. A reduction in canopy condition is especially likely given the minimal forested area within the watershed and minimal extent of wooded wetland within the riparian zone of Cowarts Creek.

8) Merritts Mill Pond –North

i) Land Use & Cover—Agriculture area increases in this scenario, from 44.9 to 46% by 2040 and 50.3% by 2060. Urbanized area increases from 2.3 to 2.7% by 2040 and 3.2 % by 2060. Forested area decreases from 35.7 to 34.4% by 2040 and 29.4 % by 2060.

ii) Water Quality and Quantity—A TMDL related to nutrient impairment in the Chipola River should be completed by 2023 or sooner, but impairments could return with the increase in agricultural area. Water flows in the Chipola River are protected from consumptive uses by water reservation (legal protection), but Waddells Mill Creek does not have a water reservation. The increase in agricultural area could lead to water impairment in the future. Tributaries of the Chipola River are expected to experience a reduction in baseflow.

iii) Species Occupancy and Abundance— Occupancy decrease by one rank in 20 years, and abundance reduced in 40 years compared to current condition. The newly occupied area within the Waddells Mill Creek subwatershed (031300120302) is expected to be lost, as only fresh dead individuals were recorded in 2019 and current habitat conditions are likely poor (record is adjacent to a road and agriculture) and expected to worsen with the trend in land use change and tributary baseflow. There were no records from this watershed historically, so occupancy is reduced one rank to good in 2040. Slabshell likely remain in the Chipola River mainstem which is protected, but the single record of two known live individuals from the Carter’s Mill Branch subwatershed (031300120305) is vulnerable to stochastic events and becomes difficult to relocate with an increase in dead individuals, lowering the abundance rank by one by 2060.

iv) Sedimentation and Canopy—No change from current condition. The riparian buffer is largely protected.

Table 5-17. Change in condition rank for Chipola slabshell resilience factors under the Higher Range Scenario. Population and habitat factors are evaluated for MU 3 in both a 20-year and 40-year projection. Time periods with (-) indicate no change, otherwise the condition may increase or decrease by one rank compared to the current condition.

MU	**HUC 10s**	**Population Factors (20/40)**		**Habitat Factors (20/40)**	
		Occupancy	**Abundance**	**Sedimentation**	**Canopy**
3	Marshall Creek	Decrease /-	Decrease /-	Decrease /-	Decrease / -
	Cowarts Creek	Decrease /-	Decrease / Decrease	Decrease /-	Decrease /-
	Merritts Mill Pond –North	Decrease /-	- / Decrease	- / -	- / -

Table 5-18. Summary of future resiliency for Chipola slabshell management units (MUs) in the Higher Range Scenario at the end of the 20 and 40-year projection. Where condition ranks differ between projections, ranks for each projection are included. The final watershed score and MU resiliency are summarized separately for each projection.

MU	**HUC 10s**	**Population Factors**		**Habitat Factors**		**20-year Projection**		**40-year Projection**	
		Occupancy	**Abundance**	**Sedimentation**	**Canopy**	**Watershed Score**	**Overall MU Resiliency**	**Watershed Score**	**Overall MU Resiliency**
1	River Styx & Douglas Slough	Excellent	20: Good 40: Fair	Excellent	Excellent	High (3.7)	**High (3.7)**	Moderate (3.4)	**Moderate (3.4)**
2	Merritts Mill Pond –South	20: Good 40: Poor	20: Good 40: Fair	20: Good 40: Fair	20: Excellent 40: Good	Moderate (3.2)	**Moderate (3.3)**	Very Low (1.9)	**Low (3.0)**
	Mill Creek	20: Good 40: Fair	Excellent	Good	Good	Moderate (3.3)		Moderate (3.3)	
	Tenmile Creek	Good	Excellent	Excellent	Good	High (3.5)		High (3.5)	
	Dead Lake	Good	Good	Excellent	Good	Moderate (3.3)		Moderate (3.3)	
3	Marshall Creek	Good	Poor	Poor	Fair	Very Low (1.8)	**Very Low (2.3)**	Very Low (1.8)	**Very Low (2.1)**
	Cowarts Creek	Good	20: Fair 40: Poor	Poor	Fair	Very Low (2.1)		Very Low (1.8)	
	Merritts Mill Pond –North	Good	20:Fair 40: Poor	Good	Excellent	Low (2.9)		Low (2.6)	

5.4 Future Resiliency and Redundancy

The goal of this assessment was to describe the viability of the Chipola slabshell in terms of resiliency and redundancy by using the best science available at the time of the analysis. To capture the uncertainty associated with the degree and extent of potential future risks and their impacts on species' needs, resiliency and redundancy were assessed using three plausible future scenarios (Lower, Moderate, and High Range Scenarios). These scenarios were based, in part, on the results of climate-informed land use change (Sohl et al. 2014) and climate models (IPCC 2013) that predict general changes in habitat used by the Chipola slabshell.

The results of the future condition analysis describe a range of possible conditions in terms of the number and distribution of Chipola slabshell records in both a 20-year (Table 5-19) and 40-year projection (Table 5-20). An important assumption of the future projection was that future population resiliency is largely dependent on the retention of existing records and changes in water quality, water flow, riparian, and instream habitat conditions that could lead to reductions in abundance and/or occupancy of Chipola slabshell records. In general, anthropogenic landscapes experienced slight decreases in the Lower Range Scenario, and increases in the Moderate and Higher Range Scenarios. The model parameters for land use change in the Lower Range Scenario generally decreased hay/pasture area with an increase in cropland, however this did not occur within the Chipola River Basin. FORE SCE projections differ the most in areas of marginal agricultural land, and in areas suitable for both agricultural and forest land uses. In general, differences between land use projections are low in high-value agricultural land. The future condition of Chipola slabshell varied amongst scenarios and is depicted in Figure 5-5.

In the Lower Range Scenario, we project no loss in MU resiliency and redundancy compared to the current condition. MUs 1 and 2 would retain resiliency (in high or moderate resiliency), and MU 3 would not (low resiliency). For this scenario, the Chipola slabshell population is expected to persist in much the same condition as it is found currently, with some increases in watershed resilience through time given positive trends (e.g., future forest cover, recent population expansions).

Table 5-19. Summary of resiliency for Chipola slabshell management units (MUs) in the current condition and each of three future scenarios (Lower, Moderate, and Higher Range) at the end of the 20-year assessment period.

Scenario		**Current**		**Lower Range**		**Moderate Range**		**Higher Range**	
MU	**HUC 10s**	**Watershed Score**	**MU**	**Watershed Score**	**MU**	**Watershed Score**	**MU**	**Watershed Score**	**MU**
1	River Styx & Douglas Slough	High (3.7)	**High (3.7)**	High (3.7)	**High (3.7)**	High (3.7)	**High (3.7)**	Moderate (3.4)	**Moderate (3.2)**
2	Merritts Mill Pond –South	Moderate (3.2)	**Moderate (3.3)**	Moderate (3.2)	**Moderate (3.5)**	Moderate (3.2)	**Moderate (3.3)**	Moderate (3.2)	**Moderate (3.3)**
	Mill Creek	Moderate (3.3)		High (3.7)		Moderate (3.3)		Moderate (3.3)	
	Tenmile Creek	High (3.5)		High (3.7)		High (3.5)		High (3.5)	
	Dead Lake	Moderate (3.2)		Moderate (3.2)		Moderate (3.2)		Moderate (3.2)	
3	Marshall Creek	Low (2.8)	**Low (3.0)**	Low (2.8)	**Low (3.0)**	Very Low (1.8)	**Very Low (2.3)**	Very Low (1.8)	**Very Low (2.3)**
	Cowarts Creek	Moderate (3.1)		Moderate (3.1)		Very Low (2.1)		Very Low (2.1)	
	Merritts Mill Pond –North	Moderate (3.2)		Moderate (3.2)		Low (2.9)		Low (2.9)	

Table 5-20. Summary of resiliency for Chipola slabshell watersheds and management units (MUs) in the current condition and each of three future scenarios (Lower, Moderate, and Higher Range) at the end of the 40-year assessment period.

<table>
<tr><th colspan="2">Scenario</th><th colspan="2">Current</th><th colspan="2">Lower Range</th><th colspan="2">Moderate Range</th><th colspan="2">Higher Range</th></tr>
<tr><th>MU</th><th>HUC 10s</th><th>Watershed Score</th><th>MU</th><th>Watershed Score</th><th>MU</th><th>Watershed Score</th><th>MU</th><th>Watershed Score</th><th>MU</th></tr>
<tr><td>1</td><td>River Styx & Douglas Slough</td><td>High (3.7)</td><td>High (3.7)</td><td>High (4)</td><td>High (4.0)</td><td>High (3.7)</td><td>High (3.7)</td><td>Moderate (3.4)</td><td>Moderate (3.4)</td></tr>
<tr><td rowspan="4">2</td><td>Merritts Mill Pond –South</td><td>Moderate (3.2)</td><td rowspan="4">Moderate (3.3)</td><td>Moderate (3.2)</td><td rowspan="4">Moderate (3.5)</td><td>Low (2.5)</td><td rowspan="4">Moderate (3.1)</td><td>Very Low (1.9)</td><td rowspan="4">Low (3.0)</td></tr>
<tr><td>Mill Creek</td><td>Moderate (3.3)</td><td>High (3.7)</td><td>Moderate (3.3)</td><td>Moderate (3.3)</td></tr>
<tr><td>Tenmile Creek</td><td>High (3.5)</td><td>High (3.7)</td><td>High (3.5)</td><td>High (3.5)</td></tr>
<tr><td>Dead Lake</td><td>Moderate (3.2)</td><td>Moderate (3.2)</td><td>Moderate (3.2)</td><td>Moderate (3.2)</td></tr>
<tr><td rowspan="3">3</td><td>Marshall Creek</td><td>Low (2.8)</td><td rowspan="3">Low (3.0)</td><td>Low (2.8)</td><td rowspan="3">Low (3.0)</td><td>Very Low (1.8)</td><td rowspan="3">Very Low (2.3)</td><td>Very Low (1.8)</td><td rowspan="3">Very Low (2.1)</td></tr>
<tr><td>Cowarts Creek</td><td>Moderate (3.1)</td><td>Moderate (3.1)</td><td>Very Low (2.1)</td><td>Very Low (1.8)</td></tr>
<tr><td>Merritts Mill Pond –North</td><td>Moderate (3.2)</td><td>Moderate (3.2)</td><td>Low (2.9)</td><td>Low (2.6)</td></tr>
</table>

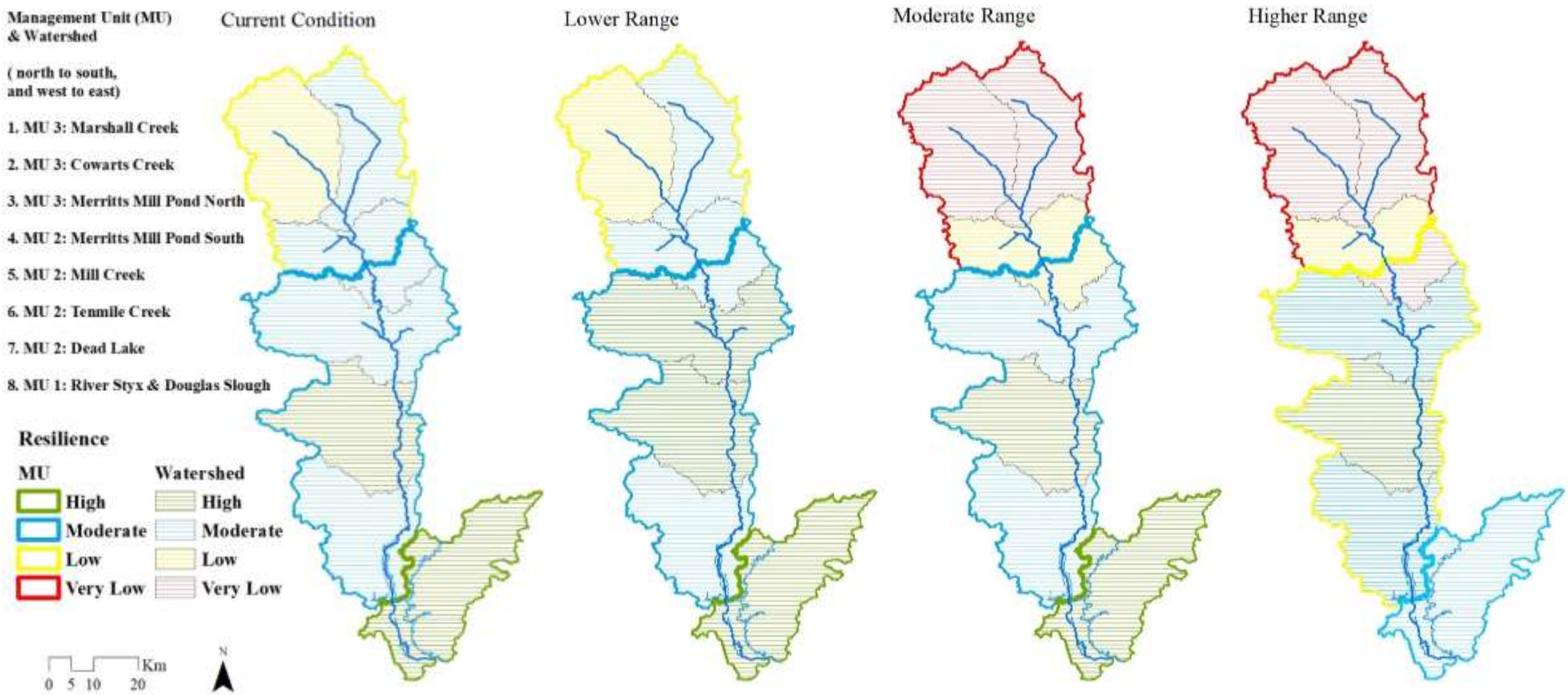


Figure 5-5. Current and future condition for Chipola slabshell. Future condition is depicted as three scenarios (Lower, Moderate, and Higher Range) based on climate and land use change and the potential effects on Chipola slabshell viability 40 years from the current condition. Resiliency is denoted for each of the three Management Units (MUs), and the HUC 10 watersheds that comprise them. Occupied MUs are identified as having very low (i.e., no survival or survival uncertain; no longer observable), low, moderate, or high resiliency condition.

In the Moderate Range Scenario, a loss of resiliency and redundancy is expected. MUs 1 and 2 retain resiliency, but MU 3 will likely become extirpated given its resiliency (very low). MU 1 retains high resiliency. The condition of MU 2 is within the low range of moderate resiliency, and so there is a possibility that it does not retain resiliency by 2060. Redundancy would be reduced to three watersheds, with likely extirpation in two of eight currently extant watersheds. Only MU 2 retains more than one watershed with resiliency, and MU 3 retains only one occupied watershed (Merritts Mill Pond North) with low resiliency.

In the Higher Range Scenario, we anticipate impacts to resiliency in all management units. MU 1 has moderate resiliency with a reduced capacity to mitigate stochastic events. MU 2 and 3 do not exhibit resiliency (low and very low, respectively), with MU 3 likely extirpated. MU 2 retains resiliency in the center of the Chipola slabshell range within the Mill Creek and Tenmile Creek watersheds, with sparse to no observable presence in the Merritts Mill Pond South and Dead Lake watersheds. Similarly to the Moderate Range Scenario, redundancy would be reduced to three watersheds with likely extirpation in three of eight currently extant watersheds. Only MU 2 retains more than one watershed with resiliency, and MU 3 retains only one occupied watershed (Merritts Mill Pond North) with low resiliency.

