Conservation Plan for the Yellow Lampmussel, *Lampsilis cariosa*, in North Carolina

Prepared by:
Michael Fisk, Eastern Region Aquatic Wildlife Diversity Coordinator

Cover photo:
Female (top) and male (bottom) Yellow Lampmussel, credit Michael Fisk, NCWRC

Acknowledgements:
Jacob Hill, Eastern Region Aquatic Wildlife Diversity Technician

Recommended citation:
North Carolina Wildlife Resources Commission. 2025. Conservation Plan for the Yellow Lampmussel, *Lampsilis cariosa,* in North Carolina, Raleigh, NC.

Table of Contents

EXECUTIVE SUMMARY

The North Carolina Wildlife Resources Commission developed this conservation plan to direct management activities for the Yellow Lampmussel*, Lampsilis cariosa,* known in North Carolina from the Chowan, Roanoke, Tar, Neuse, Cape Fear, Yadkin-Pee Dee, and Lumber River basins. The species requires high-quality waterways containing cool, well oxygenated and unpolluted water. Waterways must contain adequate suitable habitat, including a variety of substrates like sand, silt, gravel, and cobble. Direct threats to these species include pollution (chemical and thermal), altered flow conditions, sedimentation, unstable or fragmented habitat, invasive species, and diseases.

The Yellow Lampmussel is listed as state endangered. The conservation goal is to prevent the extinction of this species and ensure population viability within North Carolina for the next 100 years. The plan focuses on identifying and reducing threats, promoting population viability, habitat protection, population monitoring, research, and partnerships. Establishing and maintaining partnerships between North Carolina Wildlife Resources Commission staff and other state agencies, federal agencies, universities, non-profit organizations, industry, local governments, and the public are essential to the implementation of this conservation plan. The management of this species will require collaborative stakeholder efforts to protect sensitive habitats and maintain high-quality water resources throughout North Carolina.

BIOLOGICAL INFORMATION

Description and Taxonomic Information

The Yellow Lampmussel, *Lampsilis cariosa*, is a freshwater mussel that is a member of the family Unionidae.

Taxonomic Hierarchy (Integrated Taxonomic Information System, 2020)

Phylum: Mollusca
Class: Bivalvia
Order: Unionoida
Family: Unionidae
Genus: *Lampsilis*
Species: *Lampsilis cariosa* (Say 1817)
Synonyms: *Unio crocatus* (Lea 1841), *Lampsilis* pallida (Rafinesque 1820), *Unio oratus* (Conrad 1849)

The Yellow Lampmussel is a medium sized mussel reaching up to 130 mm in length (Johnson, 1970; Bogan and Alderman 2008). The shell shape is obovate. Shell thickness is thin in juveniles becoming thicker with age and is moderately inflated. The anterior margin is rounded with the ventral margin slightly curved, and posterior margin bluntly rounded. The Yellow Lampmussel exhibits sexual dimorphism: male shells are elliptical and somewhat elongate in outline with the ventral margin evenly convex, whereas female shells are subovate to obovate in outline with the ventral margin expanded near the posterior margin, sloping up to a very bluntly rounded posterior margin (Bogan and Alderman 2008). The umbo extends beyond the hinge line (Kendig 2014).

The periostracum is waxy yellow and sometimes thinly rayed with linear dark green rays primarily restricted to the posterior slope and dorsal side. The periostracum also contains significant growth rests (Kendig 2014). The rays are variable in width, but usually thin, sharp, and dark green to black, contrasting with the yellow of the background. Older specimens become stained brown and lose much of the luster. Nacre color is bluish white, often tinged with cream or salmon (Bogan and Alderman 2008).

The left valve is composed of two compressed pseudocardinal teeth, the posterior tooth is low and immediately under the umbo with two delicate lateral teeth. The right valve has a single compressed pseudocardinal tooth, and a single lamellar lateral tooth. The pseudocardinal teeth tend to become stumpy and more ragged with age. The interdentum is narrow but obvious compared with Tidewater Mucket, *Atlanticoncha ochracea* (Bogan and Alderman 2008).

Yellow Lampmussel may resemble Tidewater Mucket when young, but the mucket exhibits rays all over the shell when young as opposed to having rays primarily confined to the posterior area as in Yellow Lampmussel. The Yellow Lampmussel also has a mantle flap used as a display mechanism (Kendig 2014). The mantle flap is used as a lure and resembles a small fish to attract host fish. The Tidewater Mucket does not have a modified mantle flap.

Life History and Habitat

The Yellow Lampmussel is a long-term (bradytictic) brooder. Fertilization occurs in the late summer and early fall, with glochidia then overwintering within the female before being released in the spring of the next year (Johnson 1970; Bogan and Alderman 2008).

