

B. Aquatic Systems

The overall richness of North Carolina's aquatic fauna is directly related to the geomorphology of the state, which defines the major drainage divisions and the diversity of habitats found within them. Seventeen major river basins are designated in North Carolina (Figure 5B.1). The headwaters of 11 of these basins begin in North Carolina, but only four basins are contained entirely within the state (Cape Fear, Neuse, White Oak, Tar-Pamlico). Five western basins are part of the Interior Basin and drain to the Mississippi River and the Gulf of Mexico (Hiwassee, Little Tennessee, French Broad, Watauga, and New). The other 12 basins are part of the Atlantic Slope and flow to the Atlantic Ocean. The long history of separation between these major drainage basins has apparently led to significant differentiation of their respective faunas. Distinct aquatic communities are found on each side of the Eastern Continental Divide with relatively few native species in common.

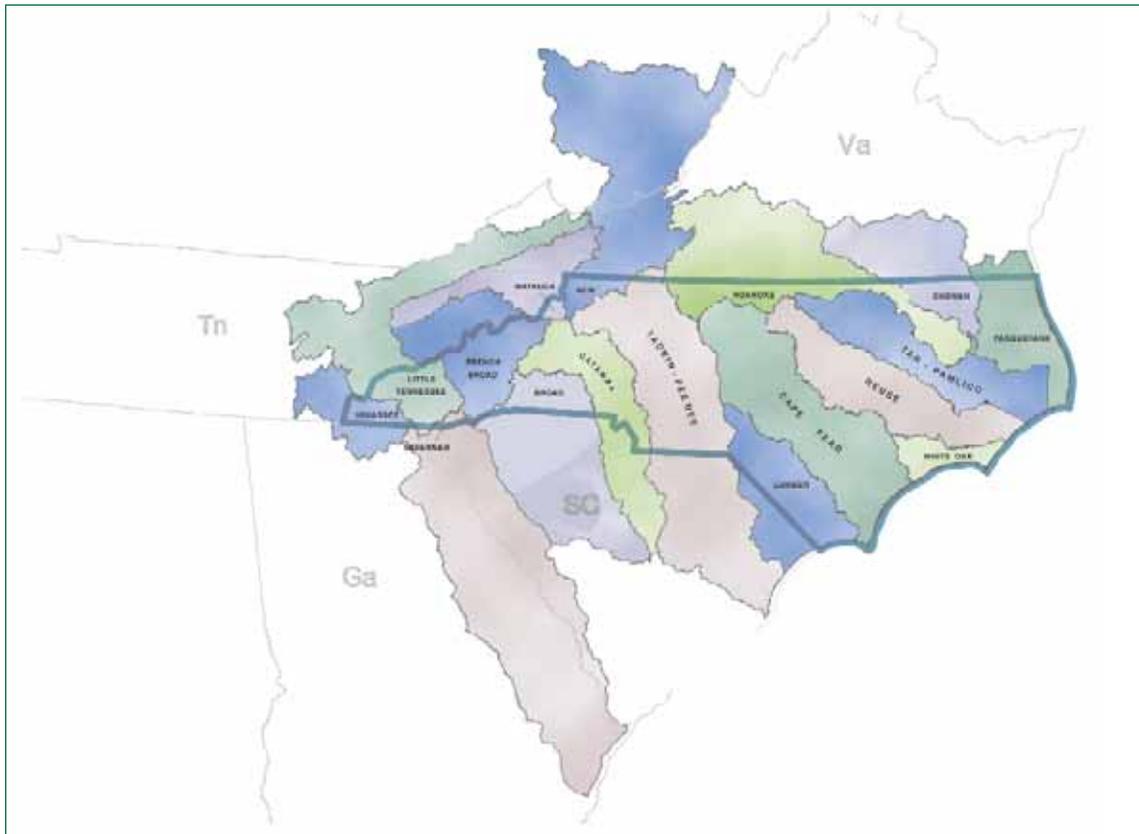


Figure 5B.1. North Carolina's river basins (source: NC Wildlife Resources Commission).

Within each major drainage basin, individual river basins drain broadly diverse terrain and a wide variety of aquatic habitats exist among them. In an assessment of southeastern states, North Carolina ranked third highest in overall diversity of stream-types (Warren et al. 1997). The mountains of the Blue Ridge physiographic province dominate the western third of the state. Generally, streams in the Blue Ridge are relatively high gradient, cool, have boulder and cobble-gravel bottoms, and are of low to moderate fertility; however, the larger streams and rivers have historically supported exceptionally diverse warm-water communities. The five river basins of the Interior Basin, along with the Savannah, are entirely within the Blue Ridge in North Carolina. The headwaters of the Broad, Catawba, and Yadkin-PeeDee river basins drain the eastern slopes of the Blue Ridge. These river systems continue toward the sea through the rolling topography of the Piedmont, where all but three of the remaining river basins arise. The Piedmont is a mosaic of broad valleys interspersed with highlands of varying topography and geology. Streams in the Piedmont are generally warm, have cobble-gravel and sand bottoms, and are of intermediate gradient and fertility. The Fall Line demarks a change in topography from the Piedmont to the flat terrain of the Atlantic

Coastal Plain. The White Oak, Chowan, and Pasquotank basins are entirely within the Coastal Plain in North Carolina. Low gradient, warm water, sand and mud bottom, and high fertility generally characterize freshwater Coastal Plain streams. Natural lakes and extensive wetlands are important aquatic habitats found only in the Coastal Plain in North Carolina.

Biodiversity in Aquatic Ecosystems

The southeast region has the highest aquatic species diversity in the entire United States (Burr and Mayden 1992, Taylor et al. 1996, Warren et al. 2000, Williams et al. 1993). Southeastern fishes make up 62% of the United States fauna, and nearly 50% of the North American fish fauna (Burr and Mayden 1992). Molluscan diversity in the region is 'globally unparalleled', with 91% of all United States mussel species found in the southeast (Neves et al. 1997). Crayfish diversity and global importance in the region rivals that of mollusks (Taylor et al. 1996). Crayfish in the southeast comprise 95% of the total species found in all of North America (Butler 2002a). North Carolina freshwaters support a significant proportion of that diversity with at least 240 fish, 125 mollusk, and 45 crayfish species.

Unfortunately, patterns of imperilment are similar. Greater than two-thirds of the nation's freshwater mussel and crayfish species are extinct, imperiled, or vulnerable (Williams et al. 1993, Neves et al. 1997, Master et al. 1998). The majority of these at-risk species are native to the southeast. The number of imperiled freshwater fishes in the southeast (84) is greater than any other region in the country and the percentage of imperiled species is second only to the western United States (Minckley and Deacon 1991, Warren and Burr 1994). Twenty-eight percent of southeastern freshwater and diadromous fishes have a status of extinct, endangered, threatened, or vulnerable, which represents a 125% increase in 20 years (Warren et al. 2000). North Carolina ranks third among southeastern states in number (21) and percentage (11.5%) of imperiled fishes (Warren et al. 1997). Freshwater mollusks are suffering even greater declines. Thirty-six mussel species and 26 snail species that formerly occurred in the southeast (13% of all United States mussel species and 8% of southeastern snails) are presumed extinct (Neves et al. 1997). By state, between 34% and 71% (mean = 58%) of mussel species, or populations of species, are imperiled in the southeast, which represents 98% of all rare mussel species in the United States (Neves et al. 1997). Fifty-nine percent of freshwater mussel species in North Carolina are imperiled (Neves et al. 1997). Assessments of North Carolina mussel populations in the 1990's reported 62 of 147 known populations (42%) to be "in poor or very poor condition" (Rader 1994) and only 51 populations (35%) are likely to maintain viable populations over the next 30 years (Alderman et al. 1992). Among crustaceans listed as endangered or threatened in the United States, 54% are from the southeast (Schuster 1997). Twelve species (26%) of North Carolina crayfish are listed as species of concern or rare in the state (Clamp 1999, LeGrand et al. 2004).

Causes of declines among all aquatic taxa are widely attributed to habitat destruction and degradation, and the introduction of nonindigenous species (Williams et al. 1993, Taylor et al. 1996, Etnier 1997, Warren et al. 1997). Fishes inhabiting medium-sized rivers and creeks rely on coarse substrates that are relatively silt-free; however, these streams are often heavily impounded and have altered substrates. Habitat alteration from nonpoint source pollution and flow alteration (i.e., impoundments) are the primary cause of population declines for 72% of southeastern fishes considered imperiled (Etnier 1997). Not surprisingly, nonpoint source pollution and the effects of dams and impoundments are also the leading historic and current threats to freshwater mollusks (Bogan 1993, Neves et al. 1997, Richter et al. 1997). The complex life cycles and habitat requirements of mussels make them especially vulnerable to these perturbations (Adams 1990, Bogan 1993, Neves et al. 1997). The small native range of many crayfish species is a primary factor in their vulnerability to habitat loss and competition (Clamp 1999, Taylor et al. 1996). Threats to crayfish include pollution and impoundment, but competition with nonindigenous species is also a primary threat to many species (Taylor et al. 1996).

In North Carolina, threats to biodiversity are similar to those listed above and include point and nonpoint source pollution, hydrologic alteration, physical habitat manipulation, and biological pollution. In recent decades, water quality has improved in many waters that were historically polluted primarily by point-source discharges; however, overall habitat degradation continues to

threaten the health of aquatic communities. Increased development and urbanization, poorly managed crop and animal agriculture, and mining impact aquatic systems with point and nonpoint source inputs. Impoundments on major rivers and tributaries drastically alter the hydrologic regime of many North Carolina waterways and result in habitat fragmentation, blockage of fish migration routes, and physical habitat alterations.

Assessments of Aquatic Conservation Priorities and Strategies

Over the past decade or so, increased attention has been focused on analysis of aquatic biodiversity, patterns of imperilment, and threats to distill priorities for proactive management and/or conservation triage. A few efforts have gone beyond (or bypassed) identifying specific priorities to propose strategies to address long-term aquatic conservation needs and actions to address these priorities. To the greatest extent possible and where applicable, the guidance provided by these important efforts have been incorporated into this Plan. The following is a brief review of some of the more influential literature that applies to aquatic conservation priorities and strategies in North Carolina.

Priorities

Broad assessments of aquatic conservation priorities were recently completed by two private conservation organizations, each addressing freshwater biodiversity conservation needs at a different scale. These assessments largely built upon existing information to identify significant regions and priority areas for freshwater conservation. The World Wildlife Fund conducted a conservation assessment of freshwater ecoregions of North America (Abell et al. 2000). The Nature Conservancy assessed smaller-scale watersheds across the country (Master et al. 1998), and subsequently identified priority areas within four freshwater ecoregions in the southeast (Smith et al. 2002). Predictably, all three efforts identify the southeast as a key region for freshwater conservation efforts. Many of the most critical areas identified in those efforts overlap North Carolina's borders.

Abell et al. (2000) identified the entire South Atlantic freshwater ecoregion (southern Virginia through central Georgia) as a key region in which to focus aquatic conservation efforts in North America.

Out of 327 key small watershed areas identified across the country by Master et al. (1998), 21 are found in North Carolina (Figure 5B.2).

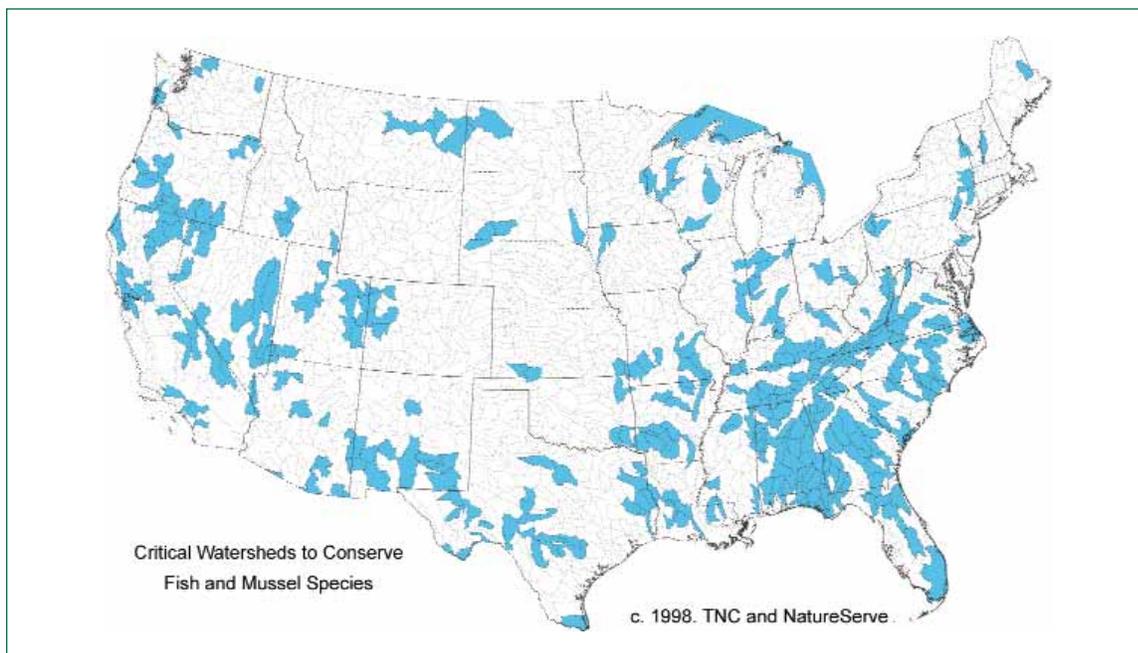


Figure 5B.2. Key watersheds for freshwater conservation in the United States (source: Master et al. 1998).

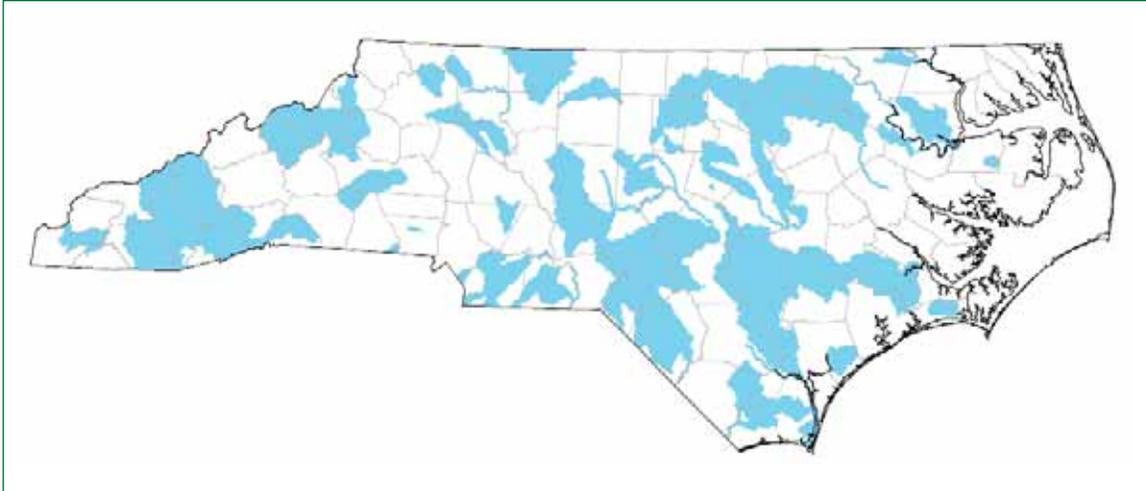


Figure 5B.3. Priority sites for freshwater conservation in North Carolina (data source: Smith et al. 2002).

A number of other studies (results of some were synthesized in the broader assessments cited above) focused on other aspects and scales that are useful in determining conservation priorities. Etnier (1997) and Warren et al. (1997) identified patterns of imperilment among southeastern fishes by family and major habitat preference. Medium-sized rivers and creeks (not including first and second order headwaters) support the greatest number of species (90 and 248, respectively), the highest number of jeopardized species (36 and 32), and the greatest proportion of jeopardized species overall (75% total). The fish families Percidae (darters) and Cyprinidae (minnows) contain the highest numbers of species (152 and 155, respectively) and jeopardized species (46 and 18). However, the greatest percentage of jeopardized species within family were among the Acipenseridae (sturgeons, six of seven species: 86%), the Elasmobranchii (pygmy sunfishes, three of six species: 50%), the Percidae (31%), and the Ictaluridae (catfishes [specifically, madtoms], eight of 33 species; 24%). These families are characteristically dependent on benthic habitats or vegetated, isolated wetlands (Warren et al. 1997).

Butler (2002b) assessed conservation priorities for fishes in the Southern Appalachian Ecoregion (SAE, as defined by the US Fish & Wildlife Service). In North Carolina, the SAE includes all Tennessee River tributary basins, as well as the New, upper Roanoke, Yadkin-PeeDee, Catawba, and Savannah basins in the Blue Ridge and eastern foothills. That effort prioritized stream systems having extant populations of imperiled fishes, identified fishes with a relatively high potential for imperilment and deemed to have the greatest need for conservation status assessment, and proposed critical research and conservation needs for those fishes. While federally-listed species were obviously high priorities, emphasis was placed on the non-federally listed fish fauna of the SAE with the intent of preventing further declines. The Little Tennessee and Hiwassee river systems (primarily in North Carolina) were identified among the highest priority stream systems in the SAE for fish conservation.

While we know of no work to date that has specifically focused on prioritizing mollusk species or habitats for conservation priority, priorities are implicit (and addressed explicitly in some cases) in federal and state protection and conservation lists (e.g., LeGrand et al. 2004), and reviews of conservation status and patterns of imperilment (e.g., Williams et al. 1993, Neves et al. 1997). Representatives from federal and state resource management agencies and universities are presently attempting to prioritize mussel species and specific conservation actions in the Cumberlandian region (Tennessee and Cumberland river systems in TN, VA, NC, AL, MS, and KY), analogous to the document produced for the Mobile Basin (Hartfield 2003). This effort will be completed in mid-2005 and should provide guidance useful in refining priorities in western North Carolina.

Similar to the case with mollusks, Taylor et al. (1996) identified conservation status of North American crayfishes and hotspots of diversity and threats that implies conservation priorities. In a more regionally-focused document, Butler (2002a) identified the upper Little Tennessee and Hiwassee river basins in North Carolina and Georgia as the highest priorities for crayfish conservation in the SAE. That effort also identified 12 crayfish taxa “deemed to have the greatest need for current conservation status assessment,” five of which occur in North Carolina, and two of which are endemic to the state.

By state statute, the NC Wildlife Resources Commission maintains a Nongame Wildlife Advisory Committee to help guide nongame wildlife management policies and actions. This body, in turn, relies on taxa-specific Scientific Advisory Councils to make recommendations for policies and actions. Specific to aquatic taxa, these councils recommend fish, mollusk, and crustacean species for state listing as endangered, threatened, and species of concern, as well as potentially injurious non-native species. Publications, bulletins, and informal communications are periodically produced by these bodies that contain these and other recommendations (e.g., Adams et al. 1990, Menhinick and Braswell 1997, Clamp et al. 1999).

Strategies

Shute et al. (1997) provided an excellent historical perspective of, and recommendations for, aquatic resource management and conservation strategies. Historically, aquatic conservation and management strategies have typically focused on a few commercially or recreationally significant game fish species, with stock enhancement as a primary goal. The passage of the 1973 Endangered Species Act and 1977 Clean Water Act stressed ecosystem protection and allowed for focused attention on all species and their habitats. Ecosystem management is likely the most effective strategy for conserving rare aquatic species because it factors in ecological relationships, land-use patterns, and threats to habitat and water quality. It is a complicated and often costly approach and relies heavily on cooperation among federal and state agencies, local governments, private organizations, and individual citizens. However, its holistic approach can benefit all species within the watershed.

The US Fish & Wildlife Service has led in the development of detailed conservation strategies for mussels in the United States (Biggins et al. 1997) and fishes in the southeast (Bibb et al. 2002). Both of these important documents identified specific goals and detailed strategies for achieving them. Interestingly, in listing seven major issues impacting southeastern fishes that the strategic goals were designed to address, the first two issues were not directly related to threats to the species or their habitats. They were: “1) Insufficient coordination among existing and potential partners and stakeholders, and; 2) A lack of concern, awareness, and understanding of the values (e.g., ecological, scientific, aesthetic, economic) of our native fish fauna and healthy aquatic ecosystems and the human related impacts to them” (Bibb et al. 2002). In addition to the National Strategy (Biggins et al. 1997), Jenkinson and Todd (1997) provided an historical perspective of mollusk management in the United States and proposed general strategic guidance for habitat protection, population enhancement, harvest controls, public appreciation, and invasive species control and prevention.

Conservation efforts have only recently been focused on crayfish. Schuster (1997), and to some extent Taylor et al. (1996), identify the present state of crayfish management (and crustaceans in general) and the challenges that face developing adequate management plans.

The Commission prepared a draft Wildlife Diversity Plan that identified a number of general needs and objectives for wildlife management, conservation education, and recreation in the state (NCWRC 1999). That draft was prepared in anticipation of passage of the Conservation and Reinvestment Act and was generally a precursor of this Plan. Primary objectives stated in that document were to protect and enhance native wildlife populations and to enhance public awareness and appreciation of wildlife through education, outreach, and recreation opportunities. A list of general priority actions to meet the general objectives was identified; however, no specific priorities or strategies were identified.

Biological Needs: Knowledge Gaps and Ubiquitous Concerns

In order to address species and habitat conservation needs, it is important to first acknowledge our current state of understanding about the target species groups. While the Species Prioritization process (described in Chapter 2) was used to identify aquatic species most in need of conservation attention, basic taxonomy and distribution remains unresolved for a number of crayfish, snails and mussels. Indeed, molecular taxonomists and systematists predict sizeable increases in the numbers of species for most groups, thus sizable decreases in range with concomitant increases in the number of species deemed endangered or threatened (Agapow et al. 2004). It is important that these yet-undescribed species be considered in future conservation planning.

Even for many aquatic species that are relatively well-known taxonomically, information is still lacking on distributions, and population strength and trends. These gaps are especially pronounced among mollusks and crustaceans. While considerable knowledge gaps exist for freshwater mussels, they are even greater for snails and pea clams. Likewise, information vital to effective management of crayfish is lacking; such information for microcrustaceans (e.g., water fleas, seed shrimp, scuds) is practically non-existent.

Filling all knowledge gaps for every taxonomic group is arguably not necessary to achieve effective conservation. Effective monitoring and management of aquatic communities can generally be achieved through focused attention on key elements of those communities among the more well-known fish, mollusks, and crayfishes. Even this, however, is a daunting challenge. Realistically, all necessary tasks cannot be accomplished by the Commission alone. Sharing and consolidation of data from various sources to more completely assess information gaps and help meet vital goals for inventory and monitoring must be improved. The existing Commission aquatics database and the NC Natural Heritage Program database are important tools to meet these goals. Improvements should be made in sharing data between these two databases and broadening the scope of data captured between them. Other state and federal agencies (e.g., NC Division of Water Quality, NC Department of Transportation, US Fish & Wildlife Service, US Forest Service, Tennessee Valley Authority), universities and museums, private consultants, and certain industries (e.g., hydropower and forestry) are engaged, to various degrees and purposes, in monitoring aquatic communities. These and other sources of data should be exploited to the greatest practical extent that their quantity and quality will allow.

Cooperation and coordination is also essential to fulfill research needs for basic life history and ecology, resolve taxonomic problems, vulnerability to specific threats, restoration techniques, etc. Opportunities to partner and leverage limited funds should be explored and pursued to the maximum extent possible.

Freshwater Fishes

Fairly complete distribution information exists for most fish species in the state. Most spatial and temporal fish distribution data is collected by the NC Division of Water Quality's Basinwide Monitoring Program, which samples fish communities in all 17 basins on a 5-year rotation. The Tennessee Valley Authority also monitors fish communities at numerous sites throughout the western Tennessee River tributary basins. But basin level surveys and monitoring need to be expanded, as there are over 60 species listed as significantly rare or higher within the state status listings. A great percentage of tributaries are rarely to never sampled, except for incidental/specific studies. In addition, main stem river habitats are only spottily sampled in conjunction with various projects (e.g., Federal Energy Regulatory Commission relicensing). So at any given time, while we have a decent idea of what fish distribution was in the state, based on records compiled over decades, contemporary status and distribution of a given species is harder to assess with a real degree of certainty. Under-sampled habitats occur in every region, though the Coastal Plain basins likely lead, due to the difficulty of habitat sampling (i.e., inability to find small, flowing Wadeable streams; W. Starnes, pers. comm., B. Tracy, pers. comm.). Other issues of great importance are non-native species introductions and the redistribution of regionally native species via human introductions. Each year, instances of non-native species introductions and inter-basin transfers grow in number. The resultant impacts on native species, which are inevitable given past examples, will take time to assess.

Freshwater Mussels

Compared to other invertebrate taxa, we have decent knowledge levels and data regarding freshwater mussels. However, accurate distribution information is still lacking for many species, as is work related to fish host identification, ecology (both of individual species and among communities of organisms), and basic systematics (genetics, taxonomy, and morphology). Extensive monitoring of populations is generally lacking. There are endemism concerns associated with many species, both throughout the Tennessee River Basin tributaries, as well as concerns about the distribution of some species with rather restricted ranges within the South Atlantic rivers. Taxonomic difficulties have yet to be resolved for several genera, most notably *Elliptio*. There is an extreme knowledge deficit regarding the pea clams; attaining information on their distributions should be pursued whenever possible.

Freshwater Crayfish

Though we have basic information about crayfish fauna distribution by major hydrologic units (river basins), we have relatively low knowledge levels and understanding of crayfish conservation status. Impeding our knowledge of crayfish conservation status is a general lack of biologists that actively study them. Existing collections, maintained by the NC Museum of Natural Sciences, are more extensive for some basins than for others. Distribution information is limited and based on records from specific survey efforts; we know next to nothing about distribution changes. Except for the rare occasion of collections being made at the same sites over a period of years (e.g., NC Division of Water Quality, Basinwide Monitoring Program), not a great deal can be ascertained about population trends. Additional information on crayfish distribution and threats is necessary in order to ascertain status. Extensive monitoring is lacking, in part because it is difficult to impossible to identify most species in the field. Taxonomists that can reliably identify specimens and effective river basin keys are needed¹, along with extensive field surveys and voucher specimens. Endemism concerns are high; there is a strong need to identify and protect areas of endemism (perhaps in conjunction with fish, mussels, and snails).

Freshwater Snails

We have extremely low knowledge levels and understanding of our freshwater snails, especially South Atlantic coastal slope species. As with crayfish, a major challenge is simply the lack of biologists dedicated to the study of freshwater snails. Basic survey and distribution information is lacking for most species. Endemism concerns are high. Extensive survey efforts are needed. There is particular need to focus on the very small and highly endemic snails within family Hydrobiidae. The NC Division of Water Quality (Basinwide Monitoring Program) collects some data on freshwater snails; though spotty, it is a good starting point.

Other Invertebrates

The NC Natural Heritage Program tracks species within all the aforementioned taxa, in addition to rare species in the following invertebrate groups: terrestrial gastropods, arachnids, other crustaceans (e.g., ostracods), millipedes, mayflies, stoneflies, caddisflies, dragonflies, damselflies, flies, moths, butterflies, grasshoppers and katydids, beetles, true bugs, and annelids. Much of the aquatic insect data is provided by the Biological Monitoring group of the NC Division of Water Quality. However, the Commission does not have jurisdiction over most of these taxa, and there is a scarcity of biologists focused on these groups. Knowledge levels and data availability for insects, terrestrial gastropods, and arachnids are the lowest of any animal groups in the state. However, these taxa are an integral part of the ecosystems they share with other invertebrate and vertebrate species. Opportunities to expand our knowledge and understanding of these groups should be taken when possible, as should the establishment of habitat-based projects that are mutually beneficial to these groups and to higher taxa. For more information on invertebrate conservation needs, see Appendix D.

¹As of 2005, John Cooper of the NC Museum of Natural Sciences is developing 'basin-specific' field keys that are being tested by agency field biologists (J. Cooper, pers. comm.).

Organization and Content

The following sections are organized by river basins, as designated by the NC Division of Water Quality for their Basinwide Water Quality plans. Each section offers a more detailed view of the threats, needs, and conservation priorities of the individual basins. Priority species found within each basin are listed in a table at the start of each section. (Also see Appendix H for basin distributions for all priority aquatic species). Map Series 5B (following each basin section) identifies geo-political information and priority conservation areas for each basin. Supporting references are included to direct readers towards other information sources that might be useful to review for conservation planning in the basin.

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1. Hiwassee River Basin

Priority aquatic species in the Hiwassee River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish	<i>Clinostomus funduloides</i> ssp.	"Smoky" Dace ¹	SC
	<i>Erimystax insignis</i>	Blotched Chub	SR
	<i>Etheostoma</i> sp.cf. <i>blenniodes</i>	"Hiwassee" Greenside Darter ¹	
	<i>Etheostoma</i> sp.cf. <i>rufilineatum</i>	"Hiwassee" Redline Darter ¹	
	<i>Ichthyomyzon greeleyi</i>	Mountain Brook Lamprey	
	<i>Moxostoma</i> sp 1	Sicklefin Redhorse	SR
	<i>Notropis photogenis</i>	Silver Shiner	
	<i>Percina aurantiaca</i>	Tangerine Darter	
	<i>Percina squamata</i>	Olive Darter	SC
	<i>Pimephales notatus</i>	Bluntnose Minnow	
Mussels	<i>Elliptio dilatata</i>	Spike	SC
	<i>Fusconaia barnesiana</i>	Tennessee Pigtoe ²	E
	<i>Fusconaia subrotunda</i>	Longsolid ²	SR
	<i>Lampsilis fasciola</i>	Wavyrayed Lampmussel	SC
	<i>Pegias fabula</i>	Littlewing Pearlymussel ³	E (E)
	<i>Pleurobema oviforme</i>	Tennessee Clubshell ²	E
	<i>Villosa iris</i>	Rainbow ²	SC
	<i>Villosa trabalis</i>	Cumberland Bean	SR (E)
	<i>Villosa vanuxemensis</i>	Mountain Creekshell ²	T
Crayfish ⁴	<i>Cambarus acanthura</i>	Spinytail Crayfish	SR
	<i>Cambarus hiwaseensis</i>	Hiwassee Crayfish	
	<i>Cambarus nodosus</i>	Knotty Burrowing Crayfish	SR
	<i>Cambarus parrishi</i>	Hiwassee Headwaters Crayfish	SC
Snails	<i>Elimia christyi</i>	Christy's Elimia ⁵	E
	<i>Leptoxis virigata</i>	Smooth Mudalia ⁶	SR

A. Location and condition of basin (see Maps 5B.1a, 5B.1b):

The Hiwassee River basin is located in the southwestern corner of North Carolina in Cherokee and Clay counties. The headwaters begin in Georgia and the Hiwassee River flows generally to the northwest into Tennessee where it joins the Tennessee River. The Hiwassee River is part of the Tennessee/Ohio/Mississippi River System. The North Carolina portion of the Hiwassee basin is entirely within the Blue Ridge physiographic province and covers approximately 625 sq. miles. Major tributaries in the basin include the Hiwassee River, Valley River, Nottely River, and Brasstown Creek.

¹ Potential taxonomic revision, may be described as new species.

² Taxonomy of *Fusconaia*, *Pleurobema*, and *Villosa* spp. in western North Carolina is presently unclear

³ Apparently extirpated from the basin.

⁴ At least two additional putative taxa are presently under review and will likely be described as new species. The known range of these is limited and they will be considered as priority species.

⁵ Also known as Knotty elimia (*Elimia interupta*).

⁶ Occurrence record in basin may be result of misidentification.

Land use in the basin is 70% forested, 3% urban/built-up, and 27% agriculture/pasture (NCDWQ 2002). Impoundments total 10,850 acres, including Appalachia, Hiwassee, Chatuge (Tennessee Valley Authority), and Mission (Duke Energy). Major landownership in the basin is private, but other significant holdings include Nantahala National Forest and the Tennessee Valley Authority (primarily around their reservoirs). The Eastern Band of the Cherokee Indians also controls some large tracts of land in the basin (primarily within the Hanging Dog Creek watershed). Much of the higher elevations are within the National Forest and developed land is primarily in the valleys; however, there are substantial private holdings in the middle and higher elevations. Development is increasing in these areas, including steeply sloped mountainsides.

There are no designated impaired waters in the basin (74% fully supporting, 26% not rated) (NCDWQ 2002). Two streams are designated as Outstanding Resource Waters (Gipp Creek and Fires Creek) and one stream is designated as High Quality Water (Tusquitee Creek). Higher elevation cold water streams are generally in good to excellent condition. Impacts from non-point sources (primarily erosion) generally increase as streams flow into the more developed valleys and merge into larger streams.

Species diversity is potentially greatest in large and medium-sized rivers, especially in riffle and run habitats. The Valley River and Brasstown Creek are the largest unimpounded streams in the basin in North Carolina and remain in relatively good shape. These streams support most of their historically known fauna; however, at least a few species are extirpated and some have evidently declined. The mainstem Hiwassee and Nottely rivers are either impounded or regulated throughout their lengths in North Carolina. In these rivers, habitats for native species are variously degraded.

B. Problems affecting species and habitats:

Impacts from hydropower development in the basin have altered and degraded a substantial portion of habitat for most native aquatic species, primarily in large streams and rivers. The mainstem Hiwassee and Nottely rivers are significantly altered by direct and indirect impacts from impoundment. Fifty-seven miles of historically free-flowing riverine habitats are now either seasonally or permanently flooded by Chatuge, Mission, Hiwassee, and Appalachia reservoirs or are affected by indirect impacts from impoundment. The unimpounded reaches of the Nottely and Hiwassee rivers are affected by cold water, altered hydrologic regimes, and periodic low levels of dissolved oxygen due to hypolimnetic and peaking power production releases from Chatuge and Nottely dams. Impoundment and thermal alteration may further affect native species by fragmenting available suitable habitat and isolating historically contiguous populations in tributaries.

As is common throughout the state, erosion and sedimentation are the primary forms of non-point source pollution affecting the Hiwassee Basin. Impacts are evident in Brasstown Creek, Peachtree Creek, lower Valley River, and other smaller watersheds. Sources of erosion are primarily ground disturbance from development activities (e.g., residential, commercial, transportation, and utility construction) and agriculture. Stream bank and other erosion from poorly managed cattle pastures (primarily caused by lack of fenced buffers along streams) and erosion from row crops contribute most of the sediment from agriculture. Timber harvest with insufficient erosion controls may be another source of sediment in the basin. Other non-point sources of pollution include the quantity and quality of runoff from built-up areas and roadways.

Point-source discharges do not appear to be a major source of pollution in the basin at present. Sewage treatment plants and light industry make up most of the presently permitted discharges (see NCDWQ 2002). A large landfill along the Valley River, just upstream from Murphy, appears to be leaching directly to the river. Any specific impacts from this are unknown, but it may warrant investigation.

Non-native species also pose potential threats to native aquatic species in the Hiwassee basin. The blueback herring, Asian clam, striped bass, snail bullhead, rainbow trout, and brown trout are known to be established in the basin. Blueback herring appear to be having impacts on game species in Hiwassee Reservoir and Hiwassee River (i.e. walleye, Wheeler et al. 2004), but impacts to nongame species are unknown at present. Specific impacts from Asian clam and the introduced game fishes are unclear. Other species not presently known from the basin, but known to have invaded surrounding areas include the zebra mussel and rusty crayfish. Other potential problems are indirect effects from invasive plant species and exotic pathogens that can significantly alter riparian vegetation (e.g., Japanese knotweed, hemlock wooly adelgid).

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

Inventory: distributional and status surveys – General surveys are needed to complete the distributional status for aquatic snails, crayfish, mussels, and fish (in order of general need). (Cooperators in North Carolina include: NC Division of Water Quality, Tennessee Valley Authority, NC Department of Transportation, US Fish & Wildlife Service, US Forest Service, NC Museum of Natural Sciences; interstate, intrabasin cooperators are the Georgia Department of Natural Resources, Tennessee Wildlife Resources Agency)

- Sicklefin redhorse – complete distribution surveys, identify important spawning areas.
- Crayfish – complete primary inventories and determine status of rare species.
- Snails – inventory primary distribution; determine potential habitats and distribution surveys for hydrobiids, complete distribution surveys for Christy's elimia.
- Determine distribution of non-native species (e.g., blueback herring).

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed.

- Sicklefin redhorse – support completion of species description (cooperate with Roanoke College).
- “Hiwassee” greenside and redline darters – support resolution of taxonomic problems and species descriptions (if required) (potential cooperators include Southeastern Louisiana University, St. Louis University, and NC Museum of Natural Sciences).
- Mussels in the genera *Villosa*, *Pleurobema*, and *Fusconaia* – support resolution of taxonomic problems and species descriptions (if required) (cooperate with NC Museum of Natural Sciences and NC State University).
- Crayfish – support description and species diagnosis of all crayfish species in the basin. At least two putative undescribed species are presently known (cooperate with NC Museum of Natural Sciences).

Research to facilitate appropriate conservation actions – Research should generally focus on life history of priority species. Specific questions to be addressed include: habitat use/preferences, spawning location and timing, fecundity, population dynamics, population genetics, feeding, competition, predation. Research must also be conducted to determine vulnerability of priority species to specific threats, particularly as related to Commission permit review and conditions responsibilities. Studies should provide recommendations for mitigation and restoration.

- Sicklefin redhorse – support completion of life history studies (partners: Roanoke College, NC State University, and Duke Power).
- Priority mollusk species – support research to facilitate population augmentation and restoration (e.g., translocation and propagation techniques) (cooperate with NC State University; other potential cooperators include Virginia Tech. and Tennessee Tech.).

- All other priority species:
 - Review available information and support life history investigations where lacking.
 - Support investigations into impacts from habitat fragmentation in the basin (due to impoundments or other factors).
 - Support determination of specific factors that limit populations downstream from dams, and in the Valley River.
 - Support investigations of population response to stream restoration projects (especially in priority areas).

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible. (Hiwassee basin cooperators in North Carolina include: NC Division of Water Quality, Tennessee Valley Authority, US Fish & Wildlife Service, US Forest Service, Hiwassee Watershed Coalition, Duke Energy, Eastern Band of the Cherokee Indians, NC Museum of Natural Science; interstate, intrabasin cooperators include the Georgia Department of Natural Resources, Tennessee Wildlife Resources Agency).

- Conduct long-term monitoring to identify population trends of priority species. Establish protocol, schedule, and sites for long-term population monitoring.
 - Basin specific priorities include the sicklefin redhorse, blotched chub, Christy's elimia, all priority mussel species.
- Conduct special purpose monitoring to assess performance of specific conservation actions:
 - Performance of stream restoration projects.
 - Performance of hydropower remediation.
 - Performance of species restoration projects.
- Assess non-native species impacts – monitor populations of potentially injurious non-native species and impacts on priority species:
 - Basin specific priority: blueback herring.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration – Promote and support habitat conservation and restoration efforts by external entities. (Potential partners in the Hiwassee Basin include: Hiwassee Watershed Coalition, Natural Resources Conservation Service, Ecosystem Enhancement Program, county-based soil and erosion control efforts, US Forest Service, Tennessee Valley Authority, Duke Energy, Eastern Band of Cherokee Indians, and private landowners).