5.5 Future Scenario Summary

The northern portion of the species range comprising the Chipola River headwaters was the most susceptible to change through time; MU 3 was low resiliency in the current condition and was predicted to have very low resiliency (possibly extirpated) under the Moderate and Higher scenarios. Chipola slabshell presence within the Alabama portion of MU 3 was not documented between 1916 and 2006 (Garner et al. 2009). The habitat in MU 3 is thought to be inherently variable (e.g., sediment) or be low suitability (e.g., substrate, watershed position) for slabshell. With the exception of small portions of MU 1 and 3, almost the entirety of the Chipola slabshell population is contained within the Chipola River mainstem in MU 2. MU 2 is anticipated to retain resiliency (ranked moderate) into 2060 in the Moderate Range Scenario, but resiliency is lost (ranked low) by 2060 in the Higher Range Scenario. MU 2 retains one watershed (Tenmile Creek) at high resiliency through all scenarios and projection periods. MU 1 was projected to retain resiliency under all scenarios, benefitting from the presence of extensive protected areas and more favorable watershed position (larger streams) for Chipola slabshell. Additionally, redundancy changed the most between the conservation-minded Lower Range Scenario compared to the Moderate and Higher Range Scenarios that projected greater land use and climate change.

5.5.1 Consideration of a Catastrophic Spill

Despite the predicted resiliency of MU 1, the linear distribution of the species within the mainstem in MU 2 leaves the majority of the species' range vulnerable to a catastrophic event, such as a spill of toxic materials. Multiple high traffic roads traverse the Chipola River: highway 90 at Marianna, the I-10 interstate south of Marianna, highway 20 in the Tenmile Creek watershed, and highway 71 north of Dead Lake. A spill at any of these crossings would negatively affect MU 2 which contains the bulk of known slabshell records. The Merritt's Mill Pond South watershed contains records north of Marianna that would not be affected by a spill on highway 90 or I-10. The Mill Creek watershed contains slabshell within Dry Creek that could help recolonize the area following a spill on I-10 or further upstream on highway 90. Only the southern portion of the Tenmile Creek watershed would be affected from a spill on highway 20. A spill on highway 71 would impact records at the northern end of Dead Lake, but the area immediately downstream of a spill (i.e., Dead Lake) does not contain slabshell habitat. The lake would help slow the spread of a spill (low water velocity), limiting the likelihood that MU 1 would be affected by a spill on highway 71. Thus, a single spill from known crossings on the Chipola River should not result in extirpation of the species given the projected future scenarios.

CHAPTER 6 – SUMMARY

Estimates of current and future resiliency and redundancy for Chipola slabshell are generally good, and the historic range largely remains occupied. Where losses occur, they often occur in what is considered more marginal habitat (e.g., tributaries and headwater streams) as a product of synergistic effects. Chipola slabshell faces a variety of threats from declines in water quality, loss of stream flow, riparian and instream fragmentation, and deterioration of instream habitats. These threats, which are expected to be exacerbated by urbanization and climate change, were important factors in our assessment of the future viability of Chipola slabshell. Given current and future decreases in resiliency, sub-populations become more vulnerable to extirpation from stochastic events, in turn, resulting in concurrent losses in redundancy. Projections of Chipola slabshell habitat conditions and population factors suggest possible extirpation in up to three of eight currently extant watersheds. Two of the three MUs (MU 1 & 2) comprising the southern distribution of the species are predicted to retain resiliency, with the maintenance of one high resiliency watershed in the core of the range (Tenmile Creek) even in the most extreme future projection.

Our review of the best available scientific and commercial information revealed that the Chipola slabshell is still poorly known and additional research is needed to define the importance of sedimentation, optimal and suboptimal habitat, and population demographics, abundance, and recruitment. However, during our status review, we did not document any specific significant threats to the species or its habitat throughout the currently known range, or within a significant portion of the range. We found no evidence that the species has experienced curtailment of range or habitat, or is affected by disease or predation, commercial or recreational harvest, the inadequacy of existing regulatory mechanisms, or any other natural or manmade factor.

Very narrow endemic freshwater mussels are susceptible to extinction from even relatively minor habitat losses (Herrig and Shute, 2002, p. 1). Stream habitat can be subject to pollution and degradation from a variety of sources including adjacent land use alteration, point source and non-point source pollution, and in-water activities. Land use changes (e.g., logging, agriculture, and development) and anthropogenic activities have been occurring throughout the range of these species for more than a century, causing channel instability, affecting the aquatic habitat, and negatively impacting the Chipola slabshell population. Best management practices either have been or are being developed to alleviate these threats. If the Chipola River Basin provides adequate fresh water, suitable water quality and adequate habitat, we anticipate the Chipola slabshell will survive and thrive in abundance.

This concludes our assessment of Chipola slabshell needs, current condition, and future condition. This SSA will follow the species through its ESA life cycle, through recovery planning, consultations, and all policy-related decision-making until recovery and eventual delisting. To better assess the status of the species in the future, regular monitoring of populations and habitat is needed, and this SSA should be updated as new information becomes available.

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Appendices

Appendix A: ITIS Search Results for species within the genus *Elliptio*. Valid species are highlighted.

Kingdom Animalia

- Elliptio Rafinesque, 1819 – valid
- Elliptio ahenea (Lea, 1845) – valid – southern lance
- Elliptio angustata (Lea, 1831) – valid – Carolina lance
- Elliptio arca (Conrad, 1834) – valid – Alabama spike
- Elliptio arctata (Conrad, 1834) – valid – delicate spike
- Elliptio beadleiana (Lea, 1861) – invalid
- Elliptio buckleyi (Lea, 1843) – invalid – Florida shiny spike
- Elliptio chipolaensis (Walker, 1905) – valid – Chipola slabshell
- Elliptio cistellaeformis (Lea, 1863) – valid – box spike
- Elliptio collina (Conrad, 1837) – invalid
- Elliptio complanata (Lightfoot, 1786) – valid – eastern elliptio
- Elliptio congaraea (Lea, 1831) – valid – Carolina slabshell
- Elliptio crassidens (Lamarck, 1819) – valid – elephant-ear, elephantear
- Elliptio cylindracea Frierson, 1927 – valid
- Elliptio dariensis (Lea, 1842) – valid – Georgia elephantear
- Elliptio dilatata (Rafinesque, 1820) – valid – spike
- Elliptio dilatata sterkii Grier, 1918 – invalid
- Elliptio divaricatus Marshall, 1926 – invalid
- Elliptio downiei (Lea, 1858) – valid – Satilla elephantear
- Elliptio errans (Lea, 1856) – valid – oval Elliptio
- Elliptio fisheriana (Lea, 1838) – valid – northern lance
- Elliptio folliculata (Lea, 1838) – valid – pod lance
- Elliptio fraterna (Lea, 1852) – valid – brother spike
- Elliptio fumata (Lea, 1857) – valid
- Elliptio haricotti Frierson, 1927 – invalid
- Elliptio hepatica (Lea, 1859) – valid – brown elliptio
- Elliptio hermanni Haas, 1929 – invalid
- Elliptio herrerae Marshall, 1923 – invalid
- Elliptio hopetonensis (Lea, 1838) – valid – Altamaha slabshell
- Elliptio icterina (Conrad, 1834) – valid – variable spike
- Elliptio jayensis (Lea, 1838) – valid – flat spike
- Elliptio judithae Clarke, 1986 – valid – plicate spike
- Elliptio lanceolata (Lea, 1828) – valid – yellow lance
- Elliptio liebmanni cuatolopamensis H.B. Baker, 1922 – invalid
- Elliptio lugubris (Lea, 1838) – invalid – sad elliptio
- Elliptio macmichaeli Clench & Turner, 1956 – invalid – fluted elephant-ear
- Elliptio marsupiobesa Fuller, 1972 – valid – Cape Fear spike
- Elliptio maywebbae B.H. Wright, 1934 – invalid
- Elliptio mcmichaeli Clench & Turner, 1956 – valid – fluted elephantear
- Elliptio monichaeli Clench & Turner, 1956 – invalid
- Elliptio monroensis (Lea, 1843) – valid – St. Johns elephantear
- Elliptio nigella (Lea, 1852) – valid – winged spike
- Elliptio occulta (Lea, 1843) – valid
- Elliptio producta (Conrad, 1836) – valid – Atlantic spike
- Elliptio pullata (Lea, 1856) – valid
- Elliptio purpurella (Lea, 1857) – valid
- Elliptio raveneli (Conrad, 1834) – valid – Carolina spike
- Elliptio roanokensis (Lea, 1838) – valid – Roanoke slabshell
- Elliptio sajensis Frierson, 1927 – invalid
- Elliptio shepardiana (Lea, 1834) – valid – Altamaha lance
- Elliptio spinosa (Lea, 1836) – valid – Altamaha spinymussel
- Elliptio steinstansana R.I. Johnson & Clarke, 1983 – valid – Tar River spinymussel, Tar spinymussel
- Elliptio waccamawensis (Lea, 1863) – valid – Waccamaw spike
- Elliptio waltoni (B.H. Wright, 1888) – invalid – Florida lance
- Elliptionini Modell, 1942 – invalid

Appendix B : Surface Water Quality Criteria for class III surface water from the Florida Administrative Code (62-302.530, F.A.C.). This table includes constituents for which a surface water criteria exists. Unless otherwise stated, all criteria express the maximum values not to be exceeded at any time.

Parameter	Units	Class III Surface Water
Alkalinity	Milligrams/L as $CaCO_3$	Shall not be depressed below 20. In waterbodies with natural alkalinity levels below 20 mg/L, alkalinity shall not be reduced by more than 25%.
Aluminum	Milligrams/L	N/A
Ammonia (Total Ammonia Nitrogen) (Class I, Class III fresh water, and Class III-Limited fresh water)	Milligrams/L as Total Ammonia Nitrogen (TAN = NH_4^+ + NH_3)	The 30-day average TAN value shall not exceed the average of the values calculated from the following equation, with no single value exceeding 2.5 times the value from the equation: $30 - \text{day Average} = 0.8876 \times \left(\frac{0.0278}{1 + 10^{7.688-pH}} + \frac{1.1994}{1 + 10^{pH-7.688}}\right) \times (2.126 \times$ *T* and *pH* are defined as the paired temperature (°C) and pH associated with the TAN sample. For purposes of total ammonia nitrogen criterion calculations, pH is subject to the range of 6.5 to 9.0. The pH shall be set at 6.5 if measured pH is < 6.5 and set at 9.0 if the measured pH is > 9.0.
Antimony	Micrograms/L	$\leq$ 4,300
Arsenic (total)	Micrograms/L	$\leq$ 50
Bacteriological Quality (*Escherichia coli* Bacteria)	Number per 100 ml (Most Probable Number (MPN) or Membrane Filter (MF))	MPN or MF counts shall not exceed a monthly geometric mean of 126 nor exceed the Ten Percent Threshold Value (TPTV) of 410 in 10% or more of the samples during any 30-day period. Monthly geometric means shall be based on a minimum of 10 samples taken over a 30-day period.
Barium	Milligrams/L	N/A
Benzene	Micrograms/L	$\leq$ 71.28 annual avg.
Beryllium	Micrograms/L	$\leq$ 0.13 annual avg.
Biological Health (Shannon-Weaver Diversity Index using Hester-Dendy type samplers)	Per cent reduction of Shannon-Weaver Diversity Index	The Index for benthic macroinvertebrates shall not be reduced to less than 75% of established background levels as measured using organisms retained by a U. S. Standard No. 30 sieve and collected and composited from a minimum of three Hester-Dendy type artificial substrate samplers of 0.10 to 0.15 m^2 area each, incubated for a period of four weeks.
BOD (Biochemical Oxygen Demand)		Shall not be increased to exceed values which would cause dissolved oxygen to be depressed below the limit established for each class and, in no case, shall it be great enough to produce nuisance conditions.
Cadmium	Micrograms/L See Notes (1) and (3).	$Cd \leq e^{(0.7409[\ln H]-4.719)}$;
Carbon tetrachloride	Micrograms/L	$\leq$ 4.42 annual avg.

Chlorine (total residual)	Milligrams/L	≤ 0.01
Chromium (trivalent)	Micrograms/L measured as total recoverable Chromium See Notes (1) and (3).	Cr (III) $\leq e^{(0.819[\ln H]+0.6848)}$
Chromium (hexavalent)	Micrograms/L See Note (3)	≤ 11
Conductance, Specific	Micro mhos/cm	Shall not be increased more than 50% above background or to 1275, whichever is greater.
Copper	Micrograms/L See Notes (1) and (3).	Cu $\leq e^{(0.8545[\ln H]-1.702)}$
Cyanide	Micrograms/L	≤ 5.2
Detergents	Milligrams/L	≤ 0.5
1,1-Dichloroethylene (1,1-dichloroethene)	Micrograms/L	≤ 3.2 annual avg.
Dichloromethane (methylene chloride)	Micrograms/L	≤ 1,580 annual avg.
2,4-Dinitrotoluene	Micrograms/L	≤ 9.1 annual avg.
Dissolved Oxygen	Milligrams/L	See Rule 62-302.533, F.A.C. e.g., No more than 10 percent of the daily average percent dissolved oxygen (DO) saturation values shall be below 67 percent (in the Panhandle West bioregion).
Fluorides	Milligrams/L	≤ 10.0
Halomethanes (individual): Bromoform	Micrograms/L	≤ 360 annual avg.
Halomethanes (individual): Chlorodibromo-methane	Micrograms/L	≤ 34 annual avg.
Halomethanes (individual): Chloroform	Micrograms/L	≤ 470.8 annual avg.
Halomethanes (individual): Chloromethane (methyl chloride)	Micrograms/L	≤ 470.8 annual avg.
Halomethanes (individual): Dichlorobromomethane	Micrograms/L	≤ 22 annual avg.
Hexachlorobutadiene	Micrograms/L	≤ 49.7 annual avg.
Iron	Milligrams/L	≤ 1.0

Lead	Micrograms/L See Notes (1) and (3).	Pb $\leq e^{(1.273 [\ln H] -4.705)}$
Mercury	Micrograms/L	$\leq$0.012
Nickel	Micrograms/L See Notes (1) and (3).	Ni $\leq e^{(0.846[\ln H]+0.0584}$
Nonylphenol (4-nonylphenol)	Micrograms/L	$\leq$ 6.6
Nuisance Species		Substances in concentrations which result in the dominance of nuisance species: none shall be present.
Nutrients		The discharge of nutrients shall continue to be limited as needed to prevent violations of other standards contained in this chapter. Man-induced nutrient enrichment (total nitrogen or total phosphorus) shall be considered degradation in relation to the provisions of Rules 62-302.300, 62-302.700, and 62-4.242, F.A.C.
Nutrients		In no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna.
Oils and Greases	Milligrams/L	Dissolved or emulsified oils and greases shall not exceed 5.0
Oils and Greases		No undissolved oil, or visible oil defined as iridescence, shall be present so as to cause taste or odor, or otherwise interfere with the beneficial use of waters.
2,4,5-TP	Micrograms/L	N/A
2-4-D	Micrograms/L	N/A
Aldrin	Micrograms/L	$\leq$ .00014 annual avg.; 3.0 max
Beta-hexachlorocyclohexane (b-BHC)	Micrograms/L	$\leq$ 0.046 annual avg.
Carbaryl	Micrograms/L	$\leq$ 2.1
Chlordane	Micrograms/L	$\leq$ 0.00059 annual avg.; 0.0043 max
Chlorpyrifos	Micrograms/L	$\leq$ 0.041
DDT	Micrograms/L	$\leq$ 0.00059 annual avg.; 0.001 max
Demeton	Micrograms/L	$\leq$ 0.1
Diazinon	Micrograms/L	$\leq$ 0.17
Dieldrin	Micrograms/L	$\leq$ 0.00014 annual avg.; 0.0019 max
Endosulfan	Micrograms/L	$\leq$ 0.056
Endrin	Micrograms/L	$\leq$ 0.0023
Guthion	Micrograms/L	$\leq$ 0.01
Heptachlor	Micrograms/L	$\leq$ 0.00021 annual avg.; 0.0038 max
Lindane (g-benzene hexachloride)	Micrograms/L	See Minimum criteria in paragraph 62-302.500(1)(d), F.A.C.
Malathion	Micrograms/L	$\leq$ 0.1
Methoxychlor	Micrograms/L	$\leq$ 0.03
Mirex	Micrograms/L	$\leq$ 0.001
Parathion	Micrograms/L	$\leq$ 0.04