Like most unionids, the Yellow Lampmussel has a complex life cycle that requires an intermediate host. To infest host fish, the Yellow Lampmussel uses a lure that extends along the ventral margin of the mussel and resembles a small fish. When a fish attacks the lure, the mantle tissue is ruptured and a cloud of glochidia is released. The glochidia then latch on the gills and external tissues of the fish, which they parasitize for 2 – 4 weeks before dropping off and beginning the more sedentary phase of their life. Host fish species for the Yellow Lampmussel include the Yellow Perch, *Perca flavescens*, and the White Perch, *Morone americana* (Kneeland and Rhymer 2008). In laboratory settings, Largemouth Bass, *Micropterus nigricans,* have been successful hosts (Eads et al. 2007). Other studies have found White Bass, Striped Bass, *Morone saxatilis*, Black Crappie, *Pomoxis nigromaculatus*, and Smallmouth Bass, *Micropterus dolomieu,* to serve as hosts in laboratory trials (Eads et al. 2015). Females start displaying when temperatures reach ~12 C (reviewed in Kurth 2007). Females displaying have been observed in May, July, August, and September in North Carolina when water temperatures were > 20 C up to 31.5 C, respectively (NCWRC unpublished data). Considering the temperature that females start to display, this could start as early as March and extend into September. Observations of displaying females in Virginia have occurred in April into June and one observation in October (B. Watson, VDWR personal communication).

There is little information pertaining to the age structure of Yellow Lampmussel throughout its range. Individuals have been aged up to 17 years old in Canada with a mean age of 8 years (White 2003). Age distributions of Yellow Lampmussel are unknown in North Carolina's populations but likely live 10 – 15 years.

Yellow Lampmussel are typically found in medium to large rivers in a variety of substrates including sand, silt, gravel, and cobble (Bogan and Alderman 2008). The species inhabits lakes and ponds, especially in the northern part of its range. In North Carolina, Yellow Lampmussel are found more often in medium to large rivers (Kendig 2014). The species prefers clean water with ample flow to receive appropriate oxygenation and access to food (Martell 2020). Like other mussels, Yellow Lampmussel populations are patchy and tend to clump together in aggregates (Wick and Huryn 2003; Sabine et al. 2004; Bogan and Alderman 2008).

Distribution and Population Status

Yellow Lampmussel inhabit the Atlantic slope from the Ogeechee River system, Georgia, north to the Sydney River in Nova Scotia (Johnson 1970). In North Carolina, Yellow Lampmussel occurs in the Chowan, Tar-Pamlico, Neuse, Cape Fear, Lumber (Waccamaw sub-basin), Yadkin-Pee Dee, and Roanoke River basins, most commonly near the fall line (Kendig 2014, NCWRC unpublished data). The oldest known record in North Carolina comes from a collection in the

late 1800s from the Neuse River, near Raleigh. Historically, the Yellow Lampmussel has been found in 50 HUC10s across 7 river basins. These include the Tar (16 HUC10s), Cape Fear (12 HUC10s), Yadkin-Pee Dee (7 HUC10s), Neuse (8 HUC10s), Roanoke (3 HUC10s), Chowan (2 HUC10s), and Lumber (2 HUC10s) river basins. In the last 20 years, the Yellow Lampmussel has been detected in 37 HUC10s across all 7 river basins. The species has not been detected in over 20 years in 13 HUC10s, a 26% overall decline. Of these, the species has not been detected in over 40 years in just one HUC10 in the Neuse River basin. The largest declines are in the Tar and Cape Fear River basins where 31% (Tar) and 42% (Cape Fear) of occupied HUC10s have not detected Yellow Lampmussel in 21 – 40 years (Figure 1). More recent collections in other basins include: 3 HUC10s in the Yadkin-Pee Dee, 4 HUC10s in the Neuse, 3 HUC10s in the Roanoke, and 2 HUC10s in the Chowan and Lumber River basins (unpublished data, NCWRC).

Mussel survey techniques and methods vary throughout the state considerably so overall trend comparisons can be difficult. For the Yellow Lampmussel, surveys where search effort and number of live mussels collected were recorded, Catch Per Unit Effort (CPUE, mussels collected/person hour) was calculated to examine general trends. Detections of Yellow Lampmussel are from both non-targeted and targeted surveys but are combined here to compare between river basins. The Lumber River Basin has the highest mean CPUE of 12.1 mussels/hr. This is due to the population of Yellow Lampmussel in Lake Waccamaw. In the Roanoke Basin, specifically, the Dan River has a mean CPUE = 2.0 mussels/hr, followed by the Chowan (1.9 mussels/hr), Cape Fear (1.2 mussels/hr), and Tar River basins (1.1 mussels/hr). The Neuse and Pee Dee River basins have the lowest mean CPUE at 0.5 and 0.3 mussels/hr, respectively (NCWRC, unpublished data). Collections of Yellow Lampmussel are typically low although up to 138 individuals have been observed at Lake Waccamaw in one survey in 2018. Other large collections have occurred in the Eno River in 2007 and the South Flat River in 2001 where more than 20 individuals were collected. Additionally, detections have exceeded 10 individuals in the Dan River several times and 24 were observed in 2019.