- Identify priority areas for habitat conservation and restoration. Criteria include areas with high species diversity, rare species, and endemic species; specific areas that are critical to the survival of priority species (e.g., particular streams or spawning sites); and areas recognized by previous national and/or regional prioritization efforts.
 - Priority watersheds for freshwater conservation in the Hiwassee basin include (based in part on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.1b):
 - o Valley River
 - o Brasstown Creek
 - o Hiwassee River
 - o Hanging Dog Creek
 - o Tusquitee Creek
 - o Fires Creek

- Support conservation and restoration of streams and riparian zones in priority areas (acquisition, easements, and buffers). Support stream conservation and restoration by working collaboratively with other organizations (cooperators include: Hiwassee Watershed Coalition, Natural Resources Conservation Service, Ecosystem Enhancement Program, Tennessee Valley Authority, US Forest Service).
 - Support Hiwassee Watershed Coalition restoration efforts in Brasstown Creek and Valley River watersheds.
 - Encourage conservation of existing good riparian and stream conditions in priority areas.
- Promote and support conservation and restoration efforts within the Commission.
 - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, into Game Lands management, and into Game Lands acquisitions.

Population management and restoration – Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

- Investigate potential for reintroduction of extirpated mollusk and fish species to the basin in restored or improved habitats as opportunities become available.
- Investigate potential for priority mollusk (esp. Christy's elimia) and fish population restoration in restored or improved habitats as opportunities become available. Restoration of species that are known or believed to be extirpated from the basin should be considered.

Data collection, management, and dissemination

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Coordinate sampling with other resource groups.
- Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.
- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources. Improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
 - Update crayfish and mussel atlases with presently known species occurrence and distributions in the Hiwassee basin.
 - Compile and post species accounts to fish atlas for federal and state listed fishes from the Hiwassee basin.
- Develop and disseminate print media, including: stand alone documents, press releases, newspaper and magazine articles, and displays.
 - Produce materials focused on Hiwassee basin species richness and conservation goals (especially in the Valley River).
- Direct public involvement/outreach:
 - Deliver oral presentations.
 - Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, Federal Energy Regulatory Commission, and US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection

- Support strengthening of water quality protection.
 - Support water quality rules and watershed designations that conserve habitats for priority aquatic species. Outstanding Resource Water and High Quality Water designations should be supported wherever the criteria for designation are met, especially in watersheds that support priority species.
 - Support incentive and information programs that help reduce sedimentation/erosion (e.g., fencing livestock from streams, improve tilling practices), minimize pesticide and herbicide use, modernize wastewater treatment facilities, etc.
- Work through the Federal Energy Regulatory Commission (FERC) relicensing process and other opportunities to mitigate negative impacts from hydropower development. Support practicable mitigation and restoration for hydropower impacts in Hiwassee and Nottely rivers. Work with Duke Energy to fulfill relicense settlement agreements at Mission project (Tennessee Valley Authority projects are outside FERC jurisdiction).

Land-use planning efforts – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishing riparian buffers along streams, implement low impact development, and better stormwater management (e.g., secondary and cumulative impacts; NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

- Support federal and state species listing processes.
 - Focus analysis and synthesis of inventory and monitoring data and reporting to inform decision making pertaining to initial species listing and status revision.
 - Cooperate with US Fish & Wildlife Service to evaluate the status of sicklefin redhorse as a Candidate for federal listing as Threatened or Endangered, and explore opportunities for Candidate Conservation Agreements.
 - Assess other species in the Hiwassee basin for recommendation for state listing (e.g., longsolid, “Hiwassee” redline and greenside darters).
 - When warranted, make recommendations for state listing to the Commission’s Nongame Wildlife Advisory Committee.
- Improve coordination with US Fish & Wildlife Service to focus Section 6 (US Endangered Species Act) activities on priorities for listing and recovery. Activities that are applicable to goals and objectives of recovery plans should be tracked and recovery plans should be updated and revised as necessary.
 - Coordinate with US Fish & Wildlife Service to plan and align activities for federal Candidate species and Species of Concern with specific information or management needs.
- Investigate, implement, and support (as appropriate) programs that are directed at listed species recovery (e.g., Habitat Conservation Planning, Landowner Incentive Program, Safe Harbor).

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

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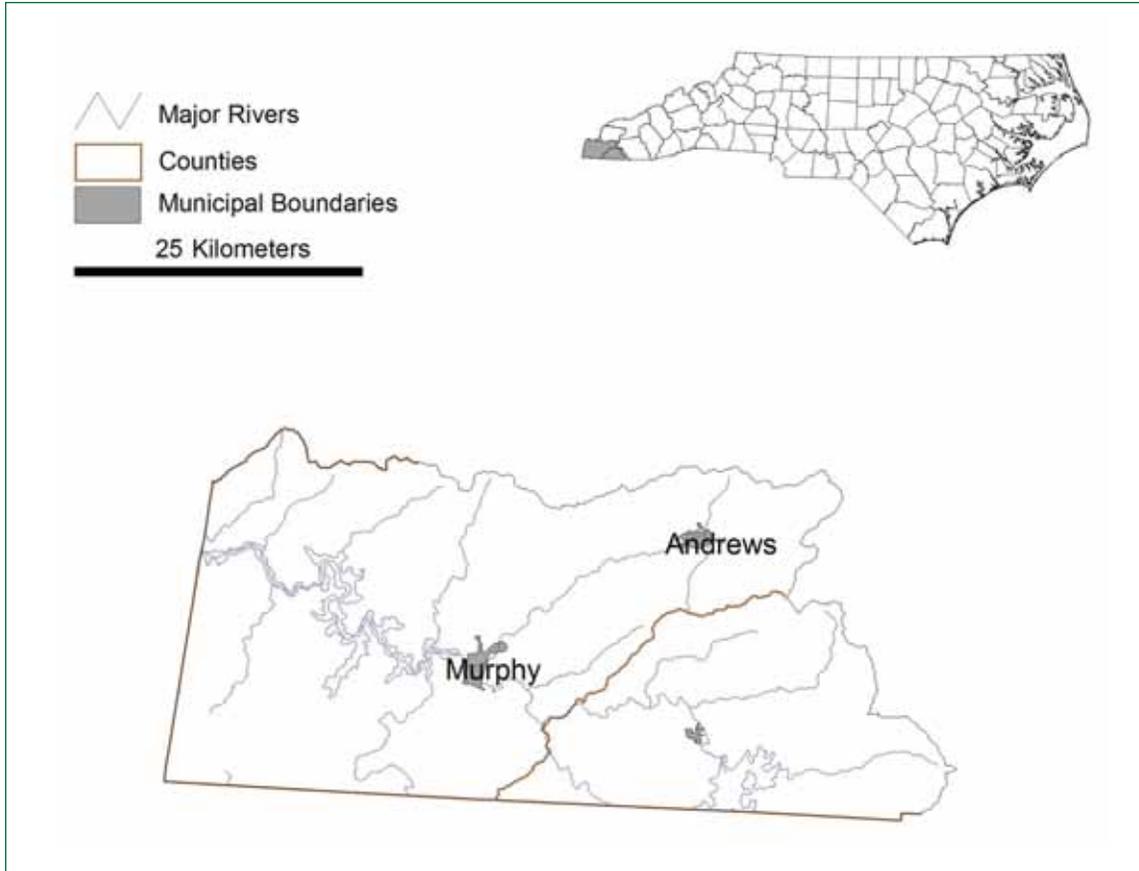
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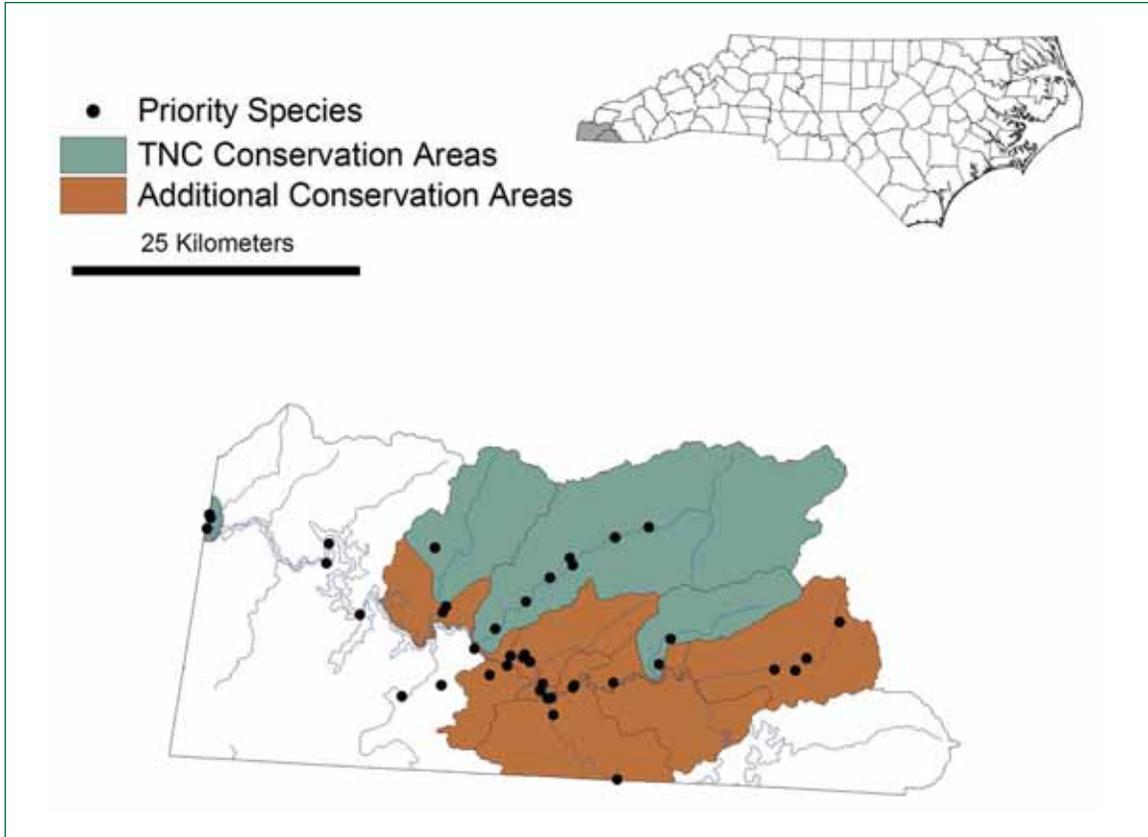
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Map 5B.1a. Hiwassee River basin, political information.



Map 5B.1b. Hiwassee River basin, priority species occurrences and priority areas for freshwater conservation.

2. Little Tennessee River Basin

Priority aquatic species in the Little Tennessee River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish ¹	<i>Clinostomus funduloides</i> sp.	"Smoky" Dace ²	SC
	<i>Cyprinella monacha</i> ³	Spotfin Chub	T (T)
	<i>Etheostoma vulneratum</i>	Wounded Darter	SC
	<i>Ichthyomyzon greeleyi</i>	Mountain Brook Lamprey	
	<i>Labidesthes sicculus</i>	Brook Silverside ⁴	
	<i>Moxostoma</i> sp 1	Sicklefin Redhorse	SR
	<i>Notropis photogenis</i>	Silver Shiner	
	<i>Notropis volucellus</i>	Mimic Shiner	
	<i>Noturus flavus</i>	Stonecat	E
	<i>Percina aurantiaca</i>	Tangerine Darter	
	<i>Percina burtoni</i>	Blotchside Logperch	E
	<i>Percina squamata</i>	Olive Darter	SC
Mussels	<i>Alasmidonta raveneliana</i>	Appalachian Elktoe	E (E)
	<i>Alasmidonta viridis</i>	Slippershell Mussel	E
	<i>Elliptio dilatata</i>	Spike	SC
	<i>Fusconaia barnesiana</i>	Tennessee Pigtoe ⁵	E
	<i>Fusconaia subrotunda</i>	Longsolid ⁴	SR
	<i>Lampsilis fasciola</i>	Wavyrayed Lampmussel	SC
	<i>Lasmigona holstonia</i>	Tennessee Heelsplitter ⁶	E
	<i>Pegias fabula</i>	Littlewing Pearlymussel	E (E)
	<i>Pleurobema oviforme</i>	Tennessee Clubshell ⁴	E
	<i>Villosa iris</i>	Rainbow ⁴	SC
Crayfish	<i>Cambarus georgiae</i>	Little Tennessee River Crayfish	SC
	<i>Cambarus reburus</i>	French Broad River Crayfish	SR
	<i>Cambarus tuckasegee</i>	Tuckasegee Stream Crayfish	SR
	<i>Orconectes</i> sp. cf. <i>spinosus</i>	No common name until status finalized	SR

A. Location and condition of basin (see Maps 5B.2a, 5B.2b):

The Little Tennessee River basin drains part of southwestern North Carolina in Graham, Macon, Swain, Jackson, and Clay counties in the Blue Ridge physiographic province. The headwaters of the Little Tennessee River are in northeastern Georgia where it flows for seven miles before entering North Carolina. The mainstem Little Tennessee River flows 125 miles through North Carolina before entering Tennessee where it joins the Tennessee River. It is part of the Tennessee/Ohio/Mississippi river system. Total watershed area in North Carolina: 1,797 sq. miles, including 2,565 stream miles and 21,158 reservoir acres. Major tributaries include the Cullasaja, Nantahala, Tuckasegee, Oconaluftee, and Cheoah rivers.

¹Yellowfin shiner (*Notropis lutipinnis*) is a native priority fish species in the adjacent Savannah basin, but is an introduced non-native in the Little Tennessee.

²Potential taxonomic revision, may be described as new species.

³Currently know by *Erimonax monachus* (as of 2005).

⁴Native only in Little Tennessee, non-native in Yadkin-PeeDee, Lumber rivers.

⁵Taxonomy of *Fusconaia*, *Pleurobema*, and *Villosa* spp. in western North Carolina is presently unclear.

⁶Occurrence record in basin may be result of misidentification.

Land use in the basin is 89% forested, 5% urban/built-up, 6% pasture (NCDWQ 2002). Impoundments include Fontana, Nantahala, Calderwood, Cheoah, Santeetlah, Glenville, Bear Creek, Cedar Cliff, Wolf Creek, Tanasee Creek, Dillsboro, Ela, Emory, and Sequoyah. Land ownership is >50 % publicly owned. Portions of the basin lie within the boundaries of the Great Smoky Mountains National Park and Nantahala National Forest. The Needmore Tract (~4600 acres) is a recently acquired Commission Game Land along the Little Tennessee River in Macon and Swain counties. The Qualla Boundary Cherokee Indian Reservation covers portions of the Oconaluftee and Tuckasegee watersheds. Much of the higher elevations are within the National Forest and National Park; however, development on private holdings in the higher elevations is increasing. Development is presently greatest and is increasing in the valleys and along the major waterways. The mainstem Little Tennessee River from the Georgia state line to Franklin, much of the Tuckasegee River from Cullowhee to Bryson City, and the Oconaluftee River from the National Park boundary to the Tuckasegee confluence are experiencing increasing disturbance and development.

Water quality ratings in the basin are generally good with 97% of streams rated as fully supporting; however, 2.4% of streams are impaired and 0.6% are not rated (NCDWQ 2002). The upper headwaters of the East Fork Tuckasegee and Nantahala rivers are designated Outstanding Resource Waters and multiple higher elevation streams are designated High Quality Waters. As is generally true throughout the Mountain Region, habitats with greatest potential for species diversity are in the larger, cool-warm water streams and rivers at lower elevations.

The 24 mile-long reach of the Little Tennessee River between Franklin and Fontana Reservoir supports the greatest diversity and abundance of native aquatic species in the region. Strong populations of Appalachian elktoe, spotfin chub, sicklefin redhorse and most other priority species generally thrive in the high quality habitat conditions. Good habitat conditions and native aquatic communities also exist in the lower Tuckasegee. Instream habitat conditions in the upper Little Tennessee River are severely impaired by excessive sedimentation. Habitat for sensitive aquatic species within this reach is presently marginal to totally lacking. Impacts from hydropower development substantially impair and limit native aquatic communities in the upper Tuckasegee, Nantahala, and Cheoah river systems. However, recognition needs to be given to the upper Little Tennessee basin's role as a key migratory flyway for birds, given its north-south orientation into the mountains and its large concentration of wetland habitat.

B. Problems affecting species and habitats:

The major problems affecting species and habitats in the Little Tennessee basin are impoundment (dams) and associated impacts, and excessive erosion and stream sedimentation. Of the entire 144 miles of the mainstem Little Tennessee River (in Georgia, North Carolina, and Tennessee), only 47 miles in Georgia and North Carolina remain unimpounded. Much of the Tuckasegee River is either impounded or altered by cold water releases and peaking flow regulation from dams. The Cheoah River is entirely altered by diversion of practically all flow from the remaining nine mile reach downstream from Santeetlah Dam. Loss of habitat due to impoundment, thermal and hydrologic alteration, as well as population fragmentation are the primary impacts from hydropower development.

Potentially high-quality habitats are further degraded from non-point source pollution, primarily from erosion and sedimentation from disturbance related to development and agriculture. Water and habitat quality upstream from Lake Emory at Franklin (upper Little Tennessee River, Cullasaja River, Cartoogechaye Creek, and tributaries) varies considerably (see Little Tennessee Watershed Association 2003 for further information). Portions of the Cullasaja River and Cartoogechaye Creek are presently in relatively good shape. While some tributaries in this area contribute significantly to the problem, substantial amounts of sediment result from bank erosion along the upper Little Tennessee mainstem. Erosion and sedimentation are also problems in the Tuckasegee River watershed, especially in the larger tributaries between Cullowhee and Bryson City (e.g., Savannah and Scott creeks). Impaired Waters in the basin include: Cullasaja River, Mill Creek, upper Little Tennessee River, Beech Flats Prong, and West Buffalo Creek arm of Santeetlah Reservoir (NCDWQ 2002).

Invasive, non-native species are a potential problem. The yellowfin shiner has apparently been introduced to the upper Little Tennessee River and is expanding downstream from Franklin. Other non-native fish species (e.g., bluehead chub and yellow perch) also inhabit portions of the basin. The Asian clam is established in the Little Tennessee and Tuckasegee rivers. Chinese mystery snails have been found in Cowee Creek and could spread to the mainstem Little Tennessee River (M. Cantrell, pers. comm). The rusty crayfish is apparently established in at least one stream downstream from Fontana Reservoir (Cooper 2005). Zebra mussels are not yet known from North Carolina, but are known from Tellico Reservoir (Little Tennessee River) in Tennessee. Exotic pathogens and parasites may also present threats. Spotfin chubs from the Little Tennessee River were recently discovered to be infested with a tapeworm native to Asia (N. Heil, pers. comm.). Non-native vegetation can also negatively impact native aquatic animal communities. This includes both aquatic and riparian plant species and non-native plant pathogens that can alter riparian vegetation and affect aquatic habitats (e.g., hemlock wooly adelgid).

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

Inventory: distributional and status surveys – General surveys are needed to complete the distributional status for aquatic snails, crayfish, mussels, and fish (in order of general need). (Cooperators in North Carolina include: NC Division of Water Quality, Tennessee Valley Authority, Little Tennessee Watershed Association, NC Department of Transportation, US Fish & Wildlife Service, US Forest Service, National Park Service (Great Smoky Mts National Park), NC Museum of Natural Science; interstate, intrabasin cooperators are the Georgia Department of Natural Resources, Tennessee Wildlife Resources Agency)

- Snails – inventory primary distribution; determine potential habitats and distribution surveys for hydrobiids.
- Sicklefin redhorse – complete distribution surveys; identify important spawning areas.
- Tennessee heelsplitter – determine distribution and status.
- Crayfish – complete primary inventories and determine status of endemic species.
- Determine distribution of non-native species (e.g., yellowfin shiner, Chinese mystery snails, rusty crayfish).
- Conduct distribution surveys in the Tuckasegee River for the blotchside logperch.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed.

- Sicklefin redhorse – support completion of species description (cooperate with Roanoke College).
- Mussels in the genera *Villosa*, *Pleurobema*, and *Fusconaia* – support resolution of taxonomic problems and species descriptions (if required) (cooperate with NC Museum of Natural Science, NC State University).
- Crayfish – support description and species diagnosis of all crayfish species in the basin. At least two putative undescribed species are presently known (cooperate with NC Museum of Natural Science).
- “Smoky” dace – support taxonomic resolution and species description (if required).
- Stonecat – support taxonomic resolution of the species in the basin.

Research to facilitate appropriate conservation actions – Research should generally focus on life history of priority species. Specific questions to be addressed include: habitat use/preferences, spawning location and timing, fecundity, population dynamics, population genetics, feeding, competition, predation. Research must also be conducted to determine

vulnerability of priority species to specific threats, particularly as related to our permit review and conditions responsibilities. Studies should provide recommendations for mitigation and restoration.

- Sicklefin redhorse – support completion of life history studies, identify critical spawning habitat, identify seasonal habitat use (cooperate with Roanoke College, NC State University, and Duke Power).
- Priority mollusk species – support research to facilitate population augmentation and restoration (e.g., translocation and propagation techniques). Determine feasibility, appropriate species, and techniques for reintroduction to Cheoah River (cooperate with US Fish & Wildlife Service, US Forest Service, and NC State University, with support from the NC Resource Management and Enhancement Fund- provided through Alcoa Power Federal Energy Regulatory Commission [FERC] settlement).
- Spotfin chub – support investigation of potential for reintroduction to Cheoah River (cooperate with US Fish & Wildlife Service, US Forest Service; other potential cooperators include the University of Tennessee, Conservation Fisheries, Inc., with support from NC Resource Management and Enhancement Fund- provided through Alcoa Power FERC settlement).
- All other priority species:
 - Review available information and support life history investigations where lacking.
 - Support investigation of potential for reintroduction of priority species to Cheoah River.
 - Support investigations into impacts from habitat fragmentation in the basin (due to impoundments or other factors).
 - Support investigations of population response to stream restoration projects (especially in priority areas).
 - Support research to improve habitat conditions in regulated rivers.

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible. (Cooperators in North Carolina include: NC Division of Water Quality, Tennessee Valley Authority, Little Tennessee Watershed Association, US Fish & Wildlife Service, US Forest Service, National Park Service (Great Smoky Mountains National Park), Duke Energy, Eastern Band of the Cherokee Indians, NC Museum of Natural Science; interstate, intrabasin cooperators are the Georgia Department of Natural Resources, Tennessee Wildlife Resources Agency).

- Conduct long-term monitoring to identify population trends of priority species. Establish protocol, schedule, and sites for long-term population monitoring.
 - Basin specific priorities include the Appalachian elktoe, littlewing pearly mussel, spotfin chub, sicklefin redhorse, stonecat.
- Conduct special purpose monitoring to assess performance of specific conservation actions:
 - Performance of stream restoration projects.
 - Performance of hydropower remediation.
 - o Monitor aquatic community response to remediation of hydropower impacts in Cheoah River (partners include: US Fish & Wildlife Service, US Forest Service, with support from NC Resource Management and Enhancement Fund- provided through Alcoa Power FERC settlement).
 - Performance of species restoration projects.
- Assess non-native species impacts – monitor populations of potentially injurious non-native species and impacts on priority species:
 - Basin specific priorities include the spotfin chub parasites, yellowfin shiner, bluehead chub, yellow perch, Chinese mystery snail, Asian clam, rusty crayfish.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration – Promote and support habitat conservation and restoration efforts by external entities. (Potential partners in the Little Tennessee River basin include: Little Tennessee Watershed Association, Land Trust for the Little Tennessee, Watershed Association for the Tuckasegee River, Natural Resources Conservation Service, Ecosystem Enhancement Program, county-based soil and erosion control efforts, US Forest Service, US Fish & Wildlife Service, TVA, Duke Energy, Alcoa Power, NC Resource Management and Enhancement Fund, Eastern Band of Cherokee Indians, and private landowners).

- Identify priority areas for habitat conservation and restoration. Criteria include areas with high species diversity, rare species, and endemic species; specific areas that are critical to the survival of priority species (e.g., particular streams or spawning sites); and areas recognized by previous national and/or regional prioritization efforts.
 - Priority watersheds for freshwater conservation in the Little Tennessee River basin include (based in part on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.2b):
 - o Little Tennessee River
 - o Tuckasegee River
 - o Cheoah River
- Support conservation and restoration of streams and riparian zones in priority areas (acquisition, easements, and buffers). Support stream conservation and restoration by working collaboratively with other organizations (e.g., Land Trust for the Little Tennessee, Little Tennessee Watershed Association).
 - Support conservation and restoration efforts in the Little Tennessee River through participation in the Little Tennessee Watershed Association Technical Advisory Committee and through support of implementation of the “Upper Little Tennessee River Basin: A conservation assessment and strategy” (Desmond 2003).
 - Encourage conservation of existing good riparian and stream conditions in priority areas.
- Promote and support conservation and restoration efforts within the Commission.
 - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, into Game Lands management, and into Game Lands acquisitions.
 - Incorporate management goals for aquatic community conservation and enhancement into management plan for Needmore Game Lands.

Population management and restoration – Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

- Investigate potential for priority mollusk and fish population restoration in Cheoah River. As appropriate, support and participate in specific activities to restore populations in the Cheoah River.
- Investigate potential for priority mollusk and fish population restoration in restored or improved habitats as other opportunities become available.
- Support captive propagation of spotfin chubs from Little Tennessee River for various purposes, including restoration efforts.
- Support development of propagation techniques and production capacity for augmentation and reintroduction of other priority fish and mollusk species.

Data collection, management, and dissemination

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Coordinate sampling with other resource groups.
- Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.
- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources. Improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
 - Update crayfish and mussel atlases with presently known species occurrence and distributions in the Little Tennessee basin.
 - Compile and post species accounts to fish atlas for federal and state listed fishes from the Little Tennessee basin.
- Develop and disseminate print media, including: stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
 - Deliver oral presentations.
 - Participate in educational activities.
 - o Participate in “Kids in the Creek” program for Macon County schools.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, Federal Energy Regulatory Commission, and US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection – Work with regulatory agencies (e.g., US Army Corps of Engineers, NC Division of Water Quality, Federal Energy Regulatory Commission, US Fish & Wildlife Service) and processes to conserve and restore water and habitat quality.

- Support strengthening of water quality protection.
 - Support water quality rules and watershed designations that conserve habitats for priority aquatic species. Outstanding Resource Water and High Quality Water designations should be supported wherever the criteria for designation are met, especially in watersheds that support priority species.
 - Support incentive and information programs that help reduce sedimentation/erosion (e.g., fencing livestock from streams, improve tilling practices), minimize pesticide and herbicide use, modernize wastewater treatment facilities, etc.
 - Support adoption of site specific water quality standards for waters that support federally listed species in the Little Tennessee basin (cooperate with NC Division of Water Quality, US Fish & Wildlife Service, and local governments).
 - Coordinate efforts with Georgia to reduce point and non-point sources of pollution in upper Little Tennessee River.

- Work through the FERC re-licensing process and other opportunities to mitigate negative impacts from hydropower development. Specific basin priorities include:
 - Cooperate with Duke Energy, FERC, and resource agency cooperators to assess potential for removing Dillsboro Dam on the Tuckasegee River and minimizing potential impacts of removal.
 - Work with Duke Energy, Alcoa Power, FERC, and resource agency cooperators to fulfill relicense settlement agreements for Little Tennessee basin projects (Tennessee Valley Authority projects are outside FERC jurisdiction).
 - Investigate potential for removing Cullhowhee Dam on the Tuckasegee River.
 - Support practicable mitigation and restoration for hydropower impacts throughout the Little Tennessee basin.

Land-use planning efforts – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishing riparian buffers along streams, implement low impact development, and better stormwater management (e.g., secondary and cumulative impacts; NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

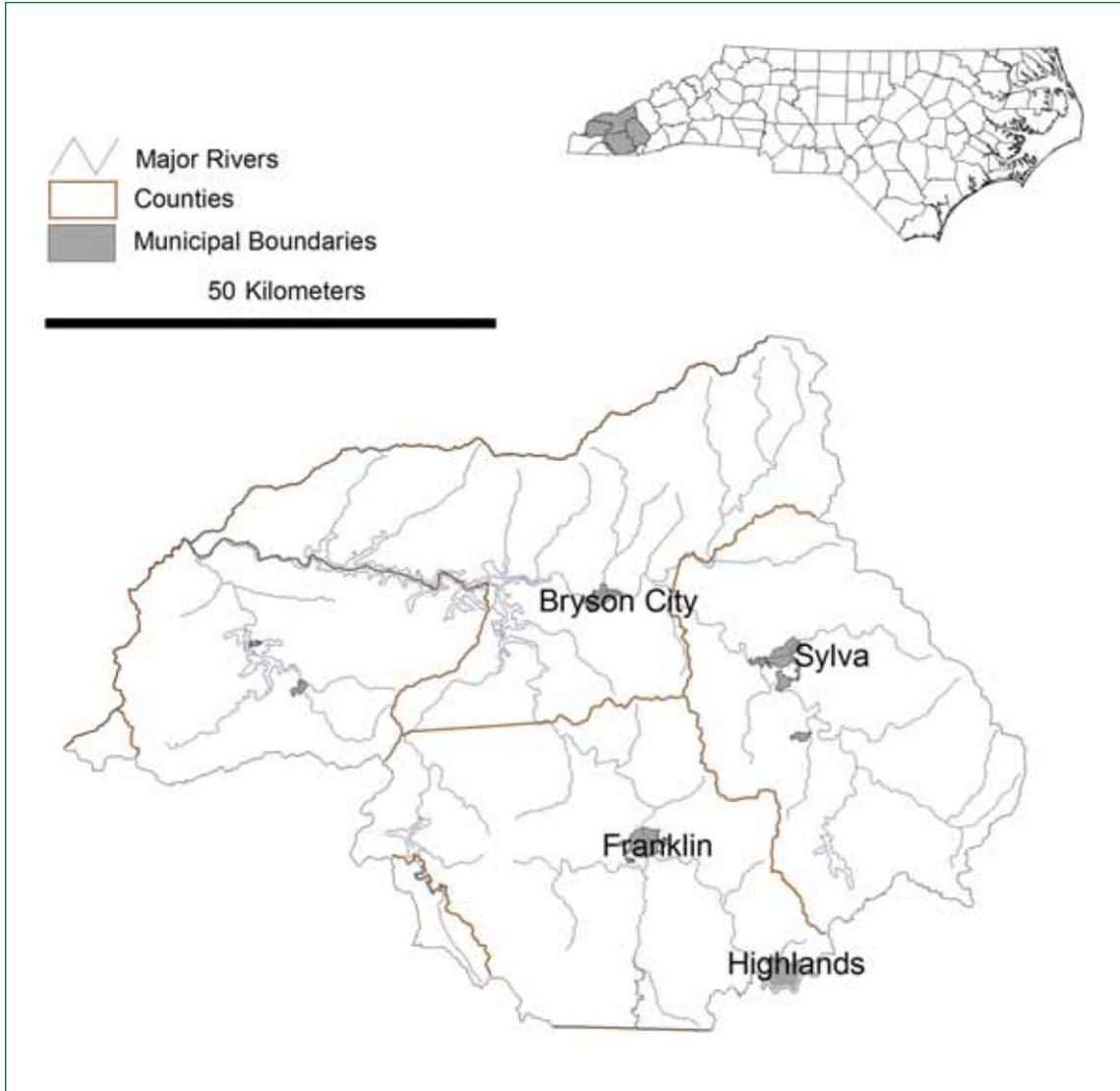
- Support federal and state species listing processes.
 - Focus analysis and synthesis of inventory and monitoring data and reporting to inform decision making pertaining to initial species listing and status revision.
 - Cooperate with US Fish & Wildlife Service to evaluate the status of sicklefin redbone as a Candidate for federal listing as Threatened or Endangered, and explore opportunities for Candidate Conservation Agreements.
 - Assess other species in the Little Tennessee basin for recommendation for state listing (e.g., longsolid).
 - When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.
- Improve coordination with US Fish & Wildlife Service to focus Section 6 (US Endangered Species Act) activities on priorities for listing and recovery. Activities that are applicable to goals and objectives of recovery plans should be tracked and recovery plans should be updated and revised as necessary.
 - Coordinate with US Fish & Wildlife Service to:
 - o Plan and align activities for Appalachian elktoe, littlewing pearly mussel, and spotfin chub with recovery plan goals,
 - o Better track and record activities that apply to recovery plan objectives, and
 - o Plan and align activities for federal Candidate species and Species of Concern with specific information or management needs.
- Investigate, implement, and support (as appropriate) programs that are directed at listed species recovery (e.g., Habitat Conservation Planning, Safe Harbor agreements). (Potential partners include: US Fish & Wildlife Service, NC Natural Heritage Program, Duke Power, The Nature Conservancy, Little Tennessee Watershed Association, Land Trust for the Little Tennessee, Watershed Association of the Tuckasegee River, local governments, private landowners, Eastern Band of the Cherokee Indians, Natural Resources Conservation Service, Coweeta Hydrological Laboratory).
 - o Investigate opportunities to utilize any available and applicable program (especially Habitat Conservation Planning) to conserve habitat and recover the federally listed species in the Little Tennessee basin (e.g., Appalachian elktoe, littlewing pearly mussel, and spotfin chub).

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

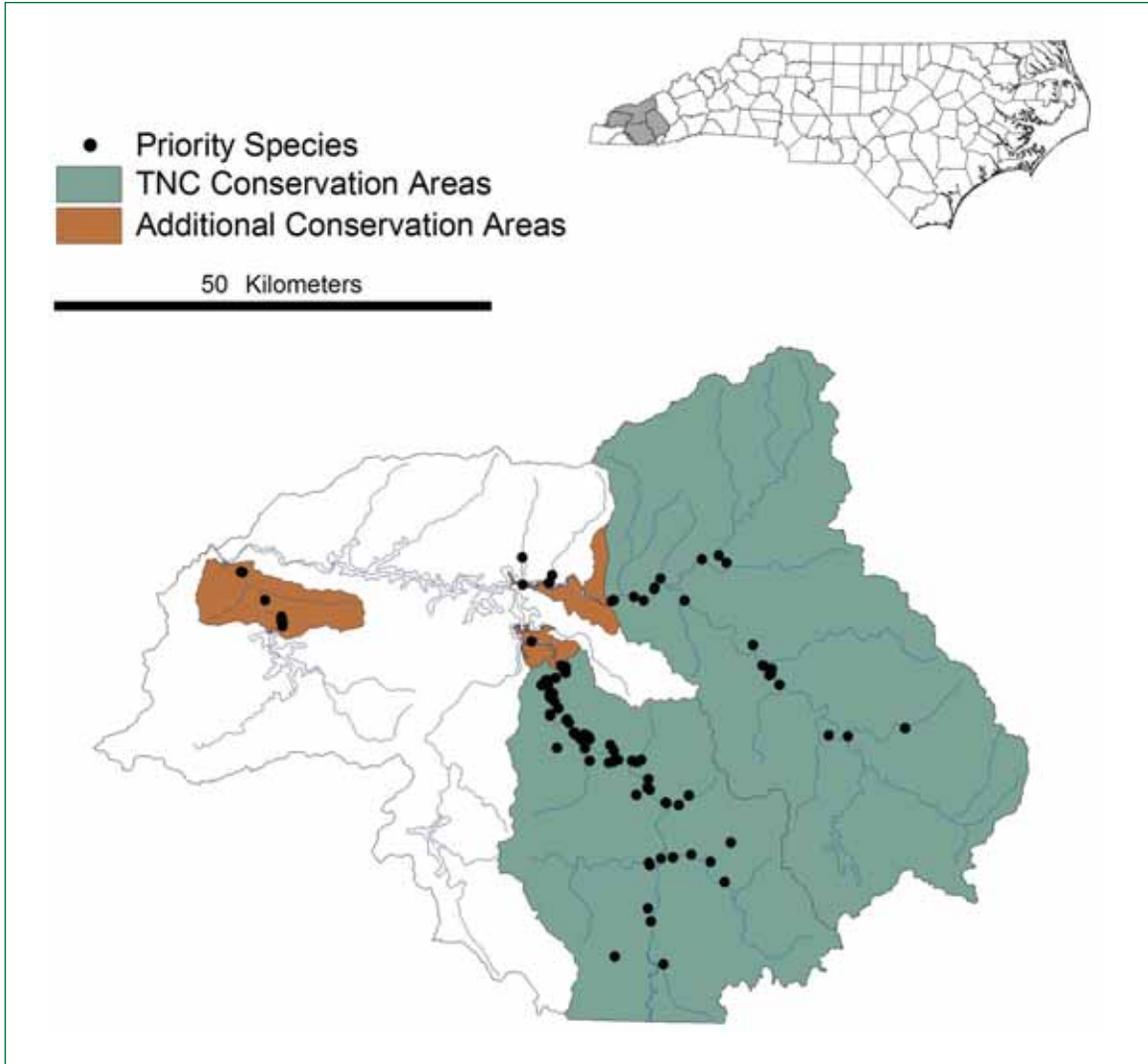
- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

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Map 5B.2a. Little Tennessee River basin, political information.



Map 5B.2b. Little Tennessee River basin, priority species occurrences and priority areas for freshwater conservation.

3. French Broad River Basin

Priority aquatic species in the French Broad River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish	<i>Carpion carpio</i>	River Carpsucker	SC
	<i>Carpion cyprinus</i>	Quillback	
	<i>Erimystax insignis</i>	Blotched Chub	SR
	<i>Etheostoma acuticeps</i>	Sharphead Darter	T
	<i>Etheostoma jessiae</i>	Blueside Darter ¹	SC
	<i>Etheostoma vulneratum</i>	Wounded Darter	SC
	<i>Ichthyomyzon greeleyi</i>	Mountain Brook Lamprey	
	<i>Ictiobus bubalus</i>	Smallmouth Buffalo ²	
	<i>Lampetra appendix</i>	American Brook Lamprey	T
	<i>Luxilis chrysocephalus</i>	Striped Shiner	T
	<i>Notropis photogenis</i>	Silver Shiner	
	<i>Notropis volucellus</i>	Mimic Shiner	
	<i>Noturus eleutherus</i>	Mountain Madtom ¹	SC
	<i>Noturus flavus</i>	Stonecat	E
	<i>Percina aurantiaca</i>	Tangerine Darter	
	<i>Percina burtoni</i>	Blotchside Darter	E
	<i>Percina caprodes</i>	Logperch	T
	<i>Percina macrocephala</i>	Longhead Darter ¹	SC
	<i>Percina squamata</i>	Olive Darter	SC
	<i>Pimephales notatus</i>	Bluntnose Minnow	
Mussels	<i>Alasmidonta raveneliana</i>	Appalachian Elktoe	E (E)
	<i>Alasmidonta viridis</i>	Slippershell Mussel	E
	<i>Fusconia subrotunda</i>	Longsolid	SR
	<i>Lampsilis fasciola</i>	Wavyrayed Lampmussel	SC
	<i>Lasmigona holstonia</i>	Tennessee Heelsplitter ³	E
	<i>Pleurobema oviforme</i>	Tennessee Clubshell	E
	<i>Strophitus undulatus</i>	Creeper (Squawfoot)	T
	<i>Villosa trabalis</i>	Cumberland Bean ¹	SR (E)
Crayfish	<i>Cambarus reburus</i>	French Broad River crayfish	SR

A. Location and condition of basin (see Maps 5B.3a, 5B.3b):

The French Broad river basin in North Carolina is composed of three major sub-basins, each of which individually flow northwest into Tennessee: French Broad River, Pigeon River, and Nolichucky River.