Toxaphene	Micrograms/L	≤ 0.0002
pH	Standard Units	Shall not vary more than one unit above or below natural background of predominantly fresh waters and coastal waters as defined in paragraph 62-302.520(3)(b), F.A.C. or more than two-tenths unit above or below natural background of open waters as defined in paragraph 62-302.520(3)(f), F.A.C., provided that the pH is not lowered to less than 6 units in predominantly fresh waters, or less than 6.5 units in predominantly marine waters, or raised above 8.5 units. If natural background is less than 6 units, in predominantly fresh waters or 6.5 units in predominantly marine waters, the pH shall not vary below natural background or vary more than one unit above natural background of predominantly fresh waters and coastal waters, or more than two-tenths unit above natural background of open waters. If natural background is higher than 8.5 units, the pH shall not vary above natural background or vary more than one unit below natural background of predominantly fresh waters and coastal waters, or more than two-tenths unit below natural background of open waters.
Phenolic Compounds: Total		Phenolic compounds other than those produced by the natural decay of plant material, listed or unlisted, shall not taint the flesh of edible fish or shellfish or produce objectionable taste or odor in a drinking water supply.
Total Chlorinated Phenols and Chlorinated Cresols	Micrograms/L	1. The total of all chlorinated phenols, and chlorinated cresols, except as set forth in (c)1. to (c)4. below, shall not exceed 1.0 unless higher values are shown not to be chronically toxic. Such higher values shall be approved in writing by the Secretary. 2. The compounds listed in (c)1. to (c)6. below shall not exceed the limits specified for each compound.
Phenolic Compound: 2-chlorophenol	Micrograms/L	< 400 See Note (2).
Phenolic Compound: 2,4-dichlorophenol	Micrograms/L	< 790 See Note (2).
Phenolic Compound: Pentachlorophenol	Micrograms/L	≤ 30 max; ≤ 8.2 annual avg; ≤ $e^{(1.005[pH]-5.29)}$
Phenolic Compound: 2,4,6-trichlorophenol	Micrograms/L	≤ 6.5 annual avg.
Phenolic Compound: 2,4-dinitrophenol	Milligrams/L	≤ 14.26 See Note (2).
Phenolic Compound: Phenol	Milligrams/L	≤ 0.3
Phosphorus (Elemental)	Micrograms/L	N/A
Phthalate Esters	Micrograms/L	≤ 0.3

Polychlorinated Biphenyls (PCBs)	Micrograms/L	≤ 0.000045 annual avg.; 0.014 max
Polycyclic Aromatic Hydrocarbons (PAHs). Total of: Acenaphthylene; Benzo(a)anthracene; Benzo(a)pyrene; Benzo(b)fluoranthene; Benzo-(ghi)perylene; Benzo(k)fluoranthene; Chrysene; Dibenzo-(a,h)anthracene; Indeno(1,2,3-cd)pyrene; and Phenanthrene	Micrograms/L	≤ 0.031 annual avg.
(Individual PAHs): Acenaphthene	Milligrams/L	< 2.7 See Note (2).
(Individual PAHs): Anthracene	Milligrams/L	< 110 See Note (2).
(Individual PAHs): Fluoranthene	Milligrams/L	< 0.370 See Note (2).
(Individual PAHs): Fluorene	Milligrams/L	< 14 See Note (2).
(Individual PAHs): Pyrene	Milligrams/L	< 11 See Note (2).
Radioactive substances (Combined radium 226 and 228)	Picocuries/L	≤ 5
Radioactive substances (Gross alpha particle activity including radium 226, but excluding radon and uranium)	Picocuries/L	≤ 15
Selenium	Micrograms/L	≤ 5.0
Silver	Micrograms/L See Note (3).	≤ 0.07

Substances in concentrations which injure, are chronically toxic to, or produce adverse physiological or behavioral response in humans, plants, or animals		None shall be present.
1,1,2,2-Tetrachloroethane	Micrograms/L	$\leq$ 10.8 annual avg.
Tetrachloroethylene (1,1,2,2-tetrachloroethene)	Micrograms/L	$\leq$ 8.85 annual avg.
Thallium	Micrograms/L	< 6.3
Total Dissolved Gases	Percent of the saturation value for gases at the existing atmospheric and hydrostatic pressures	$\leq$ 110% of saturation value
Transparency	Depth of the compensation point within the water column for photosynthetic activity	The annual average value shall not be reduced by more than 10% as compared to the natural background value. Annual average values shall be based on a minimum of three samples, with each sample collected at least three months apart
Trichloroethylene (trichloroethene)	Micrograms/L	$\leq$ 80.7 annual avg.
Turbidity	Nephelometric Turbidity Units (NTU)	$\leq$ 29 above natural background conditions
Zinc	Micrograms/L See Notes (1) and (3).	$Zn \leq e^{(0.8473[lnH]+0.884)}$

Notes**:** (1) "ln H" means the natural logarithm of total hardness expressed as milligrams/L of $CaCO_3$. For metals criteria involving equations with hardness, the hardness shall be set at 25 mg/L if actual hardness is < 25 mg/L and set at 400 mg/L if actual hardness is > 400 mg/L. (2) This criterion is protective of human health not of aquatic life. (3) For application of dissolved metals criteria see paragraph 62-302.500(2)(d), F.A.C. (4) Class III-Limited waters have at least one Site Specific Alternative Criterion as established under Rule 62-302.800, F.A

Appendix C : Characterization (physical characteristics, acid volatile sulfides, and simultaneously collected metals) of sediments collected from the Chipola River, May 2- 3, 2006 (Hemming et al, 2007, p. 32). Sample sites correspond to the Chipola River headwaters (1 & 2), mainstem (3 - 7), and lower Chipola River (8).

Parameter	**Site**								
Sediment characteristics	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Control**
Moisture (%)	24.0	42.8	40.3	33.6	29.3	27.7	44.5	47.4	23.6
Total organic matter (%)	2.4	5.4	4.7	2.3	1.4	0.6	6.7	4.9	0.0
Course organic matter (%)	1.0	4.0	4.0	2.0	1.0	0.0	6.0	5.0	0.0
Sand (%)	88	90	80	96	95	95	85	49	93
Silt (%)	1	5	10	0	2	3	9	29	7
Clay (%)	11	4	9	4	3	2	6	22	1
AVS (µmol/g)	0.14	0.10	2.51	0.21	0.00	0.00	0.44	2.13	0.00
SEM (µmol/g)	0.10	0.14	0.20	0.87	0.10	0.06	0.26	0.52	0.02
SEM/AVS	0.74	1.36	0.08	4.13	-	-	0.59	0.25	-
Copper (ng/g)	53	23	25	233	11	5	17	73	3
Cadmium (ng/g)	2	9	6	4	5	3	12	5	0
Tin (ng/g)	3	1	1	3	1	1	1	2	1
Mercury (ng/g)	1	1	0	0	0	0	0	0	0
Lead (ng/g)	100	82	192	140	65	31	124	227	9
Zinc (ng/g)	116	132	208	1130	131	90	291	535	35

Appendix D: Survey Results (USFWS 2019).

COLL_NO	LIVE	DEAD	TOTAL	SURVEY_DATE	DRAINAGE	STATE	County	STREAM	SOURCE
MCZ 190111	0	0	2	10/9/1953	Apalachicola	FL	Calhoun	Chipola River	Museum
FLMNH 4977	0	0	11	8/30/1954	Apalachicola	FL	Calhoun	Chipola River	Museum
MCZ 191917	0	0	11	8/30/1954	Apalachicola	FL	[Calhoun]	Chipola River	Museum
FLMNH 389	0	0	6	9/2/1954	Apalachicola	FL	Jackson	Chipola River	Museum
FLMNH 419	0	0	5	9/2/1954	Apalachicola	FL	Jackson	Marshall Creek	Museum
MCZ 190294	0	0	5	9/2/1954	Apalachicola	FL		Big Creek	Museum
MCZ 190295	0	0	6	9/2/1954	Apalachicola	FL	[Jackson]	Chipola River	Museum
MCZ 190296	0	0	1	9/2/1954	Apalachicola	FL		Reedy Creek	Museum
FLMNH 428	0	0	3	9/3/1954	Apalachicola	FL	Calhoun	Chipola River	Museum
FLMNH 5000	0	0	1	9/3/1954	Apalachicola	FL	Calhoun	Chipola River	Museum
MCZ 190293	0	0	8	9/3/1954	Apalachicola	FL	[Calhoun]	Chipola River	Museum
MCZ 190297	0	0	6	9/3/1954	Apalachicola	FL		Chipola River	Museum
WJC56-092	0	0	1	1/1/1956	Apalachicola	FL	Calhoun	Chipola River	Literature
FSU C-104	0	0	3	9/24/1965	Apalachicola	FL	Jackson	Chipola River	Literature
WHH75-002	0	0	1	1/1/1975	Apalachicola	FL	Calhoun	Chipola River	Literature
EPK78-001	0	0	1	8/27/1978	Apalachicola	FL	Jackson	Cowarts Creek	Literature
ANSP 348868z	0	0	1	10/18/1978	Apalachicola	FL	Jackson	Chipola River	Museum
WHM80-001	0	0	1	8/23/1980	Apalachicola	FL	Calhoun	Chipola River	Literature
GTW80-001	0	0	1	10/23/1980	Apalachicola	FL	Calhoun	Chipola River	Literature
EPK81-005	0	0	1	6/15/1981	Apalachicola	FL	Jackson	Chipola River	Literature
NCSM 86630	0	0	1	7/28/1981	Apalachicola	FL	Jackson	Chipola River	Museum
FLMNH 243937	0	0	18	6/28/1986	Apalachicola	FL	Calhoun	Chipola River	Museum
	0	0	1	6/28/1986	Apalachicola	FL	Calhoun	Chipola River	Literature
	0	0	1	7/26/1987	Apalachicola	FL	Calhoun	Chipola River	Literature

RSB87-004	0	0	2	10/10/1987	Apalachicola	FL	Jackson	Chipola River	Field
RSB87-008	0	0	1	10/10/1987	Apalachicola	FL	Jackson	Marshall Creek	Field
OSUM 76083	0	0	1	6/26/1988	Apalachicola	FL	Calhoun	Chipola River	Museum
RSB88-005	0	0	2	6/26/1988	Apalachicola	FL	Calhoun	Chipola River	Field
RSB88-007	0	0	1	6/26/1988	Apalachicola	FL	Calhoun	Chipola River	Field
RSB88-012	0	0	7	6/26/1988	Apalachicola	FL	Calhoun	Chipola River	Field
RSB88-057	0	0	3	6/26/1988	Apalachicola	FL	Jackson	Dry Creek	Field
WHM88-002	0	0	1	8/14/1988	Apalachicola	FL	Gulf	Chipola River	Literature
GTW90-001	0	0	1	8/29/1990	Apalachicola	FL	Calhoun	Chipola River	Literature
JCB91-037	0	0	2	1/1/1991	Apalachicola	FL	Calhoun	Chipola River	Field
JCB91-045	0	0	8	1/1/1991	Apalachicola	FL	Gulf	Chipola River	Field
JCB91-120	0	0	1	1/1/1991	Apalachicola	FL	Jackson	Chipola River	Field
JCB91-121	0	0	1	1/1/1991	Apalachicola	FL	Jackson	Chipola River	Field
ENV-1020	1	0	1	10/24/2005	Apalachicola	FL	Gulf	Chipola River	Field
CSU2006-12	1	0	1	4/1/2006	Apalachicola	FL	Jackson	Chipola River	Field
CSU2006-13	1	0	1	6/25/2006	Apalachicola	FL	Jackson	Chipola River	Field
CSU2006-02	2	0	2	7/5/2006	Apalachicola	FL	Gulf	Chipola River	Field
CSU2006-04	1	0	1	7/8/2006	Apalachicola	FL	Calhoun	Chipola River	Field
CSU2006-04	9	0	9	7/8/2006	Apalachicola	FL	Gulf	Chipola River	Field
CSU2006-07	1	0	1	7/8/2006	Apalachicola	FL	Calhoun	Chipola River	Field
CSU2006-11	5	0	5	7/9/2006	Apalachicola	FL	Jackson	Dry Creek	Field
CSU2006-03	10	0	10	7/13/2006	Apalachicola	FL	Gulf	Chipola River	Field
CSU2006-01	3	0	3	8/1/2006	Apalachicola	FL	Gulf	Chipola River	Field
CSU2006-05	56	11	67	8/12/2006	Apalachicola	FL	Gulf	Chipola River	Field
CSU2006-16	4	0	4	8/26/2006	Apalachicola	FL	Jackson	Cowarts Creek	Field
AU06-02	198	0	198	9/4/2006	Apalachicola	FL	Jackson	Chipola River	Field
CSU2006-14	10	0	10	10/13/2006	Apalachicola	FL	Jackson	Chipola River	Field

CSU2007-02	2	0	2	4/13/2007	Apalachicola	FL	Jackson	Chipola River	Field
Garner2007-04-25.01	3	0	3	4/25/2007	Apalachicola	AL	Houston	Cowarts Creek	Field
Garner2007-04-25.02	2	0	2	4/25/2007	Apalachicola	AL	Houston	Big Creek	Field
CSU2007-03	6	0	6	6/9/2007	Apalachicola	FL	Jackson	Cowarts Creek	Field
CS08-01	46	0	46	10/3/2008	Apalachicola	FL	Calhoun	Chipola River	
MMG08-01	7	0	7	10/10/2008	Apalachicola	FL	Gulf	Chipola River	Distribution Study
MMG2010-13	3	0	3	7/29/2010	Apalachicola	FL	Gulf	Chipola River	Distribution Study
FWS2010-03	1	0	1	9/17/2010	Apalachicola	FL	Gulf/Liberty	Apalachicola River	field notes
FWS2011-01	14	0	14	6/6/2011	Apalachicola	FL	Gulf	Chipola River	field notes
FWS2011-02	2	0	2	7/16/2011	Apalachicola	FL	Calhoun	Chipola River	field notes
FWS2011-03	1	0	1	7/16/2011	Apalachicola	FL	Calhoun	Chipola River	field notes
FWS2013-06-05.01	1	0	1	6/5/2013	Apalachicola	FL	Gulf	Chipola River	Field notes
FWS2013-11-06	7	0	7	11/6/2013	Apalachicola	FL	Calhoun	Chipola River	Field notes
ENV13-01	1	0	1	11/12/2013	Apalachicola	FL	Gulf	Apalachicola River	e-mail
FWS2013-11-18.01	68	0	68	11/18/2013	Apalachicola	FL	Calhoun	Chipola River	Relocation Rpt from Stantec 10Feb2013
FWC2014-08-07.1	18	0	18	8/7/2014	Apalachicola	FL	Jackson	Chipola River	
FWC2014-08-07.2	7	0	7	8/7/2014	Apalachicola	FL	Jackson	Chipola River	
FWS2014-08-07	18	0	18	8/7/2014	Apalachicola	FL	Jackson	Chipola River	
FWC2014-08-08.1	3	0	3	8/8/2014	Apalachicola	FL	Jackson	Chipola River	
FWC2014-08-08.2	2	0	2	8/8/2014	Apalachicola	FL	Jackson	Chipola River	
FWC2014-08-08.3	19	0	19	8/8/2014	Apalachicola	FL	Jackson	Chipola River	
FWC2014-08-08.4	2	0	2	8/8/2014	Apalachicola	FL	Jackson	Chipola River	
FWS2014-08-08	3	0	3	8/8/2014	Apalachicola	FL	Jackson	Chipola River	
FWS2014-08-26.01	1	1	2	8/26/2014	Apalachicola	FL	Jackson	Dry Creek	field data sheet