In North Carolina, the Yellow Lampmussel is listed as state endangered and is ranked as S3 in the NC Natural Heritage Program's Rare Species list (Ratcliffe et al. 2024). Federally, the Yellow Lampmussel is considered a species of concern (USFWS 1994). The Yellow Lampmussel is similarly considered under threat by prominent non-governmental organizations. NatureServe lists the species as vulnerable (G3) both throughout its whole range and in North Carolina (Cordeiro 2011). The International Union for the Conservation of Nature's most recent assessment categorizes the Yellow Lampmussel as vulnerable as well, citing significant losses of mature individuals across its range (Bogan and Woolnough 2017).

Historic Conservation Efforts

The Commission has conducted general surveys for the Yellow Lampmussel throughout its range in North Carolina, although most collections of this species are from community-based mussel surveys. Host fish have been identified in laboratory trials (Eads et al. 2015) and confirmed in field trials utilizing genetic techniques (Kneeland and Rhymer 2008). Glochidia

have also been successfully transformed using in-vitro methodologies using a sterile media solution with equine serum (Walter 2020). The microbiomes of *in vitro* and *in vivo* transformed mussels were compared and it was found that *in vitro* Yellow Lampmussel had significantly fewer bacterial families than *in vivo* transformation at day 0. However, with time, the bacterial composition converged and by day 15 were similar (Walter 2020). As a result of conservation efforts associated with the 2014 coal ash spill in the Dan River, propagated individuals of Yellow Lampmussel were successfully released into authorized areas in the Dan River by NCWRC staff. Yellow Lampmussel genetic diversity has not been assessed throughout the state. A study describing the genetic diversity of two populations of Yellow Lampmussel in Virginia as well as the South Flat River in the upper Neuse River basin in NC described these populations as small, isolated, and subject to random genetic drift and inbreeding (Olivera-Hyde and Hallerman 2018).

THREAT ASSESSMENT

Reason for Listing

No population or density estimates are available for North Carolina populations of Yellow Lampmussel but based on NCWRC survey data, the species' current range is more restricted and fragmented when compared to where it historically occurred. The species was evaluated for listing in 2016 using the North Carolina Species Assessment Tool (Harris et al. 2016). Evaluations indicated the Yellow Lampmussel has experienced a 47.5–50.9% decline in Area of Occupancy.

Present and Anticipated Threats

As with all aquatic species, there are many natural and anthropogenic factors that threaten the long-term viability of Yellow Lampmussel. Extinction and decline of North American unionid bivalves can be linked to impoundment and inundation of riffle habitat from dams throughout the United States. The loss of obligate hosts, coupled with increased siltation, and various types of industrial and domestic pollution have resulted in the rapid decline of the unionid bivalve fauna in North America (Bogan 1993, NCWRC 2015). Dams, both manmade and natural (e.g., beavers: Hoch 2012; Kemp et al. 2012), are a barrier to dispersal of host fish and attached glochidia. Beaver dams not only inundate and alter riffle/run mussel habitat upstream of the dam but also affect mussel populations downstream of the dam by increasing fluctuations in flow regime, decreasing dissolved oxygen levels, and increasing the variability of food quality and quantity (Hoch 2012, Kemp et al. 2012). Wastewater that contains monochloramine and unionized ammonia compounds are acutely toxic and pose a significant threat to all aquatic species, especially mussels. Point source discharges from municipalities may be responsible for glochidia mortality that results in local extirpation of mussels (Goudreau et al. 1993, Gangloff et al. 2009, NCWRC 2015). Impervious surfaces in urbanized watersheds exacerbate high water levels, even during short rainfall events, which can result in flash flooding. These high or flashy flow events contribute to increased sediment loads and erosion, turbidity throughout the water

column, and stream bed movements that stress mussel populations (Gangloff et al. 2009, NCWRC 2015). Climate change and development will continue to bring additional stressors that need to be evaluated for mussels. Furthermore, specific pollutants that may be introduced into the aquatic environment, the interactions of pollutants and temperature (from climate change), salinity (related to sea level rise), and lower dilution (from altered flows) will need to be considered (NCWRC 2015). In addition, invasive species such as Basket Clam, *Corbicula fluminea,* Flathead Catfish, *Pylodictis olivaris,* and Hydrilla, *Hydrilla verticillata,* can create competitive pressures on food resources and habitat availability. In addition, these factors can decrease oxygen availability, cause ammonia spikes, alter benthic substrates, impact host fish communities, reduce stream flow, and increase sediment buildup (Belanger et al. 1991, Scheller 1997, NCANSMPC 2015, NCWRC 2015).