- The **French Broad River** sub-basin can be divided further into three more or less geomorphologically distinct units.
 - *Upper mainstem and headwater streams*
 - Major tributaries: North, West, and East Forks of French Broad River

¹Possibly extirpated.

²Native only in French Broad basin, non-native in Catawba, Yadkin-PeeDee, Neuse basins.

³Occurrence record in basin may be result of misidentification.

³Questionable records in the basin

- *Middle mainstem and tributaries*
Major tributaries: Little River, Mills River, Davidson River, Swannanoa River; Mud Creek, Cane Creek, and Hominy Creek,
- *Lower mainstem and tributaries*
Major tributaries: Sandymush Creek, Big Ivy River; Big Laurel and Spring Creeks

- **Pigeon River**

Major tributaries: East and West Forks Pigeon River; Jonathan, Richland, Cataloochee, and Big creeks

- **Nolichucky River**

Major tributaries: North and South Toe Rivers, Cane River, and Big Rock Creek.

The French Broad river watershed in North Carolina encompasses 2,830 sq. miles, including 4,136 stream miles in Haywood, Madison, Buncombe, Transylvania, Henderson, Yancy, Mitchell, and Avery counties, and is entirely within the Blue Ridge physiographic province. The headwaters are entirely within North Carolina. The basin drains the north and western slopes of the Black Mountains, the highest range in the eastern United States. The upper mainstem French Broad River system drains the high mountains of the Blue Ridge and flows through the broad, flat valley of the Asheville Basin. Within the Asheville Basin, the French Broad and tributaries are relatively low gradient and share many habitat characteristics with streams in the Valley and Ridge physiographic province. Consequently, a number of aquatic species more typical of the Valley and Ridge are known from this part of the French Broad and virtually nowhere else in the Blue Ridge. Near the city of Asheville, the French Broad flows out of the Asheville Basin and descends a relatively steep, narrow gorge before entering Tennessee. The topography of the Pigeon River watershed is similar, with high gradient headwaters, a relatively flat midsection, and a steep gorge near the Tennessee border. The midsection of the Nolichucky River watershed lacks substantial flat areas and remains more high-gradient and gorge-like throughout its length in North Carolina.

Approximately 50% of the basin is forested. Much of the forested land is at the higher elevations and lies within the boundaries of Pisgah National Forest, Blue Ridge Parkway, and a portion within the Great Smoky Mountains National Park. Most agricultural and developed lands are concentrated within the river valleys; however, residential development is increasing on steeper slopes. Between 1982 and 1992, cultivated and uncultivated croplands decreased by ~67%, while urban and developed lands increased by 42%. Agriculture covers 17% of the land area in the basin and 10% of the basin is considered urban (NCDWQ 2000).

Dams on the French Broad River and tributaries include: Craggy, Capitola, and Redmon (run of river with small detention pool). Impoundments include Lake Julian, Burnett Reservoir, Beetree Reservoir, Busbee Reservoir, Enka Lake, and many other small impoundments throughout the watershed, especially in the upper portion in Henderson and Transylvania counties. Dams and impoundments in the Pigeon River sub-basin include Walters Dam/Waterville Lake (with a 12 mile bypassed reach downstream), Lake Junaluska, Allen Creek Reservoir, and Lake Logan. While there are a few small impoundments on minor tributaries, there are no dams on the Nolichucky River and its major tributaries.

Water quality ratings in the basin include 77% fully supporting waters, 2% impaired waters, 21% not rated (NCDWQ 2000). Overall, water quality is good throughout most of the basin. The middle and lower French Broad River and tributaries are impacted by agriculture, dairy farms, and urbanization. In 2000, there were 16 streams designated as Impaired Waters. Almost half of these (seven) are within the Asheville Basin portion of the middle French Broad River sub-basin. Outstanding Resource Waters in the basin include Cataloochee Creek, the upper South Toe River watershed, and South Fork Mills River. Significant watersheds with High Quality Waters designation include Big Creek and the upper Davidson River. Some significant watershed areas are also designated Water Supply I and II and they include the North Fork Mills River, and the upper portions of Ivy, Cane, and Swannanoa rivers (see NCDWQ 2000 and <http://h2o.enr.state.nc.us/bims/Reports/reportsWB.html> for further stream designations).

B. Problems affecting species and habitats:

Habitat degradation resulting from non-point source pollution is the most widespread problem in the basin. Large-scale development and urbanization, as well as agriculture are significant sources of non-point source pollution and sedimentation. Nutrient enrichment is a greater problem in the French Broad basin than in any other Interior Basin drainage in the region (Hampson et al. 2000). Highway construction and associated indirect and secondary impacts are a significant concern in many parts of the basin. Poorly managed development on steep slopes and within riparian areas along tributaries apparently contributes much of the sedimentation from development activities. Threats from hydrologic modifications resulting from increased urbanization (i.e. increased impervious surfaces, flood plain development and filling, stream channel alterations) are apparently increasing throughout the basin, with some areas experiencing greater impacts than others. Habitat degradation from point sources of pollution is also a significant problem in portions of the basin, if not as widespread as non-point sources. Compared to other basins in the region (e.g., Hiwassee, Little Tennessee, and Catawba) impacts from impoundments are relatively minor in the French Broad basin; however, some significant problems exist in portions of the basin.

Problems associated with non-native and invasive species are unclear at present; however, the native long-ear sunfish has apparently been displaced entirely throughout the basin by the non-native redbreast sunfish. The Atlantic Slope native White River crayfish and white catfish are established in the Pigeon sub-basin. Other non-native fishes, such as common carp, goldfish, rainbow trout, and brown trout, are long established in the basin with apparently minimal impacts on native non-game communities. A number of exotic tropical fish species (e.g., tilapia, armored catfish, pacu) are established in Lake Julian, but over winter survival is apparently restricted to the warm waters of a power plant discharge. The Asian clam is known from the French Broad sub-basin, but its extent throughout the basin is not fully documented. As identified in previous basin accounts, non-native vegetation can also negatively impact native aquatic animal communities. This includes both aquatic and riparian plant species and non-native plant pathogens that can alter riparian vegetation and affect aquatic habitats (e.g., hemlock wooly adelgid).

French Broad River sub-basin

Habitat for priority aquatic species in the French Broad River subbasin is affected by impacts related to development and urbanization, agriculture, and point sources. Sedimentation and turbidity are more or less chronic problems in most of the larger streams in the lower elevations of the Asheville Basin and surrounding area, including the mainstem French Broad River. Point source pollution, including both present problems and residual effects from much more severe pollution of the past, contributes significantly to habitat degradation and the extirpation of priority species.

Very few high-quality habitats for cool-warm water priority species in medium to large streams have remained intact through the 20th century. The mainstem French Broad River and tributaries from the confluence of the Davidson River downstream to the Tennessee border have lost a substantial portion of their aquatic species. Habitat appears to remain unsuitable for some of these species; however recovery of some of these species may be possible due to relatively recent incremental improvements in water quality. The Upper French Broad River, Little River, Mills River, and Ivy River have been the primary refuges for most of the priority species that are still extant in this subbasin. However, increased development and chance events are ever-present threats in such fragmented refugia. For example, a tanker truck accident dumped toxic chemicals in the upper California Creek and Ivy River watershed in 2002, which killed aquatic life to the confluence with the French Broad River. High quality habitat for priority mussels in the Little River is limited to a short reach between Cascade Lake and confluence of Crab Creek, where sedimentation from agriculture and development in the watershed degrades habitat. Runoff from large-scale agriculture and development threaten the lower Mills River.

Dams on the mainstem French Broad River (Craggy, Capitola, Redmon) are run of river and impacts appear to be minimal. Barrier effects and population fragmentation (at least isolation of upstream populations) may have some impact on extant riverine fishes (especially potadromous species) and potential for restoration of extirpated species (e.g., lake sturgeon, sauger).

Pigeon River sub-basin

The Pigeon River has experienced significant degradation from point source pollution and impoundment, as well as non-point sources. A paper mill at Canton (Blue Ridge Paper Products, formerly Champion Paper) discharged toxic wastes directly to the Pigeon River for much of the 20th century. Many priority species were eliminated from the mainstem Pigeon River by this pollution. Improvements in waste water treatment that began in the early 1990's have improved habitat conditions and prospects for recovery of many native species appear to be good.

The most significant impacts from impoundment in the French Broad basin are at the Walters Dam (Progress Energy) and bypass reach on the Pigeon River. Approximately 5 miles of the river is impounded in Walters Reservoir and 12 miles downstream from Walters Dam is dewatered (except for some leakage at the dam and tributary inflow) by bypassing water from the reservoir through a penstock to a powerhouse near the Tennessee state line. Restoration of minimum flows to the bypassed reach is tied to improvements in upstream water quality (per Federal Energy Regulatory Commission [FERC], Article 414). Improvements in the paper mill's impacts to the reservoir must meet certain thresholds defined by chemical and biological criteria before water can be released.

The Pigeon River and short reaches of the East and West forks of the Pigeon upstream from Canton have remained relatively high-quality cool-warm water habitat and has provided refuge for most of the priority species that are still extant in the sub-basin. Increasing development could potentially degrade this important habitat. Other tributaries, such as Jonathans Creek, Richland Creek, Fines Creek, and Crabtree Creek are variously degraded by non-point source pollution. Poorly managed agriculture and increasing development are the primary factors.

Nolichucky River sub-basin

Historically, sedimentation and pollution from several mining operations throughout the subbasin (primarily in the North Toe watershed) significantly degraded cool-warm water habitats. Encouragingly, improvements that began in the 1970's have apparently helped reduce these impacts. Recent bioassessments indicate improving conditions (NCDWQ 2000; TVA and NCWRC unpublished data). Habitat in the North Toe River between Spruce Pine and the South Toe River confluence continues to be degraded, apparently from discharges and runoff from mining operations and the town of Spruce Pine. Floodplain gravel mining in the upper Cane River watershed poses a potential threat to long-term channel stability and habitat quality. Development is increasing throughout much of the sub-basin and erosion and sedimentation may also be on the rise. Major highway projects are planned for the area and the direct, indirect, and secondary impacts could threaten the recent improvements in habitat conditions.

C. *Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:*

Inventory: distributional and status surveys – General surveys are needed to complete the distributional status for aquatic snails, crayfish, mussels, and fish (in order of general need). (Cooperators in North Carolina include: NC Division of Water Quality, Tennessee Valley Authority, Little Tennessee Watershed Association, NC Department of Transportation, US Fish & Wildlife Service, US Forest Service, National Parks Service (Great Smoky Mts National Park), NC Museum of Natural Sciences; an interstate, intrabasin cooperator is the Tennessee Wildlife Resources Agency)

- Snails – inventory primary distribution; determine potential habitats and distribution surveys for hydrobiids.
- Crayfish – complete primary distribution and status surveys.

- Mussels – complete primary distribution and status surveys in a few remaining areas; periodic surveys in areas where potential for expansion of existing populations is possible.
- Fish – distribution surveys in Nolichucky River system for blotchside logperch, stonecat, blotched chub, and sharphead darter; mainstem French Broad river for appropriate priority fish species.
- Determine distribution of non-native species.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed.

- Mussels in the genera *Strophitus*, *Pleurobema* and *Fusconaia* – support resolution of taxonomic problems and species descriptions (if required) (cooperate with NC Museum of Natural Sciences, NC State University).
- Crayfish – support description and species diagnosis of all crayfish species in the basin. At least one putative undescribed species is presently known (cooperate with NC Museum of Natural Sciences).

Research to facilitate appropriate conservation actions – Research should generally focus on life history of priority species. Specific questions to be addressed include: habitat use/preferences, spawning location and timing, fecundity, population dynamics, population genetics, feeding, competition, predation. Research must also be conducted to determine vulnerability of priority species to specific threats, particularly as related to our permit review and conditions responsibilities. Studies should provide recommendations for mitigation and restoration.

- Support research projects applicable to improving success and efficiency of Pigeon River fish re-introduction project (cooperators include: Blue Ridge Paper Products, University of Tennessee, Western Carolina University, and the NC Division of Water Quality).
- Priority mollusk species – support research to facilitate population augmentation and restoration (e.g., translocation and propagation techniques) (cooperators include: NC State University and Virginia Tech.).
- Extirpated priority species (including spotfin chub) – determine measurable habitat requirements and monitor conditions in the basin for potential reintroduction opportunities, support development of propagation techniques (cooperators include: US Fish & Wildlife Service, University of Tennessee, and Conservation Fisheries Incorporated).
- All other priority species:
 - Review available information and support life history investigations where lacking.
 - Support investigation of potential for reintroduction of priority species to upper French Broad River.
 - Support investigations into impacts from habitat fragmentation in the basin (due to impoundments or other factors).
 - Support investigations of population response to stream restoration projects (especially in priority areas).

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible. (Cooperators in North Carolina include: NC Division of Water Quality, Tennessee Valley Authority, US Fish & Wildlife Service, US Forest Service, National Park Service (Blue Ridge Parkway), Haywood Waterways Association, Blue Ridge Paper, University of Tennessee, Progress Energy, Pigeon River Fund, NC Museum of Natural Science; an interstate, intrabasin cooperator is the Tennessee Wildlife Resources Agency).

- Conduct long-term monitoring to identify population trends of priority species. Establish protocol, schedule, and sites for long-term population monitoring.
 - Basin specific priorities include the Appalachian elktoe, slippershell, stonecat, blotched chub, and sharphead darter
- Conduct special purpose monitoring to assess performance of specific conservation actions:
 - Performance of stream restoration projects.
 - o Monitor progress of Pigeon River fish restoration project (partners include: Blue Ridge Paper Products, University of Tennessee, NC Division of Water Quality).
 - Performance of hydropower remediation.
 - Performance of species restoration projects.
- Assess non-native species impacts – monitor populations of potentially injurious non-native species and impacts on priority species:
 - Basin specific priorities include the Asian clam and White River crayfish.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration – Promote and support habitat conservation and restoration efforts by external entities. (Potential partners in the French Broad River Basin include: Natural Resources Conservation Service, Ecosystem Enhancement Program, US Fish & Wildlife Service, Haywood Waterways Association, Riverlink, Mud Creek Watershed Association, Carolina Mountain Land Conservancy, county-based soil and erosion control efforts, US Forest Service, Tennessee Valley Authority, and private landowners).

- Identify priority areas for habitat conservation and restoration. Criteria include areas with high species diversity, rare species, and endemic species; specific areas that are critical to the survival of priority species (e.g., particular streams or spawning sites); and areas recognized by previous national and/or regional prioritization efforts.
 - Priority watersheds for freshwater conservation in the French Broad River River basin include (based in part on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.3b):
 - o Upper Nolichucky/Cane/Toe Rivers
 - o Little River
 - o Mills River
 - o Upper French Broad River
- Support conservation and restoration of streams and riparian zones in priority areas (acquisition, easements, and buffers). Support stream conservation and restoration by working collaboratively with other organizations.
 - Support conservation and restoration efforts in the Pigeon River sub-basin through participation in the Haywood Waterways Association Technical Advisory Committee.
 - Encourage conservation of existing good riparian and stream conditions in priority areas.
- Promote and support conservation and restoration efforts within the Commission.
 - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, into Game Lands management, and into Game Lands acquisitions

Population management and restoration – Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

- Investigate potential for reintroduction of extirpated mollusk and fish species to the basin in restored or improved habitats as opportunities become available.
 - Pigeon River fish reintroduction project – Facilitate and cooperate with partners to reintroduce common and priority fish species extirpated from Pigeon River between Canton and Walters/Waterville reservoir; support associated propagation efforts for augmentation and reintroductions of rare species.
 - Investigate potential for priority mollusk population restoration in restored or improved habitats as other opportunities become available (upper mainstem French Broad River-reintroduce and/or augment Appalachian elktoe, longsolid, Tennessee clubshell, oyster mussel, Cumberland moccasin shell; upper North Toe River – augment Appalachian elktoe and wavy-rayed lampmussel populations).
 - Support development of propagation techniques and production capacity for augmentation and reintroduction of other priority fish and mollusk species.
 - Spotfin chub – Support investigation of potential for reintroduction to suitable habitats in the French Broad basin (cooperate with US Fish & Wildlife Service and US Forest Service; other potential cooperators include: University of Tennessee, Conservation Fisheries, Inc.).

Data collection, management, and dissemination

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Coordinate sampling with other resource groups.
- Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.
- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources. Improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
 - Update crayfish and mussel atlases with presently known species occurrence and distributions in the French Broad basin.
 - Compile and post species accounts to fish atlas for federal and state listed fishes from the French Broad basin.
- Develop and disseminate print media, including stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
 - Deliver oral presentations.
 - Participate in educational activities.
 - o Participate in “Kids in the Creek” program for Haywood County schools.
- Seek opportunities for direct outreach throughout the basin, especially in the Nolichucky sub-basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, Federal Energy Regulatory Commission, and US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection – Work with regulatory agencies (e.g., US Army Corps of Engineers, NC Division of Water Quality, Federal Energy Regulatory Commission, US Fish & Wildlife Service.) and processes to conserve and restore water and habitat quality.

- Support strengthening of water quality protection.
 - Support water quality rules and watershed designations that conserve habitats for priority aquatic species. Outstanding Resource Water and High Quality Water designations should be supported wherever the criteria for designation are met, especially in watersheds that support priority species.
 - Support incentive and information programs that help reduce sedimentation/erosion (e.g., fencing livestock from streams, improve tilling practices), minimize pesticide and herbicide use, modernize wastewater treatment facilities, etc.
 - Support adoption of site specific water quality standards for waters that support federally listed species in the French Broad basin (cooperate with the NC Division of Water Quality, US Fish & Wildlife Service, and local governments).
- Work through the FERC relicensing process and other opportunities to mitigate negative impacts from hydropower development (Partners include: Progress Energy, Metropolitan Sewerage District of Buncombe County, US Fish & Wildlife Service, NC Division of Water Resources, NC Division of Water Quality).
 - Work with Progress Energy, FERC, and resource agency cooperators to fulfill relicense settlement agreements for Walters/Waterville hydropower project on the Pigeon River.
 - Support practicable mitigation and restoration for hydropower impacts throughout the French Broad basin.

Land-use planning efforts – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishing riparian buffers along streams, implement low impact development, and better stormwater management (e.g., secondary and cumulative impacts; NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

- Support federal and state species listing processes.
 - Focus analysis and synthesis of inventory and monitoring data and reporting to inform decision making pertaining to initial species listing and status revision.
 - When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.
 - Assess species in the French Broad basin for recommendation for state listing (e.g., longsolid).

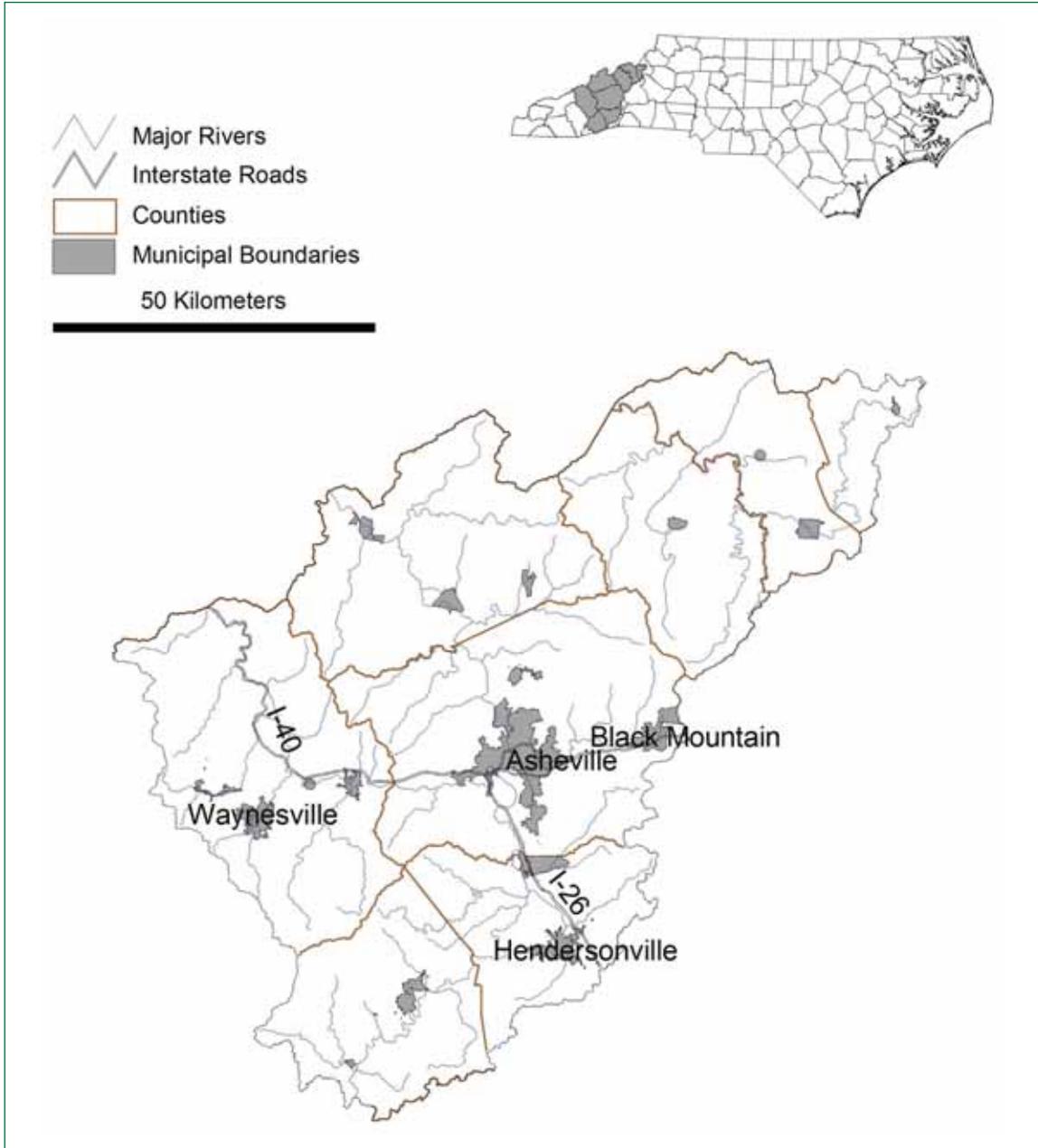
- Improve coordination with US Fish & Wildlife Service to focus Section 6 (US Endangered Species Act) activities on priorities for listing and recovery. Activities that are applicable to goals and objectives of recovery plans should be tracked and recovery plans should be updated and revised as necessary.
 - Coordinate with US Fish & Wildlife Service Asheville Field Office to:
 - o Plan and align activities for Appalachian elktoe and spotfin chub with recovery plan goals.
 - o Better track and record activities that apply to recovery plan objectives, and
 - o Plan and align activities for federal Candidate species and Species of Concern with specific information or management needs.
- Investigate, implement, and support (as appropriate) programs that are directed at listed species recovery (e.g., Habitat Conservation Planning, Safe Harbor agreements). (Potential partners include: US Fish & Wildlife Service, NC Natural Heritage Program, The Nature Conservancy, Riverlink, Carolina Mountain Land Conservancy, local governments, private landowners).
 - o Investigate opportunities to utilize any available and applicable program (especially Habitat Conservation Planning) to conserve habitat and recover the federally listed species in the Little Tennessee basin (Appalachian elktoe, littlewing pearly mussel, and spotfin chub).

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

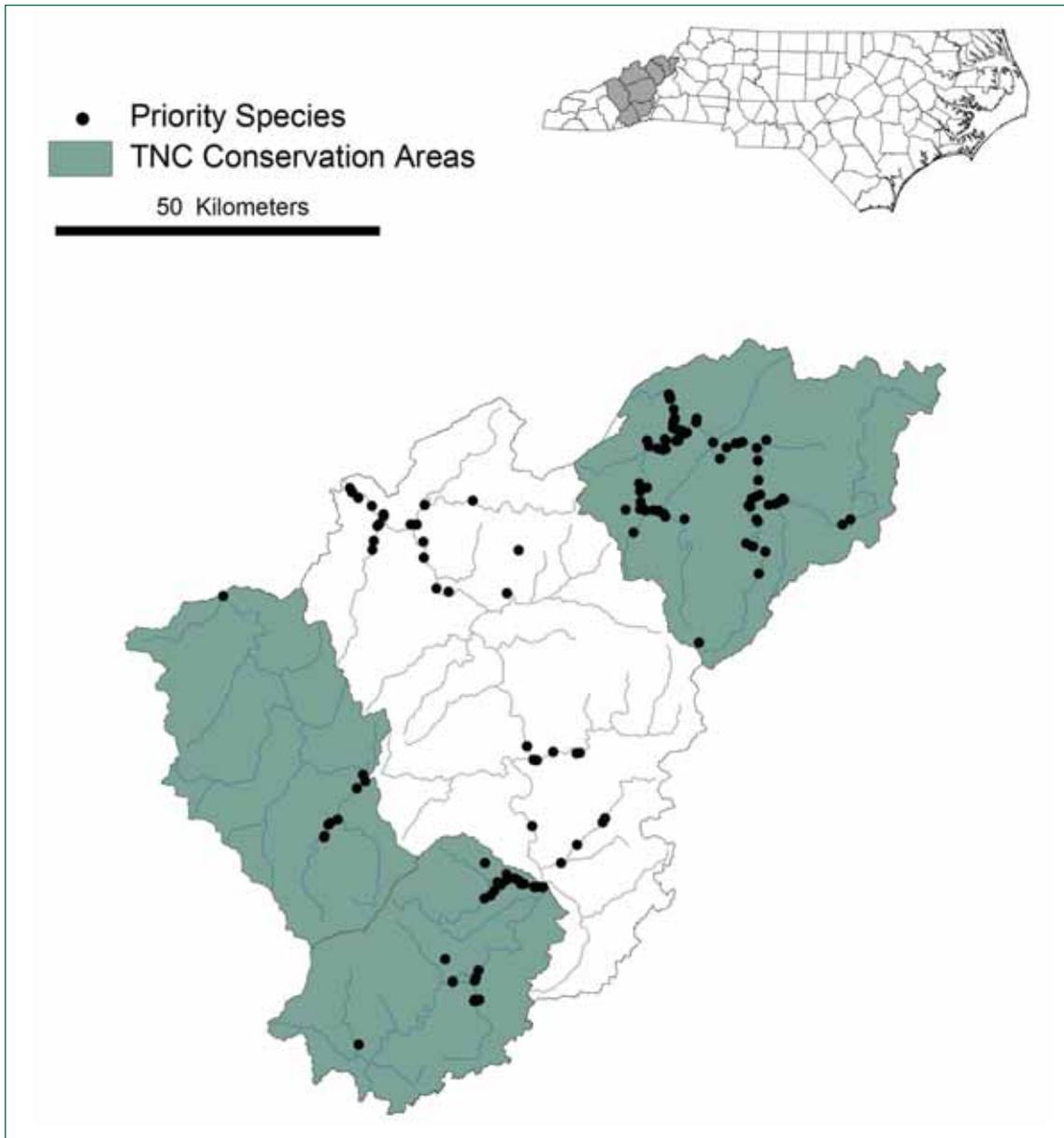
- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

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Map 5B.3a. French Broad River basin, political information.



Map 5B.3b. French Broad River basin, priority species occurrences and priority areas for freshwater conservation.

4. Watauga River Basin

Priority aquatic species in the Watauga River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish	<i>Notropis photogenis</i>	Silver Shiner	
	<i>Percina aurantiaca</i>	Tangerine Darter	
	<i>Pimephales notatus</i>	Bluntnose Minnow	
Mussels	<i>Lasmigona subviridis</i>	Green Floater	E

A. Location and condition of basin (see Maps 5B.4a, 5B.4b):

The Watauga River watershed drains northwest into Tennessee where it flows into Watauga Reservoir. The Watauga River is a tributary of the Holston River, which is a major tributary of the Tennessee River. The Watauga River watershed in North Carolina encompasses 205 sq. miles, including 270 stream miles in Avery and Watauga counties, and is entirely within the Blue Ridge physiographic province. The Elk River is a major tributary.

Land use in the basin is 87% forest/wetland, 13% pasture/managed herbaceous, and >1% urban (NCDWQ 2002). Most development and agricultural activities are located in the valleys due to abundance of steep slopes within the watershed. However, development (primarily home construction) is rapidly increasing on steeper slopes. Major land ownership is private with <10% in public lands (Pisgah National Forest and the Blue Ridge Parkway). There are no major impoundments within the North Carolina portion of the basin. There is one run of the river hydro-electric facility on the Watauga River (Ward Mill Dam). There are several small impoundments on tributaries, including Beech Mountain Reservoir on Buckeye Creek (drinking water reservoir).

There are no designated impaired waters within the basin (83% fully supporting, 17% not rated) (NCDWQ 2002). Overall, water quality in the Watauga basin is very good. The primary water quality concerns stem from non-point inputs, primarily siltation

B. Problems affecting species and habitats:

While water quality conditions are generally very good at present, past pollution events may have had a profound effect on the extant aquatic fauna in the Watauga River. Local accounts indicate that a tannic acid factory near Valle Crucis caused severe pollution in the early 20th century and may have led to the extirpation of many native species. Apparently, no extensive surveys for aquatic species were made prior to this period of degradation and the extent of species loss is unknown. Presently, excessive erosion and sedimentation from non-point sources is the primary problem affecting species and habitats. Narrow riparian corridors or total lack of riparian vegetation along portions of the Watauga River and many tributaries have led to excessive stream bank erosion and loss of habitat to sediment deposition and over-widening of channels. Impacts from row-crop agriculture and poorly managed livestock pasture (sedimentation from runoff and stream bank erosion) are also significant. As residential development increases (vacation homes, golf courses, etc.) stormwater run-off is a major contributor to sedimentation and other non-point problems. The area appears to be experiencing an acceleration of development and threats to water and habitat quality are increasing. Christmas tree farming is also increasing in the basin. Relatively large amounts of herbicides and pesticides are used in this form of silviculture. Impacts of runoff from tree farms is unclear, but should be monitored for potential effects. Impacts from non-native species (e.g., margined madtom) are unknown, but could be a negative impact on native fish communities.

Little is known of the extent to which non-native aquatic species have become established in the Watauga basin in North Carolina. Non-native trout species (rainbow and brown trout) are well established. As identified in previous basin accounts, non-native vegetation can also negatively

impact native aquatic animal communities. This includes both aquatic and riparian plant species and non-native plant pathogens that can alter riparian vegetation and affect aquatic habitats (e.g., hemlock wooly adelgid).

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

Inventory: distributional and status surveys – General surveys are needed to complete the distributional status for aquatic snails, crayfish, mussels, and fish (in order of general need). (Partners include: NC Division of Water Quality, Tennessee Valley Authority, NC Department of Transportation, US Forest Service, National Parks Service (Blue Ridge Parkway), Appalachian State University).

- Review existing data and determine information needs for all taxa (cooperate with NC Museum of Natural Sciences).
- Snails – inventory primary distribution; determine potential habitats and distribution surveys for hydrobiids.
- Crayfish – complete primary distribution and status surveys.
- Determine distribution of non-native species.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed.

- Crayfish – support description and species diagnosis of all crayfish species in the basin. At least one putative undescribed species is presently known (cooperate with NC Museum of Natural Science).
- Snails – support identification and description of all species in the basin.

Research to facilitate appropriate conservation actions – Research should generally focus on life history of priority species. Specific questions to be addressed include: habitat use/preferences, spawning location and timing, fecundity, population dynamics, population genetics, feeding, competition, predation. Research must also be conducted to determine vulnerability of priority species to specific threats, particularly as related to our permit review and conditions responsibilities. Studies should provide recommendations for mitigation and restoration.

- Support life history and habitat requirement studies for green floater, especially focused on factors that may limit populations in the Watauga River.
- Continue cooperation with Appalachian State University to investigate potential impacts of seasonal delayed harvest trout stocking on native cool-warm water communities in Watauga River.
- Support investigations into potential impacts to aquatic systems from intensive silvicultural applications of pesticides.
- All other priority species:
 - Review available information and support life history investigations where lacking.
 - Support investigation of potential for reintroduction of priority species to Watauga River.
 - Support investigations of population response to stream restoration projects (especially in priority areas).

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible. (Cooperators in North Carolina include: NC Division of Water Quality, Tennessee Valley Authority, NC Department of Transportation, US Fish & Wildlife Service, US Forest Service, National Parks Service (Blue Ridge Parkway), Appalachian State University; an interstate, intrabasin cooperator is the Tennessee Wildlife Resources Agency).

- Conduct long-term monitoring to identify population trends of priority species. Establish protocol, schedule, and sites for long-term population monitoring.
- Conduct special purpose monitoring to assess performance of specific conservation actions:
 - Performance of stream restoration projects.
 - Performance of hydropower remediation.
 - Performance of species restoration projects.
- Assess non-native species impacts – monitor populations of potentially injurious non-native species and impacts on priority species:
 - Basin specific priority: margined madtom.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration – Promote and support habitat conservation and restoration efforts by external entities. (Potential partners in the Watauga River Basin include: Natural Resources Conservation Service, Ecosystem Enhancement Program, US Fish & Wildlife Service, county-based soil and erosion control efforts, US Forest Service, Tennessee Valley Authority, and private landowners).

- Identify priority areas for habitat conservation and restoration. Criteria include areas with high species diversity, rare species, and endemic species; specific areas that are critical to the survival of priority species (e.g., particular streams or spawning sites); and areas recognized by previous national and/or regional prioritization efforts.
 - Priority watersheds for freshwater conservation in the Watauga River River basin include (based in part on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.4b):
 - o Watauga River
- Support conservation and restoration of streams and riparian zones in priority areas (acquisition, easements, and buffers). Support stream conservation and restoration by working collaboratively with other organizations.
- Promote and support conservation and restoration efforts within the Commission.
 - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, into Game Lands management, and into Game Lands acquisitions

Population management and restoration

- Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.
- Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.
- Investigate potential for reintroduction of common upper Tennessee River basin species (i.e. wavy-rayed lampmussel, rainbow) to the upper Watauga River, as habitat conditions dictate. No stocks for reintroduction are available from the basin in North Carolina— these would have to come from elsewhere in the upper Holston River system in Tennessee or Virginia.

Data collection, management, and dissemination

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships

- Coordinate sampling with other resource groups.
- Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.
- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources. Improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
 - When available, update crayfish and mussel atlases with presently known species occurrence and distributions in the Watauga basin.
- Develop and disseminate print media, including stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
 - Deliver oral presentations.
 - Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, Federal Energy Regulatory Commission, and US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection

- Support strengthening of water quality protection.
 - Support water quality rules and watershed designations that conserve habitats for priority aquatic species. Outstanding Resource Water and High Quality Water designations should be supported wherever the criteria for designation are met, especially in watersheds that support priority species.
 - Support incentive and information programs that help reduce sedimentation/erosion (e.g., fencing livestock from streams, improve tilling practices), minimize pesticide and herbicide use, modernize wastewater treatment facilities, etc.

Land-use planning efforts – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishing riparian buffers along streams, implement low impact development, and better stormwater management (e.g., secondary and cumulative impacts; NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

- Support federal and state species listing processes.
 - Focus analysis and synthesis of inventory and monitoring data and reporting to inform decision making pertaining to initial species listing and status revision.
 - When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.

- Improve coordination with US Fish & Wildlife Service to focus Section 6 (US Endangered Species Act) activities on priorities for listing and recovery. Activities that are applicable to goals and objectives of recovery plans should be tracked and recovery plans should be updated and revised as necessary.
 - Coordinate with US Fish & Wildlife Service to plan and align activities for federal Candidate species and Species of Concern with specific information or management needs.