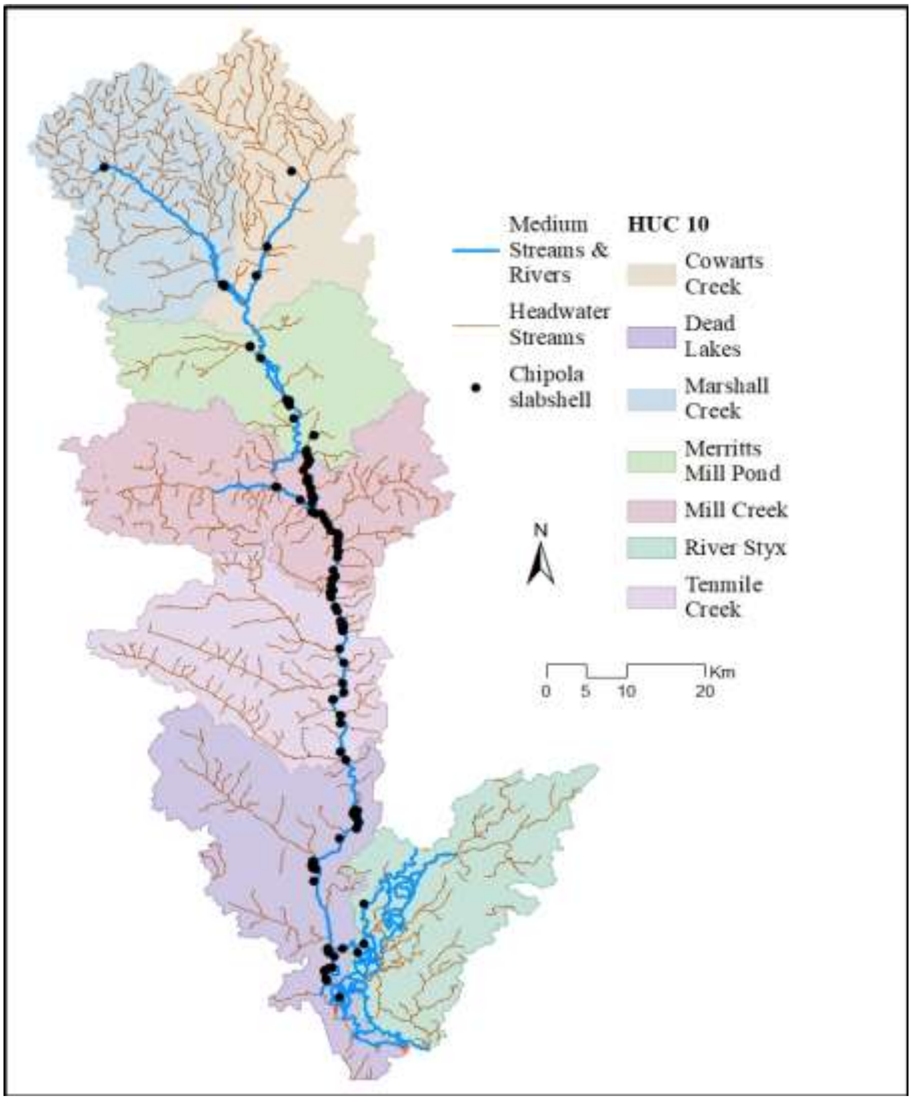
FWS2014-08-26.02	1	0	1	8/26/2014	Apalachicola	FL	Jackson	Dry Creek	field data sheet
FWS2014-09-11.02	3	0	3	9/11/2014	Apalachicola	FL	Gulf	Chipola River	field sheet
FWC2015-07-14.1	2	0	2	7/14/2015	Apalachicola	FL	Jackson	Chipola River	
FWC2015-07-14.2	8	0	8	7/14/2015	Apalachicola	FL	Jackson	Chipola River	
FWC2015-07-15.1	17	0	17	7/15/2015	Apalachicola	FL	Jackson	Chipola River	
FWC2015-07-15.2	64	0	64	7/15/2015	Apalachicola	FL	Jackson	Chipola River	
FWC2015-07-15.3	8	0	8	7/15/2015	Apalachicola	FL	Jackson	Chipola River	
FWC2015-07-15.4	30	0	30	7/15/2015	Apalachicola	FL	Jackson	Chipola River	
FWC2015-07-16.1	2	0	2	7/16/2015	Apalachicola	FL	Jackson	Chipola River	
FWC2015-07-16.2	5	0	5	7/16/2015	Apalachicola	FL	Jackson	Chipola River	
FWC2015-07-16.3	7	0	7	7/16/2015	Apalachicola	FL	Jackson	Chipola River	
FWC2015-07-16.4	11	0	11	7/16/2015	Apalachicola	FL	Jackson	Chipola River	
FWC2015-07-16.5	34	0	34	7/16/2015	Apalachicola	FL	Jackson	Chipola River	
FWC2015-07-16.R2	1	0	1	7/16/2015	Apalachicola	FL	Jackson	Chipola River	
FWC2015-07-17.2	9	0	9	7/17/2015	Apalachicola	FL	Jackson/Calhoun	Chipola River	
FWC2015-07-17.3	1	0	1	7/17/2015	Apalachicola	FL	Jackson	Chipola River	
FWC2015-07-17.4	4	0	4	7/17/2015	Apalachicola	FL	Jackson	Chipola River	
FWC2015-07-22.1	10	0	10	7/22/2015	Apalachicola	FL	Jackson/Calhoun	Chipola River	
FWC2015-07-22.2	5	0	5	7/22/2015	Apalachicola	FL	Jackson/Calhoun	Chipola River	
FWC2015-07-22.3	4	0	4	7/22/2015	Apalachicola	FL	Jackson/Calhoun	Chipola River	
FWC2015-07-22.4	3	0	3	7/22/2015	Apalachicola	FL	Jackson/Calhoun	Chipola River	
FWC2015-07-23.1	107	0	107	7/23/2015	Apalachicola	FL	Jackson/Calhoun	Chipola River	
FWC2015-07-23.2	6	0	6	7/23/2015	Apalachicola	FL	Jackson/Calhoun	Chipola River	
FWC2015-07-23.3	17	0	17	7/23/2015	Apalachicola	FL	Jackson/Calhoun	Chipola River	
FWC2015-07-23.4	9	0	9	7/23/2015	Apalachicola	FL	Jackson/Calhoun	Chipola River	
FWC2015-07-23.5	19	0	19	7/23/2015	Apalachicola	FL	Jackson/Calhoun	Chipola River	

FWC2015-07-24.1	26	0	26	7/24/2015	Apalachicola	FL	Jackson/Calhoun	Chipola River	
FWC2015-07-24.2	20	0	20	7/24/2015	Apalachicola	FL	Jackson/Calhoun	Chipola River	
FWC2015-07-24.3	14	0	14	7/24/2015	Apalachicola	FL	Jackson/Calhoun	Chipola River	
FWS2016-09-27	8	0	8	9/27/2016	Apalachicola	FL	Calhoun	Chipola River	
FWS2016-11-10.04	4	0	4	11/10/2016	Apalachicola	FL	Liberty	Apalachicola River	
FWC-2017-08-09.4	9	9	18	8/9/2017	Chipola	FL	Jackson	Chipola River	FWC mussel DB
FWC-LTM-2017-8-9.1	14	14	28	8/9/2017	Chipola	FL	Jackson	Chipola River	FWC mussel DB
FWC-LTM-2017-8-9.2	6	6	12	8/9/2017	Chipola	FL	Jackson	Chipola River	FWC mussel DB
FWC-LTM-2017-8-9.3	9	9	18	8/9/2017	Chipola	FL	Jackson	Chipola River	FWC mussel DB
FWC-2017-08-10.1	11	11	22	8/10/2017	Chipola	FL	Gulf	Chipola River	FWC mussel DB
FWC-2017-08-10.1(second time)	3	3	6	8/10/2017	Chipola	FL	Gulf	Chipola River	FWC mussel DB
FWC-2017-08-10.2	2	2	4	8/10/2017	Chipola	FL	Gulf	Chipola River	FWC mussel DB
FWC-2017-08-10.3	16	16	32	8/10/2017	Chipola	FL	Gulf	Chipola River	FWC mussel DB
FWC-LTM-2017-10-31.1	21	21	42	10/31/2017	Chipola	FL	Calhoun	Chipola River	FWC mussel DB
FWS2017-10-31.1	3	0	3	10/31/2017	Apalachicola	FL	Calhoun	Chipola River	
FWS2017-10-31.2	6	0	6	10/31/2017	Apalachicola	FL	Calhoun	Chipola River	
FWS2017-10-31.4	2	0	2	10/31/2017	Apalachicola	FL	Calhoun	Chipola River	
FWC-LTM-2017-11-01.1	2	2	4	11/1/2017	Chipola	FL	Calhoun	Chipola River	FWC mussel DB
FWC-LTM-2017-11-01.2	53	53	106	11/1/2017	Chipola	FL	Calhoun	Chipola River	FWC mussel DB
FWC-LTM-2017-11-01.3	61	61	122	11/1/2017	Chipola	FL	Calhoun	Chipola River	FWC mussel DB
FWC-2017-11-02.3	5	5	10	11/2/2017	Chipola	FL	Calhoun	Chipola River	FWC mussel DB
FWC-LTM-2017-11-02.1	2	2	4	11/2/2017	Chipola	FL	Calhoun	Chipola River	FWC mussel DB
FWC-LTM-2017-11-02.4	7	7	14	11/2/2017	Chipola	FL	Calhoun	Chipola River	FWC mussel DB

FWC-LTM-2018-05-08.1	2	2	4	5/8/2018	Chipola	FL	Calhoun	Chipola River	FWC mussel DB
FWS2018-05-09.04	10	0	10	5/9/2018	Chipola	FL	Calhoun	Chipola River	Field sheet
FWS2018-05-10.01	2	0	2	5/10/2018	Chipola	FL	Calhoun	Chipola River	Field sheet
FWS2018-05-10.03	35	0	35	5/10/2018	Chipola	FL	Calhoun	Chipola River	Field sheet
FWS2018-06-27.07	7	0	7	5/10/2018	Chipola	FL	Calhoun	Chipola River	Field sheet
FWS2018-06-27.08	1	0	1	5/10/2018	Chipola	FL	Calhoun	Chipola River	Field sheet
FWS2018-06-27.12	5	0	5	5/10/2018	Chipola	FL	Calhoun	Chipola River	Field sheet
FWC-2018-06-13.1	6	6	12	6/13/2018	Chipola	FL	Calhoun	Chipola River	FWC mussel DB
FWS2018-06-27.01	1	1	1	6/27/2018	Chipola	FL	Calhoun	Chipola River	Field sheet
FWS2018-06-27.02	15	0	15	6/27/2018	Chipola	FL	Calhoun	Chipola River	Field sheet
FWS2018-06-27.03	1	0	1	6/27/2018	Chipola	FL	Calhoun	Chipola River	Field sheet
FWS2018-06-27.04	2	0	1	6/27/2018	Chipola	FL	Calhoun	Chipola River	Field sheet
FWS2018-06-27.06	27	0	27	6/27/2018	Chipola	FL	Calhoun	Chipola River	Field sheet
FWS2018-06-28.03	3	0	3	6/28/2018	Chipola	FL	Calhoun	Chipola River	Field sheet
FWS2018-06-28.05	1	0	1	6/28/2018	Chipola	FL	Calhoun	Chipola River	Field sheet
FWS2018-06-28.06	28	0	28	6/28/2018	Chipola	FL	Calhoun	Chipola River	Field sheet
FWS2018-07-02.02	42	0	42	7/2/2018	Chipola	FL	Calhoun	Chipola River	Field sheet
FWC-2018-07-10.3	1	1	2	7/10/2018	Chipola	FL	Jackson	Cowarts Creek	FWC mussel DB
FWC-2018-07-11.4	2	2	4	7/11/2018	Apalachicola	FL	Jackson	Marshall Creek	FWC mussel DB
FWC-2018-07-12.4	5	5	10	7/12/2018	Chipola	FL	Jackson	Chipola River	FWC mussel DB
FWS-2019-07-18.2		1.0		7/18/2019	Chipola	Florida	Jackson	Wadell Mill	
FWS-2019-07-25.1	11.0	1.0	12.0	7/25/2019	Chipola	Florida	Jackson	Chipola River	
FWS-2019-07-25.2	6.0			7/25/2019	Chipola	Florida	Jackson	Chipola River	

FWS-2019-07-25.3	5.0	1.0	6.0	7/25/2019	Chipola	Florida	Jackson	Chipola River	
FWS-2019-07-25.4	5.0			7/25/2019	Chipola	Florida	Jackson	Chipola River	
FWS-2019-07-30.2	2.0			7/30/2019	Chipola	Florida	Jackson	Chipola River	
FWS-2019-07-31.1	4.0	3.0	7.0	7/31/2019	Chipola	Florida	Jackson	Chipola River	
FWS-2019-07-31.2	1.0	3.0	4.0	7/31/2019	Chipola	Florida	Jackson	Chipola River	
FWS-2019-07-31.3	5.0	2.0	7.0	7/31/2019	Chipola	Florida	Jackson	Chipola River	
FWS-2019-08-06.3	3.0	1.0	4.0	8/6/2019	Chipola	Florida	Jackson	Marshall Creek	
FWS-2019-08-07.1	0.0	2.0	2.0	8/7/2019	Chipola	Florida	Jackson	Wadell Mill	
FWS-2019-08-08.1		4.0		8/8/2019	Chipola	Florida	Jackson	Chipola River	
ANSP 48074z	0	0	1		Apalachicola	FL		Chipola River	Museum
ANSP 90434	0	0	1		Apalachicola	FL		Chipola River	Museum
UMMZ 138388	0	0	5		Apalachicola	FL	Jackson	Chipola River	Museum
UMMZ 138409	0	0	4.5		Apalachicola	FL	Jackson	Chipola River	Museum
UMMZ 138436	0	0	1		Apalachicola	FL	Calhoun	Chipola River	Museum
UMMZ 138453	0	0	11.5		Apalachicola	FL	Calhoun	Chipola River	Museum
UMMZ 57431	0	0	4		Apalachicola	FL	Jackson	Spring Creek	Museum
UMMZ 57447	0	0	1		Apalachicola	FL	Jackson	Spring Creek	Museum
UMMZ 96362	0	0	1		Apalachicola	FL	[Unknown]	Chipola River	Museum
UMMZ 96363	0	0	1		Apalachicola	FL	[Unknown]	Chipola River	Museum

Appendix E : Available habitat for Chipola slabshell. Available habitat was identified as stream order 4 or higher (medium streams and river), though some records do come from 3rd order headwater tributaries. The limit for analysis was the watersheds (HUC 10s) in which Chipola slabshell has been reported from at any point in time.



Appendix F : BMPs and BMP manuals for the Jackson Blue Spring and Merritts Mill

Pond Basin Management Action Plan adopted by rule as of June 2017 (FDEP 2018c, p. 19).