CONSERVATION GOAL AND OBJECTIVES

Conservation Goal

To prevent the extinction of Yellow Lampmussel and promote population viability (i.e., multiple age classes and wild recruitment) within North Carolina for the next 100 years.

Conservation Objectives

1. Promote habitat protection and maintain populations of Yellow Lampmussel within Management Units (MUs). Management Units will be defined based on hydrologic units (i.e., HUC10s; Table 1; Figure 2).
2. When appropriate, utilize captive propagation and/or translocations to augment or establish populations of Yellow Lampmussel where suitable habitat exists.
3. Establish connectivity and gene flow between existing and established populations utilizing translocations and/or barrier removal.

CONSERVATION ACTIONS

Habitat Protection and Habitat Management

Protecting habitat integrity, including hydrology, is crucial for species survival. Comments on permit reviews should stress minimizing inputs that include chemical pollutants such as herbicides, pesticides, pharmaceuticals, and industrial compounds, as well as thermal plumes, sediment and nutrients carried by storm water. Find ways to reduce or prevent pharmaceuticals, personal care products, PFAS from entering surface waters from wastewater treatment plants. Staff will recommend that all permits issued within basins where Yellow Lampmussel occur follow the recommendations of the NCWRC's mitigation document entitled "Guidance Memorandum to Address and Mitigate Secondary and Cumulative Impacts to Aquatic and Terrestrial Wildlife Resources and Water Quality" (NCWRC 2002). Forestry activities should incorporate forest practice guidelines (FPGs), or best management practices (BMPs) outlined in the North Carolina Forestry Best Management Practices Manual to Protect Water Quality (NCFS 2021) and as required by certifying organizations such as those of the Sustainable

Forestry Initiative/Forest Stewardship Council/American Tree Farm System certification standards. Where applicable, the Yellow Lampmussel will be incorporated into NCWRC game land management plans to prioritize and protect suitable habitat. This includes maintaining proper riparian buffers and managing and restoring aquatic habitats through barrier removal and beaver management. Game lands may also be used for future augmentations. Restoration of habitat should be prioritized for primary HUCs and should focus on the protection of riparian habitat and associated uplands (Table 1, Figure 2).

Population Management

Yellow Lampmussel populations may be enhanced by augmenting existing populations with propagated individuals. Propagated mussels may also be reintroduced into areas that were historically occupied where suitable habitat exists. To minimize any real or perceived regulatory burden, a Conservation Benefit Agreement (CBA) could potentially be used to facilitate releases in locations with private land ownership (USFWS 2024), especially when the species is under consideration for federal protection under the Endangered Species Act. A property owner management agreement will be established prior to reintroduction into an unoccupied area under a CBA, if warranted.

Augmentations and Reintroductions will be prioritized as follows:

1. All primary river basin MUs (Table 1, Figure 2).
2. Additional augmentation areas within the known range of Yellow Lampmussel (Table 1; Figure 2), if propagation efforts exceed primary MU needs.
3. Reintroduction of Yellow Lampmussel into areas within the presumed historical range, if propagation efforts exceed MU needs. Ideally located in areas with reduced likelihood of anthropogenic threats.

If areas are identified in (2) or (3) that would provide greater conservation benefit to the Yellow Lampmussel, then these will be prioritized over (1).

Incentives

The NCWRC will encourage private landowners within Yellow Lampmussel watersheds to participate in the Wildlife Conservation Lands program. This program allows qualifying landowners whose property is in proximity to streams with statelisted species to get tax incentives for implementing conservation actions.

Monitoring and Research

Monitoring and research activities are needed to evaluate trends in abundance and distribution as well as fill knowledge gaps in species life history and habitat requirements. These actions are necessary to meet management goals. The NCWRC will conduct and engage with partners to conduct the following activities:

1. Conduct targeted surveys for Yellow Lampmussel to determine contemporary distribution.
2. Monitor known Yellow Lampmussel populations every 5–10 years within each MU to assess survival, abundance, population structure, recruitment, and genetic diversity.
3. Determine the genetic diversity and number of genetically distinct populations of Yellow Lampmussel throughout its range in North Carolina.
4. Develop captive propagation techniques to maximize yield, genetic diversity, and post release survival.
5. Determine locations for establishing Yellow Lampmussel populations and monitor the success of population establishment.
6. Conduct surveys for host fish abundance, population structure, and recruitment within each MU.
7. Investigate techniques to reduce the abundance of Basket Clam.
8. Determine the known historical range of Yellow Lampmussel by verifying the identification of specimens held in museum collections.
9. Determine the impact of Flathead Catfish and other invasive species on Yellow Lampmussel host fish populations.
10. Determine if other lakes or reservoirs are suitable for Yellow Lampmussel introductions.