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

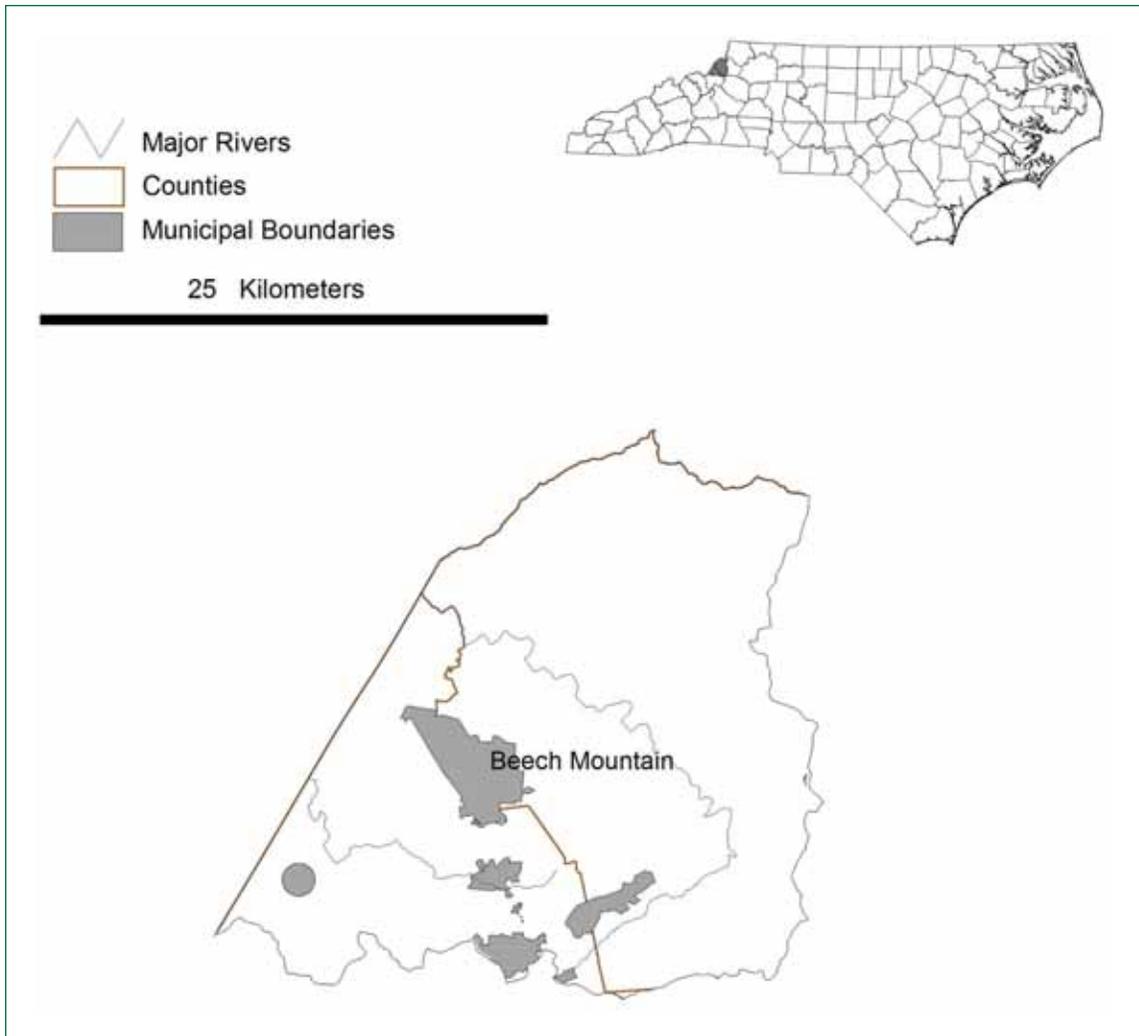
- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

Supporting References

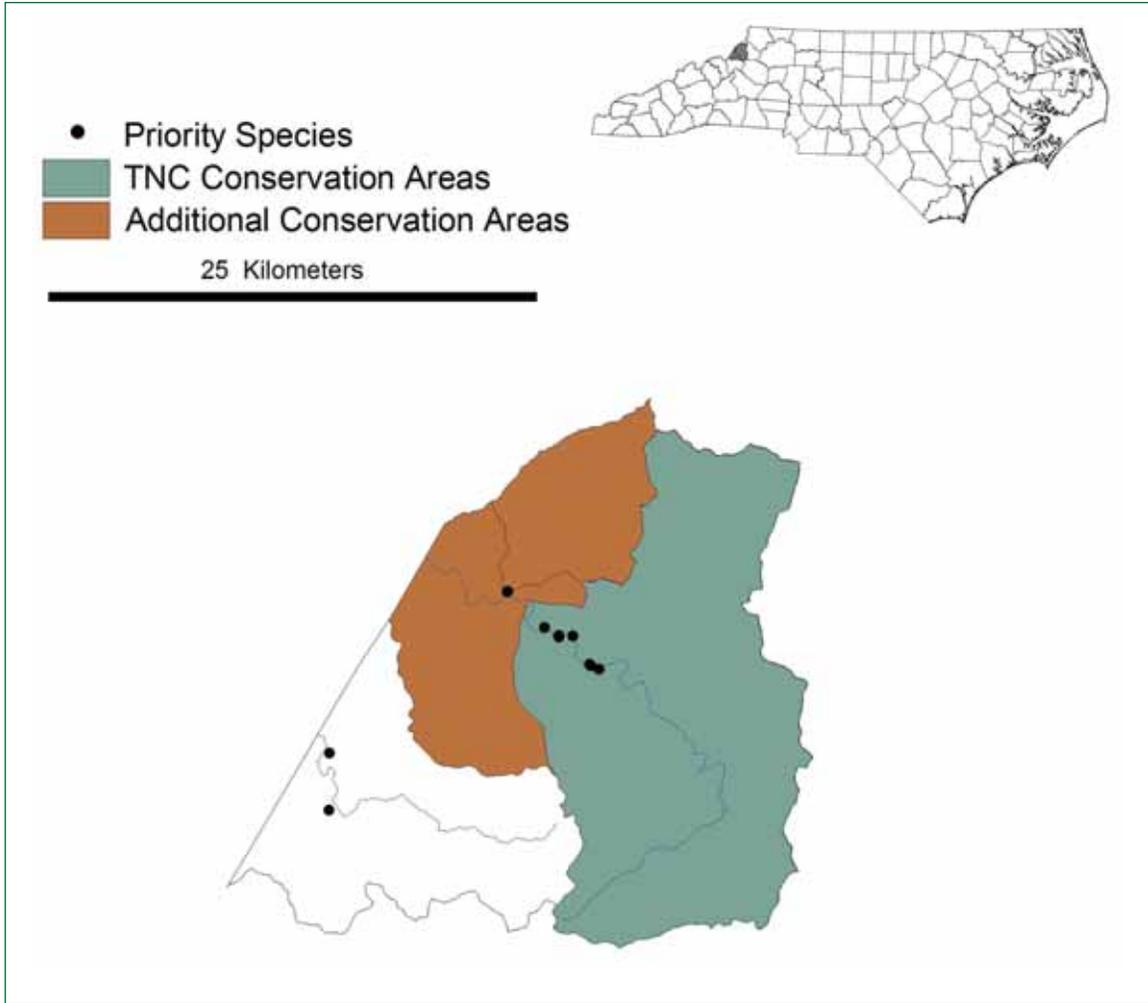
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Map 5B.4a. Watauga River basin, political information.



Map 5B.4b. Watauga River basin, priority species occurrences and priority areas for freshwater conservation.

5. New River Basin

Priority aquatic species in the New River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish	<i>Etheostoma kanawhae</i>	Kanawha Darter	SR
	<i>Exoglossum laurae</i>	Tonguetied Minnow	SR
	<i>Notropis photogenis</i>	Silver Shiner	
	<i>Notropis rubellus</i>	Rosyface Shiner	
	<i>Notropis volucellus</i>	Mimic Shiner	
	<i>Percina caprodes</i>	Logperch	T
	<i>Percina oxyrhynchus</i>	Sharpnose Darter	SC
	<i>Phenacobius teretulus</i>	Kanawha Minnow	SC
	<i>Pimephales notatus</i>	Bluntnose Minnow	
Mussels	<i>Cyclonaias tuberculata</i>	Purple Wartyback	E
	<i>Elliptio dilatata</i>	Spike	SC
	<i>Lasmigona subviridis</i>	Green Floater	E
Snails	<i>Leptoxis dilatata</i>	Seep Mudalia	T

A. Location and condition of basin (see Maps 5B.5a, 5B.5b):

The New River basin in North Carolina is located in the northwest corner of the state in Ashe, Alleghany, and Watauga counties. The basin drains 753 sq. miles in North Carolina and includes approximately 801 stream miles. It is part of the Kanawha/Ohio/Mississippi River system and is the only Interior Basin drainage in North Carolina that does not flow into the Tennessee River. It is entirely within the Blue Ridge physiographic province and is comprised of three sub-basins:

- **North Fork New River** tributaries -- Roaring, Brush, and Hoskin Forks; Helton, Silas, Buffalo, Three Top, Big Laurel, and Long Hope Creeks
- **South Fork New River** tributaries -- Meadow, Piney, East and Middle Forks; Cranberry, Peak, Howard, Meat Camp, Roan, Naked, and Winkler Creeks.
- **Little River** tributaries -- Brush Creek and Laurel Branch; Elk, Glade, Bledsoe, and Pine Swamp Creeks.

Land use in the basin is 53% forested, 33% pasture/cropland, 6% urban, and 8% other (NCDWQ 2000). The North Carolina portion of the New River basin is mountainous and rural. Most agriculture and development is concentrated in the valleys with the exception of Christmas tree farms; however, development on steeper slopes is increasing. Impoundments include Appalachian State University Lake (18 acres) on Norris Branch in the South Fork New River watershed (water supply reservoir), one hydroelectric facility at Sharpe Falls (run-of-the-river), North Fork New River. The headwaters of Laurel Branch in the Little River sub-basin contain three impoundments for irrigation to Olde Beau Golf Course Community. Public land ownership in the basin includes New River State Park (1,300 acres along the South Fork New River), Mount Jefferson State Natural Area, Three Top Mountain Game Land, and relatively small areas within the Blue Ridge Parkway (National Parks Service). Recently, 300 acres of Sparta Bog was purchased by the NC Department of Transportation for mitigation. All other land is private.

Water quality is generally good in the New River Basin. Water quality ratings include 95% fully supporting, 2% impaired, 3% not rated (NCDWQ 2000). Impaired waters within the New River Basin include Naked Creek, Little Buffalo Creek (waste water treatment plant discharge, non-point sources-sedimentation), Peak Creek, Ore Knob Branch, and Little Peak Creek (acid mine drainage). Trout waters are abundant and many streams are classified as High Quality or Outstanding Resource Waters. The 26.5 miles of the lower South Fork New River and the entire

portion of the New River in North Carolina are designated as both a National Scenic River and a state Natural and Scenic River. This reach is also classified as Outstanding Resource Waters. The entire New River was named an American Heritage River in 1998. Most of the middle reach of the South Fork New River is designated as High Quality Waters, as is the lower Little River.

B. *Problems affecting species and habitats:*

While water quality is generally good overall, there are localized problems and general habitat degradation in many cool-warm water habitats for priority species throughout the basin. The factors affecting aquatic habitat degradation (primarily through erosion and sedimentation) are development and land clearing, poorly managed livestock grazing (run-off and stream bank degradation), unpaved rural roads along streams, and general loss of riparian vegetation.

Development (primarily new home construction) is increasing throughout the basin, especially on steeper slopes. Impacts from sedimentation appear to be quite severe in some localized areas and generally degrade habitats in larger tributaries and in the mainstem New River. Increasing population is also placing greater demand on drinking water supplies. Increases in water withdrawals from streams primarily in the upper South Fork New sub-basin, is a potential problem.

Water quality is variously degraded by acid mine drainage, impacts from urban runoff, and waste water treatment plant discharge. Christmas tree production is a major agricultural enterprise in the basin and large amounts of pesticides and herbicides are used. Impacts from this on aquatic systems are largely unknown.

Numerous non-native aquatic animal species are established in the basin. As identified in previous basin accounts, non-native vegetation can also negatively impact native aquatic animal communities. This includes both aquatic and riparian plant species and non-native plant pathogens that can alter riparian vegetation and affect aquatic habitats (e.g., hemlock wooly adelgid). Impacts on populations of native species are unclear at present, but should be a focus of long-term monitoring and specific investigations.

C. *Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:*

Inventory: distributional and status surveys – General surveys are needed to complete the distributional status for aquatic snails, crayfish, mussels, and fish (in order of general need). (Partners in North Carolina include: NC Division of Water Quality, NC Department of Transportation, US Forest Service, National Parks Service (Blue Ridge Parkway), Appalachian State University, National Committee for the New River, New River State Park; an interstate, intrabasin partner is the Virginia Department of Game and Inland Fisheries).

- Snails – inventory primary distribution; determine potential habitats and distribution surveys for hydrobiids.
- Crayfish, mussels, and fish – update status surveys.
- Determine distribution of non-native species.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed.

- Snails – support identification and description of all species in the basin.

Research to facilitate appropriate conservation actions – Research should generally focus on life history of priority species. Specific questions to be addressed include: habitat use/preferences, spawning location and timing, fecundity, population dynamics, population genetics, feeding, competition, predation. Research must also be conducted to determine vulnerability of priority species to specific threats, particularly as related to our permit review and conditions responsibilities. Studies should provide recommendations for mitigation and restoration.

- Support life history and habitat requirement studies for green floater, especially focused on factors that may limit populations in the New River.
- Support investigations into potential impacts to aquatic systems from intensive silvicultural applications of pesticides.
- All other priority species:
 - Review available information and support life history investigations where lacking.
 - Support investigation of potential for reintroduction of extirpated species to New River.
 - Support investigations of population response to stream restoration projects (especially in priority areas).

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible. (Potential partners in North Carolina include: NC Division of Water Quality, Appalachian State University, New River State Park, National Committee for the New River, US Fish & Wildlife Service, US Forest Service, and the National Parks Service (Blue Ridge Parkway); an interstate, intrabasin cooperator is the Virginia Department of Game and Inland Fisheries).

- Conduct long-term monitoring to identify population trends of priority species. Establish protocol, schedule, and sites for long-term population monitoring.
 - Basin specific priorities include the green floater, Kanawha darter, Kanawha minnow, tongue-tied minnow, sharpnose darter, seep mudalia.
- Conduct special purpose monitoring to assess performance of specific conservation actions:
 - Performance of stream restoration projects.
 - o Continue to cooperate with US Army Corps of Engineers to assess stream restoration projects on South Fork New River.
 - Performance of hydropower remediation.
 - Performance of species restoration projects.
- Assess non-native species impacts – monitor populations of potentially injurious non-native species and impacts on priority species:
 - Monitor spread of multiple introduced fish species and potential impacts to native communities.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration – Promote and support habitat conservation and restoration efforts by external entities. (Potential partners in the New River Basin include: Natural Resources Conservation Service, Ecosystem Enhancement Program, National Committee for the New River, New River State Park, US Fish & Wildlife Service, US Forest Service, county-based soil and erosion control efforts, and private landowners).

- Identify priority areas for habitat conservation and restoration. Criteria include areas with high species diversity, rare species, and endemic species; specific areas that are critical to the survival of priority species (e.g., particular streams or spawning sites); and areas recognized by previous national and/or regional prioritization efforts.
 - Priority watersheds for freshwater conservation in the Watauga River River basin include (based in part on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.5b):
 - o Mainstem New River
 - o South Fork New River
 - o Lower North Fork New River
 - o Little River

- Support conservation and restoration of streams and riparian zones in priority areas (acquisition, easements, and buffers). Support stream conservation and restoration by working collaboratively with other organizations.
- Promote and support conservation and restoration efforts within the Commission.
 - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, into Game Lands management, and into Game Lands acquisitions

Population management and restoration

- Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

Data collection, management, and dissemination among agencies

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Coordinate sampling with other resource groups.
- Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.
- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources. Improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
 - When available, update crayfish and mussel atlases with presently known species occurrence and distributions in the New basin.
- Develop and disseminate print media, including: stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
 - Deliver oral presentations.
 - Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, Federal Energy Regulatory Commission [FERC], US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection

- Support strengthening of water quality protection.
 - Support water quality rules and watershed designations that conserve habitats for priority aquatic species. Outstanding Resource Water and High Quality Water designations should be supported wherever the criteria for designation are met, especially in watersheds that support priority species.

- Support incentive and information programs that help reduce sedimentation/erosion (e.g., fencing livestock from streams, improve tilling practices), minimize pesticide and herbicide use, modernize wastewater treatment facilities, etc.
- Work through the FERC re-licensing process and other opportunities to mitigate negative impacts from hydropower development. Support practicable mitigation and restoration for hydropower impacts throughout the New River basin

Land-use planning efforts – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishing riparian buffers along streams, implement low impact development, and better stormwater management (e.g., secondary and cumulative impacts; NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

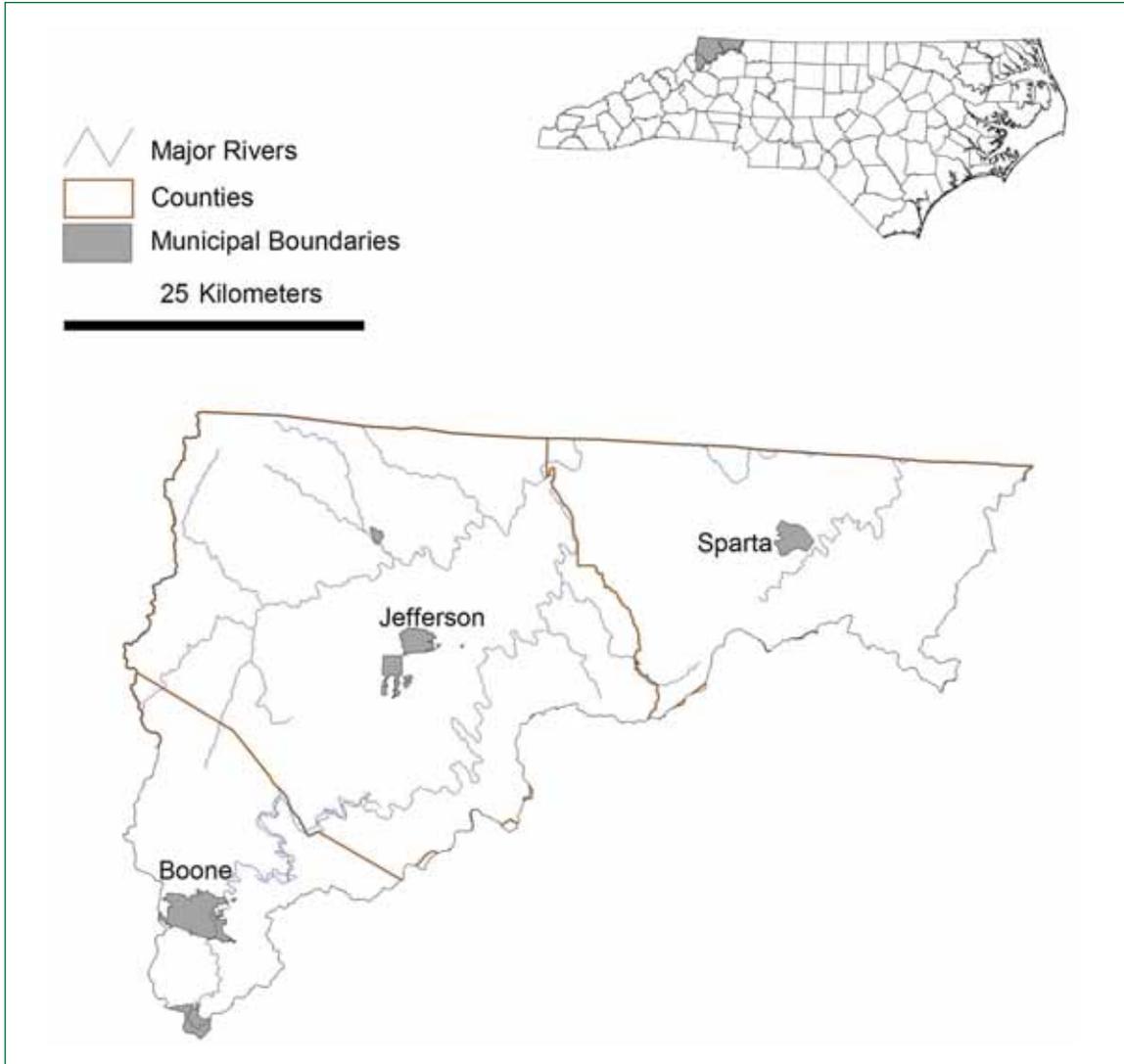
- Support federal and state species listing processes.
 - Focus analysis and synthesis of inventory and monitoring data and reporting to inform decision making pertaining to initial species listing and status revision.
 - When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.
- Improve coordination with US Fish & Wildlife Service to focus Section 6 (US Endangered Species Act) activities on priorities for listing and recovery. Activities that are applicable to goals and objectives of recovery plans should be tracked and recovery plans should be updated and revised as necessary.
 - Coordinate with US Fish & Wildlife Service to plan and align activities for federal Candidate species and Species of Concern with specific information or management needs.
- Investigate, implement, and support (as appropriate) programs that are directed at listed species recovery (e.g., Habitat Conservation Planning, Landowner Incentive Program, Safe Harbor).

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

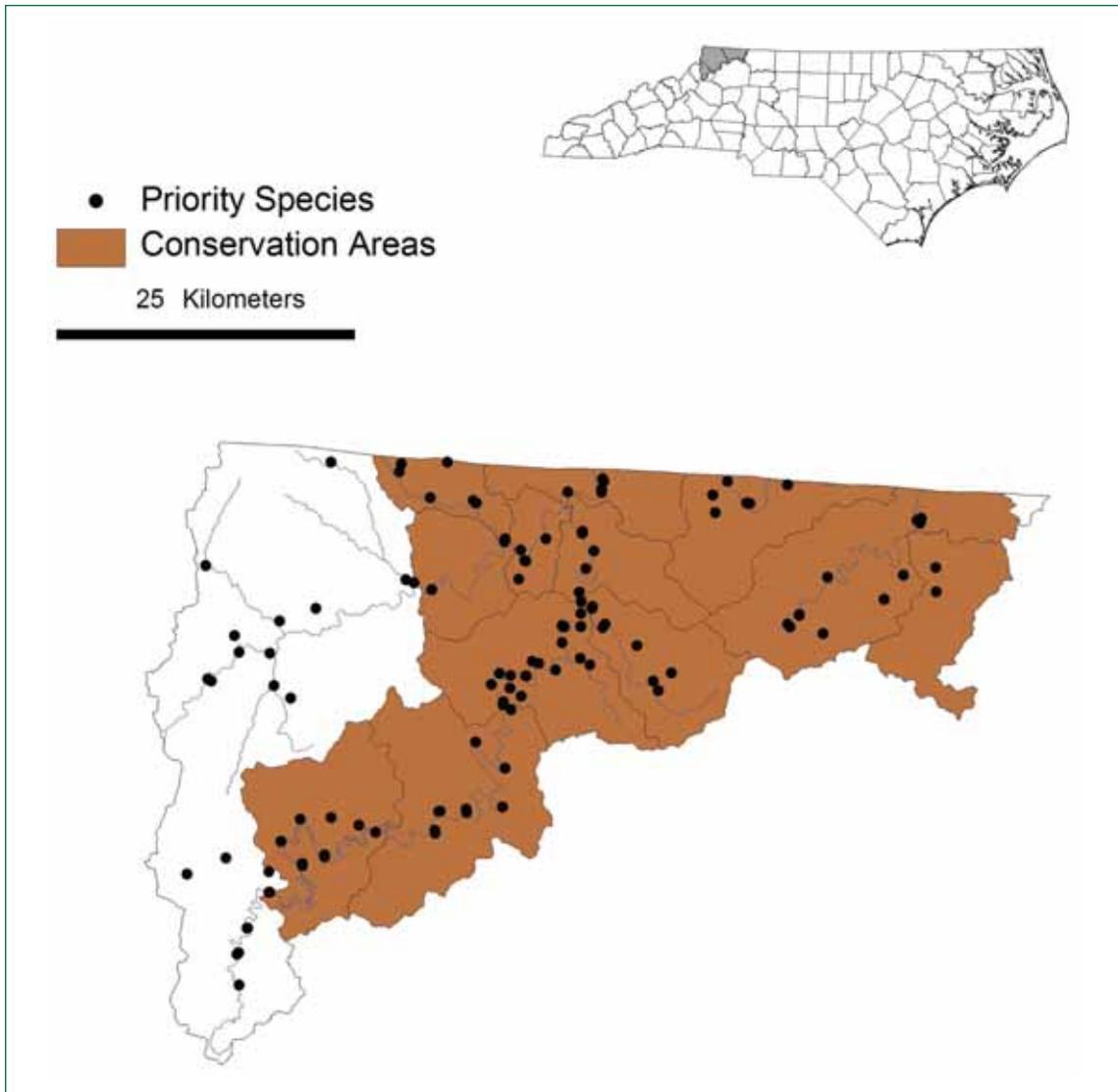
- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

Supporting References

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Map 5B.5a. New River basin, political information.



Map 5B.5b. New River basin, priority species occurrences and priority areas for freshwater conservation.

6. Savannah River Basin

Priority aquatic species in the Savannah River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish	<i>Ameiurus brunneus</i>	Snail Bullhead	
	<i>Etheostoma inscriptum</i>	Turquoise Darter	SC
	<i>Hybopsis rubifrons</i>	Rosyface Chub	T
	<i>Notropis lutipinnis</i>	Yellowfin Shiner	SC
	<i>Percina nigrofasciata</i>	Blackbanded Darter	
Crayfish	<i>Cambarus chaugaensis</i>	Oconee Stream Crayfish	SC
	<i>Cambarus reburus</i>	French Broad River Crayfish	SR

A. Location and condition of basin (see Maps 5B.6b¹):

The headwaters of the Savannah River basin begin along the eastern slopes of the Blue Ridge Mountains. The river flows south through Georgia and South Carolina and empties into the Atlantic Ocean. Only 2% of the total Savannah River basin is in North Carolina, encompassing 172 sq. miles in small portions of Macon, Jackson, Transylvania, and Clay counties. The North Carolina portion of the basin is entirely within the Blue Ridge physiographic province and consists of 176 miles of streams and 1,366 reservoir acres. Streams in North Carolina are part of the Tugaloo River and Seneca River sub-basins; however, both of these named rivers begin outside the state. Major tributaries of the Tugaloo in North Carolina are the Overflow and Big creeks, and the Chattooga River. Major tributaries of the Seneca River in North Carolina include the Toxaway, Horsepasture, Thompson, and Whitewater rivers.

Land use in the basin is 96% forest/wetland, 2.1% pastureland, and <1% urban (NCDWQ 2002). Much of the basin is publicly owned, including portions of Nantahala National Forest, 3,000 acres of Commission lands, and 7,000 acres within NC Gorges State Park. There are a few small reservoirs, include Cashiers Reservoir, Fairfield Reservoir, and Toxaway Reservoir. Many ponds associated with golf courses and second home developments in the Cashiers/Highlands area contribute to habitat fragmentation, temperature pollution and a source of non-native introductions.

There are no impaired waters within the basin (62% fully supporting, 38% not rated) (NCDWQ 2002). Water quality in this basin is excellent in major streams and most small headwater streams. Some small headwater streams are being impacted by runoff from construction in developing areas. Most of the Tugaloo River tributaries in North Carolina are designated Outstanding Resource Waters, including the Chattooga River, Big Creek, and Overflow Creek. The Whitewater River and lower Bear Wallow Creek are designated High Quality Waters in the Seneca River sub-basin.

B. Problems affecting species and habitats:

While much of the basin in North Carolina is in National Forest and State Park lands, development is increasing on private lands. Non-point source problems (primarily erosion and sedimentation) from land clearing, removal of riparian vegetation, and rural roads are potential problems. Numerous small impoundments fragment headwater habitats. All of the major tributaries in North Carolina are upstream from major impoundments in Georgia and South Carolina that isolate them from the rest of the basin. Short reaches of the Horsepasture and Toxaway rivers are impounded just inside the North Carolina border (Lake Jocassee, Duke Power).

¹There is no political map ('5B.6a') for the Savannah River basin because the basin occupies such a small portion of North Carolina.

Little is known of the extent to which non-native aquatic species have become established in the Savannah basin in North Carolina. Non-native vegetation can also negatively impact native aquatic animal communities. This includes both aquatic and riparian plant species and non-native plant pathogens that can alter riparian vegetation and affect aquatic habitats (e.g., hemlock woolly adelgid).

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

Inventory: distributional and status surveys – General surveys are needed to complete the distributional status for aquatic snails, crayfish, mussels, and fish (in order of general need) (Potential partners in the Savannah basin include: NC Division of Water Quality, NC Department of Transportation, US Forest Service, Gorges State Park; interstate, intrabasin partners include the South Carolina Department of Natural Resources and the Georgia Department of Natural Resources).

- Review existing data and determine information needs for all taxa.
- Inventory and status surveys per identified needs (especially primary distribution of crayfish and snails).
- Determine distribution of non-native species.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed.

- Snails – support identification and description of all species in the basin.
- Collect specimens of redhorse suckers for taxonomic study (cooperate with Roanoke College).

Research to facilitate appropriate conservation actions – Research should generally focus on life history of priority species. Specific questions to be addressed include: habitat use/preferences, spawning location and timing, fecundity, population dynamics, population genetics, feeding, competition, predation. Research must also be conducted to determine vulnerability of priority species to specific threats, particularly as related to our permit review and conditions responsibilities. Studies should provide recommendations for mitigation and restoration.

- Review available information and support life history investigations where lacking.
- Support investigations into impacts from habitat fragmentation in the basin (due to impoundments or other factors).
- Support investigations of population response to stream restoration projects (especially in priority areas).

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible. (Potential partners in North Carolina include: NC Division of Water Quality, NC Department of Transportation, US Forest Service, Gorges State Park; interstate, intrabasin partners include the South Carolina Department of Natural Resources and the Georgia Department of Natural Resources).

- Conduct long-term monitoring to identify population trends of priority species. Establish protocol, schedule, and sites for long-term population monitoring.
- Conduct special purpose monitoring to assess performance of specific conservation actions:
 - Performance of stream restoration projects.
 - Performance of hydropower remediation.
 - Performance of species restoration projects.

- Assess non-native species impacts :
 - Monitor populations of potentially injurious non-native species and impacts on priority species.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration – Promote and support habitat conservation and restoration efforts by external entities. (Potential partners in the Savannah River Basin include: Natural Resources Conservation Service, Ecosystem Enhancement Program, US Forest Service, Gorges State Park, county-based soil and erosion control efforts, and private landowners).

- Identify priority areas for habitat conservation and restoration. Criteria include areas with high species diversity, rare species, and endemic species; specific areas that are critical to the survival of priority species (e.g., particular streams or spawning sites); and areas recognized by previous national and/or regional prioritization efforts.
 - Priority watersheds for freshwater conservation in the Savannah River basin include (based in part on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.6b):
 - o Chattooga River
 - o Toxaway River
 - o Whitewater River
- Support conservation and restoration of streams and riparian zones in priority areas (acquisition, easements, and buffers). Support stream conservation and restoration by working collaboratively with other organizations.
- Promote and support conservation and restoration efforts within the Commission.
 - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, into Game Lands management, and into Game Lands acquisitions

Population management and restoration

- Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

Data collection, management, and dissemination among agencies

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships

- Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.
 - Coordinate sampling with other resource groups.
 - Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.
- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources. Improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
 - Update crayfish and mussel atlases with presently known species occurrence and distributions in the Savannah basin.

- Develop and disseminate print media, including: stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
 - Deliver oral presentations.
 - Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection – Work with regulatory agencies (e.g., US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, etc.) and processes to conserve and restore water and habitat quality.

- Support strengthening of water quality protection.
 - Support water quality rules and watershed designations that conserve habitats for priority aquatic species. Outstanding Resource Water and High Quality Water designations should be supported wherever the criteria for designation are met, especially in watersheds that support priority species.
 - Support incentive and information programs that help reduce sedimentation/erosion (e.g., fencing livestock from streams, improve tilling practices), minimize pesticide and herbicide use, modernize wastewater treatment facilities, etc.
- Work through the Federal Energy Regulatory Commission relicensing process and other opportunities to mitigate negative impacts from hydropower development.

Land-use planning – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishing riparian buffers along streams, implement low impact development, and better stormwater management (e.g., secondary and cumulative impacts; NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

- Support federal and state species listing processes.
 - Focus analysis and synthesis of inventory and monitoring data and reporting to inform decision making pertaining to initial species listing and status revision.
 - When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.
- Improve coordination with US Fish & Wildlife Service to focus Section 6 (US Endangered Species Act) activities on priorities for listing and recovery. Activities that are applicable to goals and objectives of recovery plans should be tracked and recovery plans should be updated and revised as necessary.
 - Coordinate with US Fish & Wildlife Service to plan and align activities for federal Candidate species and Species of Concern with specific information or management needs.

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

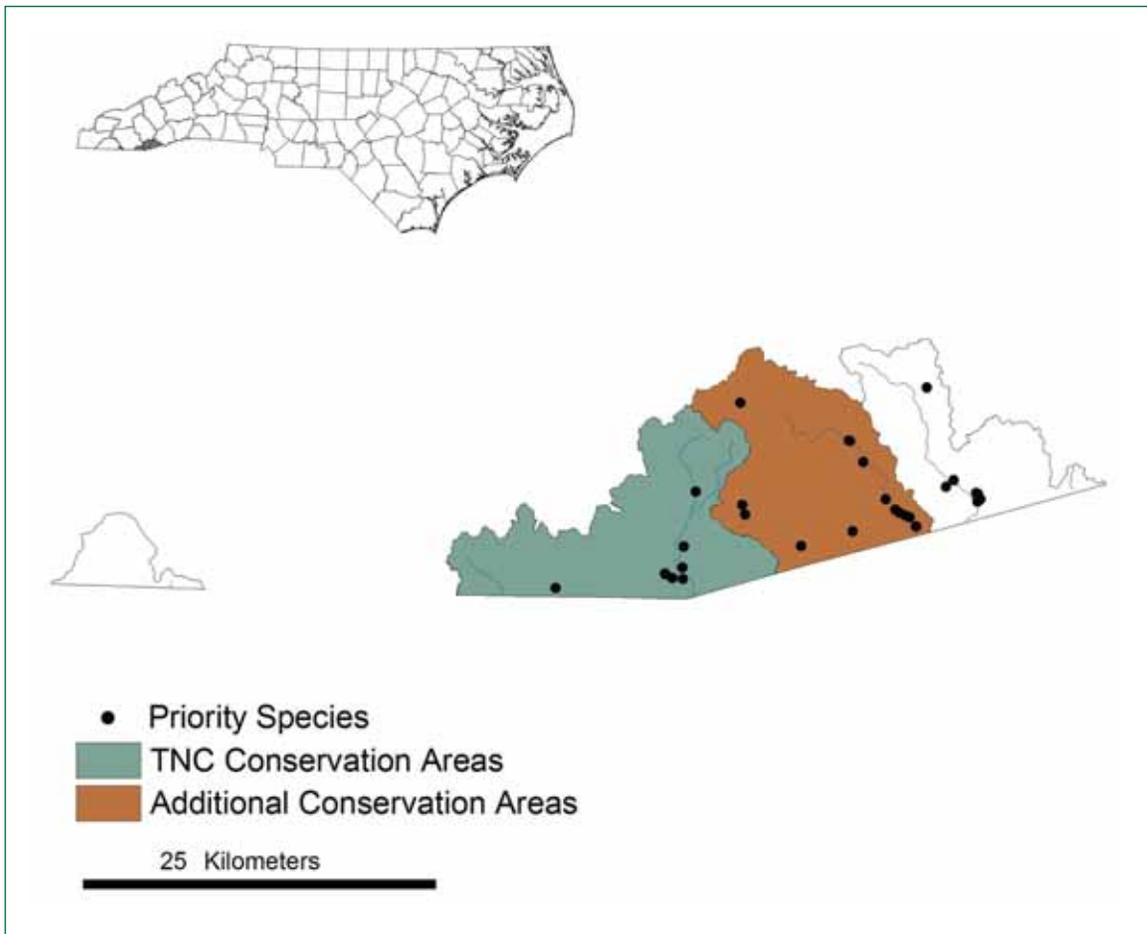
- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

Supporting References

N.C. Division of Water Quality (NCDWQ). 2002. Savannah River basinwide water quality plan. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

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Map 5B.6b. Savannah River basin, priority species occurrences and priority areas for freshwater conservation.

7. Broad River Basin

Priority aquatic species in the Broad River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish	<i>Ameiurus brunneus</i>	Snail Bullhead	
	<i>Carpiodes cyprinus</i>	Quillback	
	<i>Moxostoma collapsum</i>	Notchlip Redhorse	
	<i>Moxostoma pappillosum</i>	V-lip Redhorse	
Mussels	<i>Elliptio icterina</i>	Variable Spike	
	<i>Strophitus undulatus</i>	Creeper (Squawfoot)	T
Crayfish	<i>Cambarus lenati</i>	Broad River Stream Crayfish	SR
	<i>Cambarus spicatus</i>	Broad River Spiny Crayfish	SC

A. Location and condition of basin (see Maps 5B.7a, 5B.7b):

Headwaters of the Broad River basin begin along the eastern slopes of the Blue Ridge Mountains (Blue Ridge Physiographic province) and flow southeast through foothills and piedmont (Inner Piedmont physiographic province) before crossing into South Carolina. The Broad River drains to the Atlantic Ocean via the Congaree and Santee Rivers in South Carolina. The basin area in North Carolina is 1,513 sq. miles, with 1,495 stream miles, and 1,954 reservoir acres. The basin primarily drains Polk, Rutherford, and Cleveland counties, with small portions of Henderson, Buncombe, and McDowell counties in the headwaters, and Lincoln and Gaston counties in the lower basin.

Land use in the basin is 74% forested, 22% pastureland, 2% urban (NCDWQ 2003). Land ownership in the Broad river basin is primarily private. Publicly owned lands include South Mountains Game Land (17,000 acres), Green River Game Land (11,000 acres), and a small portion of Crowders Mountain State Park.

The upper Broad River and major tributaries (Green River, Mountain Creek, Whiteoak Creek, and North Pacolet River) begin in the Blue Ridge physiographic province and flow through the foothills. The Second Broad River, First Broad River, Buffalo Creek and the lower Broad River drain the foothills and Inner Piedmont. Overall stream gradient decreases as the topography changes from the mountains of the Blue Ridge to the hills and rolling landscape of the Inner Piedmont. Soils in the piedmont generally contain greater proportions of sand and clay and higher erosion potential than those in the upper portion of the basin. Stream habitats in the lower basin are generally dominated by runs and pools with high proportions of sandy and silty substrates.

Major reservoirs (by tributary) include:

- Green River – Lake Summit and Lake Adger (Northbrook Carolina Hydro)
- Broad River – Lake Lure (Carolina Mountain Power, Town of Lake Lure) and Gaston Shoals (Duke Power)
- First Broad River – Stice Shoals (Northbrook Carolina Hydro)
- Second Broad River – Cliffside (Duke Power), Henrietta, and Caroleen
- Buffalo Creek – Kings Mountain Reservoir
- Britten Creek – Pavillon

Water quality ratings in the basin include 56.5% fully supporting, 0.3% impaired, 1.1% not rated, 42.1% no data (NCDWQ 2003). Overall, water quality is generally good where NC Division of Water Quality data are available; however, there are problems in parts of the basin and the lack of data for nearly half the basin leaves an unclear assessment of overall water quality.

B. Problems affecting species and habitats:

Habitat degradation primarily resulting from sedimentation is the main water quality issue in the basin. Stream sedimentation is severe and widespread in the Piedmont portion of the basin. The major causes of sedimentation are land clearing activities (construction, row crop agriculture, timber harvest, and mining), stream bank erosion, and runoff from unpaved rural roads and eroding road grades (NCDWQ 2003). Poorly managed pasture lands contribute substantially to overall soil and stream bank erosion. Often, riparian vegetation is minimal or non-existent and cattle have unlimited direct access to streams. Overall lack of riparian vegetation is a widespread problem throughout the basin.

Hydraulic and hydrologic alterations to streams, through accelerated stream bank erosion and channel instability, also contribute both directly and indirectly to habitat degradation. Streams have been channelized in both rural and developed areas in the basin. Development and urbanization also increase impervious surfaces and often produce drainage patterns and structures that speed the runoff of rainwater and alter hydrograph curves. This hydrologic alteration (flashiness) further accelerates stream bank erosion and channel degradation.

Water quality problems are attributable to both point and non-point sources. Point sources are primarily waste water treatment plants and industrial dischargers. Both municipal waste water treatment plants and industrial sources discharge colored effluents to streams in the basin, especially in the Second Broad River watershed. The impacts of these effluents at permitted levels are generally regarded as minimal, but effects on native aquatic communities from other solutes in these and other discharges are unclear. Problems with meeting permitted discharge limits have occurred at several waste water treatment plants in the basin (NCDWQ 2003). There may also be problems related to unpermitted waste water discharges. Additionally, there are 11 golf courses in the basin that add additional non-point inputs and contribute to overall water quality problems.

There are significant impacts to native aquatic communities in the Broad River basin from impoundments; however, they are not as widespread as in some of the other Western basins (e.g., Hiwassee, Little Tennessee, and Catawba). Lake Lure, Kings Mountain, and Lake Adger impoundments appear to have the greatest impact on aquatic resources. Impacts include thermal and hydrologic alteration to tailwaters, water quality issues due to nonexistent or inadequate minimum flow requirements, direct effects of impoundment, and fragmentation of upstream populations.

Several existing impoundments are used for water supply and new impoundments are being proposed within the basin for the same reason. As human population increases, water supply is an increasing burden on surface waters. Water withdrawals, impoundments, and interbasin water transfers can significantly alter habitats for native aquatic species. This is an emerging problem that will likely increase in importance in the near future.

Non-native species known from the Broad River basin include the Asian clam, common carp, smallmouth bass, muskellunge, and rainbow and brown trout. Some stream fishes found in the headwaters may also be introduced (e.g., warpaint shiner). Landlocked blueback herring and alewife are also present in some reservoirs. Non-native vegetation can also negatively impact native aquatic animal communities. This includes both aquatic and riparian plant species and non-native plant pathogens that can alter riparian vegetation and affect aquatic habitats (e.g., hemlock woolly adelgid). Presently, specific impacts from non-native species in the Broad River basin are unclear.