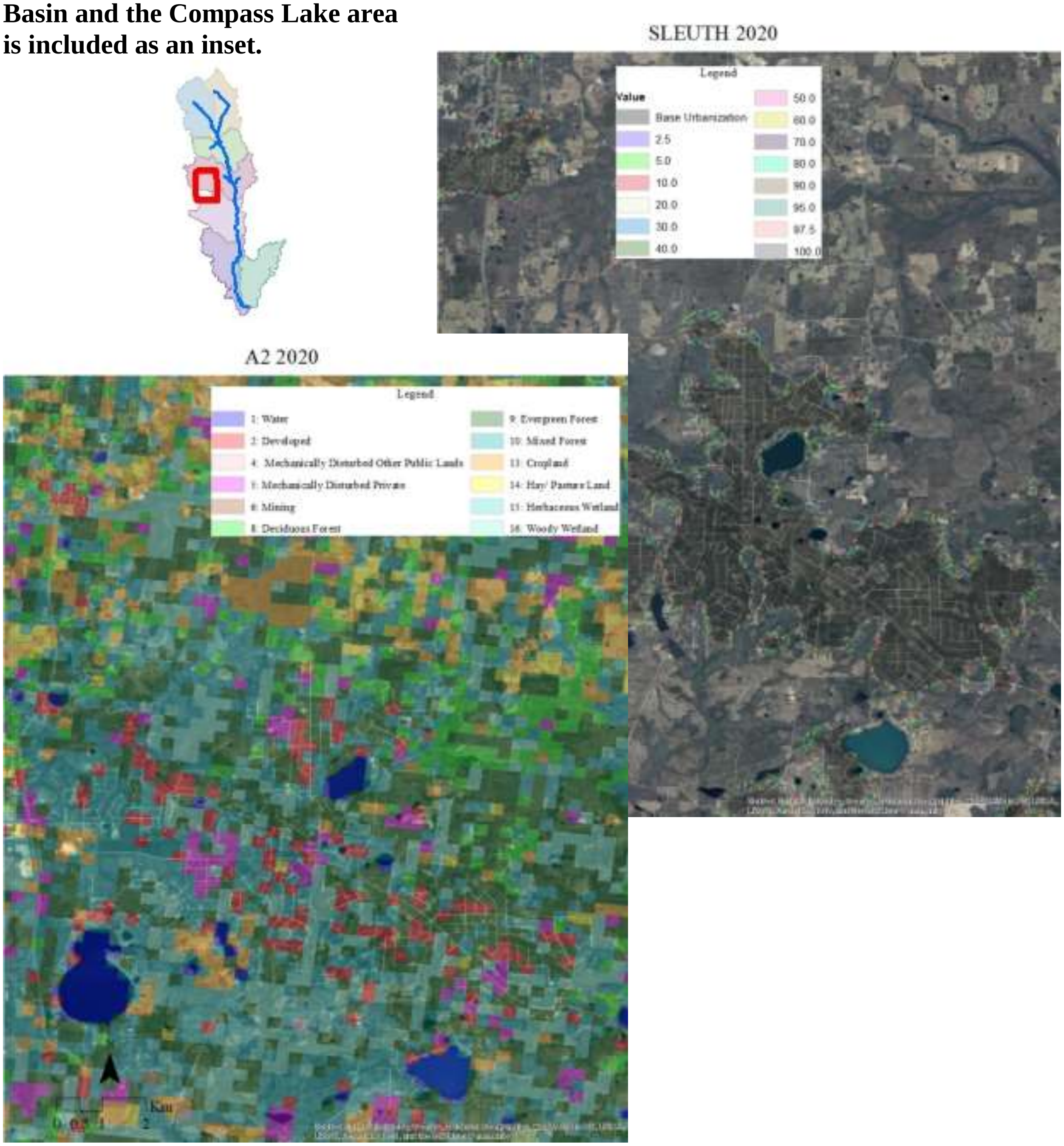
Agency	F.A.C. Chapter	Chapter Title
FDACS Office of Agricultural Water Policy (OAWP)	5M-6	Florida Container Nursery BMP Guide
FDACS OAWP	5M-8	BMPs for Florida Vegetable and Agronomic Crops
FDACS OAWP	5M-9	BMPs for Florida Sod
FDACS OAWP	5M-11	BMPs for Florida Cow/Calf Operations
FDACS OAWP	5M-12	Conservation Plans for Specified Agricultural Operations
FDACS OAWP	5M-13	BMPs for Florida Specialty Fruit and Nut Crop Operations
FDACS OAWP	5M-14	BMPs for Florida Equine Operations
FDACS OAWP	5M-16	BMPs for Florida Citrus
FDACS OAWP	5M-17	BMPs for Florida Dairies
FDACS OAWP	5M-18	Florida Agriculture Wildlife BMPs
FDACS OAWP	5M-19	BMPs for Florida Poultry
FDACS Division of Agricultural Environmental Services	5E-1	Fertilizer
FDACS Division of Aquaculture	5L-3	Aquaculture BMPs
FDACS Florida Forest Service	5I-6	BMPs for Silviculture
FDACS Florida Forest Service	5I-8	Florida Forestry Wildlife BMPs for State Imperiled Species
DEP	62-330	Environmental Resource Permitting

Appendix G : Weighting scheme for factors used in the current resiliency assessment. Factor weights were determined by the most likely importance value for a given factor in Step 4, divided by the sum of importance factors.

Average

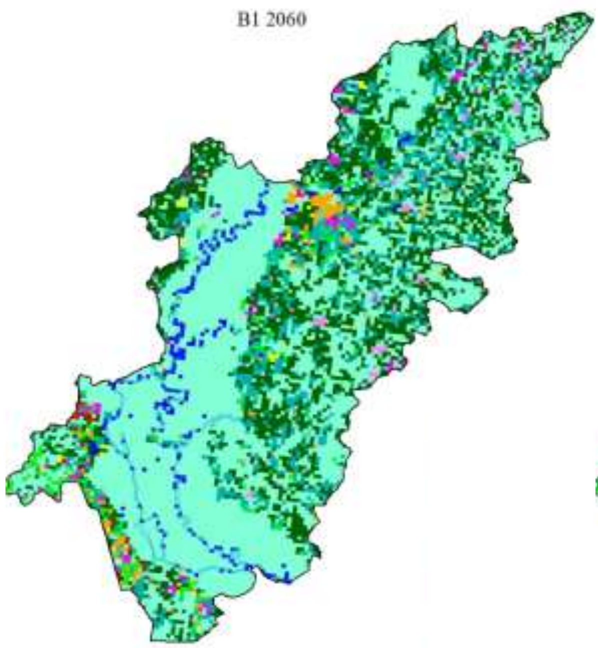
		Step 1	Step 2	Step 3	Step 4	Step 5	
Factor #	Factor Name	Rank	Lowest Importance Score	Highest Importance Score	Most Likely Importance Score	Confidence in range (50-100%)	Factor weight
A	Occupancy	2	37	80	67	88	0.296
B	Abundance & Recruitment	1	58	82	68	90	0.304
C	Sedimentation Index	4	24	48	40	83	0.178
D	Canopy	3	35	60	50	70	0.222

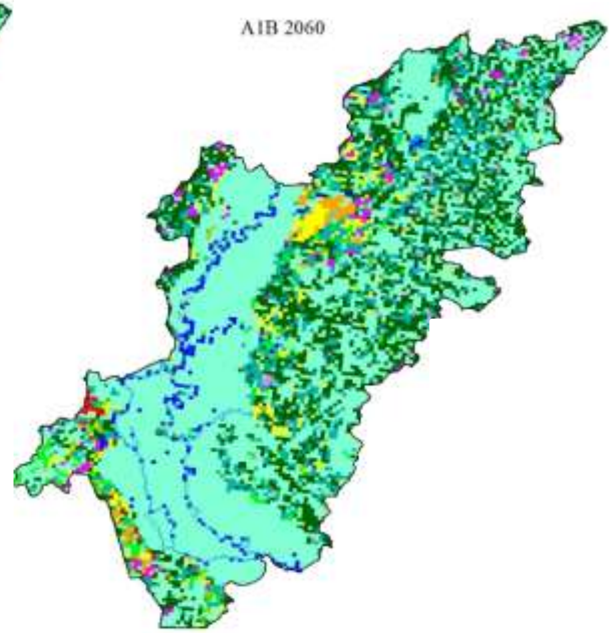
Appendix H: A comparison of areas classified as developed under the SLEUTH and FORE SCE models in 2020 in a rural landscape near Compass Lake, Florida. The SLEUTH model over-estimates developed area even within its most conservative base urbanization estimate, while the FORE SCE (A2) model depicts scattered development within a forested and agricultural matrix that more accurately reflects current land use. The Chipola River Basin and the Compass Lake area is included as an inset.

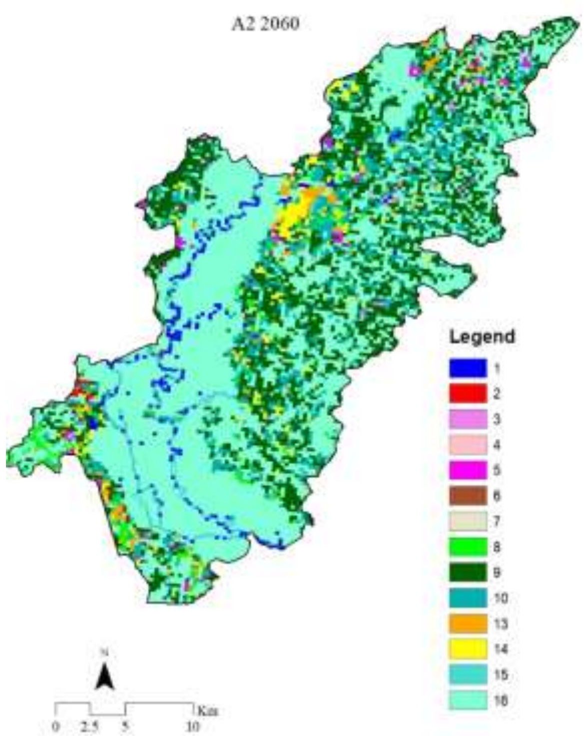


Appendix I: FORE SCE future land use projections from SRES models B1, A1B and A2.

Management Unit 1:







Value	Definition
1	Water
2	Developed
3	Mechanically Disturbed National Forests
4	Mechanically Disturbed Other Public Lands
5	Mechanically Disturbed Private
6	Mining
7	Barren
8	Deciduous Forest
9	Evergreen Forest
10	Mixed Forest
13	Cropland
14	Hay/Pasture Land
15	Herbaceous Wetland
16	Woody Wetland

Management Unit 1 trends within HUC 10s for SRES model B1:

a)River Styx & Douglas Slough

Land Use/ Cover	2020	2030	**2040**	2050	**2060**	2070
Agriculture (crop, hay/pasture)	2.5	2.1	**2.1**	2.1	**2.1**	2.2
Urbanized (developed, mining)	0.2	0.2	**0.2**	0.2	**0.2**	0.2
Silviculture (mechanically disturbed)	2.3	1.6	**1.7**	1.6	**2.1**	1.2
Forest (decidouss, evergreen, mixed)	38.2	39.2	**39.1**	39.2	**38.7**	39.5
Wetlands (herbaceous,woody)	54.6	54.6	**54.6**	54.6	**54.6**	54.6
Other (water, barren)	2.3	2.3	**2.3**	2.3	**2.3**	2.3

Management Unit 1 trends within HUC 10s for SRES model A1B:

a)River Styx & Douglas Slough

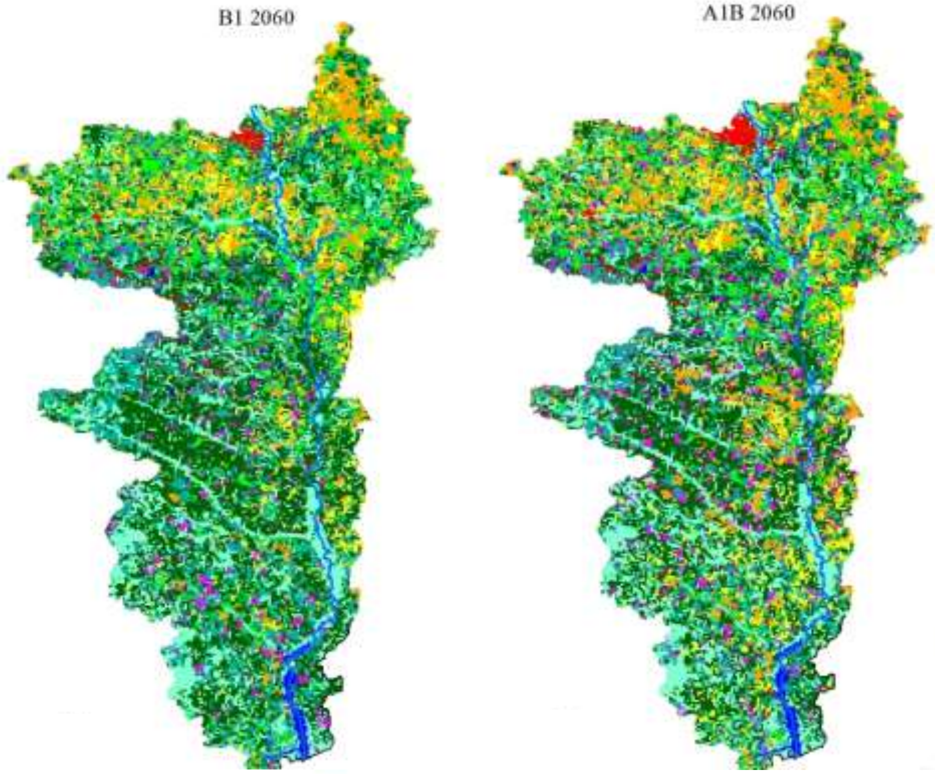
Land Use/Cover	2020	2030	**2040**	2050	**2060**	2070
Agriculture (crop, hay/pasture)	2.9	3.2	**3.9**	4.6	**5.1**	5.7
Urbanized (developed, mining)	0.2	0.2	**0.3**	0.3	**0.3**	0.3
Silviculture (mechanically disturbed)	1.7	2.0	**1.5**	2.1	**2.1**	2.1
Forest (deciduous, evergreen, mixed)	38.4	37.9	**37.7**	36.3	**35.8**	35.2
Wetlands (herbaceous,woody)	54.4	54.4	**54.4**	54.4	**54.4**	54.4
Other (water, barren)	2.3	2.3	**2.3**	2.3	**2.3**	2.3

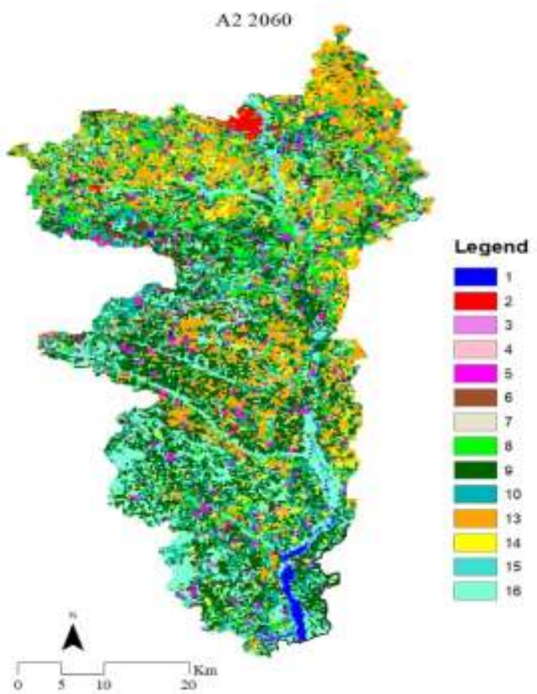
Management Unit 1 trends within HUC 10s for SRES model A2:

a) River Styx & Douglas Slough

Land Use/ Cover	2020	2030	**2040**	2050	**2060**	2070
Agriculture (crop, hay/pasture)	3.3	3.5	**3.4**	3.8	**4.5**	5.4
Urbanized (developed, mining)	0.2	0.2	**0.2**	0.2	**0.3**	0.3
Silviculture(mechanically disturbed)	1.2	1.4	**1.3**	1.6	**1.3**	1.4
Forest (decidouss, evergreen, mixed)	38.4	38.1	**38.2**	37.5	**37.1**	36.1
Wetlands (herbaceous,woody)	54.5	54.5	**54.5**	54.5	**54.5**	54.5
Other (water, barren)	2.3	2.3	**2.3**	2.3	**2.3**	2.3