Education and Outreach

Staff will continue to develop publications and reports as well as highlight conservation efforts through channels such as the NC Chapter of the American Fisheries Society and the Freshwater Mollusk Conservation Society. Results of research and monitoring projects will be presented at professional and non-technical meetings. Aquatic Wildlife Diversity staff will coordinate with Wildlife Education staff to promote education and awareness of the Yellow Lampmussel. Highlighting efforts to conserve the species and its habitat will be important for public awareness.

Regulations

Take or possession of this species without a valid permit is currently prohibited under NC law and administrative code (15A NCAC 10I .0102) and is considered a Class 1 misdemeanor (§ 113 337b). Harvest of state listed mussels is prohibited. Currently, individuals with a valid fishing license can harvest up to 200 non-listed mussels per day, but only within specified impounded waters (NCWRC 2025). An exception to this is there is no daily creel limit on the introduced Basket Clam (listed as Asian Clam in NC regulations digest) in impounded waters. Harvest of any mussels is prohibited in Lake Waccamaw, which has a unique mussel assemblage including the Yellow Lampmussel. In other impounded waters, the chance that a Yellow Lampmussel will be misidentified and harvested is minimal.

Literature Cited

Belanger, S. E. 1991. The effect of dissolved oxygen, sediment, and sewage treatment plant discharges upon growth, survival and density of Asiatic clams. Hydrobiologia 218:113–126.

Bogan, A. E. 1993. Freshwater bivalve extinctions (Mollusca: Unionoida): a search for causes. American Zoologist 33:599–609.

Bogan, A., and Alderman, J. 2008. Workbook and key to the freshwater bivalves of South Carolina.

Bogan, A., and D. Woolnough, 2017. *Lampsilis cariosa*, Yellow Lampmussel THE IUCN RED LIST OF THREATENED SPECIES. https://doi.org/10.2305/IUCN.UK.2017.

Cordeiro, J. 2011. Lampsilis cariosa, NatureServe Explorer. NatureServe Explorer. https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.109623/Lampsilis_cariosa.

Eads, C. B., M. E. Raley, E. K. Schubertand, A. E. Bogan, and J. F. Levine. 2007. Propagation of freshwater mussels for release into North Carolina waters. Report to North Carolina Department of Transportation. Project Number: HWY-2005-07.

Eads, C. B., J. E. Price, and J. F. Levine. 2015. Fish Hosts of Four Freshwater Mussel Species in the Broad River, South Carolina, Southeastern Naturalist 14:85–97

Fisheries and Oceans Canada. 2009. Management Plan for the Yellow Lampmussel (Lampsilis cariosa) in Canada [Proposed] (Species at Risk Act Management Plan Series). Fisheries and Oceans Canada. http://www.sararegistry.gc.ca/approach/act/default_e.cfm.

Gangloff, M. M., L. Siefferman, W. Seesock, and E. C. Webber. 2009. Influence of urban tributaries on freshwater mussel populations in a biologically diverse piedmont (USA) stream. Hydrobiologia 636:191–201.

Goudreau, S. E., R. J. Neves, and R. J. Sheehan. 1993. Effects of wastewater treatment plant effluents on freshwater mollusks in the upper Clinch River, Virginia, USA. Hydrobiologia 252:211–230.

Haag, W. R. 2012. North American freshwater mussels: Natural history, ecology, and conservation. Cambridge University Press.

Harris, M., L. Siefferman, J. A. Jones, and M. Gangloff. 2016. Evaluation of the North Carolina (Conservation Status) Assessment Tool. Report to the NCWRC.

Hoch, R. A. 2012. Beaver and mill dams alter freshwater mussel habitat, growth, and survival in North Carolina Piedmont streams. Master's thesis. Appalachian State University, Boone, North Carolina.

Johnson, R. I. 1970. The systematics and zoogeography of the Unionidae (Mollusca: Bivalvia) of the southern Atlantic Slope Region. Bulletin of the Museum of Comparative Zoology 140:263–449.

Kemp, P. S., T. A. Worthington, T. E. L. Langford, A. R. J. Tree, and M. J. Gaywood. 2012. Qualitative and quantitative effects of reintroduced beavers on stream fish: Impacts of beaver on freshwater fish. Fish and Fisheries 13:158–181.

Kendig, K. M. 2014. Freshwater Mussels of North Carolina (Atlantic Slope). North Carolina Department of Transportation, Raleigh, North Carolina.