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

Inventory: distributional and status surveys – General surveys are needed to complete the distributional status for aquatic snails, crayfish, mussels, and fish (in order of general need). (Cooperators in North Carolina include the NC Division of Water Quality, NC Department of Transportation, US Fish & Wildlife Service, NC Museum of Natural Sciences; an interstate, intrabasin cooperator is the South Carolina Department of Natural Resources).

- Snails – inventory primary distribution; determine potential habitats and distribution surveys for hydrobiids.
- Crayfish – complete primary inventories and determine status of endemic species.
- Determine distribution of non-native species.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed.

- Mussels in the genera *Elliptio* and *Strophitus* – support resolution of taxonomic problems and species descriptions (if required) (cooperate with the NC Museum of Natural Sciences, NC State University).
- Crayfish – support description and species diagnosis of all crayfish species in the basin (cooperate with the NC Museum of Natural Sciences).

Research to facilitate appropriate conservation actions – Research should generally focus on life history of priority species. Specific questions to be addressed include: habitat use/preferences, spawning location and timing, fecundity, population dynamics, population genetics, feeding, competition, predation. Research must also be conducted to determine vulnerability of priority species to specific threats, particularly as related to our permit review and conditions responsibilities. Studies should provide recommendations for mitigation and restoration.

- Review available information and support life history investigations where lacking.
- Support investigations into impacts from habitat fragmentation in the basin (due to impoundments or other factors).
- Support investigations of population response to stream restoration projects (especially in priority areas).
- Support research to improve habitat conditions in regulated rivers.

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible. (Cooperators in North Carolina include the: NC Division of Water Quality, NC Department of Transportation, Duke Power, US Fish & Wildlife Service, and the NC Museum of Natural Sciences; an interstate, intrabasin cooperator is the South Carolina Department of Natural Resources).

- Conduct long-term monitoring to identify population trends of priority species. Establish protocol, schedule, and sites for long-term population monitoring.
- Conduct special purpose monitoring to assess performance of specific conservation actions:
 - Performance of stream restoration projects.
 - Performance of hydropower remediation.
 - Performance of species restoration projects.
- Assess non-native species impacts and monitor populations of potentially injurious non-native species and their impacts on priority species.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration – (Potential partners in the Broad River Basin include: Upper Broad River Watershed Protection Program, Carolina Mountain Land Conservancy, Foothills Conservancy, Catheys Creek Watershed Technical Advisory Committee, Natural Resources Conservation Service, Ecosystem Enhancement Program, NC Natural Heritage Program, US Forest Service, county-based soil and erosion control efforts, and private landowners).

- Identify priority areas for habitat conservation and restoration. Criteria include areas with high species diversity, rare species, and endemic species; specific areas that are critical to the survival of priority species (e.g., particular streams or spawning sites); and areas recognized by previous national and/or regional prioritization efforts.
 - Priority watersheds for freshwater conservation in the Broad River basin include (based in part on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.7b):
 - o Green River
 - o Upper First Broad River
 - o Kings Creek (mostly in South Carolina, headwaters in North Carolina)
- Support conservation and restoration of streams and riparian zones in priority areas (acquisition, easements, and buffers). Support stream conservation and restoration by working collaboratively with other organizations.
- Promote and support conservation and restoration efforts within the Commission.
 - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, into Game Lands management, and into Game Lands acquisitions
 - Specific to the Broad River basin: incorporate management goals for aquatic community conservation and enhancement into management plan for Green River Game Lands.

Population management and restoration – Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

- Investigate potential for reintroduction of extirpated mollusk and fish species to the basin in restored or improved habitats as opportunities become available.

Data collection, management, and dissemination among agencies

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Coordinate sampling with other resource groups.
- Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.
- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources. Improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.). Specific basin priorities include updating crayfish and mussel atlases with presently known species occurrence and distributions in the Broad basin.
- Develop and disseminate print media, including: stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
 - Deliver oral presentations.
 - Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include the: NC Division of Water Quality, NC Division of Land Quality, US Army Corps of Engineers, Federal Energy Regulatory Commission [FERC], US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection

- Support strengthening of water quality protection.
 - Support water quality rules and watershed designations that conserve habitats for priority aquatic species. Outstanding Resource Water and High Quality Water designations should be supported wherever the criteria for designation are met, especially in watersheds that support priority species.
 - Support incentive and information programs that help reduce sedimentation/erosion (e.g., fencing livestock from streams, improve tilling practices), minimize pesticide and herbicide use, modernize wastewater treatment facilities, etc.
- Work through the FERC relicensing process and other opportunities to mitigate negative impacts from hydropower development. Support practicable mitigation and restoration for hydropower impacts throughout the Broad River basin.

Land-use planning – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishing riparian buffers along streams, implement low impact development, and better stormwater management (e.g., secondary and cumulative impacts; NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

- Support federal and state species listing processes.
 - Focus analysis and synthesis of inventory and monitoring data and reporting to inform decision making pertaining to initial species listing and status revision.
 - When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

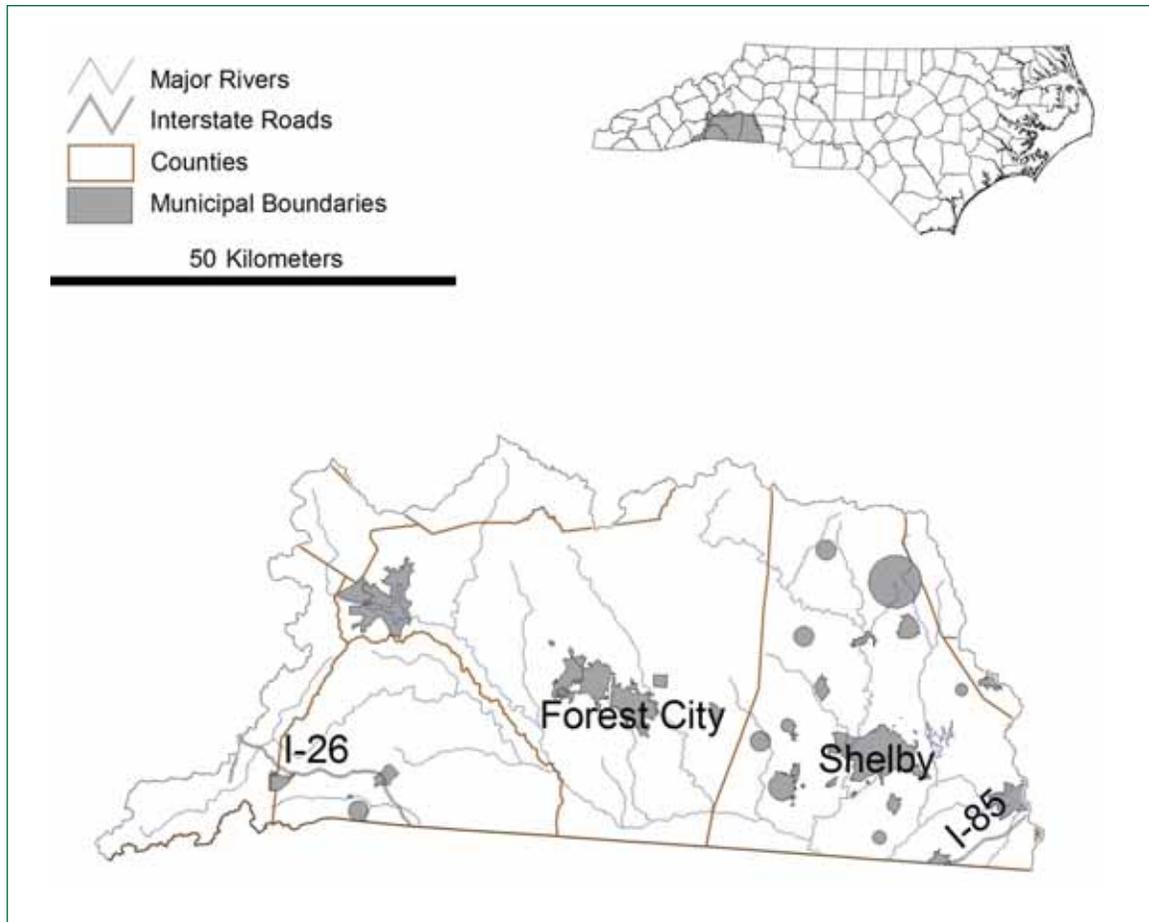
- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

Supporting References

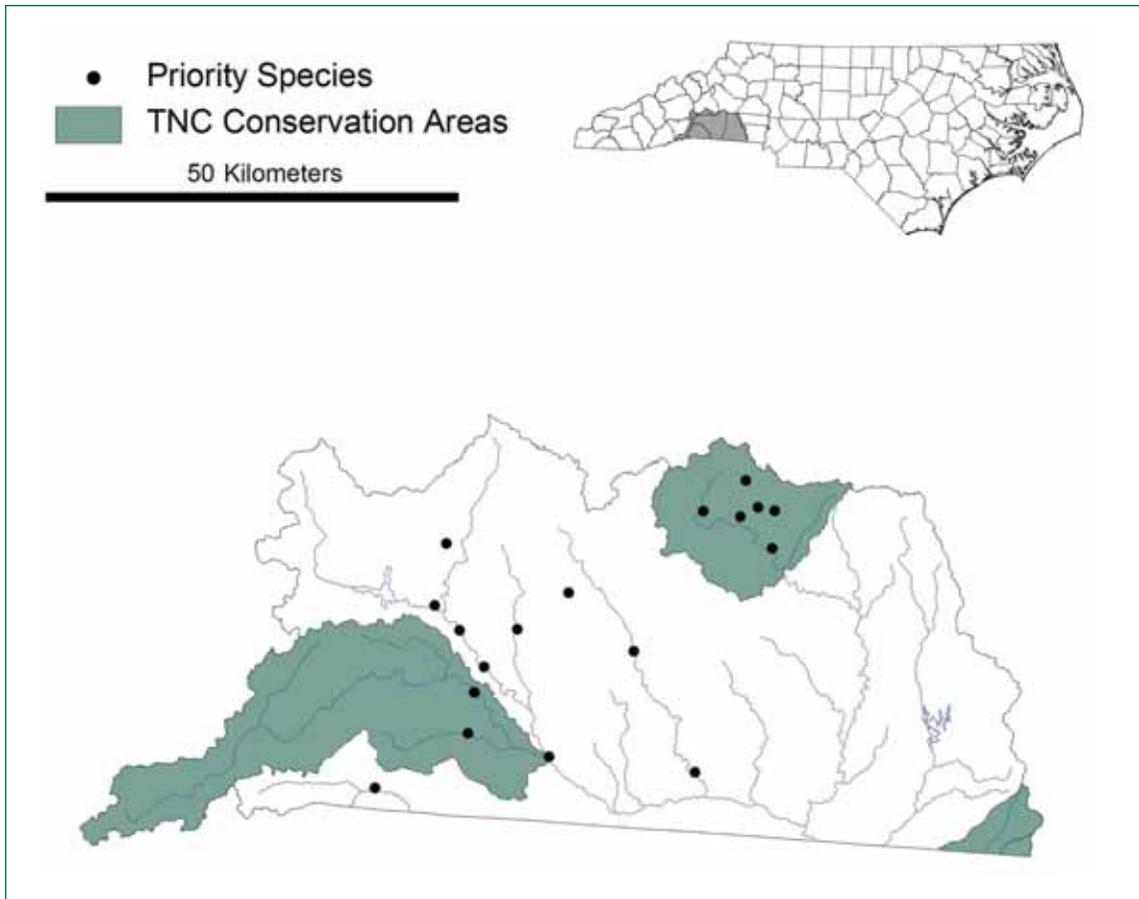
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Map 5B.7a. Broad River basin, political information.



Map 5B.7b. Broad River basin, priority species occurrences and priority areas for freshwater conservation.

8. Catawba River Basin

Priority aquatic species in the Catawba River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish ¹	<i>Ameiurus brunneus</i>	Snail bullhead	
	<i>Carpiodes cyprinus</i>	Quillback	
	<i>Carpiodes velifer</i>	Highfin Carpsucker	SC
	<i>Etheostoma collis</i>	Carolina Darter	SC
	<i>Lepomis marginatus</i>	Dollar Sunfish	
	<i>Moxostoma collapsum</i>	Notchlip Redhorse	
	<i>Moxostoma macrolepidotum</i>	Shorthead Redhorse	
	<i>Moxostoma pappilosum</i>	V-lip Redhorse	
Mussels	<i>Alasmidonta robusta</i>	Carolina Elktoe ²	SR
	<i>Alasmidonta varicosa</i>	Brook Floater	E
	<i>Elliptio cistellaeformis</i>	Box Spike	
	<i>Elliptio icterina</i>	Variable Spike	
	<i>Lasmigona decorata</i>	Carolina Heelsplitter	E (E)
	<i>Villosa constricta</i>	Notched Rainbow	SC
	<i>Villosa delumbis</i>	Eastern Creekshell	SR
	<i>Villosa vaughaniana</i>	Carolina Creekshell	E

A. Location and condition of basin (see Maps 5B.8a, 5B.8b):

The Catawba River basin begins on the eastern slopes of the Blue Ridge (Blue Ridge Physiographic Province) and flows southeast through the Inner Piedmont to the South Carolina border near Charlotte. This system, along with the Broad system, forms the headwaters of the Santee-Cooper River system which flows through South Carolina to the Atlantic Ocean. The basin drains 3,285 sq. miles in primarily Avery, Burke, Caldwell, McDowell, Mecklenburg, Catawba, Caldwell, Alexander, Iredell, Lincoln, and Gaston counties. There are 3,005 stream miles in the North Carolina portion of the basin. There are three major river drainages in the basin:

- **Upper Catawba** – tributaries include Catawba River headwaters, Linville River, North Muddy Creek, Warrior Fork, Johns River, Silver Creek, Lower Creek, Little River, Gunpowder Creek, Muddy Fork, Dutchmans Creek, and Crowders Creek.
- **Lower Catawba** – tributaries include Twelve Mile Creek, Six Mile Creek, Waxhaw Branch, Irwin Creek, McAlpine Creek, and Sugar Creek.
- **South Fork Catawba** – tributaries include Henry Fork, Jacob Fork, Clark Creek, and Long Creek.

The upper Catawba River watershed begins along the eastern slopes of the Blue Ridge and descends into the foothills and Inner Piedmont physiographic province. Overall stream gradient decreases as the topography changes from the mountains of the Blue Ridge to the hills and rolling landscape of the Inner Piedmont. Soils in the Piedmont generally contain greater proportions of sand and clay and higher erosion potential than those in the upper portion of the basin. Stream habitats in the lower basin are generally dominated by runs and pools with high proportions of sandy and silty substrates.

¹ Smallmouth buffalo (*Ictiobus bubalus*) is a native priority fish species in the French Broad basin, but is a non-native in other basins (Catawba, Yadkin PeeDee, and Neuse). In non-native basins, this species is not a priority for conservation. Rather, monitoring and possible control of range expansion should be initiated.

² Taxonomic status is unclear in the basin.

Land use in the basin is 67% forested, 24% pasture/managed herbaceous/cultivated, and 6% urban (NCDWQ 1999). Publicly owned lands in the basin include Pisgah National Forest, four state parks (parks total 17,700 acres), and South Mountains Game Land (20,697 acres). All other lands are privately owned. Land cover shifts from forested areas to agricultural and urban uses as the basin enters the Piedmont from the mountains. The lower Catawba region is highly developed and growing (Charlotte, major metropolitan area). This urban growth has greatly affected the water quality in the basin, along with nutrient enrichment and sedimentation from agricultural operations. Water quality ratings in the basin include 6% impaired, 79% fully supporting, and 15% not rated (NCDWQ 1999).

There are numerous hydropower facilities that impound over 60,000 reservoir acres within the Catawba basin. They include (by stream):

- Catawba River: James, Rhodhiss, Hickory, Lookout Shoals, Norman, Mountain Island, Wylie
- Lower Little River: Brushy Mountain
- South Fork Catawba River: McAdenville, Spencer Mountain, Hardins, High Shoals, and Long Shoals
- Henry Fork: Henry River

There are numerous small, non-hydropower producing dams scattered throughout the basin. Some of the larger of these dams include (by stream):

- Buck Creek: Lake Tahoma
- Linville River: Loch Dornie and Land Harbor
- Laurel Branch: Blue Ridge Country Club irrigation intake
- Killian Creek: Duke Power combustion turbine station
- Long Creek: Bessemer City intake

B. Problems affecting species and habitats:

Impoundment is a major factor in the loss and degradation of habitat for priority aquatic species in the Catawba basin. All but the upper headwater reaches of the Catawba River (upstream from Lake James) are either impounded or regulated by hydropower projects (Duke Energy). Cold water releases degrade the Lake James tailwater for many native species and it is presently managed as a stocked trout fishery. Migration of anadromous and potadromous fishes are severely limited, if not altogether prevented by dams. The few remaining free-flowing, cool-warm water high quality habitats in larger tributary streams are isolated and fragmented by the impoundment effects on the mainstem Catawba River. The impacts of this habitat fragmentation on priority species populations in not entirely clear; however, some impacts are evident. Habitats may be recovering in some streams where species were extirpated by past habitat loss. Potential recolonization of these recovering habitats may be impossible due to barriers created by dams, impoundments, and/or intervening habitat made unsuitable by other factors.

With the exception of streams located on public lands, streams within the basin are degraded or threatened by a number of factors, including sedimentation, loss of riparian woody vegetation, water withdrawals, channelization and/or relocation, point source pollution, and nutrient loading. Ground disturbance from development activities and agriculture are the primary sources of erosion, sedimentation, and nutrient enrichment. Point sources of pollution include waste water treatment plants and permitted industrial dischargers (much of the basin flows through highly urbanized areas). Alterations to stream channels, increased impervious surfaces (resulting in increased flashiness), and loss of riparian vegetation contribute to stream channel and bank erosion, which in turn contribute to sedimentation and other physical habitat degradation.

Several existing impoundments are used for water supply and new impoundments are being proposed within the basin for the same reason. As human population increases, water supply is an increasing burden on surface waters. Water withdrawals, impoundments, and interbasin water transfers can significantly alter habitats for native aquatic species. This is an emerging problem that will likely increase in importance in the near future.

Non-native species known from the basin include Asian clams, grass carp, blue, channel, and flathead catfishes, smallmouth bass, muskellunge, white bass, yellow bass, and rainbow and brown trout. Land-locked blueback herring, alewife, and white perch are known from several impoundments (in fact, over 33 exotic fish species have been identified in the basin, Bryn Tracy, pers. comm.). Non-native vegetation can also negatively impact native aquatic animal communities. This includes both aquatic and riparian plant species and non-native plant pathogens that can alter riparian vegetation (e.g., hemlock woolly adelgid). Non-native aquatic plants are also present in the Catawba basin and are a known nuisance, especially in reservoirs. Specific impacts in the Catawba basin from these and other introduced species are unclear.

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

Inventory: distributional and status surveys – General surveys are needed to complete the distributional status for aquatic snails, crayfish, mussels, and fish (in order of general need). (Cooperators in North Carolina include the NC Division of Water Quality, NC Department of Transportation, US Fish & Wildlife Service, NC Museum of Natural Sciences; an interstate, intrabasin cooperator is the South Carolina Department of Natural Resources).

- Snails – inventory primary distribution; determine potential habitats and distribution surveys for hydrobiids.
- Crayfish – complete primary inventories and determine status of endemic species.
- Determine distribution of non-native species.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed.

- Mussels in the genera *Alasmidonta*, *Elliptio* and *Strophitus* – support resolution of taxonomic problems and species descriptions (if required) (cooperate with the NC Museum of Natural Sciences, NC State University).
- Crayfish – support description and species diagnosis of all crayfish species in the basin – (cooperate with the NC Museum of Natural Sciences).

Research to facilitate appropriate conservation actions – Research should generally focus on life history of priority species. Specific questions to be addressed include: habitat use/preferences, spawning location and timing, fecundity, population dynamics, population genetics, feeding, competition, predation. Determine vulnerability of priority species to specific threats, particularly as related to our permit review and conditions responsibilities. Studies should provide recommendations for mitigation and restoration.

- Review available information and support life history investigations where lacking.
- Support investigations into impacts from habitat fragmentation in the basin (due to impoundments or other factors).
- Support investigations of population response to stream restoration projects (especially in priority areas).
- Support research to improve habitat conditions in regulated rivers.
- Support investigations into specific water and habitat quality impacts that limit populations of priority species throughout the basin.

- Investigate habitat requirements of mussel species and assess potential for reintroduction in recovering habitats (e.g., Jacobs Fork, Henry Fork, Catawba River-Lake James tailwater).
- Support life history research aimed at development of propagation techniques for priority mussel species (cooperate with NC State University).

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible. (Cooperators in North Carolina include the: NC Division of Water Quality, NC Department of Transportation, South Mountains State Park, US Forest Service, US Fish & Wildlife Service, NC Museum of Natural Sciences; an interstate, intrabasin cooperator is the South Carolina Department of Natural Resources).

- Conduct long-term monitoring to identify population trends of priority species. Establish protocol, schedule, and sites for long-term population monitoring.
 - Basin specific priorities include the Carolina heelsplitter, brook floater, Carolina creekshell, notched rainbow.
- Conduct special purpose monitoring to assess performance of specific conservation actions:
 - Performance of stream restoration projects.
 - Performance of hydropower remediation.
 - Performance of species restoration projects.
- Assess non-native species impacts. Monitor populations of potentially injurious non-native species and impacts on priority species.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration – Promote and support habitat conservation and restoration efforts by external entities. (Potential partners in the Catawba River Basin include: Natural Resources Conservation Service, Ecosystem Enhancement Program, NC Natural Heritage Program, US Forest Service, Duke Power, Crescent Lands, Carolina Mountain Land Conservancy, Foothills Conservancy, Bi-state Catawba River Task Force, South Mountains State Park, Lake James State Park, county-based soil and erosion control efforts, and private landowners).

- Identify priority areas for habitat conservation and restoration. Criteria include areas with high species diversity, rare species, and endemic species; specific areas that are critical to the survival of priority species (e.g., particular streams or spawning sites); and areas recognized by previous national and/or regional prioritization efforts.
 - Priority watersheds for freshwater conservation in the Broad River basin include (based in part on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.7b):
 - o Johns River
 - o Warrior Fork
 - o Linville River
 - o Waxhaw Creek
 - o South Fork Catawba River headwaters
 - Jacob Fork
 - Henry Fork
 - o Long Creek
 - o Sixmile Creek
- Support conservation and restoration of streams and riparian zones in priority areas (acquisition, easements, and buffers). Support stream conservation and restoration by working collaboratively with other organizations.

- Promote and support conservation and restoration efforts within the Commission.
 - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, into Game Lands management, and into Game Lands acquisitions
 - Support efforts to acquire Game Lands in Johns River watershed.

Population management and restoration – Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

- Investigate potential for reintroduction of extirpated mollusk and fish species to the basin in restored or improved habitats as opportunities become available.
- Investigate potential and seek opportunities for reintroduction of common mussel species to portions of Jacobs and Henry Forks.
- Support development of propagation techniques and production capacity for augmentation and reintroduction of priority mollusk species.

Data collection, management, and dissemination among agencies

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Coordinate sampling with other resource groups.
- Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.
- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources. Improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.). Specific basin priorities include updating crayfish and mussel atlases with presently known species occurrence and distributions in the Broad basin.
 - Update crayfish and mussel atlases with presently known species occurrence and distributions in the Catawba basin.
 - Compile and post species accounts to fish atlas for state listed fishes from the Catawba basin.
- Develop and disseminate print media, including stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
 - Deliver oral presentations.
 - Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, Federal Energy Regulatory Commission, and the US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection – Work with regulatory agencies (e.g., US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, Federal Energy Regulatory Commission, and the US Fish & Wildlife Service) to conserve and restore water and habitat quality.

- Support strengthening of water quality protection.
 - Support water quality rules and watershed designations that conserve habitats for priority aquatic species. Outstanding Resource Water and High Quality Water designations should be supported wherever the criteria for designation are met, especially in watersheds that support priority species.
 - Support incentive and information programs that help reduce sedimentation/erosion (e.g., fencing livestock from streams, improve tilling practices), minimize pesticide and herbicide use, modernize wastewater treatment facilities, etc.
- Work through the Federal Energy Regulatory Commission (FERC) relicensing process and other opportunities to mitigate negative impacts from hydropower development. Specific basin priorities include:
 - Cooperate with Duke Energy, FERC, and resource agency cooperators during current hydropower relicensing process.
 - o Support habitat improvements for native species in the Lake James tailwaters.
 - o Support assessment of potential impacts to priority species from habitat fragmentation.
 - o Support practicable mitigation and restoration for hydropower impacts throughout the Catawba basin.

Land-use planning – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishing riparian buffers along streams, implement low impact development, and better stormwater management (e.g., secondary and cumulative impacts; NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

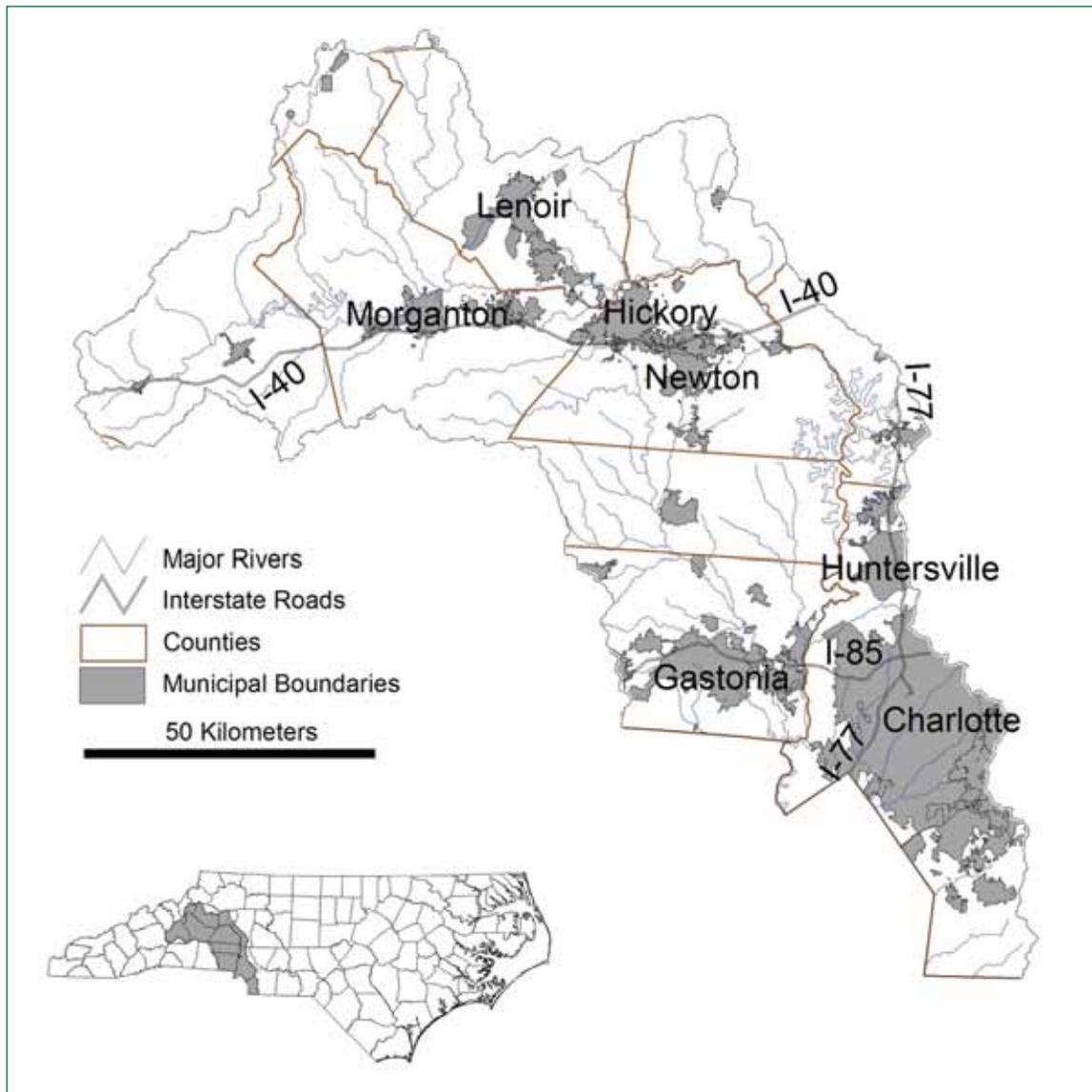
- Support federal and state species listing processes.
 - Focus analysis and synthesis of inventory and monitoring data and reporting to inform decision making pertaining to initial species listing and status revision.
 - When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.
 - Cooperate with US Fish & Wildlife Service to evaluate status of brook floater.
 - Assess other species in the Catawba basin for recommendation for state listing.
- Improve coordination with the US Fish & Wildlife Service to focus Section 6 (US Endangered Species Act) activities on priorities for listing and recovery. Activities that are applicable to goals and objectives of recovery plans should be tracked and recovery plans should be updated and revised as necessary.
- Coordinate with US Fish & Wildlife Service to plan and align activities for federal Candidate species and Species of Concern with specific information or management needs.

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

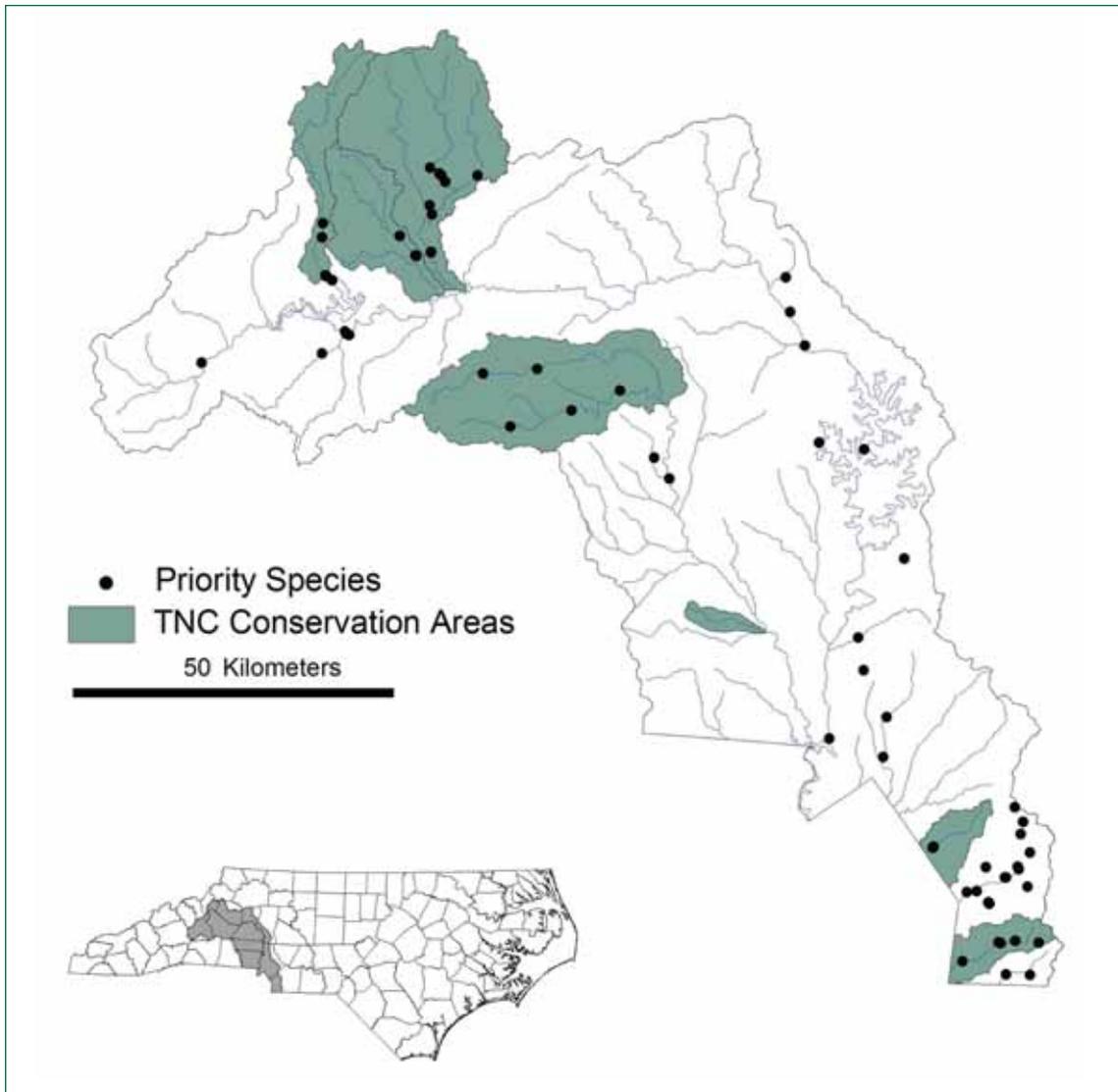
- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

Supporting References

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- Smith, R. K., P. L. Freeman, J. V. Higgins, K. S. Wheaton, T. W. FitzHugh, K. J. Ernstom, and A. A. Das. 2002. Priority areas for freshwater conservation action: a biodiversity assessment of the Southeastern United States. The Nature Conservancy.



Map 5B.8a. Catawba River basin, political information.



Map 5B.8b. Catawba River basin, priority species occurrences and priority areas for freshwater conservation.

9. Yadkin-Pee Dee River Basin

Priority aquatic species in the Yadkin-Pee Dee River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish	<i>Acipenser brevirostrum</i>	Shortnose Sturgeon	E (E)
	<i>Ameiurus brunneus</i>	Snail Bullhead	
	<i>Carpiodes cyprinus</i> ¹	Quillback	
	<i>Carpiodes velifer</i> ¹	Highfin Carpsucker	SC
	<i>Cyprinella</i> sp. (cf. <i>zanema</i>)	Thinlip Chub	
	<i>Etheostoma collis</i>	Carolina Darter	SC
	<i>Fundulus lineolatus</i>	Lined Topminnow	
	<i>Lepomis marginatus</i>	Dollar Sunfish	
	<i>Moxostoma collasum</i>	Notchlip Redhorse	
	<i>Moxostoma macrolepidotum</i>	Shorthead Redhorse	
	<i>Moxostoma pappillosum</i>	V-lip Redhorse	
	<i>Moxostoma robustum</i>	Robust Redhorse	SR
	<i>Moxostoma</i> sp 2	Carolina Redhorse	SR
	<i>Notropis maculatus</i>	Taillight Shiner	
	<i>Semotilus lumbee</i>	Sandhills Chub	SC
Mussels	<i>Alasmidonta robusta</i> ²	Carolina Elktoe	SR
	<i>Alasmidonta undulata</i>	Triangle Floater	T
	<i>Alasmidonta varicosa</i>	Brook Floater	E
	<i>Anodonta implicata</i>	Alewife Floater	T
	<i>Elliptio cistellaeformis</i>	Box Spike	
	<i>Elliptio congaraea</i>	Carolina Slabshell	
	<i>Elliptio folliculata</i>	Pod Lance	SC
	<i>Elliptio icterina</i>	Variable Spike	
	<i>Elliptio roanokensis</i>	Roanoke Slabshell	T
	<i>Fusconaia masoni</i>	Atlantic Pigtoe	E
	<i>Lampsilis radiata conspicua</i>	Carolina Fatmucket	T
	<i>Lampsilis radiata radiata</i>	Eastern Lampmussel	T
	<i>Lasmigona decorata</i>	Carolina Heelsplitter	E (E)
	<i>Ligumia nasuta</i>	Eastern Pondmussel	T
	<i>Strophitus undulatus</i>	Creeper	T
	<i>Toxolasma pullus</i>	Savannah Lilliput	E
	<i>Villosa constricta</i>	Notched Rainbow	SC
	<i>Villosa delumbis</i>	Eastern Creekshell	SR
<i>Villosa vaughaniana</i>	Carolina Creekshell	E	
Crayfish	<i>Cambarus catagius</i>	Greensboro Burrowing Crayfish	SC

¹Smallmouth buffalo (*Ictiobus bubalus*) is a native priority fish species in the French Broad basin, but is a non-native in the Catawba, Yadkin-Pee Dee, and Neuse basins. Brook silverside (*Labidesthes sicculus*) is a native priority fish species in the Little Tennessee basin, but is a non-native in the Yadkin-Pee Dee and Lumber basins. Comely shiner (*Notropis amoenus*) is a native priority fish species in the Roanoke, Cape Fear, Neuse, Tar-Pamlico, and Chowan basins, but is a non-native in the Yadkin-PeeDee basin. In non-native basins, these species are not a priority for conservation. Rather, monitoring and possible control of range expansion of the species should be initiated. It is unclear whether the Quillback (*Carpiodes cyprinus*) and highfin carpsucker (*Carpiodes velifer*) are native or introduced.

²Status in basin unknown; possibly extirpated.

A. Location and condition of basin (see Maps 5B.9a, 5B.9b):

In North Carolina, the majority of the Yadkin-Pee Dee River basin is located within the Piedmont physiographic province. The headwaters, which are partially in the Blue Ridge physiographic region, are located in northwestern North Carolina and extreme southern Virginia. Water flows southeast across the Piedmont and through North Carolina's densely populated midsection, then moves through a portion of the Coastal plain before entering South Carolina and ultimately entering the Atlantic Ocean at Winyah Bay, South Carolina. The North Carolina portion of the Yadkin-Pee Dee River drains an area of about 7,221 sq. miles, with 5,862 stream miles and 22,988 lake acres (NCDWQ 2003).

There are eight impoundments on the main stem of the Yadkin River (W. Kerr Scott Reservoir, Idols Dam, High Rock Lake, Tuckertown Reservoir, Badin Lake, Falls Reservoir, Lake Tillery, and Blewett Falls Lake), plus many smaller reservoirs on tributaries. At the confluence with the Uwharrie River the Yadkin River is then called the Pee Dee River. Major tributaries in the Yadkin-Pee Dee basin are South Yadkin, Uwharrie River, and Rocky River. Land use in the basin is 50% forested, 30% agricultural, and about 13% developed. There has been a significant increase in the amount of urban/built-up area in recent years. National Resources Inventory data indicate that from 1982–1997 the urban/built-up land use category increased 226,500 acres (NRCS 2001). Ninety-three municipalities are completely or partially located within the Yadkin-Pee Dee River basin. The estimated 2000 population was 1,463,535 (163 persons per sq. mile); the basin population is projected to increase 36 % to about 2 million people by 2020 (NCDWQ 2003). The largest population increases are projected for Union, Mecklenburg, Cabarrus, and Iredell Counties.

Public lands make up less than 5% of the Yadkin-Pee Dee basin. Impaired (303 d list) streams in this drainage total 490.7 miles (NCDWQ 2003). There are 57 stream reaches that have a NC Division of Water Quality Outstanding Resource Waters (ORW) classification and 111 stream reaches that have High Quality Waters (HQW) classification (NCDWQ 2003).