Management Unit 2:





Value	Definition
1	Water
2	Developed
3	Mechanically Disturbed National Forests
4	Mechanically Disturbed Other Public Lands
5	Mechanically Disturbed Private
6	Mining
7	Barren
8	Deciduous Forest
9	Evergreen Forest
10	Mixed Forest
13	Cropland
14	Hay/Pasture Land
15	Herbaceous Wetland
16	Woody Wetland

Management Unit 2 trends within HUC 10s (north to south) for SRES model B1:

a) Merritts Mill Pond –South

Land Use/ Cover	2020	2030	**2040**	2050	**2060**	2070
Agriculture (crop, hay/pasture)	34.3	33.7	**33.7**	33.4	**33.2**	33.1
Urbanized (developed, mining)	3.7	3.9	**4.2**	4.5	**4.9**	5.3
Silviculture(mechanically disturbed)	0.7	0.8	**0.7**	0.7	**0.8**	0.8
Forest (deciduous, evergreen, mixed)	51.8	52.0	**51.8**	51.8	**51.5**	51.2
Wetlands (herbaceous,woody)	8.4	8.4	**8.4**	8.5	**8.5**	8.5
Other (water, barren)	1.0	1.1	**1.1**	1.1	**1.1**	1.1

b) Mill Creek

Land Use/ Cover	2020	2030	**2040**	2050	**2060**	2070
Agriculture (crop, hay/pasture)	24.8	23.7	**23.6**	23.4	**23.1**	23.1
Urbanized (developed, mining)	0.8	0.8	**0.9**	0.9	**0.9**	0.9
Silviculture(mechanically disturbed)	2.7	3.4	**2.8**	2.5	**2.3**	2.3
Forest (deciduous, evergreen, mixed)	58.6	58.9	**59.7**	60.1	**60.6**	60.6
Wetlands (herbaceous,woody)	12.5	12.5	**12.5**	12.5	**12.5**	12.5
Other (water, barren)	0.6	0.6	**0.6**	0.6	**0.6**	0.6

c) Tenmile Creek

Land Use/ Cover	2020	2030	**2040**	2050	**2060**	2070
Agriculture (crop, hay/pasture)	11.0	8.5	**8.2**	8.1	**7.8**	7.7
Urbanized(developed, mining)	0.6	0.6	**0.6**	0.6	**0.6**	0.6
Silviculture(mechanically disturbed)	5.7	6.8	**4.9**	4.9	**3.8**	3.8
Forest (deciduous, evergreen, mixed)	64.0	65.3	**67.5**	67.7	**68.9**	69.1
Wetlands (herbaceous, woody)	18.0	18.1	**18.1**	18.1	**18.1**	18.2
Other (water, barren)	0.7	0.7	**0.7**	0.7	**0.7**	0.7

d) Dead Lakes

Land Use/ Cover	2020	2030	**2040**	2050	**2060**	2070
Agriculture (crop, hay/pasture)	5.0	4.2	**4.4**	4.6	**4.8**	5.0
Urbanized(developed, mining)	0.1	0.1	**0.1**	0.1	**0.2**	0.2
Silviculture(mechanically disturbed)	4.3	4.9	**4.8**	3.7	**4.4**	4.0
Forest (deciduous, evergreen, mixed)	58.7	58.9	**58.8**	59.8	**58.8**	59.0
Wetlands (herbaceous,woody)	28.6	28.6	**28.6**	28.6	**28.6**	28.6
Other (water, barren)	3.2	3.2	**3.2**	3.2	**3.2**	3.3

Management Unit 2 trends within HUC 10s (north to south) for SRES model A1B:

a) Merritts Mill Pond –South

Land Use/ Cover	2020	2030	**2040**	2050	**2060**	2070
Agriculture (crop, hay/pasture)	34.7	34.7	**34.9**	34.9	**35.0**	35.2
Urbanized(developed, mining)	4.0	5.0	**6.4**	7.3	**7.8**	8.2
Silviculture(mechanically disturbed)	3.5	3.3	**4.4**	3.4	**3.8**	6.0
Forest (deciduous, evergreen, mixed)	48.5	47.6	**45.0**	45.2	**44.1**	41.3
Wetlands (herbaceous,woody)	8.4	8.4	**8.3**	8.3	**8.3**	8.4
Other (water, barren)	1.0	1.0	**1.0**	1.0	**1.0**	1.0

b) Mill Creek

Land Use/ Cover	2020	2030	**2040**	2050	**2060**	2070
Agriculture (crop, hay/pasture)	25.4	25.4	**25.7**	26.2	**23.1**	26.8
Urbanized(developed, mining)	0.8	0.9	**0.9**	0.9	**0.9**	1.0
Silviculture(mechanically disturbed)	4.1	4.6	**4.2**	5.3	**2.3**	6.9
Forest (deciduous, evergreen, mixed)	56.7	56.1	**56.1**	54.6	**60.6**	52.2
Wetlands (herbaceous,woody)	12.4	12.5	**12.5**	12.5	**12.5**	12.4
Other (water, barren)	0.5	0.5	**0.5**	0.5	**0.6**	0.6

c) Tenmile Creek

Land Use/ Cover	2020	2030	**2040**	2050	**2060**	2070
Agriculture (crop, hay/pasture)	13.6	13.3	**13.8**	14.1	**7.8**	14.5
Urbanized(developed, mining)	0.6	0.6	**0.6**	0.6	**0.6**	0.6
Silviculture(mechanically disturbed)	7.3	5.4	**6.3**	7.8	**3.8**	9.4
Forest (deciduous, evergreen, mixed)	59.9	62.2	**60.8**	58.9	**68.9**	57.0
Wetlands (herbaceous,woody)	18.0	18.0	**18.0**	18.0	**18.1**	18.0
Other (water, barren)	0.7	0.7	**0.7**	0.7	**0.7**	0.7

d) Dead Lakes

Land Use/ Cover	2020	2030	**2040**	2050	**2060**	2070
Agriculture (crop, hay/pasture)	6.5	7.4	**10.7**	12.0	**13.1**	14.1
Urbanized (developed, mining)	0.1	0.1	**0.2**	0.2	**0.2**	0.2
Silviculture(mechanically disturbed)	3.6	5.0	**3.7**	4.1	**4.9**	5.3
Forest (deciduous, evergreen, mixed)	58.0	55.7	**53.6**	52.0	**50.0**	48.6
Wetlands (herbaceous,woody)	28.6	28.6	**28.6**	28.6	**28.6**	28.5
Other (water, barren)	3.2	3.2	**3.2**	3.2	**3.2**	3.2

Management Unit 2 trends within HUC 10s (north to south) for SRES model A2:

a) Merritts Mill Pond –South

Land Use/ Cover	2020	2030	**2040**	2050	**2060**	2070
Agriculture (crop, hay/pasture)	36.8	37.7	**37.9**	39.0	**41.4**	44.0
Urbanized(developed, mining)	3.9	4.8	**5.9**	7.0	**7.7**	8.5
Silviculture(mechanically disturbed)	2.3	3.2	**2.3**	4.0	**3.3**	2.3
Forest (deciduous, evergreen, mixed)	47.7	45.0	**44.6**	40.8	**38.3**	35.9
Wetlands (herbaceous, woody)	8.4	8.4	**8.3**	8.3	**8.3**	8.3
Other (water, barren)	1.0	1.0	**1.0**	1.0	**1.0**	1.0

b) Mill Creek

Land Use/ Cover	2020	2030	**2040**	2050	**2060**	2070
Agriculture (crop, hay/pasture)	27.6	28.0	**28.3**	29.7	**31.7**	34.7
Urbanized(developed, mining)	0.8	0.9	**0.9**	1.0	**1.0**	1.0
Silviculture(mechanically disturbed)	3.3	4.5	**4.0**	4.6	**4.5**	4.6
Forest (deciduous, evergreen, mixed)	55.4	53.7	**53.9**	51.8	**50.0**	46.8
Wetlands (herbaceous, woody)	12.4	12.4	**12.4**	12.4	**12.4**	12.4
Other (water, barren)	0.5	0.5	**0.6**	0.6	**0.6**	0.6

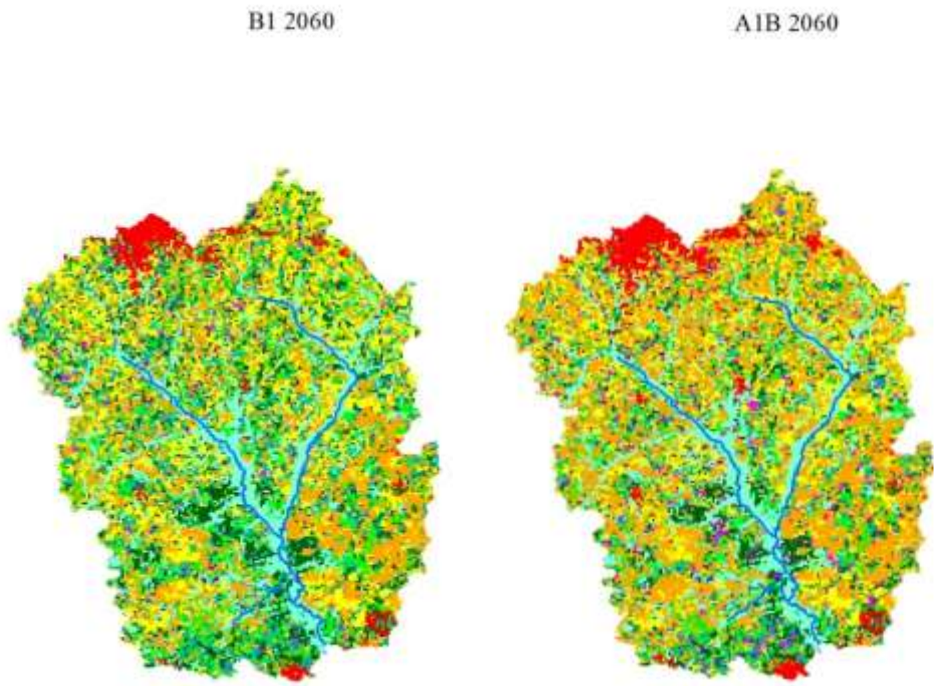
c) Tenmile Creek

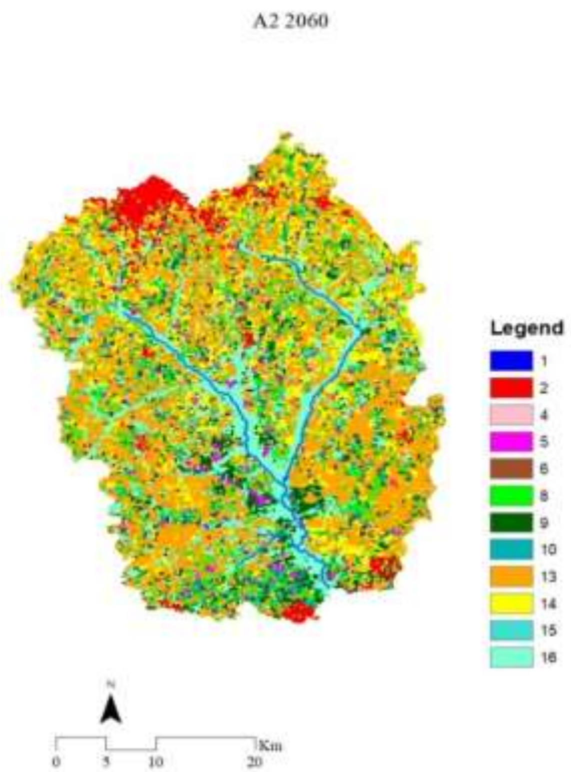
Land Use/ Cover	2020	2030	**2040**	2050	**2060**	2070
Agriculture (crop, hay/pasture)	17.1	17.7	**18.1**	19.9	**22.6**	26.4
Urbanized(developed, mining)	0.6	0.6	**0.6**	0.6	**0.6**	0.6
Silviculture(mechanically disturbed)	5.2	6.4	**5.2**	5.8	**4.6**	4.7
Forest (deciduous, evergreen, mixed)	58.5	56.7	**57.6**	55.1	**53.6**	49.7
Wetlands (herbaceous, woody)	17.9	17.9	**17.9**	17.9	**17.9**	17.9
Other (water, barren)	0.7	0.7	**0.7**	0.7	**0.7**	0.7

d) Dead Lakes

Land Use/ Cover	2020	2030	**2040**	2050	**2060**	2070
Agriculture (crop, hay/pasture)	7.5	7.5	**7.1**	7.9	**9.6**	11.3
Urbanized, Developed	0.1	0.1	**0.1**	0.1	**0.1**	0.2
Silviculture	3.9	3.8	**4.1**	4.1	**4.3**	3.2
Forest (deciduous, evergreen, mixed)	56.7	56.8	**56.9**	56.1	**54.2**	53.6
Wetlands (herbaceous,woody)	28.6	28.6	**28.6**	28.6	**28.5**	28.5
Other (water, barren)	3.2	3.2	**3.2**	3.2	**3.2**	3.2

Management Unit 3:





Value	Definition
1	Water
2	Developed
3	Mechanically Disturbed National Forests
4	Mechanically Disturbed Other Public Lands
5	Mechanically Disturbed Private
6	Mining
7	Barren
8	Deciduous Forest
9	Evergreen Forest
10	Mixed Forest
13	Cropland
14	Hay/Pasture Land
15	Herbaceous Wetland
16	Woody Wetland

Management Unit 3 trends within HUC 10s for SRES model B1:

a) Marshall Creek

Land Use/ Cover	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Agriculture (crop, hay/pasture)	48.8	45.4	**44.6**	44.0	**43.2**	42.6
Urbanized(developed, mining)	2.5	3.2	**3.9**	4.3	**4.7**	5.2
Silviculture(mechanically disturbed)	1.2	1.7	**1.7**	1.6	**1.4**	1.4
Forest (deciduous, evergreen, mixed)	30.1	32.1	**32.2**	32.5	**33.1**	33.2
Wetlands (herbaceous,woody)	16.7	16.8	**16.8**	16.8	**16.8**	16.9
Other (water, barren)	0.7	0.7	**0.7**	0.7	**0.7**	0.7

b) Cowarts Creek

Land Use/ Cover	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Agriculture (crop, hay/pasture)	52.6	49.5	**49.0**	48.3	**47.5**	47.0
Urbanized(developed, mining)	1.0	1.1	**1.5**	1.8	**2.0**	2.5
Silviculture(mechanically disturbed)	0.9	1.5	**1.4**	1.2	**0.9**	1.0
Forest (deciduous, evergreen, mixed)	29.0	31.2	**31.5**	32.0	**32.9**	32.8
Wetlands (herbaceous,woody)	16.0	16.1	**16.2**	16.2	**16.2**	16.2
Other (water, barren)	0.4	0.5	**0.5**	0.5	**0.5**	0.5

c) Merritts Mill Pond –North

Land Use/ Cover	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Agriculture (crop, hay/pasture)	41.1	40.5	**40.4**	40.2	**40.3**	40.2
Urbanized(developed, mining)	2.0	2.3	**2.5**	2.6	**2.7**	2.8
Silviculture(mechanically disturbed)	0.7	1.8	**1.7**	0.9	**0.9**	1.3
Forest (deciduous, evergreen, mixed)	41.9	40.9	**41.0**	41.9	**41.8**	41.3
Wetlands (herbaceous,woody)	13.7	13.8	**13.8**	13.8	**13.8**	13.8
Other (water, barren)	0.7	0.7	**0.7**	0.7	**0.7**	0.7