Kneeland, S. C., and J. M. Rhymer. 2008. Determination of fish host use by wild populations of rare freshwater mussels using a molecular identification key to identify glochidia. Journal of the North American Benthological Society, 27(1).

Martell, V. 2020. Improving Growth and Survival of Cultured Yellow Lampmussel (Lampsilis cariosa) for Restoring Populations.

Nichols, S. J., and D. Garling, 2000. Food-web dynamics and trophic-level interactions in a multispecies community of freshwater unionids. Canadian Journal of Zoology, 78:871–882.

NCANSMPC (North Carolina Aquatic Nuisance Species Management Plan Committee). 2015. North Carolina Aquatic Nuisance Species Management Plan. Raleigh, North Carolina.

NCFS (North Carolina Forest Service). 2021. North Carolina Forestry Best Management Practices Manual to Protect Water Quality. North Carolina Forest Service.

NCWRC (North Carolina Wildlife Resources Commission). 2002. Guidance Memorandum to Address and Mitigate Secondary and Cumulative Impacts to Aquatic and Terrestrial Wildlife Resources and Water Quality. Raleigh, North Carolina.

NCWRC (North Carolina Wildlife Resources Commission). 2015. North Carolina Wildlife Action Plan. Raleigh, North Carolina.

NCWRC (North Carolina Wildlife Resources Commission). 2025. North Carolina inland fishing, hunting, and trapping digest 2025–2026.

Olivera-Hyde, M., and E. Hallerman. 2018. Survey of Population Genetic Variation in Virginia Yellow Lampmussel, *Lampsilis cariosa.* Virginia Tech, Blacksburg VA.

PSHA and CCAA (Programmatic Safe Harbor Agreement and Candidate Conservation Agreement with Assurances). 2022. U.S. Fish and Wildlife Service.

Ratcliffe, J., L. E. Hamon, and M. B. East. 2024. Natural Heritage Program List of Rare Animal Species of North Carolina 2024.

Sabine, D. L., S. Makepeace, and D. F. McAlpine, 2004. The yellow lampmussel (Lampsilis cariosa) in New Brunswick: A population of significant conservation value. Northeastern Naturalist, 11:407–420.

Scheller, J. L. 1997. The effect of dieoffs of Asian clams (Corbicula fluminea) on native freshwater mussels (Unionidae). M.S. Thesis, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Strayer, D. L., J. A. Downing, W. R. Haag, T. L. King, J. B. Layzer, T. J. Newton, and S. J. Nichols, 2004. Changing perspectives on pearly mussels, North America's most imperiled animals. Bioscience, 54:429–439.

USFWS, 1994. Endangered and Threatened Wildlife and Plants; Animal Candidate Review for Listing as Endangered or Threatened Species. Federal Register, 59(219).

USFWS 2024. Conservation Benefit Agreements for Private Property Owners Fact Sheet. Falls Church, Virginia.

Vaughn, C. C., and C. M. Taylor, 1999. Impoundments and the decline of freshwater mussels: A case study of an extinction gradient. Conservation Biology, 13(4). https://doi.org/10.1046/j.1523-1739.1999.97343.x.

Walter, M. J., 2020. In-vitro Propagation of the Federally Endangered Dwarf Wedgemussel (Alasmidonta heterodon) and Identification of Bacterial Communities of In-vitro and In-vivo Propagated Freshwater. M.S. Thesis. North Carolina State University, Raleigh, NC.