B. Problems affecting species and habitats:

Our knowledge of aquatic species distribution is inadequate and general surveys are needed in most of the Yadkin-Pee Dee River basin (especially the upper half). We have a poor understanding of life history and habitat use for many species which is critical for managing these populations. It is difficult to monitor known populations of rare species at regular intervals which is needed to track changes in abundance and habitat quality. In addition, there are few long term data sets or monitoring sites. Invasive species have become established in the Yadkin-Pee Dee River basin, with potential to negatively impact native species populations (Fuller et al. 1999).

The Yadkin-Pee Dee River basin has numerous problems affecting both species and their habitats. There is a significant loss of riverine habitat in this basin due to eight mainstem dams and the numerous impoundments on tributaries (hydroelectric plants, water supply lakes, and mill dams). Additional consequences of these impoundments include: an unnatural flow regime in riverine sections, migration routes are blocked for diadromous species as well as resident species, and recolonization and/or dispersal potential is significantly reduced. Streams are being impacted by excessive sedimentation and changes in hydrology and geomorphology (all due to urban development, agriculture, and instream mining; Williams et al. 1993, Etnier 1997, Neves et al. 1997, Warren et al. 2000). Water quality is also degraded by excessive nutrient input and other chemicals (waste water treatment plants, industry, agriculture, and hog/chicken farms; NCDWQ 2003). In the Yadkin-Pee Dee River basin there are 240 permitted discharges (36 of which are major discharges with ≥ 1 million gallons per day; NCDWQ 2003).

C. **Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:**

Inventory: distributional and status surveys – General surveys are needed to complete the distributional status for fish, mussels, crayfish, and aquatic snails. Areas where distributional surveys should be focused can be identified using the Commission aquatic nongame database and NC Natural Heritage Program data. For example, there are very few survey records in the upper half of the Yadkin-Pee Dee River basin (Yadkin, Wilkes, Surry, Caldwell, and Forsyth counties).

- Support work to confirm the distribution of the Carolina elktoe in the basin.
- Survey for other high priority mussel species in the Yadkin-PeeDee basin.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed.

- Support genetic studies to help improve our understanding of the mussel genus *Elliptio* and the Carolina elktoe (cooperate with NC Museum of Natural Sciences, NC State University).
- Support completion of species descriptions for undescribed taxa (e.g., Carolina redhorse and thinlip chub).

Research to facilitate appropriate conservation actions – Research should focus on the life history studies of priority species. Specific questions to be addressed include: habitat use/preferences, spawning location and timing, fecundity, population dynamics, feeding, competition, predation.

- Determine vulnerability of priority species to guide permit regulations (moratoria).
- Determine how priority species are impacted by mainstem and tributary dams (habitat fragmentation). Studies should provide recommendations for mitigation and restoration.
- Study the potential effects of non-native species on native species

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible.

- Conduct long-term monitoring to identify population trends:
 - Establish protocol and schedule for long-term monitoring of priority species (collaborate with the NC Division of Water Quality, NC Museum of Natural Science, and US Fish & Wildlife Service).
- Conduct special purpose monitoring:
 - Performance of stream restoration projects.
 - Performance of hydropower remediation.
 - Performance of species restoration projects.
- Assess non-native species impacts:
 - Determine the distribution of exotics (red shiner, flathead catfish, and others) in the Yadkin-Pee Dee basin and how are they effecting native species.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration – Provide support for land protection and stream restoration (acquisition, easements, and buffers)

- Support stream protection/restoration by working collaboratively with other organizations including: Ecosystem Enhancement Program, NC Natural Heritage Program, Natural Resources Conservation Service, The Nature Conservancy, other non governmental organizations, and the US Forest Service (Uwharrie National Forest).
- Support dam removal (work with US Fish & Wildlife Service and other interested non governmental organizations).
- Negotiate a more natural flow regime in the main stem during the Federal Energy Regulatory Commission (FERC) relicensing process and support mitigation and restoration for hydropower impacts.
- Identify priority areas for habitat protection by locating areas with high species diversity, rare species, and endemic species. Identify specific areas that are critical to the survival of priority species (e.g., particular streams or spawning sites), including the robust redhorse, Carolina redhorse, brook floater, Carolina creekshell.
 - Priority watersheds for freshwater conservation in the Yadkin-Pee Dee basin include (based in part on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.9b):
 - o Roaring River
 - o Mitchell River
 - o The upper Yadkin (east of Elkin downstream to Winston-Salem)
 - o Uwharrie River
 - o Dutch Buffalo Creek
 - o Goose Creek
 - o Crooked Creek
 - o Coddle Creek
 - o Clarke Creek
 - o Back/Reedy Creeks
 - o Big Bear Creek
 - o Island Creek
 - o Long Creek
 - o Richardson Creek
 - o Lower Rocky River
 - o Brown Creek
 - o Little River
 - o Mountain Creek
 - o Lanes Creek
 - o Lower Pee Dee River (riverine section below Tillery Dam, and downstream of Blewett Falls Dam)
- Promote and support conservation and restoration efforts within the Commission.
 - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, into Game Lands management, and into Game Lands acquisitions.

Population management and restoration

- Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them (e.g., brook floater).
- Continue mussel relocation project (restore common species to recovering habitats in the Piedmont).

Data collection, management, and dissemination among agencies

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Coordinate sampling with other resource groups.
- Continue work with the Robust Redhorse Conservation Committee.

Education/outreach

- Develop new web-based resources; improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
- Develop and disseminate print media, including stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
 - Deliver oral presentations.
 - Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, FERC, US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection – Work with regulatory agencies (e.g., US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, FERC, US Fish & Wildlife Service) to conserve and restore water and habitat quality.

- Support strengthening of water quality protection.
 - Promote programs that help farmers reduce sedimentation and erosion (install fences to keep live stock out of streams and improve tilling practices) as well as reduce pesticide and herbicide use.
 - Promote programs to help modernize wastewater treatment facilities and inform public about proper upkeep of septic systems.
 - Protect existing good water and habitat quality throughout the basin (ORW and HQW streams).
 - Promote programs to upgrade hog and chicken farms waste treatment.
 - Work through the Site-Specific Management Plan process to obtain stricter regulations for waters containing federally listed species (partners include NC Division of Water Quality, NC Natural Heritage Program, and US Fish & Wildlife Service).

Land-use planning – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Work with county and city officials and developers to incorporate buffers along streams, to implement low impact development, and to develop better stormwater regulations (e.g., secondary and cumulative impacts; NCWRC 2002).
- Work with hydropower producers to develop programs to minimize their impacts.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

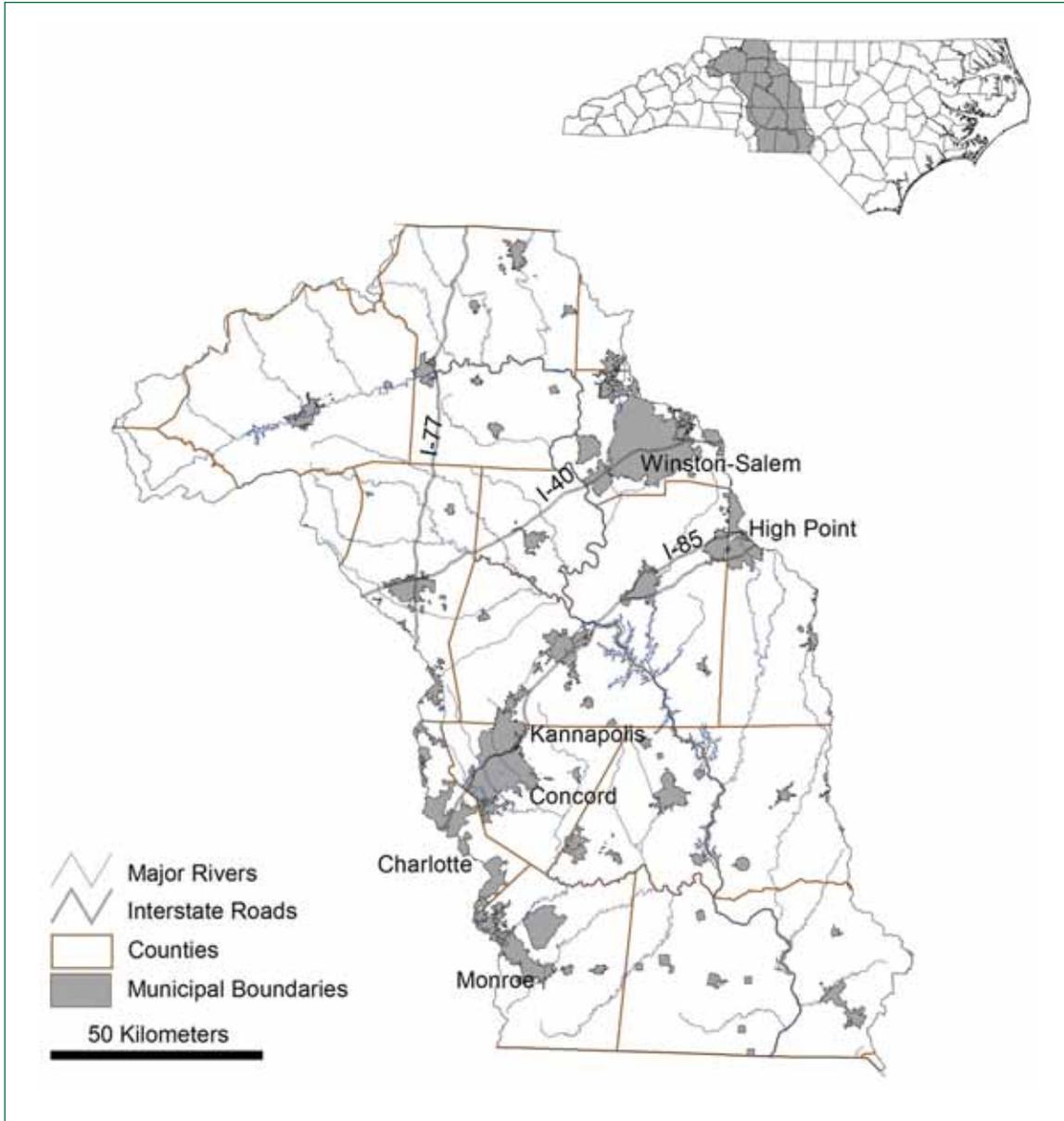
- Support federal and state species listing processes.
 - Support listing process and update recovery plans for listed species (e.g., Carolina heelsplitter).
 - When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

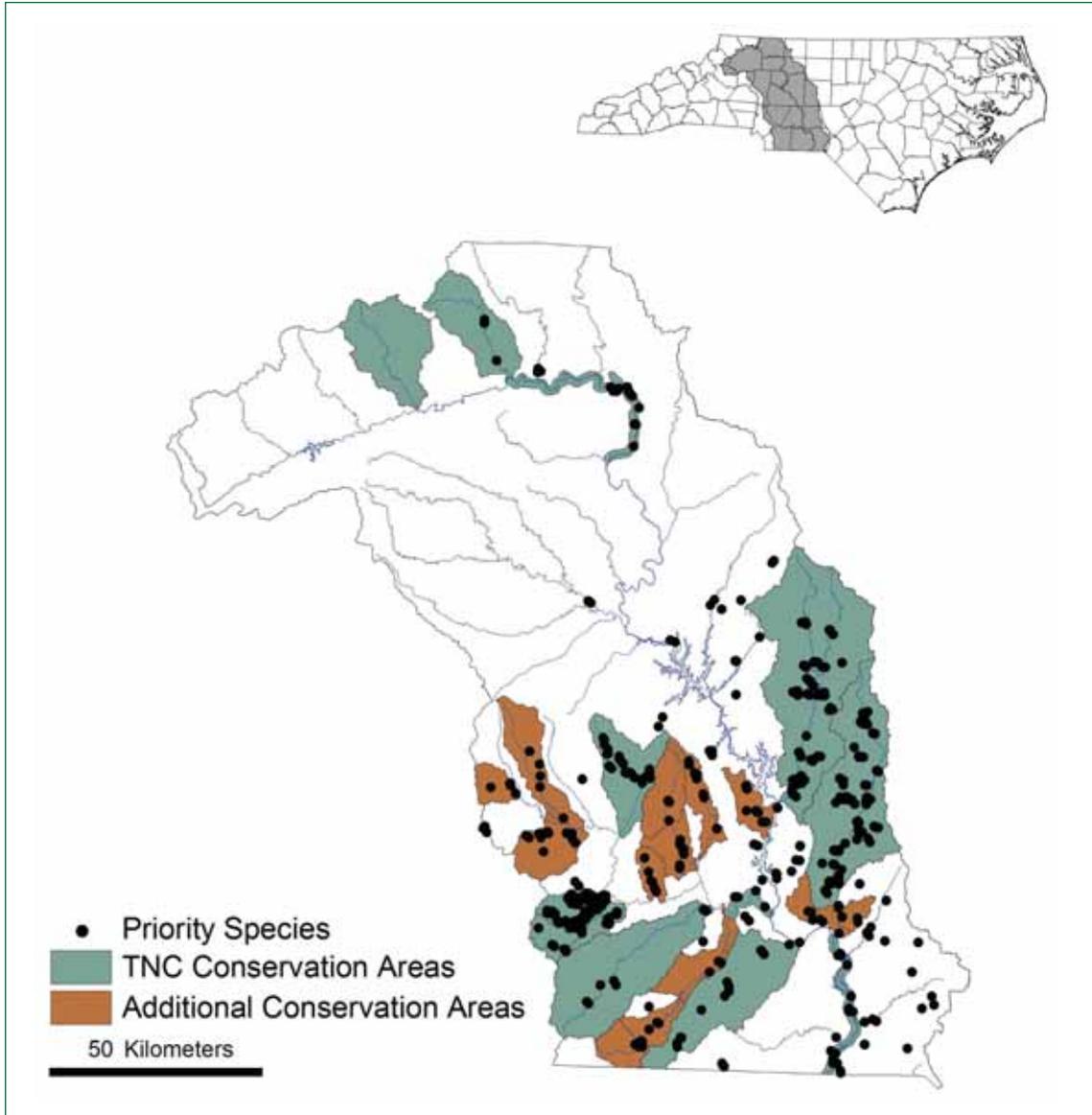
- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

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Map 5B.9a. Yadkin-PeeDee River basin, political information.



Map 5B.9b. Yadkin-PeeDee River basin, priority species occurrences and priority areas for freshwater conservation.

10. Roanoke River Basin

Priority aquatic species in the Roanoke River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish	<i>Acipenser oxyrinchus</i>	Atlantic Sturgeon	SC
	<i>Ameiurus brunneus</i>	Snail Bullhead	
	<i>Carpiodes cyprinus</i>	Quillback	
	<i>Cottus caeruleomentum</i>	Blue Ridge Sculpin	SR
	<i>Elassoma zonatum</i>	Banded Pygmy Sunfish	
	<i>Enneacanthus chaetodon</i>	Blackbanded Sunfish	
	<i>Enneacanthus obesus</i>	Banded Sunfish	
	<i>Etheostoma collis</i>	Carolina Darter	SC
	<i>Etheostoma nigrum</i>	Johnny Darter	
	<i>Etheostoma podostemone</i>	Riverweed Darter	SC
	<i>Etheostoma vitreum</i>	Glassy Darter	
	<i>Exoglossum maxillangua</i>	Cutlip Minnow	E
	<i>Fundulus diaphanus</i>	Banded Killifish	
	<i>Fundulus lineolatus</i>	Lined Topminnow	
	<i>Hypentelium roanokense</i>	Roanoke Hog Sucker	SR
	<i>Moxostoma collapsum</i>	Notchlip Redhorse	
	<i>Moxostoma macrolepidotum</i>	Shorthead Redhorse	
	<i>Moxostoma pappillosum</i>	V-lip Redhorse	
	<i>Notropis amoenus</i>	Comely Shiner	
	<i>Notropis chalybaeus</i>	Ironcolor Shiner	
<i>Noturus gilberti</i>	Orangefin Madtom	E	
<i>Scartomyzon ariommus</i>	Bigeye Jumprock	T	
<i>Thoburnia hamiltoni</i>	Rustyside Sucker	E	
Mussels	<i>Alasmidonta undulata</i>	Triangle Floater	T
	<i>Alasmidonta varicosa</i>	Brook Floater	E
	<i>Anodonta implicata</i>	Alewife Floater	T
	<i>Elliptio icterina</i>	Variable Spike	
	<i>Elliptio roanokensis</i>	Roanoke Slabshell	T
	<i>Fusconaia masoni</i>	Atlantic Pigtoe	E
	<i>Lasmigona subviridis</i>	Green Floater	E
	<i>Leptodea ochracea</i>	Tidewater Mucket	T
	<i>Ligumia nasuta</i>	Eastern Pondmussel	T
	<i>Pleurobema collina</i>	James Spiny mussel	E (E)
	<i>Strophitus undulatus</i>	Creeper (Squawfoot)	T
	<i>Villosa constricta</i>	Notched Rainbow	SC
Crayfish	<i>Orconectes virginianensis</i>	Chowanoke Crayfish	SC

Note: As a coastal basin, information contained in Chapter 5C (Marine Systems), especially related to the Coastal Habitat Protection Plan (Street et al. 2004), may also apply to this basin.

A. Location and condition of basin (see Maps 5B.10a, 5B.10b):

The Roanoke River basin is an Atlantic Slope basin with its headwaters located in the Blue Ridge Mountains of Virginia. Approximately 64% of the basin is in Virginia. The basin is the sixth largest in North Carolina and has an area of 3,503 sq. miles within the state (the entire basin is approximately 9,766 sq. miles), draining 2,213 miles of North Carolina streams. The Roanoke River carries more water and has the widest floodplain (up to 5 miles wide in parts) of any North Carolina river. There are 10 subbasins in the Roanoke River basin. Major tributaries to the Roanoke River include the Dan River, Mayo River, Smith River, Country Line Creek, Hycro Creek/River, Cashie River, and Conoho Creek (NCDWQ 2001).

The North Carolina portion has two distinct parts: the western section in the Piedmont physiographic region (87% of the North Carolina basin, above Roanoke Rapids Dam), and the eastern section in the Coastal Plain physiographic region (13% of basin, below Roanoke Rapids Dam), which is heavily used by anadromous fishes. The upper Dan River area in western North Carolina shows characteristics of both the Southern Blue Ridge and Piedmont physiographic regions. The fairly steep topography of headwater areas of most tributaries has allowed them to remain forested whereas many downstream sections are farmed (NCDWQ 2001). The Piedmont physiographic region features rolling hills and is underlain with crystalline or sedimentary rocks. Many tributary streams in the Piedmont have large sediment bedloads. The transition zone between the Piedmont and Coastal Plain occurs below Roanoke Rapids Lake with the lower 60 miles of river part of the Coastal Plain. The river terminates at Albemarle Sound, which is the second largest estuary system (Albemarle-Pamlico) in the United States (NCDWQ 2001). The Coastal Plain portion features a flat topography and is underlain by sand, silt, clay, and limestone. Tobacco, peanuts, cotton and soybeans are among the most common crops grown in the basin (NCDENR 2003).

The Coastal Plain is divided into two geographic regions by the Suffolk Scarp, which is a fossil barrier island sand ridge formed as an ocean shoreline during the previous interglacial period when sea level was higher than present. Areas west of the Suffolk Scarp feature higher elevations, slightly rolling topography, and moderately well-drained soils with sandy texture. East of the Suffolk Scarp, elevations range from 15-20 feet above sea level with gently sloping land surface. Swamps in this area have poorly drained soils organic peat, whereas non-swamp areas have fine-grained sandy soils with high organic and clay content (Rulifson and Manooch 1993).

There are 41 municipalities within the basin. The most populated areas are located northeast of the Greensboro/Winston-Salem/High Point area and around the larger municipalities in the basin such as Roanoke Rapids, Eden, Williamston and Plymouth. According to 2000 census data, the population within the basin is 335,194. Land use in the basin is 17.0% cultivated cropland, 2.1% uncultivated cropland, 3.9% pasture, 61.5% forested, 6.1% urban, 0.9% Federal, and 8.5% other (rural transportation, small water areas, census water, minor land; NCDWQ 2001).

Several tributaries within the basin have been identified as High Quality Waters by the NC Division of Water Quality. Portions of Cascade and Indian Creeks (Hanging Rock State Park) are designated as Outstanding Resource Waters due to excellent water quality and rare aquatic species. Areas within the basin identified by the NC Natural Heritage Program with significant biological diversity include the following: Hanging Rock State Park, Dan River aquatic habitat, Mayo River aquatic habitat, Caswell Game Lands, Country Line Creek aquatic habitat, Aaron's Creek aquatic habitat, Occoneechee Neck Floodplain Forest, Buzzard Point/Ventosa Plantation, Broadneck Swamp, Conoho Neck Swamp, Devil's Gut, Broad Neck Creek, Roanoke River delta islands, and Roquist Pocosin (NCDWQ 2001). The Roanoke River in the Coastal Plain is bordered by extensive floodplain forests. The Nature Conservancy has identified these high quality alluvial bottomland hardwood forests as the largest intact and least disturbed ecosystem of this type in the mid-Atlantic region. Federal and State lands within the basin include the 51,321 acre Roanoke River National Wildlife Refuge located near Albemarle Sound, Hanging Rock State Park, Kerr Lake State Recreation Area, and Morningstar Wildlife Refuge (NCDENR 2003).

There are 11 major reservoirs along the North Carolina portion of the Roanoke River; most are in the upper basin on tributaries of the Dan and Roanoke Rivers. There are three major reservoirs which regulate flow on the Roanoke River main channel: Kerr, Gaston, and Roanoke Rapids. These three reservoirs impound 82 miles of Roanoke River between South Boston, Virginia and Roanoke Rapids, North Carolina. Other reservoirs in the basin include Hanging Rock Lake, Kernersville Reservoir, Belews Lake, Farmer Lake, Hyco Lake, Lake Roxboro, Roxboro City Lake (Water Works Lake), and Mayo Reservoir (NCDWQ 2001).

There are 263.2 miles of impaired streams in the Roanoke River basin from the following locations: Cashie River (54.6), Welch Creek (13.3), Roanoke River (138.7), Quankey Creek (3.4), Smith Creek (10.4), Nutbush Creek (4.6), Marlowe Creek (10.9), Smith River (5.1), Dan River (14.2), Town Fork Creek (8.0) (NCDWQ 2004).

B. Problems affecting species and habitats:

Destruction of aquatic habitat appears to be the largest water quality issue in the basin (NCDENR 2003). Sedimentation caused by agriculture, forestry, and construction has degraded water and habitat quality. Dioxin, selenium (from historic discharge from ash pond basins), and mercury levels have resulted in fish consumption advisories. According to 1998 USDA data, the Roanoke basin is responsible for 2% of the swine, 3% of the dairy, and 2% of the poultry in North Carolina (NCDWQ 2001).

Demand for water is becoming a contentious issue in the Roanoke basin. In 1997, 43 public water systems served 114,000 consumers in the basin. Demand for water is expected to increase as much as 55% by 2020. As of 2000, there were 26 registered water withdrawals allowed in the basin (NCDWQ 2001). The Roanoke basin is viewed as a potential source of water by those living outside the basin. For example, the city of Virginia Beach withdraws up to 60 million gallons/day from Lake Gaston (NCDENR 2003). Current and future water withdrawals have the potential to reduce flows to the lower Roanoke River and, hence, increase downstream salinity levels. Although there are no current certified interbasin transfers in the Roanoke River basin, future transfers from Roanoke to Tar-Pamlico are expected to occur (NCDWQ 2001).

Several development-related issues affect the Roanoke River basin. In addition to nonpoint source pollution, point source pollution (municipal waste water treatment plants, selenium ash pond discharge, industrial facilities, small package treatment plants, urban and industrial storm-water systems) can degrade aquatic habitats. Waste water treatment plants can cause elevated nitrogen, phosphorus, copper, and fecal coliform levels. Waste water discharges have led to elevated ammonia nitrogen (NH₃) concentrations at San Souci. Stokes and Granville counties are the fastest growing counties in the basin and are expected to grow 20–30% by 2018 (NCDWQ 2001). Growth in these areas will affect land use, cover, and water quality.

Amount and timing of water releases from dams, particularly along the Roanoke River, can alter downstream aquatic and riparian flora and fauna. Many species in these areas have adapted to seasonal flooding, which has changed over time. There will be a continuing need to balance water releases to meet human and aquatic ecosystem needs (NCDENR 2003). For example, striped bass, hickory shad, American shad, and sturgeon have declined from these downstream areas compared to historic levels. Low dissolved oxygen concentrations also present a problem for the lower mainstem Roanoke River. The frequency of low dissolved oxygen events increases with distance from the Roanoke Rapids dam and usually occurs in late spring, summer, and early fall (Mulligan 1991). Over a three-year monitoring period, the month during which daily mean dissolved oxygen was most likely to be less than the standard of 5 mg/l was June, and this is typically the month when higher spawning-enhancement flows are stepped down to lower, summer load-following flows (Bales and Walters 2003). It is likely that this change in flow regime and the associated draining of the backswamps is at least partially responsible for the increased frequency of low dissolved oxygen in June (Bales and Walters 2003).

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

Inventory: distributional and status surveys – General surveys are needed to complete distributional status for fish, mussels, and crayfish priority species. Basin specific priorities include:

- Atlantic sturgeon – survey for abundance, population status, and migrations; effects of dams should be considered; should also conduct surveys for shortnose sturgeon because it could potentially use the Roanoke River.
- Carolina darter – recognized as a data gap for entire South Atlantic Aquatic Region (Smith et al. 2002) and recognized as in need of a status survey due to increased developmental pressures on North Carolina aquatic systems (Menhinick and Braswell 1997).
- Cutlip minnow – North Carolina population known from only a few streams in the upper Dan drainage; should survey for additional populations in upper Dan; focus on habitat protection due to the species' intolerance of siltation.
- Rustyside sucker – known only from one site on Little Dan River in 1986; need further status surveys and if still present, should consider the possibility of reintroductions into high quality waters.
- Orangefin madtom – restricted to upper Dan River drainage; populations could be declining due to cold water release from dams, causing disruption of reproductive cycle.
- Bigeye jumprock – known from larger, fast-flowing sections of the Dan and Mayo Rivers and associated tributaries; intolerant of sedimentation effects, therefore indicator of good water quality.
- Riverweed darter – restricted to Dan River headwaters; needs special protection because of intolerance to siltation of streams and because of restricted range.
- Chowanoke crayfish – found only in lower Roanoke basin and Chowan basin in North Carolina; need further information about life history and distribution; considered by Smith et al. (2002) as a South Atlantic Aquatic Region data gap in species knowledge.
- Survey for high priority mussel species (e.g., Atlantic pigtoe) in the Roanoke basin.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed.

- Support genetic work to gain better understanding of mussel genus *Elliptio*.
- Support taxonomic research for other species as needed.

Research to facilitate appropriate conservation actions – Research should generally focus on life history of priority species.

- Conduct life history studies for priority species including habitat use/preferences, spawning location and timing, fecundity, population dynamics, feeding, competition, predation, migration patterns (where applicable).
- Determine vulnerability of priority species to specific threats; relate results to permit condition and review responsibilities.

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible.

- Conduct long-term monitoring to identify population trends:
 - Establish protocol, schedule, and locations for long-term monitoring of priority species (collaborate with NC Division of Water Quality, NC Museum of Natural Sciences, US Fish & Wildlife Service).

- Conduct special purpose monitoring:
 - Performance of stream restoration projects.
 - Performance of restoration projects (e.g., Piedmont mussel relocation sites).
 - Performance of hydropower remediation (e.g., Roanoke Rapids bypass monitoring).
 - Performance of dam removal projects to monitor short and long-term effects on species and habitats.
- Assess non-native species impacts:
 - Establish distribution and monitoring survey protocol for non-natives, possibly incorporating strategy into long-term monitoring for native species.
 - Determine effects of non-native species on natives

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration – Promote and support habitat protection efforts of external entities

- Provide support for land protection (property purchase, land preservation agreements, buffers) and stream restoration (collaborate with Ecosystem Enhancement Program, NC Natural Heritage Program, US Fish & Wildlife Service, US Forest Service, Natural Resources Conservation Service, US Army Corps of Engineers).
- Support dam removal, as appropriate for stream restoration.
- Identify priority areas for habitat protection:
 - Priority areas for freshwater conservation in the Roanoke River basin include (based on Smith et al. 2002, NC Natural Heritage Program and Commission data) (see Map 5B.10b):
 - o Upper Dan/Mayo Rivers
 - o Country Line Creek and tributaries
 - o Aarons Creek, Grassy Creek, Gill Creek and tributaries
 - o Lower Roanoke River
- Promote and support conservation and restoration efforts within the Commission.
 - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, into Game Lands management, and into Game Lands acquisitions.

Population management and restoration

- Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

Data collection, management, and dissemination among agencies

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.
 - Coordinate sampling with other resource groups.
 - Hydropower issues: work with Cooperative Management Teams concerning Roanoke Rapids bypass relicensing.
- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources; improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
- Develop and disseminate print media, including stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
 - Deliver oral presentations.
 - Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, Federal Energy Regulatory Commission, US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection – Work with regulatory agencies (US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, Federal Energy Regulatory Commission, US Fish & Wildlife Service) to conserve and restore water and habitat quality.

- Strengthen water quality rules/issues:
 - Support clean-up efforts and stricter enforcement of animal operations in addition to promoting animal waste treatment improvements and upgrades (potential partners include the NC Division of Water Quality, Natural Resources Conservation Service, Albemarle Pamlico National Estuary Program, Ecosystem Enhancement Program, private corporations).
 - Work through Site-Specific Management Plan process to obtain stricter regulations for waters containing federally listed species (cooperators include the NC Division of Water Quality, NC Natural Heritage Program, US Fish & Wildlife Service).
 - Promote programs to reduce working farm-related sedimentation/erosion (using best management practices, fencing livestock out of stream, etc.) and reduce nutrient inputs (pesticide/herbicide use).
 - Support stormwater management and wastewater treatment plant improvements and upgrades.
- Promote protection of areas with good water quality through Outstanding Resource Water and High Quality Water designations

Land-use planning – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishment of riparian buffers along streams, implementation of low impact development and better stormwater management (e.g., secondary and cumulative impacts, NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

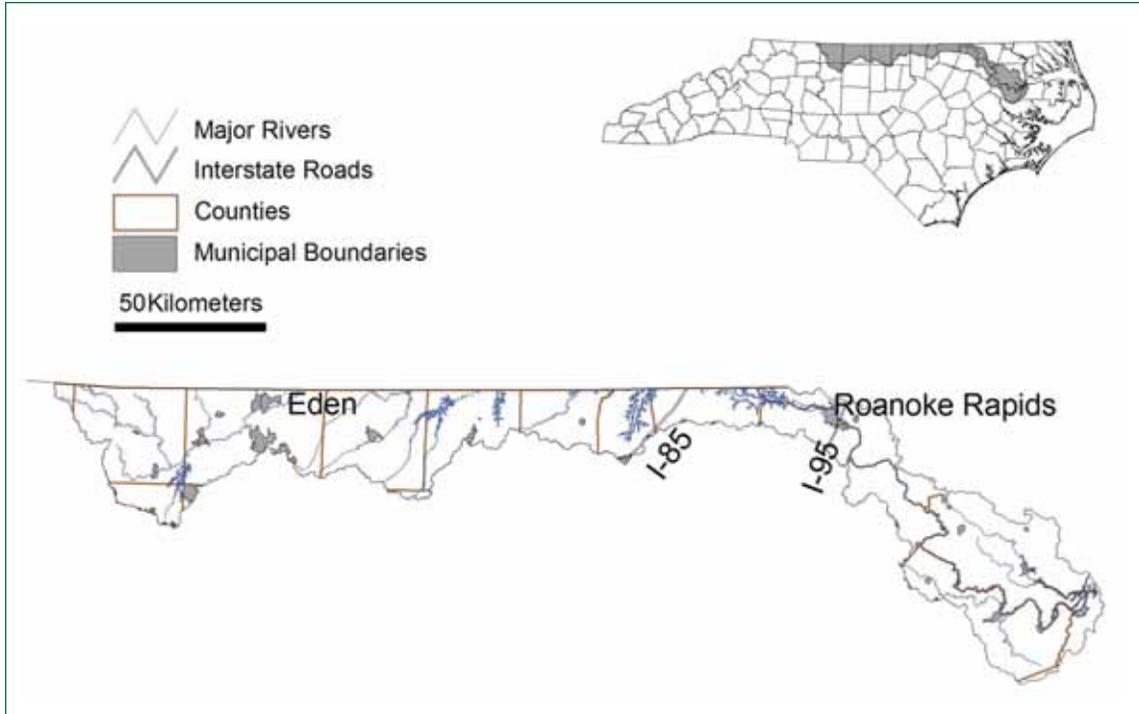
- Support federal and state species listing processes.
 - Focus analysis and synthesis of inventory and monitoring data and reporting to inform decision making pertaining to initial species listing and status revision.
 - When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

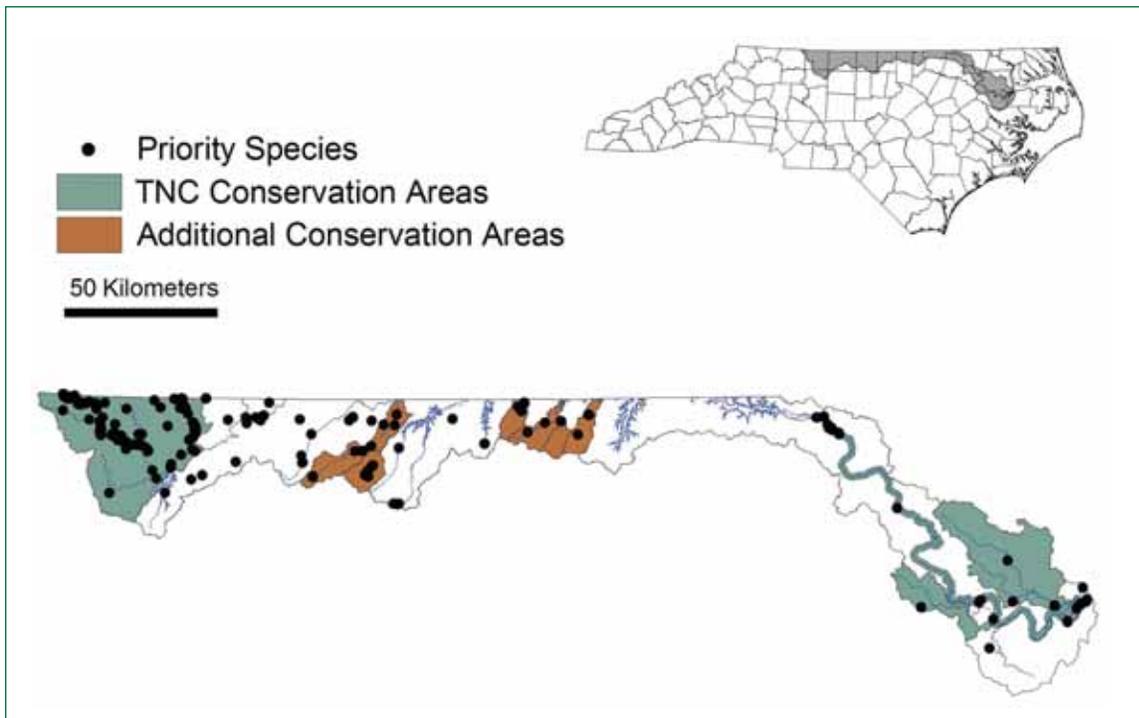
- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

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Map 5B.10a. Roanoke River basin, political information.



Map 5B.10b. Roanoke River basin, priority species occurrences and priority areas for freshwater conservation.

11. Cape Fear River Basin

Priority aquatic species in the Cape Fear River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish	<i>Acipenser brevirostrum</i>	Shortnose Sturgeon	E (E)
	<i>Acipenser oxyrinchus</i>	Atlantic Sturgeon	SC
	<i>Ambloplites cavifrons</i>	Roanoke Bass	SR
	<i>Ameiurus brunneus</i>	Snail Bullhead	
	<i>Carpiodes velifer</i>	Highfin Carpsucker	SC
	<i>Cyprinella sp. (cf. zanema)</i>	Thinlip Chub	SC
	<i>Elassoma evergladei</i>	Everglades Pygmy Sunfish	
	<i>Elassoma zonatum</i>	Banded Pygmy Sunfish	
	<i>Enneacanthus chaetodon</i>	Blackbanded Sunfish	
	<i>Enneacanthus obesus</i>	Banded Sunfish	
	<i>Erimyzon sucetta</i>	Lake Chubsucker	
	<i>Etheostoma collis</i>	Carolina Darter	SC
	<i>Fundulus diaphanus</i>	Banded Killifish	
	<i>Fundulus lineolatus</i>	Lined Topminnow	
	<i>Heterandria formosa</i>	Least Killifish	SC
	<i>Lepomis marginatus</i>	Dollar Sunfish	
	<i>Lepomis punctatus</i>	Spotted Sunfish	
	<i>Lucania goodei</i>	Bluefin Killifish	SC
	<i>Lythrurus matutinus</i>	Pinewoods Shiner	SR
	<i>Moxostoma collapsum</i>	Notchlip Redhorse	
	<i>Moxostoma macrolepidotum</i>	Shorthead Redhorse	
	<i>Moxostoma pappillosum</i>	V-lip Redhorse	
	<i>Moxostoma sp 2</i>	Carolina Redhorse	SR
	<i>Notropis amoenus</i>	Comely Shiner	
	<i>Notropis chalybaeus</i>	Ironcolor Shiner	
	<i>Notropis maculatus</i>	Taillight Shiner	
	<i>Notropis mekistocholas</i>	Cape Fear Shiner	E (E)
	<i>Noturus n. sp.</i>	Broadtail Madtom	SC
	<i>Petromyzon marinus</i>	Sea Lamprey	
	<i>Poecilia latipinna</i>	Sailfin Molly	
<i>Semotilus lumbee</i>	Sandhills Chub	SC	
Mussels	<i>Alasmidonta undulata</i>	Triangle Floater	T
	<i>Alasmidonta varicosa</i>	Brook Floater	E
	<i>Anodonta couperiana</i>	Barrel Floater ¹	E
	<i>Elliptio cistellaeformis</i>	Box Spike	
	<i>Elliptio congaraea</i>	Carolina Slabshell	
	<i>Elliptio folliculata</i>	Pod Lance	SC
	<i>Elliptio icterina</i>	Variable Spike	

¹Possibly extirpated.

Priority aquatic species in the Cape Fear River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Mussels, cont.	<i>Elliptio marsupiobesa</i>	Cape Fear Spike	SC
	<i>Elliptio roanokensis</i>	Roanoke Slabshell	T
	<i>Fuscioaia masoni</i>	Atlantic Pigtoe	E
	<i>Lampsilis cariosa</i>	Yellow Lampmussel	E
	<i>Lampsilis radiata radiata</i>	Eastern Lampmussel	T
	<i>Ligumia nasuta</i>	Eastern Pondmussel	T
	<i>Strophitus undulatus</i>	Creeper (Squawfoot)	T
	<i>Toxolasma pullus</i>	Savannah Lilliput	E
	<i>Villosa constricta</i>	Notched Rainbow	SC
	<i>Villosa delumbris</i>	Eastern Creekshell	SR
	<i>Villosa vaughaniana</i>	Carolina Creekshell	E
Crayfish	<i>Cambarus catagius</i>	Greensboro Burrowing Crayfish	SC
	<i>Cambarus davidi</i>	Carolina Ladle Crayfish	SR
	<i>Cambarus hystricosus</i>	Sandhills Spiny Crayfish	SR
	<i>Procambarus ancylus</i>	Edisto Crayfish	
	<i>Procambarus plumimanus</i>	Croatan Crayfish	SR
Snails	<i>Helisoma eucosmium</i>	Greenfield Rams-horn	E
	<i>Planorbella magnifica</i>	Magnificent Rams-horn	E
	<i>Viviparus intertextus</i>	Rotund Mysterysnail	SR

Note: As a coastal basin, information contained in Chapter 5C (Marine Systems), especially related to the Coastal Habitat Protection Plan (Street et al. 2004), may also apply to this basin.