Management Unit 3 trends within HUC 10s for SRES model A1B:

a) Marshall Creek

Land Use/ Cover	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Agriculture (crop, hay/pasture)	50.3	50.2	**51.2**	51.7	**43.2**	52.3
Urbanized(developed, mining)	3.1	4.2	**5.2**	6.0	**4.7**	7.4
Silviculture(mechanically disturbed)	2.2	2.1	**2.2**	2.1	**1.4**	2.8
Forest (deciduous, evergreen, mixed)	27.2	26.2	**24.1**	22.9	**33.1**	20.2
Wetlands (herbaceous,woody)	16.5	16.6	**16.5**	16.5	**16.8**	16.5
Other (water, barren)	0.7	0.7	**0.7**	0.7	**0.7**	0.7

b) Cowarts Creek

Land Use/ Cover	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Agriculture (crop, hay/pasture)	54.1	54.2	**54.9**	55.5	**47.5**	56.4
Urbanized(developed, mining)	1.1	1.8	**2.4**	2.8	**2.0**	3.6
Silviculture(mechanically disturbed)	1.9	2.6	**1.9**	1.9	**0.9**	3.2
Forest (deciduous, evergreen, mixed)	26.5	25.1	**24.5**	23.4	**32.9**	20.4
Wetlands (herbaceous,woody)	15.9	16.0	**16.0**	16.0	**16.2**	16.0
Other (water, barren)	0.4	0.4	**0.4**	0.4	**0.5**	0.4

c) Merritts Mill Pond –North

Land Use/ Cover	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Agriculture (crop, hay/pasture)	41.6	41.9	**43.0**	43.8	**40.3**	45.4
Urbanized(developed, mining)	2.4	2.7	**2.9**	3.2	**2.7**	3.3
Silviculture(mechanically disturbed)	2.4	4.0	**3.3**	3.1	**0.9**	4.7
Forest (deciduous, evergreen, mixed)	39.2	37.0	**36.5**	35.6	**41.8**	32.3
Wetlands (herbaceous,woody)	13.7	13.7	**13.7**	13.7	**13.8**	13.7
Other (water, barren)	0.7	0.7	**0.7**	0.7	**0.7**	0.7

Management Unit 3 trends within HUC 10s for SRES model A2:

a) Marshall Creek

Land Use/ Cover	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Agriculture (crop, hay/pasture)	52.7	53.1	**53.1**	53.9	**55.4**	57.3
Urbanized(developed, mining)	2.7	3.6	**4.2**	5.0	**5.9**	7.3
Silviculture(mechanically disturbed)	1.9	1.8	**1.7**	2.0	**2.0**	1.9
Forest (deciduous, evergreen, mixed)	25.5	24.3	**23.8**	21.8	**19.4**	16.3
Wetlands (herbaceous,woody)	16.5	16.5	**16.5**	16.5	**16.5**	16.5
Other (water, barren)	0.7	0.7	**0.7**	0.7	**0.7**	0.7

b) Cowarts Creek

Land Use/ Cover	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Agriculture (crop, hay/pasture)	55.9	56.4	**56.6**	57.3	**58.9**	61.0
Urbanized(developed, mining)	1.1	1.4	**1.9**	2.4	**2.8**	3.4
Silviculture(mechanically disturbed)	1.2	1.8	**1.9**	1.9	**1.9**	1.6
Forest (deciduous, evergreen, mixed)	25.5	24.1	**23.3**	22.1	**20.2**	17.8
Wetlands (herbaceous,woody)	15.8	15.9	**15.9**	15.9	**15.8**	15.8
Other (water, barren)	0.4	0.4	**0.4**	0.4	**0.4**	0.4

c) Merritts Mill Pond –North

Land Use/ Cover	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Agriculture (crop, hay/pasture)	44.9	45.7	**46.0**	47.7	**50.3**	54.0
Urbanized(developed, mining)	2.3	2.6	**2.7**	3.1	**3.2**	3.4
Silviculture(mechanically disturbed)	2.7	2.3	**2.4**	3.7	**2.7**	2.2
Forest (deciduous, evergreen, mixed)	35.7	35.1	**34.4**	31.0	**29.4**	26.1
Wetlands (herbaceous,woody)	13.7	13.7	**13.7**	13.7	**13.7**	13.7
Other (water, barren)	0.7	0.7	**0.7**	0.7	**0.7**	0.7

Appendix J: Relevant USGS National Climate Change Viewer (2016, p. 1 –3, 4- 9) summary data for the Chipola River watershed. Snow water equivalent metrics were omitted as snow accumulation is negligible to non-existent.

USGS science for a changing world

U.S. Geological Survey - National Climate Change Viewer

Summary of Chipola. Alabama, Florida. (03130012)

1 Maximum 2-m Air Temperature

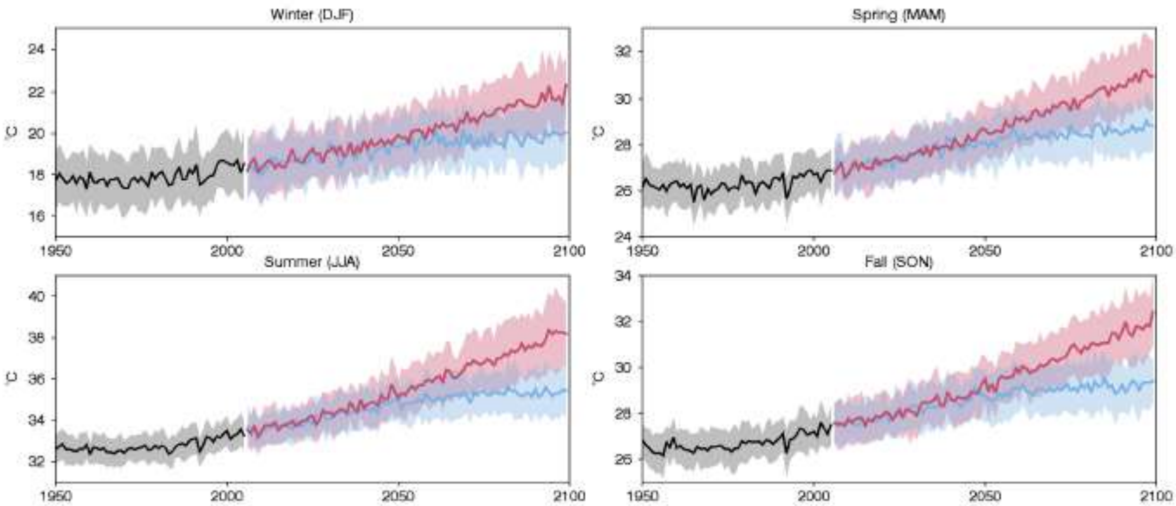


Figure 1: Seasonal average time series of maximum 2-m air temperature for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

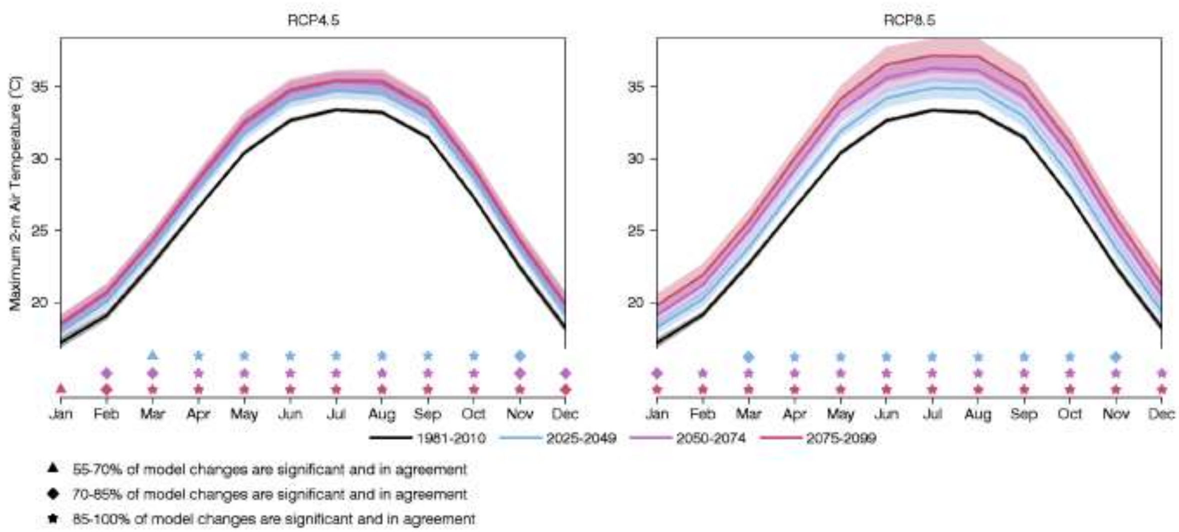


Figure 2: Monthly averages of maximum 2-m air temperature for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes. Triangle, diamond and square symbols indicate the percent of models that simulate future minus present changes that are of the same sign and significant. A two-sided Students t-test is used to establish significance ($\rho \leq 0.05$).

2 Minimum 2-m Air Temperature

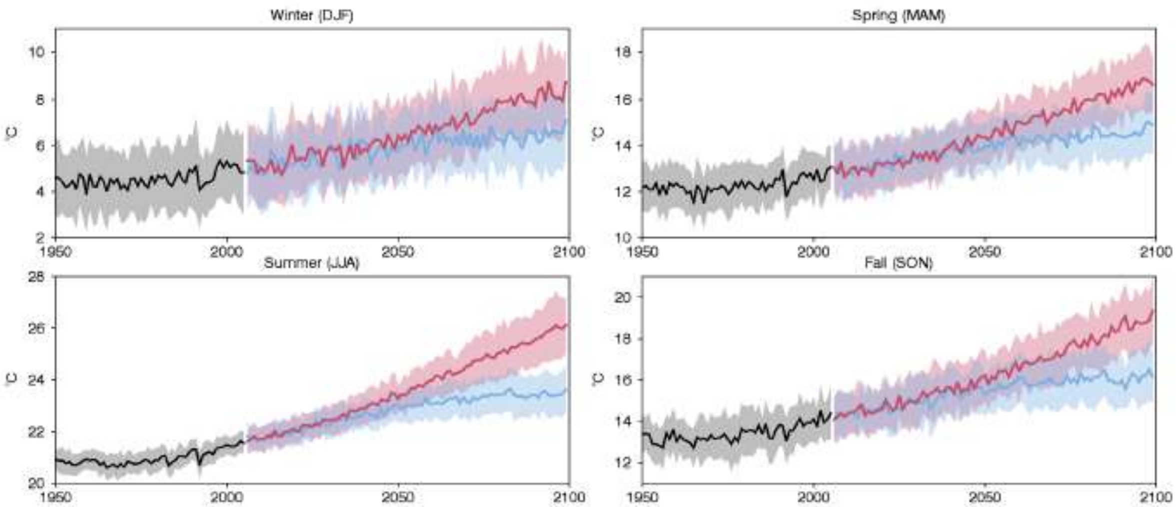


Figure 3: Seasonal average time series of minimum 2-m air temperature for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

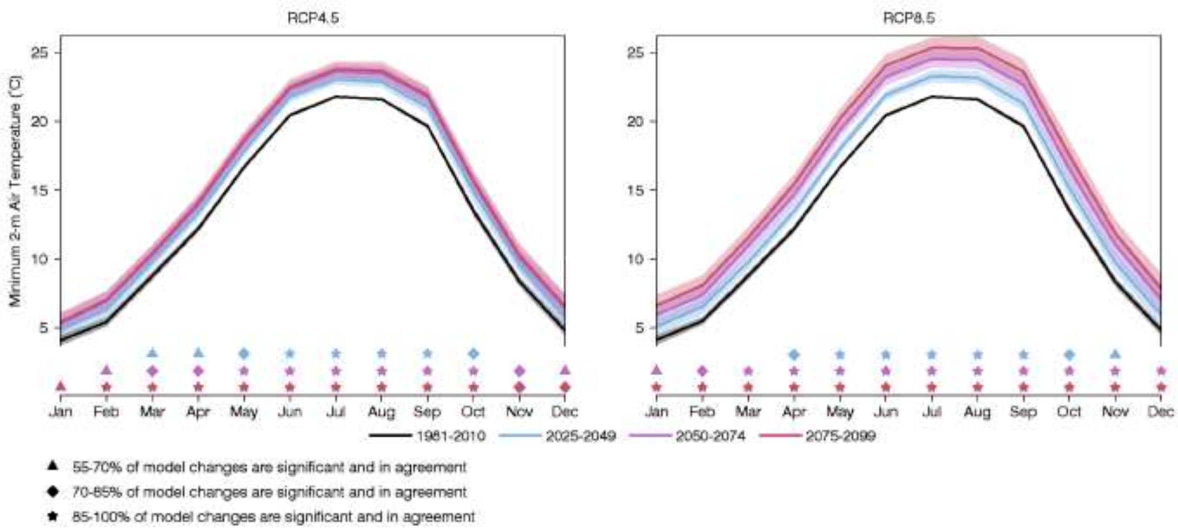


Figure 4: Monthly averages of minimum 2-m air temperature for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes. Triangle, diamond and square symbols indicate the percent of models that simulate future minus present changes that are of the same sign and significant. A two-sided Students t-test is used to establish significance ($\rho \leq 0.05$).