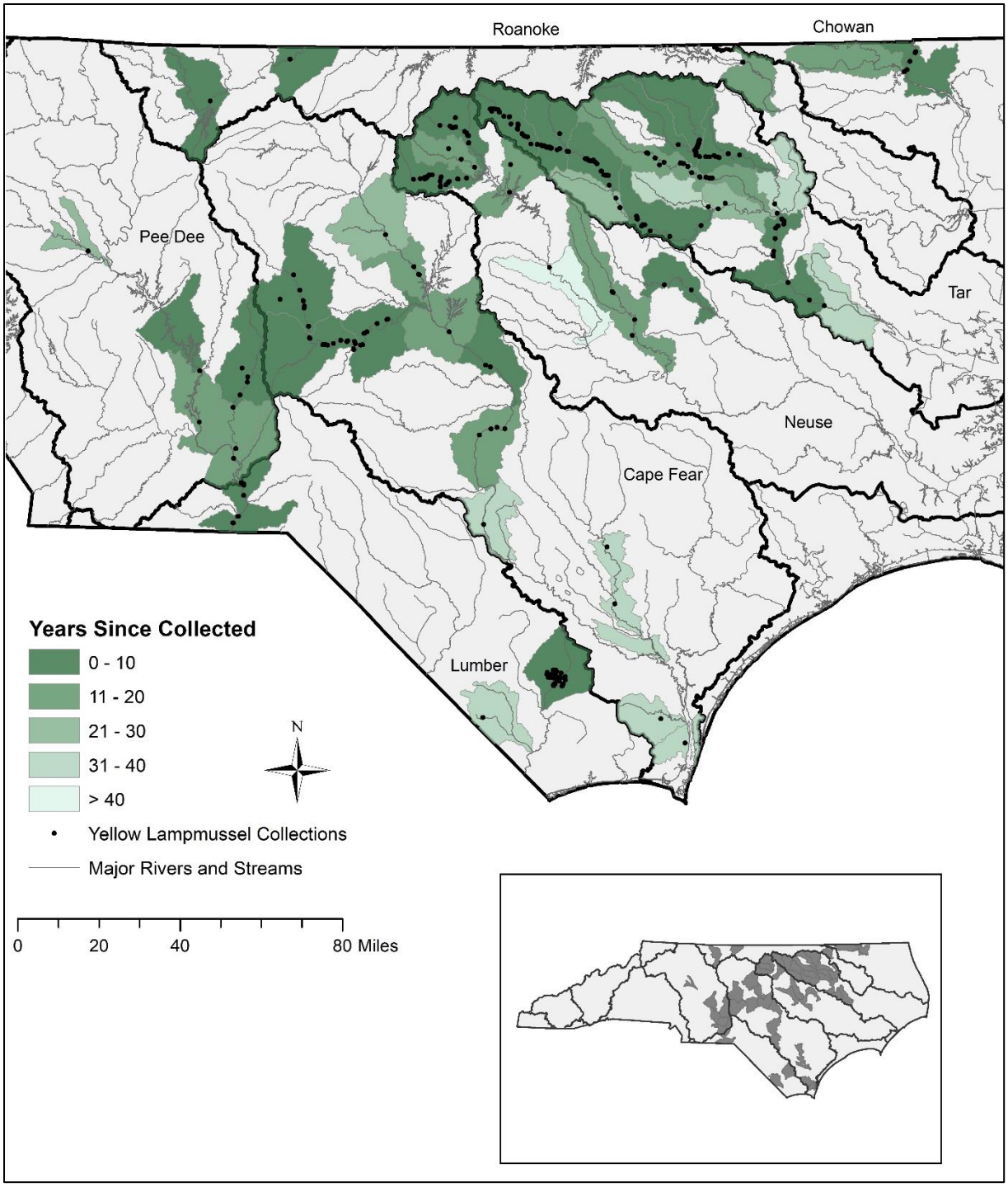
White, K. 2003. Toward Conservation of the Yellow Lampmussel (Lampsilis cariosa) in the Sydney River, Cape Breton: Establishment of a Long-term Volunteer Monitoring Program, Identification of the Obligate Fish Host(s) and the Investigation of Life History Traits. ACAP-CB Unpublished Report.

Wick, P. C., and A. D. Huryn, 2003. Fish hosts and population demographics of Lampsilis cariosa and Leptodea ochracea (Unionidae) in Maine. [Poster]. 3rd Biennial Symposium on Freshwater Mollusk Conservation Society, Durham, NC.

Yeager, M. M., D. S. Cherry, and R. J. Neves, 1994. Feeding and burrowing behaviors of juvenile rainbow mussels, Villosa iris (Bivalvia: Unionidae). Journal of the North American Benthological Society, 13:217–222.

Table 1. Prioritized management units (10-digit hydrologic units) for augmentation and conservation efforts. Categories are defined as: Primary) MUs within known range, Additional) MUs within known historical range to be used if Primary MU targets are exceeded. If Primary and Additional targets are exceeded, then reintroductions will focus within the presumed historical range of the species (not listed below) if suitable habitat exists.

Basin	Management Unit	HUC10s		Category
Chowan	Chowan River	301020409	301020302	Primary
Roanoke	Dan River	301010303	301010309	Primary
	Roanoke River	301010701		Primary
Tar	Fishing Creek	302010205	302010202	Primary
		302010203		Primary
		302010206		Additional
	Swift Creek	302010108	302010107	Primary
	Tar River	302010102	302010106	Primary
		302010109	302010103	Primary
		302010304	302010104	Primary
		302010302	302010101	Primary
		302010306		Additional
	Stoney Creek	302010105		Additional
Neuse	Contentnea Creek	302020304		Primary
		302020115	302020116	Primary
	Upper Neuse	302020105	302020102	Primary
		302020101	302020103	Primary
	Neuse River	302020111		Additional
Cape Fear	Cape Fear River	303000407	303000401	Primary
		303000405		Primary
	Deep River	303000302	303000304	Primary
		303000306	303000207	Primary
		303000205		Primary
	Black River	303000608		Additional
	Lower Cape Fear	303000507	303000501	Additional
		303000506		Additional
Pee Dee	Little River	304010403	304010404	Primary
	Pee Dee River	304010405	304010402	Primary
		304010306	304020103	Primary
	South Yadkin River	304010206		Primary
Lumber	Waccamaw	304020603		Primary
	Grissett Swamp	304020605		Additional



425

426 Figure 1: Distribution map of the Yellow Lampmussel in North Carolina depicting 10-digit
427 hydrological units (colored and categorized by year of most recent record) and collection
428 locations (black dots). River basins are labeled and outlined in black.