A. Location and condition of basin (see Maps 5B.11a, 5B.11b):

The Cape Fear River basin is the largest river basin in North Carolina and is located entirely within the state. The Cape Fear River basin can be characterized by three distinct regions: the upper Cape Fear including the headwaters in the Piedmont, the middle Cape Fear including the fall line and the sandhills regions, and the lower Cape Fear which includes the coastal region with blackwater streams, peatlands, and swamps. The headwaters include the Deep River, originating near High Point, and the Haw River, originating north of Greensboro, which join to form the Cape Fear River just downstream of the B. Everett Jordan Reservoir dam. Much of the headwaters are located in and flow through highly urbanized areas which significantly impacts water quality in the basin. The Cape Fear River flows southeast across the Piedmont, through Fayetteville, and through the Sandhills and Coastal Plain regions before reaching Wilmington and entering the ocean. Blackwater streams and rivers in the lower Cape Fear include the South River, Black River, and the Northeast Cape Fear River. The Sandhills and Coastal Plain regions have a high rate of endemism due to their unique habitats. Cape Fear River basin also includes estuarine areas along the coast that serve as fish nurseries.

The total area of the Cape Fear River basin is 9,322 sq. miles, with 6,049 total stream miles (NCDWQ 2000a). There are 26 counties and 116 municipalities in the basin. The population density is 160 people/sq. mile with the most populated areas in the Greensboro, Burlington, and High Point areas. Other large urban areas in the basin include Durham, Chapel Hill and

Fayetteville. There was a 43% increase in developed land in the basin between 1982–1992 (NCDWQ 2000b). Land cover in the basin includes 56% forest land, 24% agricultural lands, 9% urban areas, and 11% other (rural transport, small water areas, lakes and estuaries; NCDWQ 2000b).

B. Problems affecting species and habitats:

Water quality problems occur throughout the basin; there are about 730 miles of impaired waters (NCDWQ 2000b). Causes of impairment include sediment, fecal coliform, ammonia, chlorides, low dissolved oxygen, turbidity, nutrients, mercury, and other point- and non-point pollutants. Sedimentation is a major issue in the basin; sources include agriculture, forestry, construction, and stormwater discharge in urbanized areas. The Cape Fear is interrupted by three lock and dams in the middle and lower portions of the river. There are also many smaller dams on the tributaries to the Cape Fear (e.g., Rocky River, Deep, Haw, Stony Creek, Reedy Fork). The consequences of these impoundments include blocked migration routes for diadromous and resident species, reduced recolonization and dispersal potential, and unnatural flow regimes (Williams et al. 1993, Etnier 1997, Neves et al. 1997, Warren et al. 2000).

Our knowledge of aquatic species distributions in the basin is inadequate; general surveys are needed throughout much of the Cape Fear River basin. We have a poor understanding of life history and habitat use for many species, knowledge that is critical for managing these populations. We have difficulty monitoring known populations of rare species at regular intervals in order to track changes in abundance and habitat quality. In addition, there are few long term data sets or monitoring sites. Invasive species (e.g., flathead catfish, red swamp crayfish) have become established in the Cape Fear River basin and continue to negatively impact native species populations (Fuller et al. 1999, Cooper 2005).

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

Inventory: distributional and status surveys – General surveys are needed to complete the distributional status of fish, mussels, crayfish, and snails (in order of need).

- Fish – basin priorities include surveys for Cape Fear shiner and Carolina redbhorse.
- Mussels – basin priorities include surveys for rare or listed species.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed.

- Support genetic studies to improve understanding of the freshwater mussel genus *Elliptio*.
- Support species descriptions for undescribed taxa (e.g., Carolina redbhorse).

Research to facilitate appropriate conservation actions – Research should focus on life history studies of priority species and for taxa which little information is known.

- Determine vulnerability of species across all taxa groups to threats such as dams, pollutants (animal wastes, toxic releases, and nutrient loading), and sedimentation.
- Study the potential effects of non-native species on native species.

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. New monitoring plans must be developed in coordination with existing monitoring efforts in order to meet shared goals and objectives wherever possible.

- Conduct long-term monitoring to identify population trends of priority species. Establish protocol, schedule, and sites for long-term population monitoring (collaborate with the NC Division of Water Quality, NC Museum of Natural Sciences, and the US Fish and Wildlife Service).

- Conduct special purpose monitoring to assess performance of specific conservation actions:
 - Performance of stream restoration projects.
 - Impacts of dam removal projects.
- Determine distribution of non-native species (e.g., flathead catfish and introduced crayfish).

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration

- Provide support for land protection (acquisition, easements, buffers):
 - Support stream protection/restoration by working collaboratively with other organizations including: Ecosystem Enhancement Program, NC Natural Heritage Program, US Fish & Wildlife Service, Natural Resources Conservation Service, The Nature Conservancy, other non governmental organizations, and the US Forest Service (Uwharrie National Forest).
 - Support dam removal (work with US Fish & Wildlife Service and other interested non governmental organizations).
- Identify priority areas for habitat protection (areas with high species diversity, rare species, and endemic species). Identify specific areas that are critical to the survival of species (e.g., spawning areas) and/or diverse communities.:
 - Priority watersheds for conservation in the Cape Fear River basin include (based in part on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.11b):
 - o Upper Haw River
 - o Middle Haw River tributaries
 - o Deep/Rocky/Haw/Cape Fear Rivers
 - o New Hope Watershed above B. Everett Jordan Reservoir
 - o Cape Fear sandhills tributaries
 - o Lower Cape Fear/Black/South Rivers
 - o Northeast Cape Fear River
 - o Town Creek
 - o Merrick's Creek/Holly Shelter Game Lands
 - o Orton Pond/Military Ocean Terminal Sunny Point
- Promote and support conservation and restoration efforts within the Commission.
 - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, into Game Lands management, and into Game Lands acquisitions.

Population management and restoration – Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

- Investigate potential for reintroduction of extirpated mollusk and fish species to the basin in restored or improved habitats as opportunities become available.

Data collection, management, and dissemination among agencies

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Coordinate sampling with other resource groups.
- Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.

- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources; improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
- Develop and disseminate print media, including stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
 - Deliver oral presentations.
 - Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitat.

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection

- Address secondary and cumulative impacts upon water quality (e.g., buffer ordinances, water supply watershed protection, protect headwaters) (NCDWQ 2000a, NCWRC 2002).
- Promote programs to help modernize wastewater treatment facilities and inform public about proper upkeep of septic systems.
- Work with and promote existing programs that help farmers reduce sedimentation/erosion (e.g., install fences to keep live stock out of streams and improve tilling practices) as well as reduce pesticide and herbicide use.
- Protect existing good water and habitat quality throughout the basin (Outstanding Resource Water and High Quality Water streams).
- Promote programs to upgrade wastewater treatment at hog and chicken farms.
- Work through Site-Specific Management Plan process to improve water quality protection for waters containing federally listed species (potential partners include the NC Division of Water Quality, the NC Natural Heritage Program, and the US Fish & Wildlife Service).

Land-use planning

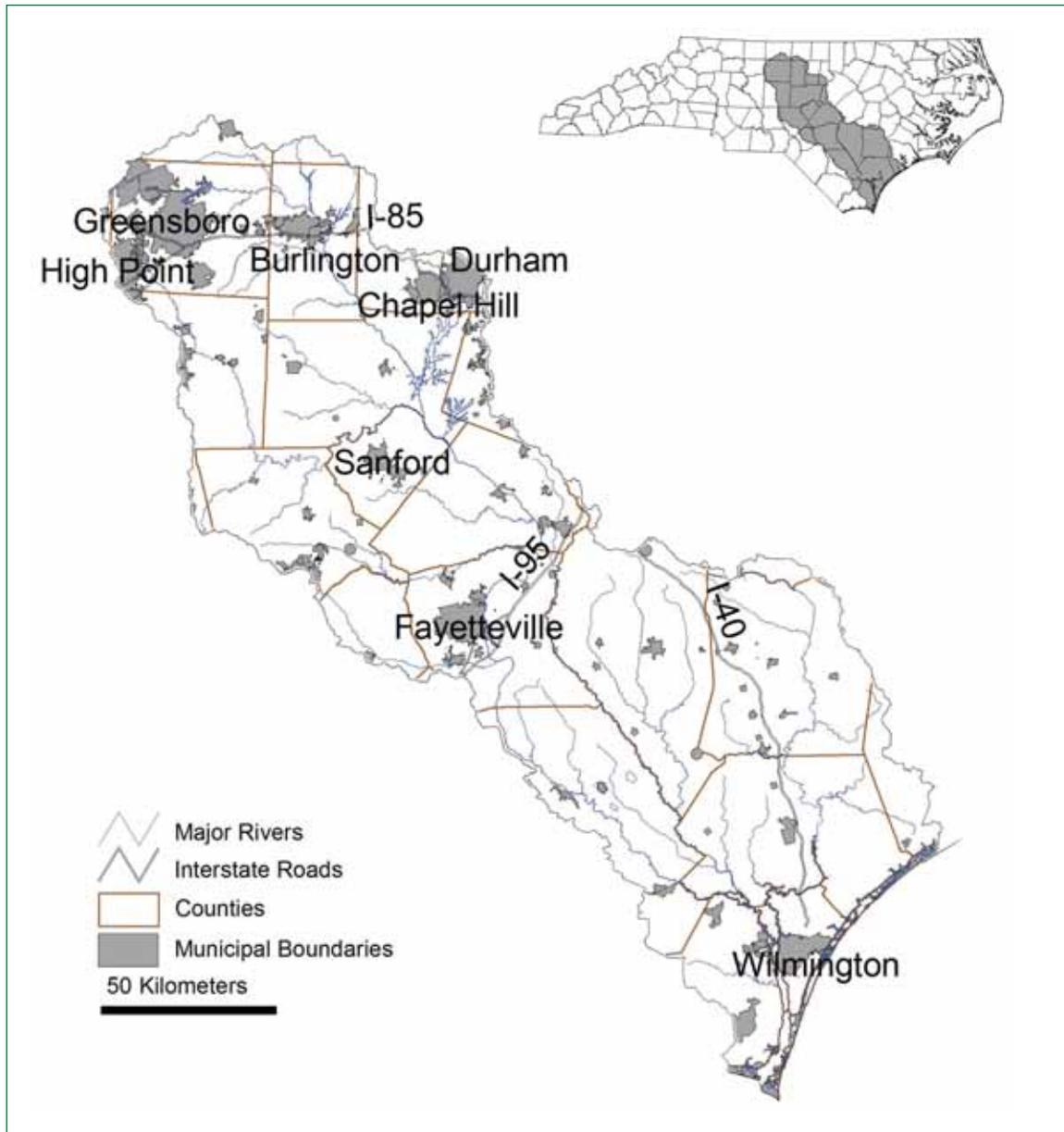
- Work with county and city officials and developers to incorporate buffers along streams, implement low impact development, and better stormwater regulations (e.g., secondary and cumulative impacts; NCWRC 2002).
- Support sustainable land use planning that considers long-term effects of development.
- Support dam and lock removal where feasible (work with US Fish & Wildlife Service, the US Army Corps of Engineers, and private dam owners).

Species protection

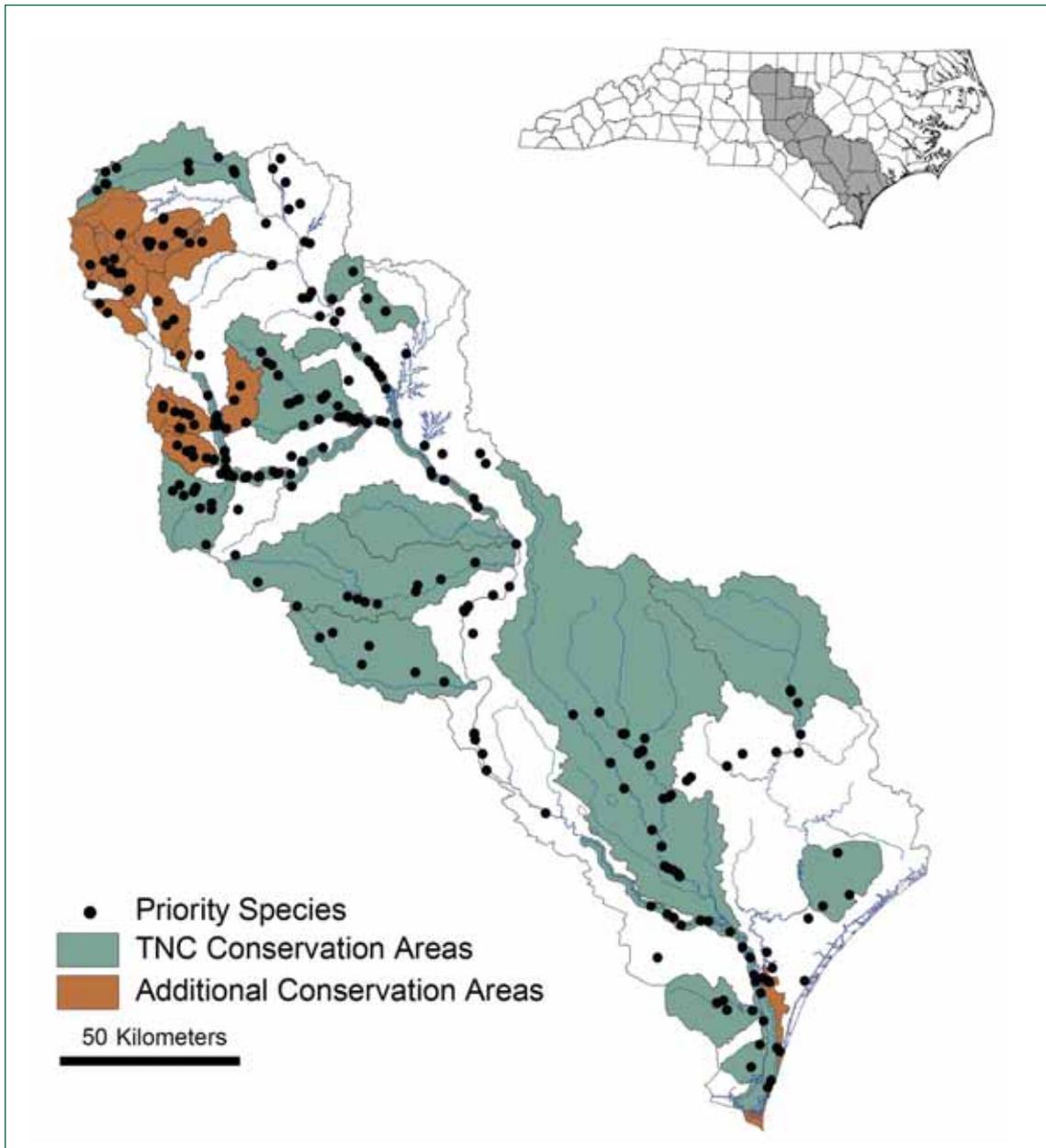
- Work with the US Fish & Wildlife Service on listed species recovery plans.
- Make recommendations, as appropriate, to the Commission's Nongame Wildlife Advisory Committee for state listed species status changes.
- Ensure that collection permits for impact assessments are issued to qualified applicants.

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Map 5B.11a. Cape Fear River basin, political information.



Map 5B.11b. Cape Fear River basin, priority species occurrences and priority areas for freshwater conservation.

12. Neuse River Basin

Priority aquatic species in the Neuse River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish ¹	<i>Acipenser oxyrinchus</i>	Atlantic Sturgeon	SC
	<i>Ambloplites cavifrons</i>	Roanoke Bass	SR
	<i>Ameiurus brunneus</i>	Snail Bullhead	
	<i>Carpiodes cyprinus</i>	Quillback	
	<i>Elassoma zonatum</i>	Banded Pygmy Sunfish	
	<i>Enneacanthus chaetodon</i>	Blackbanded Sunfish	
	<i>Enneacanthus obesus</i>	Banded Sunfish	
	<i>Erimyzon sucetta</i>	Lake Chubsucker	
	<i>Etheostoma collis</i>	Carolina Darter	SC
	<i>Etheostoma nigrum</i>	Johnny Darter	
	<i>Etheostoma vitreum</i>	Glassy Darter	
	<i>Fundulus diaphanus</i>	Banded Killifish	
	<i>Fundulus lineolatus</i>	Lined Topminnow	
	<i>Lampetra aepyptera</i>	Least Brook Lamprey	T
	<i>Lepomis marginatus</i>	Dollar Sunfish	
	<i>Lythrurus matutinus</i>	Pinewoods Shiner	SR
	<i>Moxostoma collapsum</i>	Notchlip Redhorse	
	<i>Moxostoma macrolepidotum</i>	Shorthead Redhorse	
	<i>Moxostoma pappillosum</i>	V-lip Redhorse	
	<i>Notropis amoenus</i>	Comely Shiner	
	<i>Notropis bifrenatus</i>	Bridle Shiner	SC
	<i>Notropis chalybaeus</i>	Ironcolor Shiner	
	<i>Notropis volucellus</i>	Mimic Shiner	
<i>Noturus furiosus</i>	Carolina Madtom	SC	
<i>Petromyzon marinus</i>	Sea Lamprey		
Mussels ²	<i>Alasmidonta heterodon</i>	Dwarf Wedgemussel	E (E)
	<i>Alasmidonta undulata</i>	Triangle Floater	T
	<i>Alasmidonta varicosa</i>	Brook Floater	E
	<i>Elliptio cistellaeformis</i>	Box Spike	
	<i>Elliptio congaraea</i>	Carolina Slabshell	
	<i>Elliptio icterina</i>	Variable Spike	
	<i>Elliptio lanceolata</i>	Yellow Lance	E
	<i>Elliptio marsupiobesa</i>	Cape Fear Spike	SC
	<i>Elliptio roanokensis</i>	Roanoke Slabshell	T
	<i>Elliptio steinstansana</i>	Tar River Spiny mussel	E (E)
	<i>Fusconaia masoni</i>	Atlantic Pigtoe	E
	<i>Lampsilis cariosa</i>	Yellow Lampmussel	E

¹Smallmouth buffalo (*Ictiobus bubalus*) is a native priority fish species in the French Broad basin, but is a non-native in the Catawba, Yadkin-PeeDee, and Neuse basins. In non-native basins, this species is not a priority for conservation. Rather, monitoring and possible control of range expansion should be initiated.

²An undescribed *Lampsilis* species exists in this basin.

Priority aquatic species in the Cape Fear River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Mussels, cont.	<i>Lampsilis radiata conspicua</i>	Carolina Fatmucket	T
	<i>Lampsilis radiata radiata</i>	Eastern Lampmussel	T
	<i>Lasmigona subviridis</i>	Green Floater	E
	<i>Strophitus undulatus</i>	Creepers (Squawfoot)	T
	<i>Villosa constricta</i>	Notched Rainbow	SC
Crayfish	<i>Cambarus davidi</i>	Carolina ladle crayfish	SR
	<i>Orconectes carolinensis</i>	North Carolina spiny crayfish	SC
	<i>Procambarus medialis</i>	Tar River crayfish	
	<i>Procambarus plumimanus</i>	Croatian crayfish	SR
Snails	<i>Somatogyrus virginicus</i>	Panhandle pebblesnail	SR
	<i>Viviparus intertextus</i>	Rotund Mysterysnail	SR

Note: As a coastal basin, information contained in Chapter 5C (Marine Systems), especially related to the Coastal Habitat Protection Plan (Street et al. 2004), may also apply to this basin.

A. Location and condition of basin (see Maps R12a, R12b):

The Neuse River basin is an Atlantic Slope drainage originating in Person and Orange Counties in the Piedmont region of North Carolina and flowing through the Coastal Plain to Pamlico Sound. The Neuse is the third largest basin in North Carolina and has an area of 6,235 sq. miles, draining 3,497 miles of streams. There are 16,414 freshwater lake acres, 369,977 estuarine acres, and 21 miles of coastline in the basin. The Neuse River flows as freshwater until reaching New Bern, where it turns into a 40 mile long brackish tidal estuary to the mouth of the Pamlico Sound. Major tributaries to the Neuse River include the Eno River, Flat River, Little River, Trent River, Crabtree Creek, Swift Creek, and Contentnea Creek (NCDWQ 2001).

There are two distinct portions of the Neuse River basin: the upper one-third in the Piedmont physiographic region and the lower two-thirds in the Coastal Plain physiographic region. The upper Neuse River basin, including the Flat, Eno, and Little Rivers, lies within the Slate Belt Ecoregion. The Piedmont portion typically features a low gradient with sluggish pools separated by riffles and occasional small rapids. Soils are highly erodible and are underlain by fractured rock formations that have limited water storage capacity. This portion tends to have low summer flows and limited ability to assimilate oxygen-consuming wastes. The Coastal Plain portion features slow-moving blackwater streams, low-lying swamps and productive estuarine waters. The larger waterbodies are meandering, often lined with swamps and bottomland hardwoods, and often have naturally low dissolved oxygen and pH. Soils are deep sands that have a high groundwater storage capacity. Natural lakes include the remnants of bay lakes in the lower Coastal Plain (NCDWQ 2001).

The Neuse river basin has 74 municipalities within 18 basin counties. The most urbanized section of the river basin is from Falls of the Neuse Reservoir to southern Johnston county, including Swift and Crabtree Creeks (NCDWQ 2002). Major cities include Raleigh, Durham, and Cary in the upper basin and Goldsboro, Kinston, and New Bern in the lower basin. The basin has a population of 1,320,379 (2000 census data), containing approximately one-sixth of North Carolina's total population. Population density is 211 people/sq. mile. Approximately 13% of the basin is considered urban, 45% forested, and 29% crop and pasture land (NCDWQ 2001).

The upper 22 miles of the Neuse River proper are impounded by Falls of the Neuse Dam. The river flows for approximately 185 miles below the dam until it terminates at Pamlico Sound. The Neuse River is 6 miles wide at its mouth, the widest river in America (NCDENR 2003), and the longest river within North Carolina's borders. Other major reservoirs in the Neuse River Basin include Milburnie Dam, Little River Reservoir, Lake Michie, Lake Orange, Corporation Lake, Lake Ben Johnson (run-of-the-river dam), Lake Butner, Lake Rogers, Lake Wheeler, Lake Benson, and Buckhorn Reservoir. Removal of Quaker Neck Dam (near Goldsboro) in 1997 opened up 1,000 miles of river to migratory fishes (75 miles of Neuse River, 925 miles of tributaries; NCDWQ 2001).

The West Bay subbasin (Pamlico Sound, upper Core Sound, West Bay and their embayments and tributaries) contains 63,513 acres of Outstanding Resource Waters (ORW) because of their high fisheries value. There are 582 acres of High Quality Waters (HQW), mostly associated with Greens Creek and Smith Creek in the lower Neuse River basin. (NCDWQ 2002). The basin contains 555 miles of impaired streams and all waters in the basin have a supplemental classification of Nutrient Sensitive Waters (NCDWQ 2004).

B. Problems affecting species and habitats:

Non-point source pollution from agriculture and forestry has degraded aquatic habitats within the basin. For example, animal waste byproducts cause increased levels of nitrates and phosphates, which can lead to: 1) excess growth of aquatic plants, such as algae, and 2) decreased dissolved oxygen levels (especially during summer months), resulting in fish kills. Bank erosion can result from channelization of streams for agriculture. Fertilizers and livestock contribute 60 percent of nitrates and phosphates in the basin and forestry contributes 13 and 6 percent of nitrogen and phosphorus, respectively (NCDENR 2003).

Hydrology within the basin has been altered by dam construction and water withdrawals. Impoundments in the basin have affected aquatic species by physically altering habitat, reducing flows and dissolved oxygen, and causing erosion. Modification of flow regimes by upstream impoundments affects various life history characteristics of downstream migratory fishes and other aquatic fauna, such as limiting dispersal and recolonization. Additionally, water withdrawals for irrigation reduce the quantity of available habitat for aquatic species (NCDWQ 2002).

Several development-related threat sources are negatively impacting aquatic habitats in the Neuse River basin. Increasing population leads to increased water demands and wastewater discharges. The human population within the basin is expected to grow by more than 867,000 by 2020 to almost 3 million people. Losses of natural areas and increases in impervious surfaces, as a result of rapid population growth, result in high sediment runoff from construction. More homes contribute to an increase in lawn fertilizer runoff. Heavy metal runoff contributes to elevated mercury levels in fish tissue. These point and nonpoint runoff sources accumulate in the Pamlico Sound, where researchers at the University of North Carolina at Wilmington found one-third of the sediments contaminated with chemicals and toxic metals (Powell 1999). Additionally, atmospheric deposition of nitrogen from cars and factories can lead to decreased water quality. Large quantities of nutrients, especially nitrogen, from nonpoint sources are considered the greatest threat to water quality of the Neuse River estuary. There are over 400 point source waste discharge permits for the basin from municipal wastewater treatment plants, industrial facilities, small package treatment plants, and large urban and industrial stormwater. Municipal point source waste pollution contributes 13 and 23 percent of nitrogen and phosphorus, respectively (Powell 1999).

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

Inventory: distributional and status surveys – General surveys are needed to complete distributional status for priority fish, mussels, crayfish, and snail species. Basin specific priorities include:

- Atlantic sturgeon – survey for abundance, population status, and migrations; effects of dams should be considered.
- Carolina darter – recognized as a data gap for entire South Atlantic Aquatic Region (Smith et al. 2002) and recognized as in need of a status survey due to increased developmental pressures on North Carolina aquatic systems (Menhinick and Braswell 1997).
- Least brook lamprey – status survey is needed by electroshocking; species in danger of extirpation due to its intolerance of turbidity and its historical records being close to the Raleigh area where sedimentation effects are present due to urbanization.
- Carolina madtom – endemic to North Carolina; previous records show distribution in Neuse and Tar-Pamlico River basins, but need current data on distribution in Neuse basin; could possibly be extirpated from the Neuse; water quality degradation probably cause of decline in population.
- Roanoke bass – native of the basin and populations should be monitored; populations in VA have declined due to habitat alterations and also due to the introduction of rock bass; have hybridized and displaced VA Roanoke bass.
- Bridle shiner – known from one site, Tucker Creek, in lower Neuse basin; need to resurvey Tucker Creek and other streams with similar habitat to determine if species still occurs in Neuse basin.
- Tar spiny mussel – determine if the species remains in Neuse basin and if so, determine its distribution.
- Other mussel survey priorities in the basin include the Atlantic pigtoe and yellow lance.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed.

- Support genetic work to gain better understanding of mussel genus *Elliptio*.
- Support completion of species description for undescribed taxa (mussel, *Lampsilis* sp.; possible undescribed crayfish species in *Cambarus acuminatus* complex).
- Support genetics work on Roanoke and rock bass to determine hybridization effects.
- Support work to resolve taxonomic disputes surrounding least brook lamprey.
- Determine if bridle shiner populations are native or introduced.
- Data gap exists for Carolina fatmucket for entire South Atlantic Aquatic Region (Smith et al. 2002).
- Support taxonomic research for other species as needed.

Research to facilitate appropriate conservation actions – Research should generally focus on life history of priority species.

- Conduct life history studies for priority species including habitat use/preferences, spawning location and timing, fecundity, population dynamics, feeding, competition, predation, migration patterns (where applicable).
- Determine vulnerability of priority species to specific threats; relate results to permit condition and review responsibilities.

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible.

- Conduct long-term monitoring to identify population trends. Establish protocol, schedule, and locations for long-term monitoring of priority species (collaborate with NC Division of Water Quality, NC Museum of Natural Sciences, US Fish & Wildlife Service).
- Conduct special purpose monitoring:
 - Performance of stream restoration projects.
 - Performance of restoration projects.
 - Performance of dam removal projects; many are being removed for mitigation credits – what are the short and long-term effects on species and habitat?
- Assess non-native species impacts:
 - Establish distribution and monitoring survey protocol for non-natives, possibly incorporating strategy into long-term monitoring for native species.
 - Determine effects of non-native species on natives

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration – Promote and support habitat protection efforts of external entities.

- Provide support for land protection (e.g., property purchase, land preservation agreements, buffers) and stream restoration (collaborate with Ecosystem Enhancement Program, NC Natural Heritage Program, US Fish & Wildlife Service, US Forest Service, Natural Resources Conservation Service, The Nature Conservancy, US Army Corps of Engineers).
 - Support dam removal, as appropriate for stream restoration.
- Identify priority areas for habitat protection:
 - Priority areas for freshwater conservation in the Neuse basin include (based on Smith et al., 2002, NC Natural Heritage Program, and Commission data) (see Map R12a):
 - o Neuse River headwaters
 - o Crabtree Creek
 - o Middle Neuse River and tributaries
 - o Blue Pond
 - o Mill Creek
 - o Trent River
 - o Moccasin/Turkey Creeks
 - o Knapp of Reeds Creek
 - o Middle Creek
- Promote and support conservation and restoration efforts within the Commission.
 - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, into Game Lands management, and into Game Lands acquisitions.

Population management and restoration

- Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

Data collection, management, and dissemination among agencies

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Coordinate sampling with other resource groups.
- Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.
- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources; improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
- Develop and disseminate print media, including stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
 - Deliver oral presentations.
 - Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, Federal Energy Regulatory Commission, US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection – Work with regulatory agencies to conserve and restore water and habitat quality.

- Support strengthening of water quality protection.
 - Support clean-up efforts and stricter enforcement of animal operations in addition to promoting animal waste treatment improvements and upgrades (potential cooperators include the NC Division of Water Quality, Albemarle Pamlico National Estuary Program, Ecosystem Enhancement Program, private corporations).
 - Work through Site-Specific Management Plan process to obtain stricter regulations for waters containing federally listed species (potential cooperators include the NC Division of Water Quality, the NC Natural Heritage Program, and the US Fish & Wildlife Service).
 - Promote programs to reduce working farm-related sedimentation/erosion (using best management practices, fencing livestock out of stream, etc.) and reduce nutrient inputs (pesticide/herbicide use).
 - Support stormwater management and wastewater treatment plant improvements and upgrades.
 - Promote protection of areas with good water quality through HQW/ORW designations.

Land-use planning – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishment of riparian buffers along streams, implementation of low impact development and better stormwater management (e.g., secondary and cumulative impacts, NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

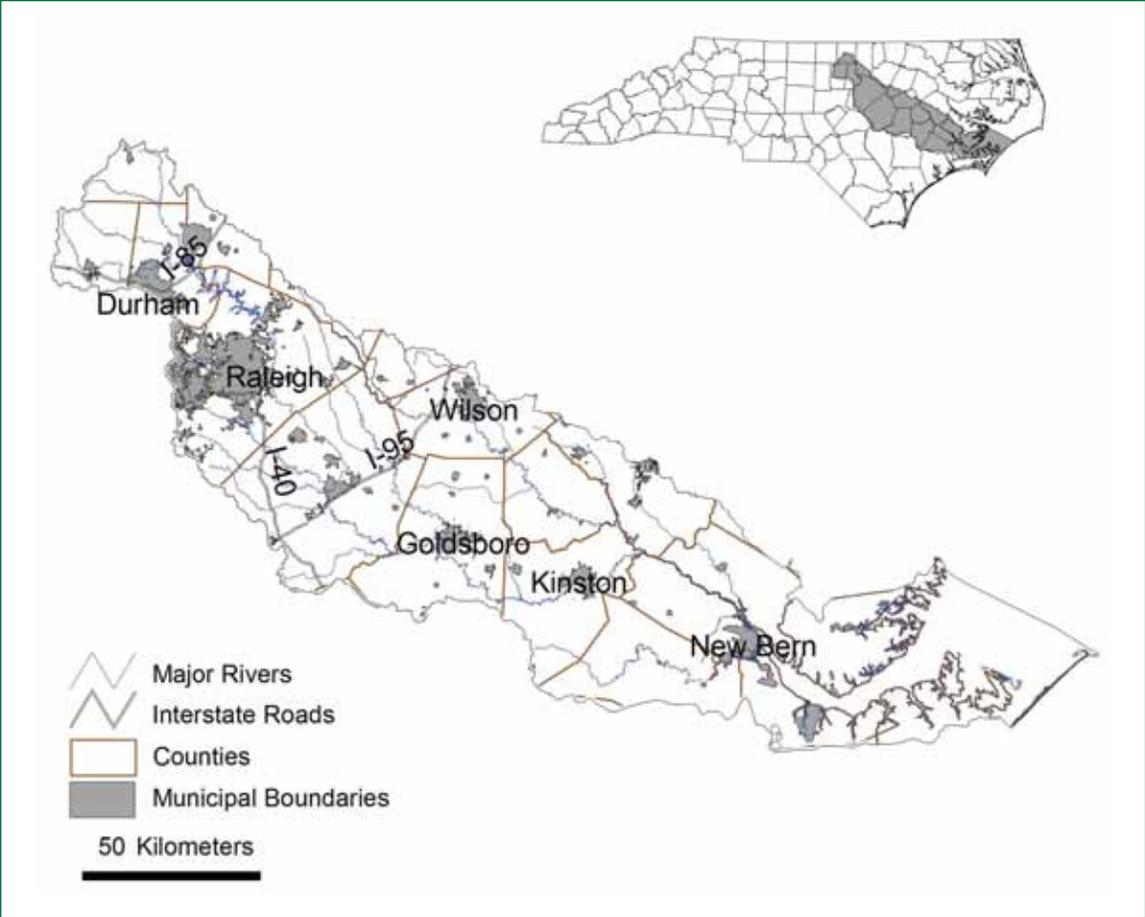
- Support federal and state species listing processes.
 - Work with the US Fish & Wildlife Service on listed species recovery plans – Dwarf wedgemussel and Tar spinymussel.
 - When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

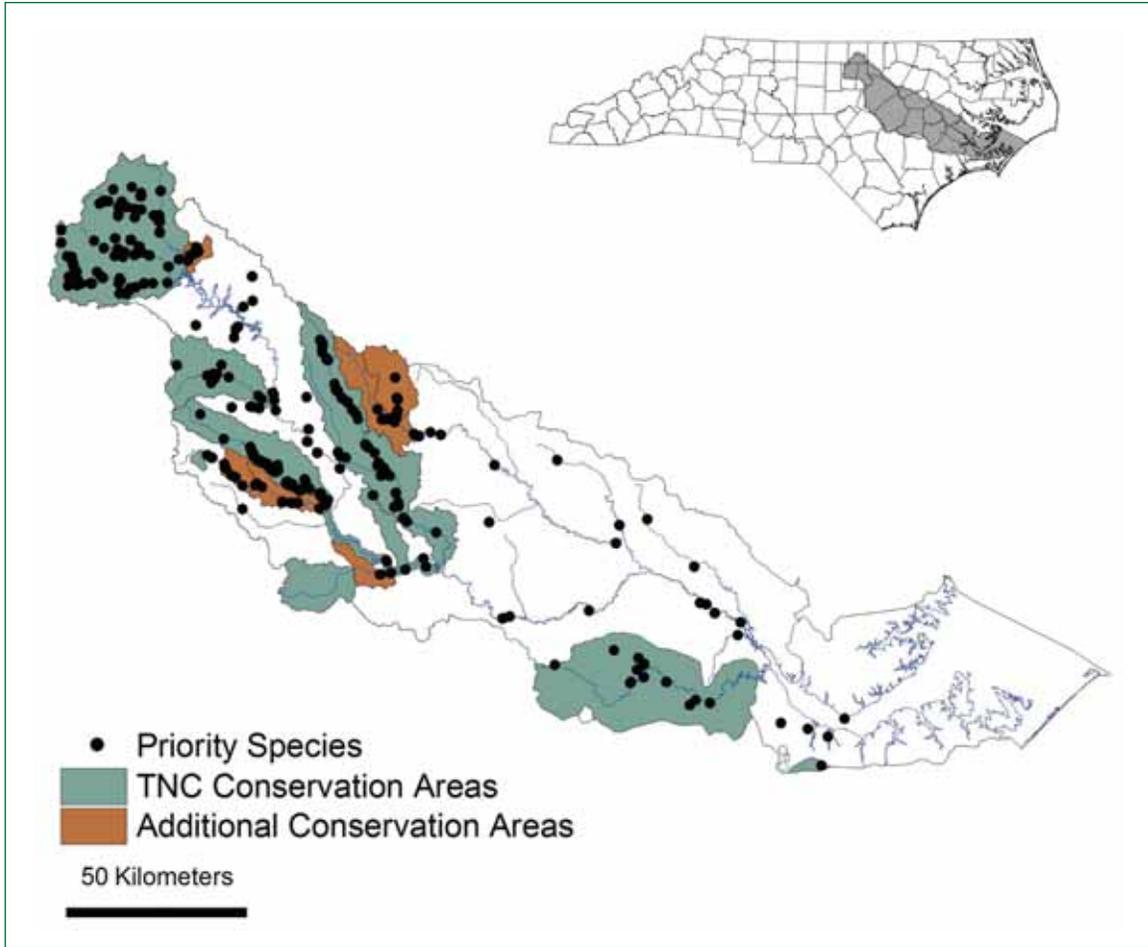
- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

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Map 5B.12a. Neuse River basin, political information.



Map 5B.12b. Neuse River basin, priority species occurrences and priority areas for freshwater conservation.