3 Precipitation

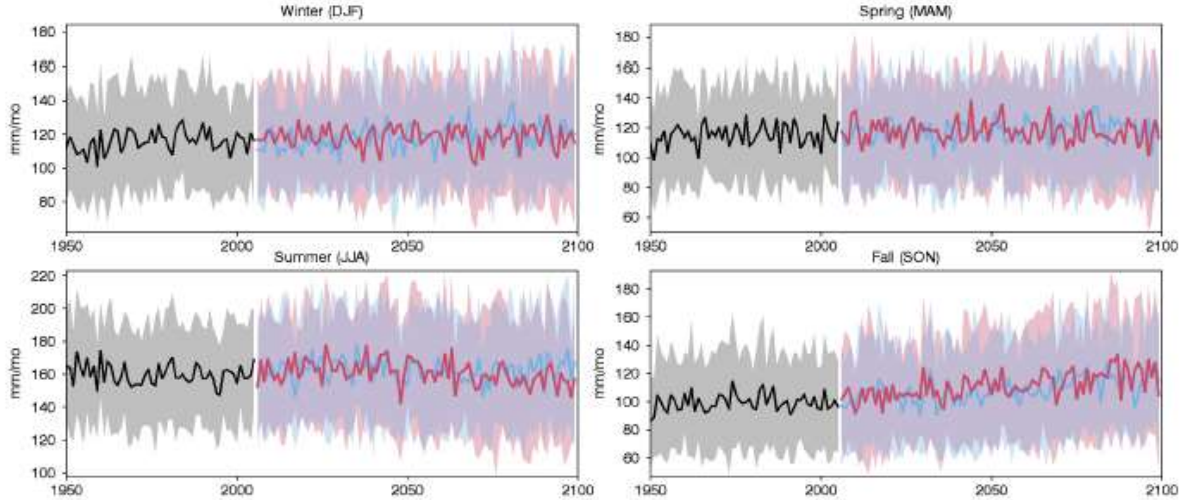


Figure 5: Seasonal average time series of precipitation for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

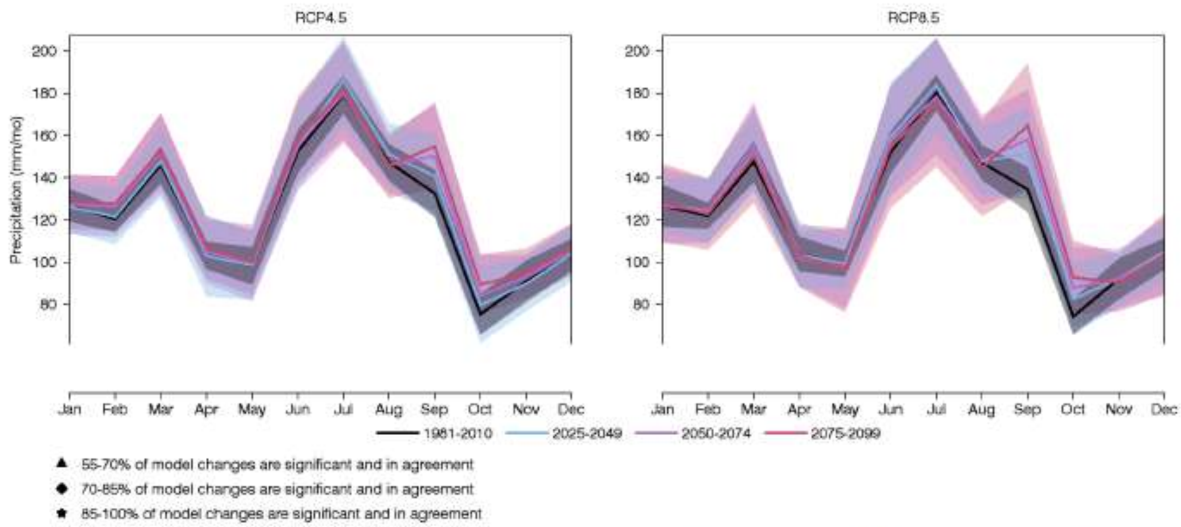


Figure 6: Monthly averages of precipitation for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes. Triangle, diamond and square symbols indicate the percent of models that simulate future minus present changes that are of the same sign and significant. A two-sided Students t-test is used to establish significance ($\rho \leq 0.05$).

5 Runoff

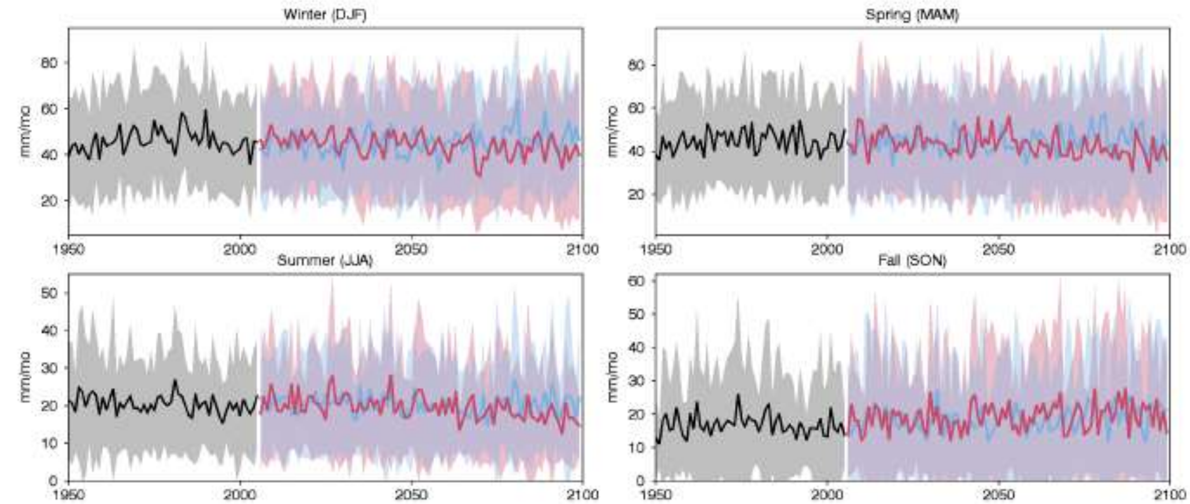


Figure 9: Seasonal average time series of runoff for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

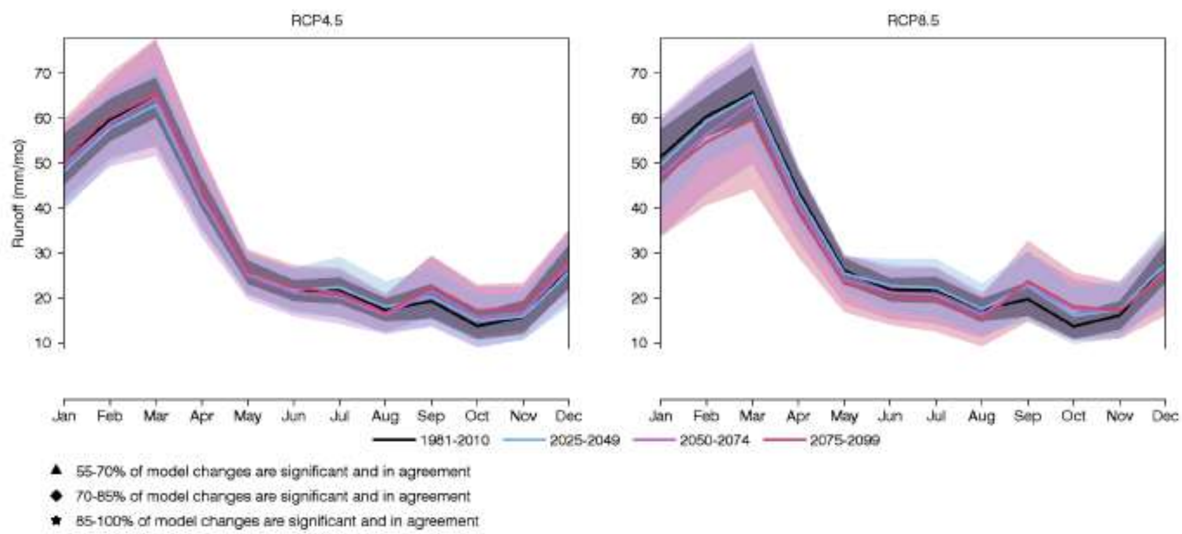


Figure 10: Monthly averages of runoff for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes. Triangle, diamond and square symbols indicate the percent of models that simulate future minus present changes that are of the same sign and significant. A two-sided Students t-test is used to establish significance ($\rho \leq 0.05$).

6 Soil Water Storage

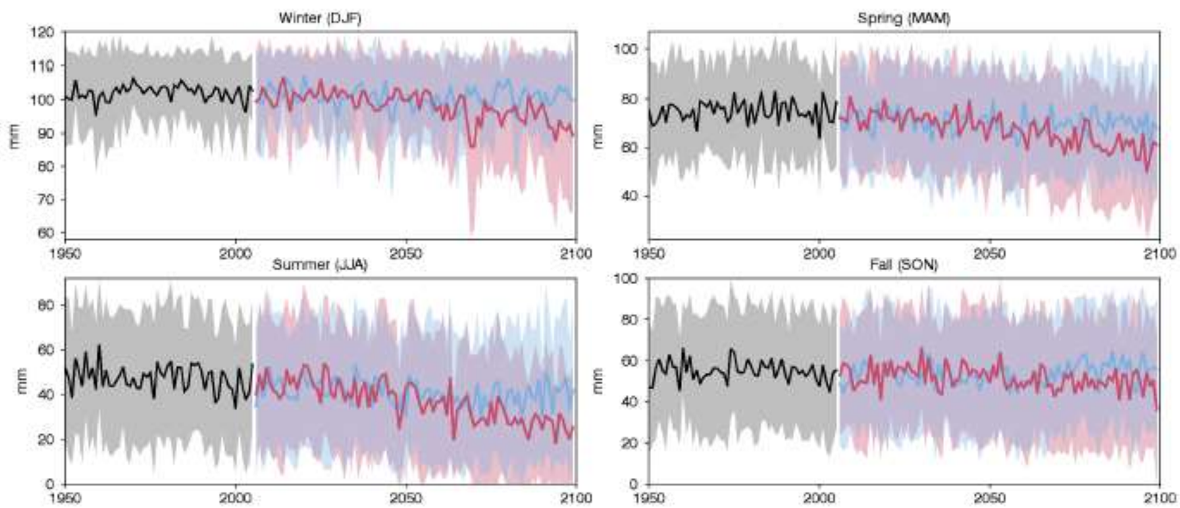


Figure 11: Seasonal average time series of soil water storage for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

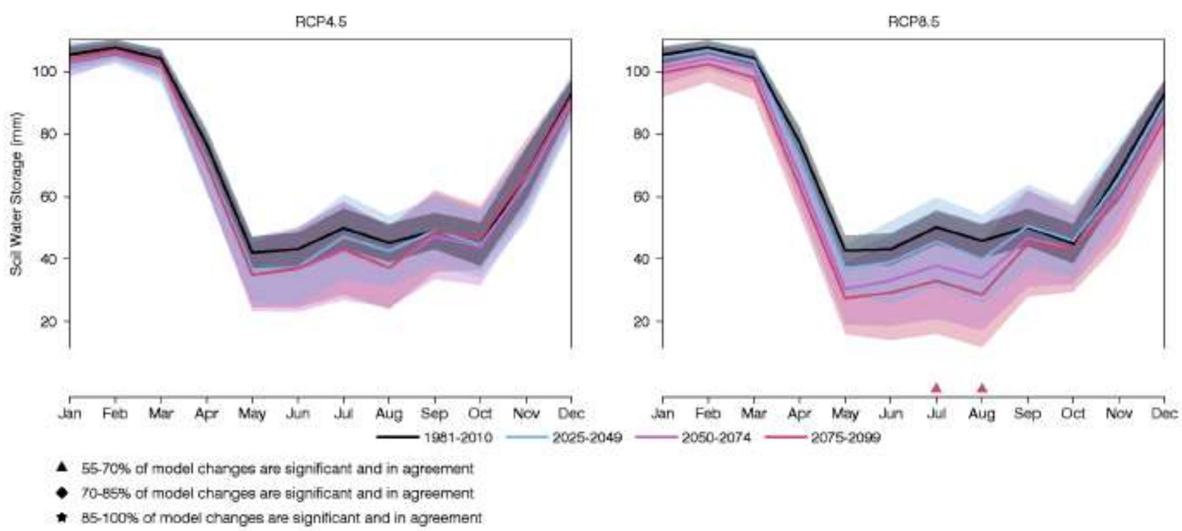


Figure 12: Monthly averages of soil water storage for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes. Triangle, diamond and square symbols indicate the percent of models that simulate future minus present changes that are of the same sign and significant. A two-sided Students t-test is used to establish significance ($\rho \leq 0.05$).

7 Evaporative Deficit

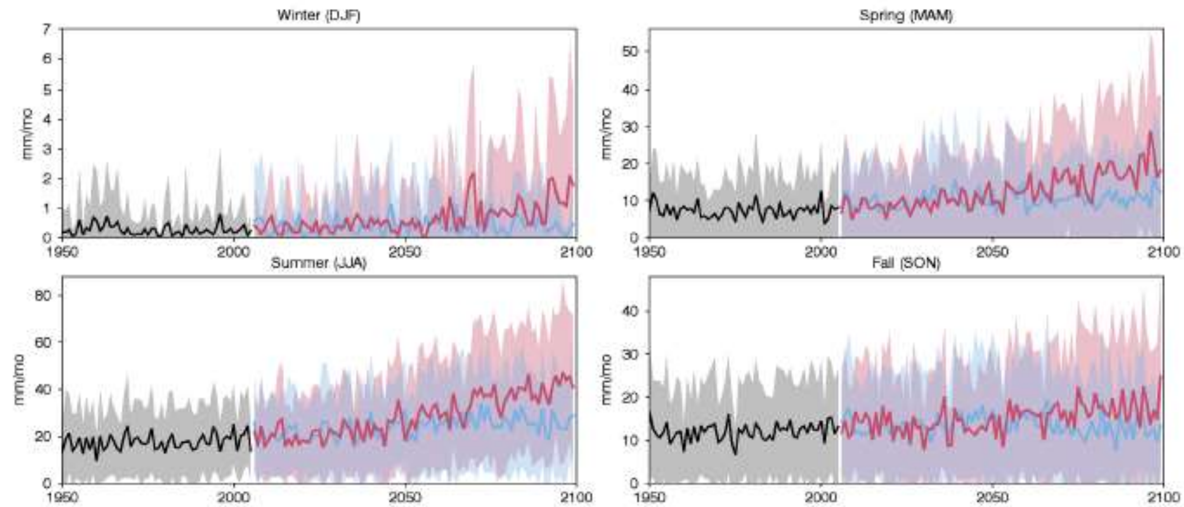


Figure 13: Seasonal average time series of evaporative deficit for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

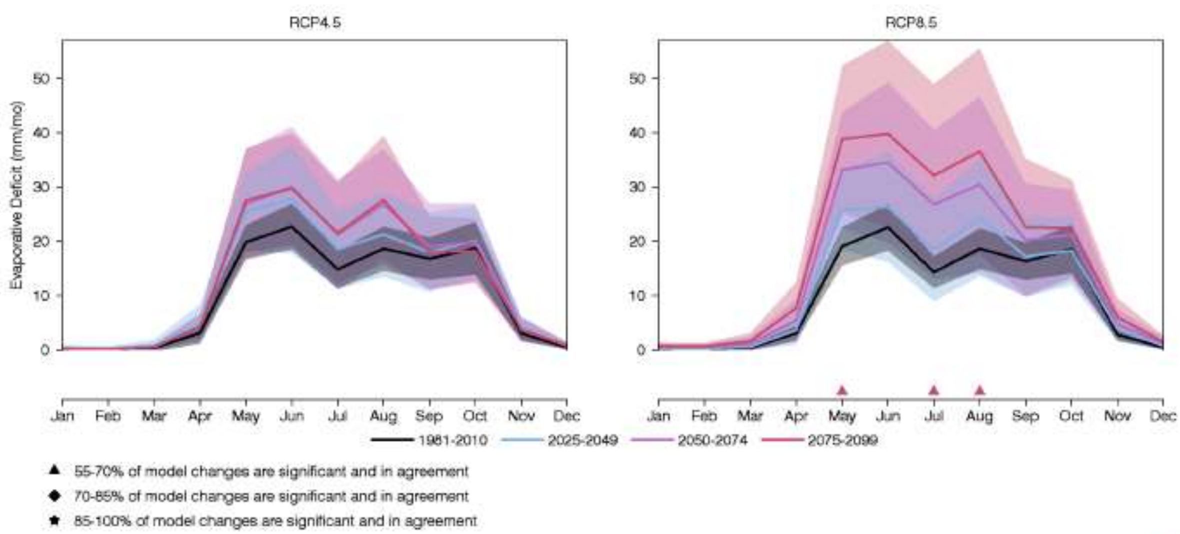


Figure 14: Monthly averages of evaporative deficit for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes. Triangle, diamond and square symbols indicate the percent of models that simulate future minus present changes that are of the same sign and significant. A two-sided Students t-test is used to establish significance ($\rho \leq 0.05$).