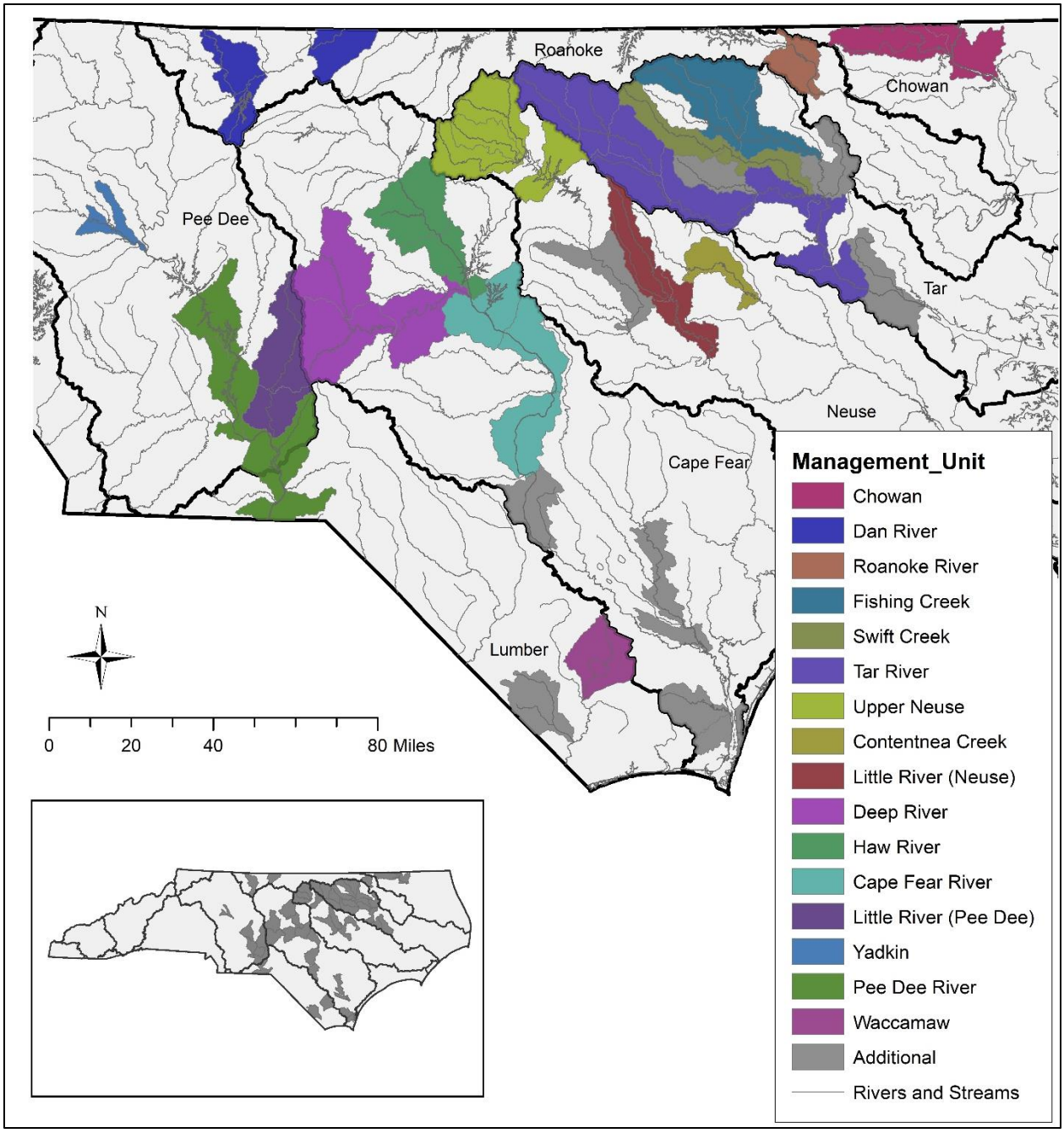


Figure 2: Management Units (MUs) in the Chowan, Roanoke, Tar, Neuse, Cape Fear, Yadkin-Pee Dee, and Lumber basins depicting 10-digit hydrologic units. Primary MUs are in color, additional augmentation/reintroduction MUs are in grey. River basins are outlined in black. Descriptions of MUs are in Table 1.