13. Tar-Pamlico River Basin

Priority aquatic species in the Tar-Pamlico River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish	<i>Acipenser oxyrinchus</i>	Atlantic Sturgeon	SC
	<i>Ambloplites cavifrons</i>	Roanoke Bass	SR
	<i>Elassoma zonatum</i>	Banded Pygmy Sunfish	
	<i>Enneacanthus chaetodon</i>	Blackbanded Sunfish	
	<i>Enneacanthus obesus</i>	Banded Sunfish	
	<i>Erimyzon sucetta</i>	Lake Chubsucker	
	<i>Etheostoma collis</i>	Carolina Darter	SC
	<i>Etheostoma nigrum</i>	Johnny Darter	
	<i>Etheostoma vitreum</i>	Glassy Darter	
	<i>Fundulus diaphanus</i>	Banded Killifish	
	<i>Fundulus lineolatus</i>	Lined Topminnow	
	<i>Lampetra aepyptera</i>	Least Brook Lamprey	T
	<i>Lepomis marginatus</i>	Dollar Sunfish	
	<i>Lythrurus matutinus</i>	Pinewoods Shiner	SR
	<i>Moxostoma collapsum</i>	Notchlip Redhorse	
	<i>Moxostoma macrolepidotum</i>	Shorthead Redhorse	
	<i>Moxostoma pappillosum</i>	V-lip Redhorse	
	<i>Notropis amoenus</i>	Comely Shiner	
	<i>Notropis chalybaeus</i>	Ironcolor Shiner	
	<i>Notropis volucellus</i>	Mimic Shiner	
<i>Noturus furiosus</i>	Carolina Madtom	SC	
Mussels ¹	<i>Alasmidonta heterodon</i>	Dwarf Wedgemussel	E (E)
	<i>Alasmidonta undulata</i>	Triangle Floater	T
	<i>Elliptio cistellaeformis</i>	Box Spike	
	<i>Elliptio congaraea</i>	Carolina Slabshell	
	<i>Elliptio icterina</i>	Variable Spike	
	<i>Elliptio lanceolata</i>	Yellow Lance	E
	<i>Elliptio roanokensis</i>	Roanoke Slabshell	T
	<i>Elliptio steinstansana</i>	Tar River Spiny mussel	E (E)
	<i>Fusconaia masoni</i>	Atlantic Pigtoe	E
	<i>Lampsilis cariosa</i>	Yellow Lampmussel	E
	<i>Lampsilis radiata radiata</i>	Eastern Lampmussel	T
	<i>Lasmigona subviridis</i>	Green Floater	E
	<i>Leptodea ochracea</i>	Tidewater Mucket	T
	<i>Ligumia nasuta</i>	Eastern Pondmussel	T
	<i>Strophitus undulatus</i>	Creeper (Squawfoot)	T
	<i>Villosa constricta</i>	Notched Rainbow	SC
Crayfish	<i>Orconectes carolinensis</i>	North Carolina Spiny Crayfish	SC
	<i>Procambarus medialis</i>	Tar River Crayfish	

¹An undescribed *Lampsilis* species exists in the basin.

Note: As a coastal basin, information contained in Chapter 5C (Marine Systems), especially related to the Coastal Habitat Protection Plan (Street et al. 2004), may also apply to this basin.

A. Location and condition of basin (see Maps 5B.13a, 13b):

The Tar-Pamlico River basin is an Atlantic Slope basin originating in Person County, in North Carolina's Piedmont region. The Tar-Pamlico is the fourth largest basin in the state, encompassing 5,440 sq. miles and draining 2,355 miles of streams. There are 3,977 lake acres, 663,593 estuary acres, and 17 coastline miles within the basin. With a length of approximately 180 miles, the Tar River becomes the Pamlico River (lowermost 40 miles) at U.S. 17 in Washington. The Tar-Pamlico River terminates at Pamlico Sound. Major tributaries include Fishing Creek, Swift Creek, Cokey Swamp, Tranters Creek and the Pungo River (NCDWQ 2004a).

There are two distinct portions of the Tar-Pamlico River basin: the upper one-fifth in the Piedmont physiographic region and the lower four-fifths in the Coastal Plain physiographic region. The Piedmont portion, running from the river headwaters to the fall line, lies on the Carolina Slate Belt and Triassic Basins ecoregion. This portion features low gradients with sluggish pools separated by riffles and occasional small rapids. Soils are highly erodible and are underlain by fractured rock formations that have limited water storage capacity. Streams and rivers in the Piedmont portion tend to have low summer flows and limited ability to assimilate oxygen-consuming wastes (NCDWQ 2003). The Coastal Plain portion features slow-moving blackwater streams, low-lying swamps and productive estuarine waters. The larger waterbodies are meandering, often lined with swamps and bottomland hardwoods, and often have naturally low dissolved oxygen and pH. Soils are deep sands that have a high groundwater storage capacity. Natural lakes include the remnants of bay lakes in the lower Coastal Plain (NCDWQ 2004a).

There are 50 municipalities within 16 counties in the Tar-Pamlico River basin. Rocky Mount, Greenville, Henderson, Oxford, Tarboro, and Washington are the largest municipalities in the basin. Population within the basin is 414,929 (2000 census, NCDWQ 2004a). At a population density of 75 people/sq. mile, compared to statewide density of 152 people/sq. mile, the basin is relatively rural (NCDWQ 2004a). Land use in the basin is approximately 38% forest and wetland, 23% crop and pasture land, and 5% urban (NCDWQ 2004a). Publicly owned lands include three National Wildlife Refuges (Lake Mattamuskeet, Pocosin Lakes, Swanquarter) and two State Parks (Goose Creek and Medoc Mountain). North Carolina's largest lake, Lake Mattamuskeet, also is located in this basin (NCDENR 2003).

Major reservoirs in the Tar-Pamlico River basin include Lake Devin (a water supply reservoir for Oxford), Lake Royale, and Tar River Reservoir in Rocky Mount. Several old millponds and beaver impoundments are found throughout the Tar-Pamlico River basin (NCDWQ 2003).

There are 24,178 total acres of Outstanding Resource Waters (ORW) in the basin. The ORWs are primarily composed of Swanquarter Bay Refuge, Juniper Bay (and many of their tributaries), and parts of Pamlico Sound. There are 80 miles of impaired stream in the Tar-Pamlico River basin and all waters in the basin have a supplemental classification of Nutrient Sensitive Waters (NCDWQ 2004b).

B. Problems affecting species and habitats:

The basin has a high rate of erosion and sedimentation as compared to other North Carolina river basins (Alderman 1999). Sedimentation can result from land clearing activities, streambank erosion, and channelization associated with construction and agriculture. Historic stream channelization for crop irrigation and drainage continues to this day in Conetoe Creek watershed (NCDWQ 2004a). According to 1998 USDA data, the Tar-Pamlico basin is responsible for 5% of the swine, 4% of the dairy, and 7% of the poultry in North Carolina (NCDWQ 2004a).

Abandoned swine lagoons in the basin are susceptible to flooding. In particular, the lower portion of Tar-Pamlico basin (below Tarboro) is heavily affected by agriculture. These agricultural activities contribute to nutrient inputs, erosion, and sedimentation. Influxes of sediment reduce the quality and quantity of necessary habitat for aquatic organisms (NCDWQ 2003).

Water supply withdrawals and interbasin transfers can be expected to increase with development pressures, which will require management measures to avoid negative impacts to aquatic habitats (NCDWQ 2004a). Currently, there are 60 (77 million gallons/day total) registered water withdrawals in the basin (NCDWQ 2004a). Water withdrawals for irrigation purposes continue to reduce the quantity of available habitat for aquatic species.

Several development-related threat sources are negatively impacting aquatic habitats in the Tar-Pamlico River basin. Population growth creates a need for increased drinking water and wastewater discharges. Franklin, Granville, and Nash counties are the fastest growing counties in the upper part of the basin; the basin population is expected to grow by more than 170,000 by 2020, to almost one million people (NCDWQ 2004a). Cumulative and secondary impacts due to urban expansion (e.g., greater Raleigh and Rocky Mount) will cause increased impervious surfaces, which in turn may lead to increased stream sedimentation. Population growth within the basin will also lead to increased demands for drinking water, wastewater discharge, and stormwater control.

Point source discharges (municipal wastewater treatment plants, industrial facilities, small package treatment plants, large urban and industrial stormwater systems) all degrade water quality in the basin. Wastewater treatment plant effluent increases conductivity, elevates nitrogen levels, and lowers dissolved oxygen (NCDWQ 2003).

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

Inventory: distributional and status surveys – General surveys are needed to complete distributional status for priority fish, mussels, crayfish, and snail species. Basin specific priorities include:

- Atlantic sturgeon – survey for abundance, population status, and migrations; effects of dams should be considered.
- Carolina darter – recognized as a data gap for entire South Atlantic Aquatic Region (Smith et al. 2002) and recognized as in need of a status survey due to increased developmental pressures on North Carolina aquatic systems (Menhinick and Braswell 1997).
- Least brook lamprey – status survey is needed by electroshocking; species in danger of extirpation due to its intolerance of turbidity and its historical records being close to the Raleigh area where sedimentation effects are present due to urbanization.
- Carolina madtom – distributional information needed; good populations in Tar-Pamlico basin; this information can be used to help locate populations within Neuse basin.
- Roanoke bass – native of the basin and populations should be monitored; populations in VA have declined due to habitat alterations and also due to the introduction of rock bass; have hybridized and displaced VA Roanoke bass.
- North Carolina spiny crayfish and Tar River crayfish – both are endemic to North Carolina.
- Mussel survey priorities in the basin include the Atlantic pigtoe and yellow lance.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed

- Support genetic work to gain better understanding of mussel genus *Elliptio*.
- Support completion of species description for undescribed taxa (mussel, *Lampsilis* sp.).
- Support genetics work on Roanoke and rock bass to determine hybridization effects.

- Support work to resolve taxonomic disputes surrounding least brook lamprey.
- Support taxonomic research for other species as needed.

Research to facilitate appropriate conservation actions – Research should generally focus on life history of priority species.

- Conduct life history studies for priority species including habitat use/preferences, spawning location and timing, fecundity, population dynamics, feeding, competition, predation, migration patterns (where applicable).
- Determine vulnerability of priority species to specific threats; relate results to permit condition and review responsibilities.

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible.

- Conduct long-term monitoring to identify population trends:
 - Establish protocol, schedule, and locations for long-term monitoring of priority species (collaborate with NC Division of Water Quality, NC Museum of Natural Sciences, US Fish & Wildlife Service).
- Conduct special purpose monitoring:
 - Performance of stream restoration projects.
 - Performance of restoration projects.
 - Performance of dam removal projects to monitor short and long-term effects on species and habitats.
- Assess non-native species impacts:
 - Establish distribution and monitoring survey protocol for non-natives, possibly incorporating strategy into long-term monitoring for native species.
 - Determine effects of non-native species on natives

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration

- Provide support for land protection (e.g., property purchase, land preservation agreements, buffers) and stream restoration (collaborate with Ecosystem Enhancement Program, NC Natural Heritage Program, US Fish & Wildlife Service, US Forest Service, Natural Resources Conservation Service, Tar River Land Conservancy, US Army Corps of Engineers).
 - Support dam removal, as appropriate for stream restoration.
- Identify priority areas for habitat protection:
 - Priority areas for freshwater conservation in the Tar-Pamlico basin include (based on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.13b):
 - o Upper Tar (designated as one of three key centers of endemism in Southern Atlantic Aquatic Region, Smith et al. 2002) - The upper Tar fits into a priority area for ecosystem management due to presence of endemics, large faunal diversity, high likelihood of restoration/conservation, etc. (Shute et al. 1997).
 - o Fishing Creek Watershed (Fishing Creek, Little Fishing creek, Shocco Creek, Little Shocco Creek, Maple Branch, Red Bud Creek, Rocky Swamp)
 - o Swift Creek Watershed
 - o Middle Tar
- Promote and support conservation and restoration efforts within the Commission.
 - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, and into Game Lands and acquisitions.
 - Explore possibilities for Shocco Game Land expansion.

Population management and restoration

- Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

Data collection, management, and dissemination among agencies

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Coordinate sampling with other resource groups.
- Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.
- Develop Habitat Conservation Plan for upper Tar (potential cooperators include US Fish and Wildlife Service, NC Department of Transportation, Tar River Land Conservancy, Clean Water Management Trust Fund, The Nature Conservancy, NC Department of Environment and Natural Resources, NC Natural Heritage Program, Natural Resources Conservation Service, Pamlico-Tar Foundation, Medoc Mountain State Park, US Army Corps of Engineers, International Paper, county governments, private landowners, NC Homebuilders Association).
- Work with Tar River Land Conservancy to support conservation priorities.
- Support other cooperative efforts as opportunities arise.
- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources; improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
- Develop and disseminate print media, including stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
 - Deliver oral presentations.
 - Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, Federal Energy Regulatory Commission, US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection – Work with regulatory agencies (e.g., US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, Federal Energy Regulatory Commission, US Fish & Wildlife Service) to conserve and restore water and habitat quality.

- Support strengthening of water quality protection.
 - Support clean-up efforts and stricter enforcement of animal operations in addition to promoting animal waste treatment improvements and upgrades (potential partners include NC Division of Water Quality, Natural Resources Conservation Service, Albemarle Pamlico National Estuary Program, Ecosystem Enhancement Program, private corporations).
 - Promote Outstanding Resource Water designation for lower Swift Creek in Nash and Edgecombe Counties; protect other areas of good water quality through Outstanding Resource Water and High Quality Water designations.
 - Work through Site-Specific Management Plan process to obtain stricter regulations for waters containing federally listed species (cooperators include NC Division of Water Quality, NC Natural Heritage Program, US Fish & Wildlife Service).
 - Promote programs to reduce working farm-related sedimentation/erosion (using best management practices, fencing livestock out of stream, etc.) and reduce nutrient inputs (pesticide/herbicide use).
 - Support stormwater management and wastewater treatment plant improvements and upgrades.

Land-use planning – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishment of riparian buffers along streams, implementation of low impact development and better stormwater management (e.g., secondary and cumulative impacts, NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

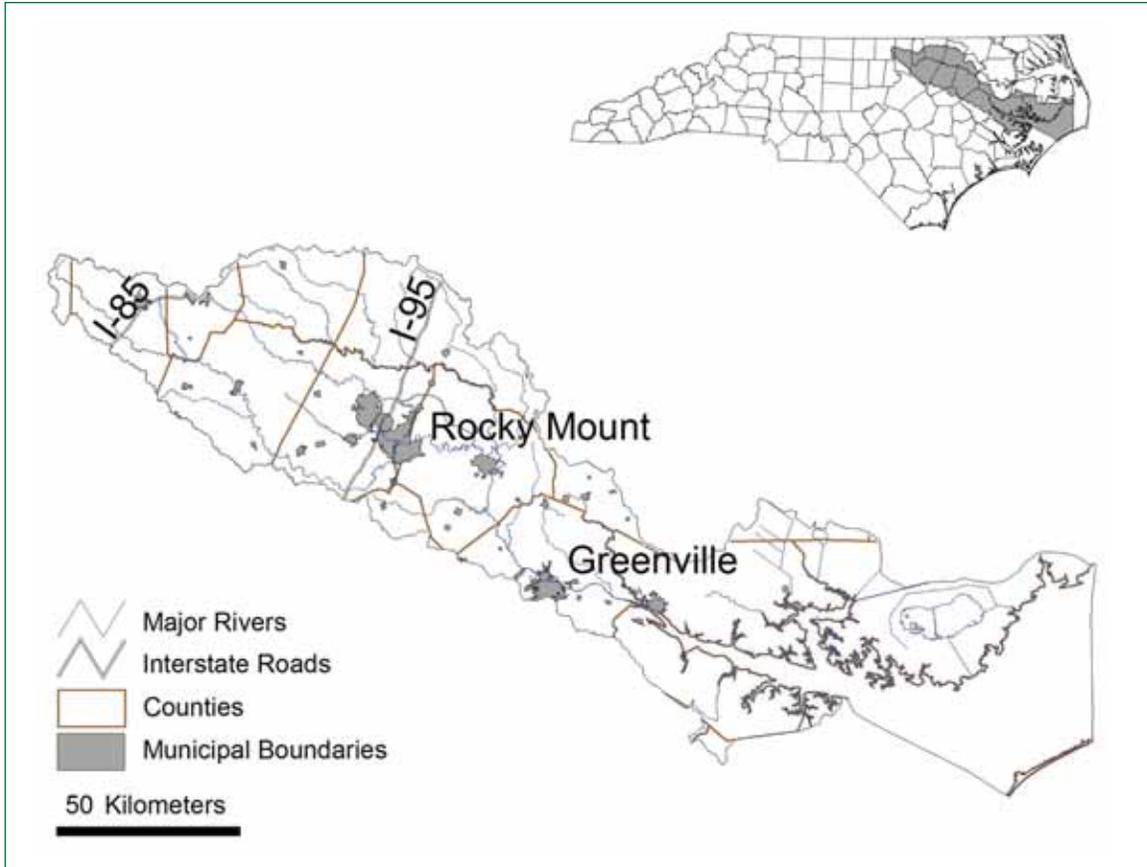
- Support federal and state species listing processes.
 - Work with the US Fish & Wildlife Service on listed species recovery plans – Dwarf wedgemussel and Tar spinymussel.
 - When warranted, make recommendations for state listing to the Commission’s Nongame Wildlife Advisory Committee.

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

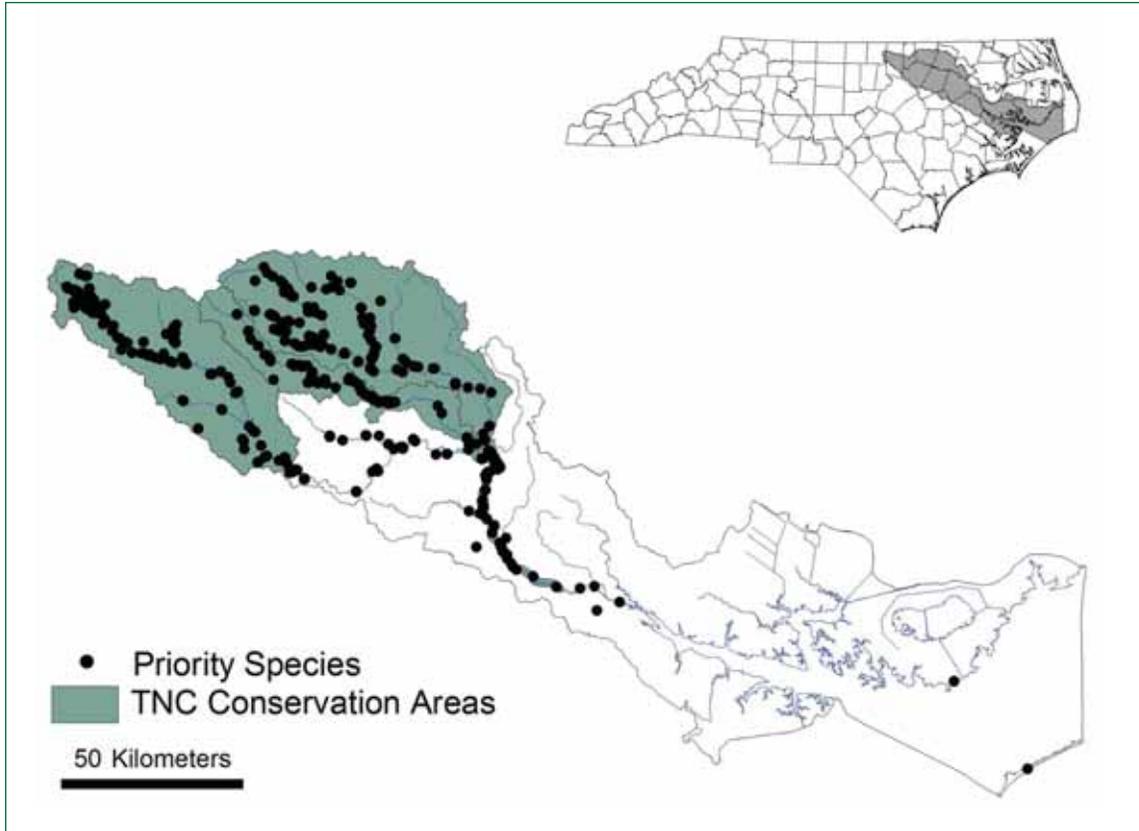
- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

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Map 5B.13a. Tar-Pamlico River basin, political information.



Map 5B.13b. Tar-Pamlico River basin, priority species occurrences and priority areas for freshwater conservation.

14. Chowan River Basin

Priority aquatic species in the Chowan River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish	<i>Acipenser brevirostrum</i>	Shortnose Sturgeon	E (E)
	<i>Acipenser oxyrinchus</i>	Atlantic Sturgeon	SC
	<i>Enneacanthus chaetodon</i>	Blackbanded Sunfish	
	<i>Enneacanthus obesus</i>	Banded Sunfish	
	<i>Erimyzon sucetta</i>	Lake Chubsucker	
	<i>Etheostoma vitreum</i>	Glassy Darter	
	<i>Fundulus diaphanus</i>	Banded Killifish	
	<i>Fundulus lineolatus</i>	Lined Topminnow	
	<i>Moxostoma macrolepidotum</i>	Shorthead Redhorse	
	<i>Moxostoma pappillosum</i>	V-lip Redhorse	
	<i>Notropis amoenus</i>	Comely Shiner	
	<i>Notropis chalybaeus</i>	Ironcolor Shiner	
	<i>Petromyzon marinus</i>	Sea Lamprey	
Mussels	<i>Alasmidonta undulata</i>	Triangle Floater	T
	<i>Anodonta implicata</i>	Alewife Floater	T
	<i>Lampsilis radiata radiata</i>	Eastern Lampmussel	T
	<i>Leptodea ochracea</i>	Tidewater Mucket	T
	<i>Ligumia nasuta</i>	Eastern Pondmussel	T
	<i>Villosa constricta</i>	Notched Rainbow	SC
Crayfish	<i>Orconectes virginensis</i>	Chowanoke Crayfish	SC

Note: As a coastal basin, information contained in Chapter 5C (Marine Systems), especially related to the Coastal Habitat Protection Plan (Street et al. 2004), may also apply to this basin.

A. Location and condition of basin (see Maps 5B.14a, 5B.14b):

The Chowan River basin is an Atlantic Slope drainage. Headwaters of the Chowan River begin in Virginia's Coastal Plain (75% of the basin is found in Virginia) in the Coastal Plain region. The Chowan is the twelfth largest river basin in North Carolina, with a watershed of 1,378 sq. miles, draining 803 miles of streams. The basin enters North Carolina in the northeastern portion of the state and empties into Albemarle Sound. The sound is part of the 2nd largest estuary system in the United States (Albemarle-Pamlico estuary), including 16,971 estuary acres. Movement of fishes between the Chowan, Roanoke and Pasquotank River basins freely occurs as a result of the common connection with Albemarle Sound. The Chowan River proper (50 miles long) forms at the North Carolina/Virginia line where the Blackwater and Nottoway Rivers meet. Major tributaries of the basin include the Meherrin River, Wiccacon River, Potecasi Creek, Ahoskie Creek, Bennetts Creek, Indian Creek, and Rockyhock Creek (NCDWQ 2002).

The Chowan River basin in North Carolina lies in the Coastal Plain Physiographic Region. Geology of this area consists of alternating layers of sand, silt, clay and limestone. Land in this area is very flat. Low flow over the warmest months of the year limits streams' ability to maintain high dissolved oxygen levels (NCDWQ 2002).

There are 19 municipalities within five basin counties. Edenton, Ahoskie, and Murfreesboro are the largest municipalities. Human population size in the basin is 61,034, which is <1% of North Carolina population (NCDENR 2003). Population density is 48 persons/sq. mile. Land use in the basin is approximately 55% forest, 34% crop and pasture land, and 3% urban (NCDWQ 2002).

Many streams in the Chowan basin have been classified as High Quality Waters (HQW). The basin contains 136 miles of impaired streams and all waters in the basin have a supplemental classification of Nutrient Sensitive Waters (NCDENR 2003).

No major reservoirs exist in the North Carolina portion of the basin. However, several small millponds exist, including 760 acre Merchant's Millpond and Bennett's Millpond, which impounds upper Rockyhock Creek near Edenton.

B. Problems affecting species and habitats:

Water quality appears to be the greatest problem within the Chowan River basin. The Chowan River was the site of North Carolina's first known large-scale coastal algae bloom in 1972 (NCDENR 2003), which resulted from excessive levels of nitrogen and phosphorus in wastewater and runoff. Lowered dissolved oxygen levels from excessive nutrient inputs killed fish and led to fish diseases. As a result, the Chowan River was the first basin in North Carolina to receive "nutrient sensitive waters" classification in 1979 by the NC Division of Water Quality (NCDWQ 2002). Chronic episodes of hypoxia exist in the Chowan River and its tributaries from late June through September during most years. Dissolved oxygen levels frequently fall below 3.0 mg/l, which negatively affects aquatic biota. Cyclonic events and their accompanying rainfall, storm surge, inundation and flushing of bottomland swamp habitats have occurred repeatedly within the basin since 1995. These tropical events exacerbate an already fragile summer ecosystem by lowering dissolved oxygen levels, which has produced major fish kills within the basin (NCDWQ 2002).

There are no interbasin transfers between the Chowan and other river basins. Water withdrawals, however, do occur, primarily for agricultural purposes (NCDWQ 2002).

Non-point pollution sources that degrade water quality include agriculture, animal operations, urban development, forestry, stormwater discharge, rural residential development, hydrologic modifications, and septic systems. Point-source pollution sources in the basin may include municipality waste water treatment plants, industrial facilities, and urban and industrial stormwater systems. As of 2001, there were 11 permitted wastewater discharges and 34 registered animal operations in the basin (NCDWQ 2002). Soil erosion and runoff of fertilizer and animal waste caused by farming has been a concern within the basin. However, farmers have taken positive steps to reduce runoff effects which have resulted in 123,244 fewer tons of eroding soils each year (NCDENR 2003).

Historically, dioxin, a by-product of paper mill bleaching practices, degraded water quality and negatively affected aquatic biota. However, new bleaching technologies have reduced contaminants from paper plant wastewater that enter the basin (NCDENR 2003).

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

Inventory: distributional and status surveys – General surveys are needed to complete distributional status for priority fish, mussels, crayfish, and snail species. Basin specific priorities include:

- Atlantic sturgeon – initiate surveys for abundance, population status, and migrations; effects of dams should be considered; should also conduct surveys for shortnose sturgeon because it could potentially use the Chowan River.
- Chowanoke crayfish – found only in lower Roanoke basin and Chowan basin in North Carolina; collect further information about life history and distribution; considered by Smith et al. (2002) as a South Atlantic Aquatic Region data gap in species knowledge.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed.

- Support genetic work to gain better understanding of mussel genus *Elliptio*.
- Support genetic work on banded killifish to determine genetic relationship to the Lake Phelps killifish in the Pasquotank basin.
- Support taxonomic research for other species as needed.

Research to facilitate appropriate conservation actions

- Life history studies for priority species including habitat use/preferences, spawning location and timing, fecundity, population dynamics, feeding, competition, predation, migration patterns (where applicable).
- Determine vulnerability of priority species to specific threats; relate results to permit condition and review responsibilities.

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible.

- Conduct long-term monitoring to identify population trends:
 - Establish protocol, schedule, and locations for long-term monitoring of priority species (collaborate with NC Division of Water Quality, NC Museum of Natural Sciences, US Fish & Wildlife Service).
- Conduct special purpose monitoring:
 - Performance of stream restoration projects.
 - Performance of restoration projects (potential renovation of Dillard's Millpond).
 - Performance of dam removal projects to monitor short and long-term effects on species and habitats.
- Assess non-native species impacts:
 - Establish distribution and monitoring survey protocol for non-natives, possibly incorporating strategy into long-term monitoring for native species.
 - Determine effects of non-native species on natives

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration

- Provide support for land protection (e.g., property purchase, land preservation agreements, buffers) and stream restoration (collaborate with the Ecosystem Enhancement Program, NC Natural Heritage Program, the US Fish & Wildlife Service, the US Forest Service, the Natural Resources Conservation Service, The Nature Conservancy, and the US Army Corps of Engineers).
 - Support dam removal, as appropriate for stream restoration.
- Identify priority areas for habitat protection:
 - Priority areas for freshwater conservation in the Chowan River basin include (based on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.14b):
 - o Lower Meherrin River/Chowan River
- Gain better understanding of land ownership in basin and begin prioritization of other important aquatic habitats (i.e., shoreline habitats, submerged aquatic vegetation [SAV] beds in sound).
- Promote and support conservation and restoration efforts within the Commission.
 - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, and into Game Lands and acquisitions.

Population management and restoration – Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

- Investigate potential for reintroduction of extirpated mollusk and fish species to the basin in restored or improved habitats as opportunities become available.

Data collection, management, and dissemination among agencies

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Protect SAV in coastal areas (collaborate with Coastal NC SAV Coalition).
- Coordinate sampling efforts with other resource groups.
- Support cooperative efforts as opportunities arise (potential collaborators include the Division of Parks and Recreation at Merchant's Millpond and Albemarle Learning Center at Bennett's Millpond).

Education/outreach

- Develop new web-based resources; improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
- Develop and disseminate print media, including stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
 - Deliver oral presentations.
 - Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats.

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection – Work with regulatory agencies (e.g., NC Division of Water Quality, US Fish & Wildlife Service, etc.) to minimize negative impacts on species and habitats.

- Support strengthening of water quality protection.
 - Support clean-up efforts and stricter enforcement of animal operations in addition to promoting animal waste treatment improvements and upgrades (potential partners include NC Division of Water Quality, Natural Resources Conservation Service, Albemarle Pamlico National Estuary Program, Ecosystem Enhancement Program, private corporations).
 - Promote programs to reduce working farm-related sedimentation/erosion (using best management practices, fencing livestock out of streams, etc.) and reduce nutrient inputs (pesticide/herbicide use).
 - Support stormwater management and wastewater treatment plant improvements and upgrades.
 - Promote protection of areas with good water quality through Outstanding Resource Water and High Quality Water designations.
- Support establishment of riparian buffers along streams, implementation of low impact development and better stormwater management (e.g., secondary and cumulative impacts; NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Land-use planning

- Work with county and city officials and developers to incorporate buffers along streams, implement low impact development, and better stormwater regulations (e.g., secondary and cumulative impacts; NCWRC 2002).
- Promote sustainable land use planning that considers long-term effects of development.
- Support dam and lock removal (work with US Fish & Wildlife Service, US Army Corps of Engineers, and private dam owners).

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

- Support federal and state species listing processes.
 - Focus analysis and synthesis of inventory and monitoring data and reporting to inform decision making pertaining to initial species listing and status revision.
 - When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.
 - Work with US Fish & Wildlife Service on listed species recovery plans, e.g., shortnose sturgeon.

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

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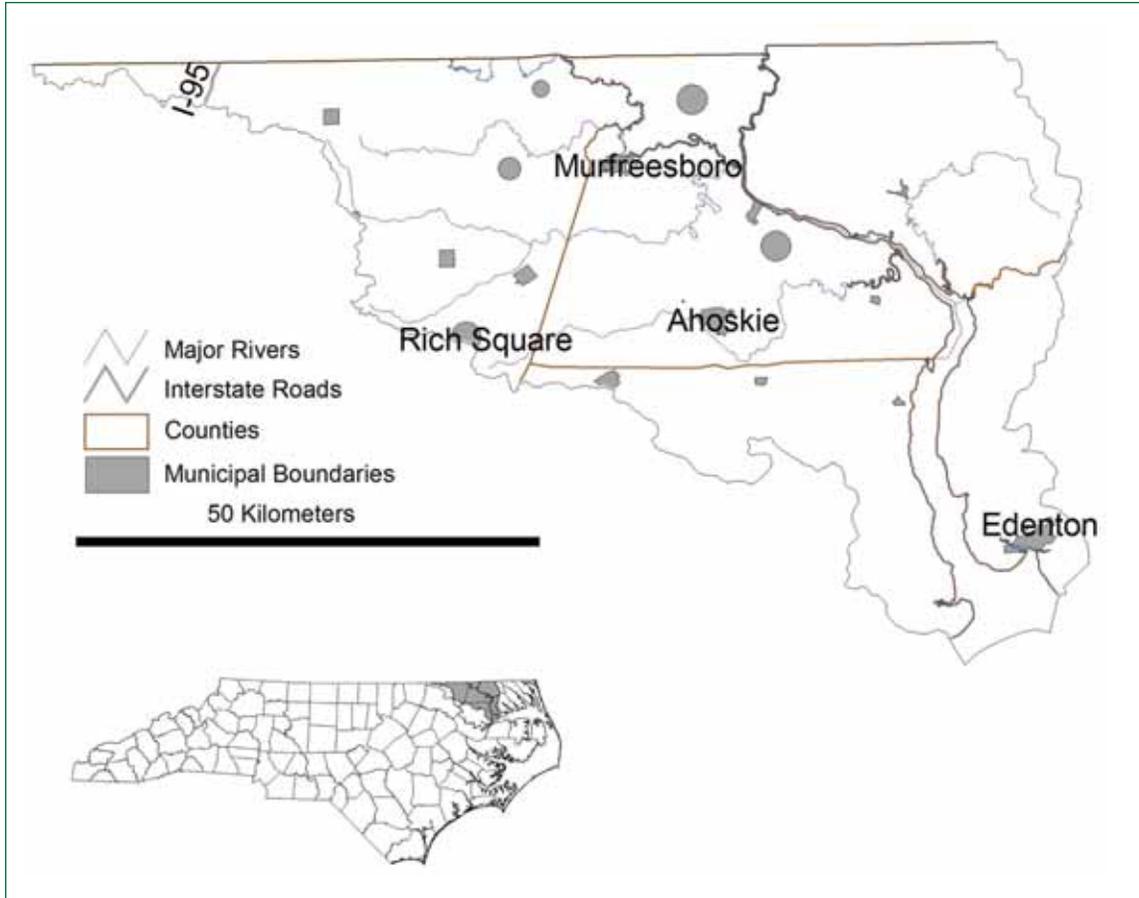
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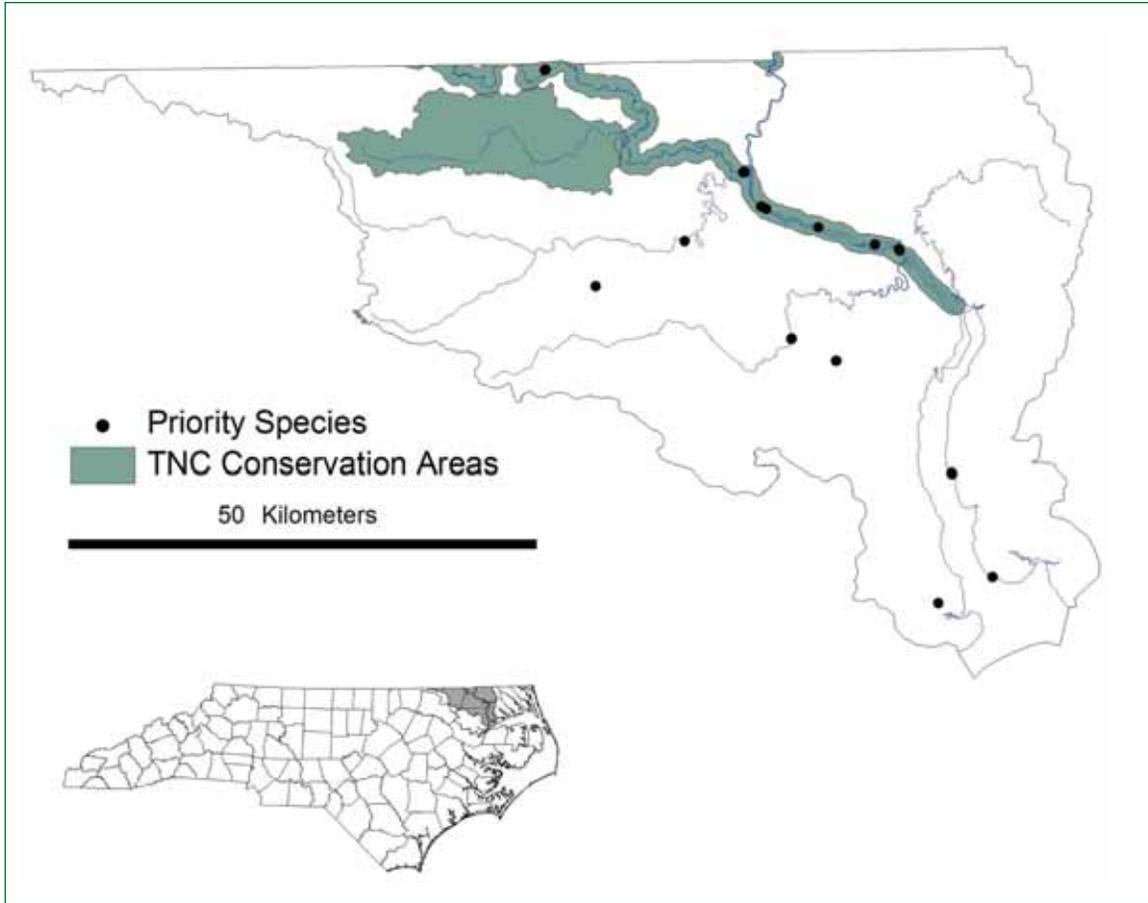
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Map 5B.14a. Chowan River basin, political information.



Map 5B.14b. Chowan River basin, priority species occurrences and priority areas for freshwater conservation.

15. Pasquotank River Basin

Priority aquatic species in the Pasquotank River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish	<i>Acipenser oxyrinchus</i>	Atlantic Sturgeon	SC
	<i>Enneacanthus chaetodon</i>	Blackbanded Sunfish	
	<i>Enneacanthus obesus</i>	Banded Sunfish	
	<i>Erimyzon sucetta</i>	Lake Chubsucker	
	<i>Fundulus cf. diaphanus</i>	Lake Phelps Killifish	SR
	<i>Notropis chalybaeus</i>	Ironcolor Shiner	
	<i>Petromyzon marinus</i>	Sea Lamprey	

Note: As a coastal basin, information contained in Chapter 5C (Marine Systems), especially related to the Coastal Habitat Protection Plan (Street et al. 2004), may also apply to this basin.

A. Location and condition of basin (see Maps 5B.15a, 5B.15b):

The Pasquotank River basin is an Atlantic Slope drainage with a small portion of its headwaters in Virginia. The remainder of the basin lies in North Carolina's Coastal Plain and drains into Albemarle Sound. The Pasquotank is the fifth largest river basin in the state, encompassing 3,635 sq. miles, draining 474 miles of streams. The entire basin is 41% water, including 22,770 freshwater acres, 918,224 estuarine acres, and 111 miles of coast. The river flows as freshwater until tidal influence begins downstream of Elizabeth City. Major tributaries within the river basin include Alligator River, Perquimans River, Little River, Yeopim River, Scuppernong River, and North River (NCDWQ 2002).

The basin lies entirely in the Coastal Plain Physiographic region. The geology of this area consists of alternating layers of sand, silt, clay and limestone. Land in the basin is very flat. Low flows over the warmest months of the year limits streams' ability to maintain high dissolved oxygen levels (NCDWQ 2002).

There are 11 municipalities within the 10 counties in the basin. The largest municipalities are Elizabeth City, Hertford, Columbia, Manteo, and the Outer Banks north of Manteo. Basin population size (based on 2000 census) is 118,912 (NCDWQ 2002). Population density is 46 persons/sq. mi (2000 census; NCDWQ 2002). Land use in the basin is approximately 24% forest land, 22% crop and pasture land, and 3% urban (NCDWQ 2002). No major reservoirs exist in the basin.

The basin (which contains approximately 13% federal lands) contains more National Wildlife Refuges than any other basin in North Carolina (Pea Island National Wildlife Refuge, Great Dismal Swamp National Wildlife Refuge, Currituck National Wildlife Refuge, Alligator River National Wildlife Refuge, Pocosin Lakes National Wildlife Refuge, and Mackay Island National Wildlife Refuge). Lake Phelps, located in Pettigrew State Park, is the state's second largest natural lake at 16,000 acres. Additionally, the basin contains the 70-mile long Cape Hatteras National Seashore (NCDENR 2003).

Lake Phelps, Alligator River and many of its tributaries, Swan Creek Lake, Stumpy Creek, The Frying Pan, Coopers Creek, and Sandy Ridge Gut have been designated as Outstanding Resource Waters (NCDWQ 2002). There are 150 miles of impaired streams in the basin (NCDWQ 2004).

B. Problems affecting species and habitats:

Physical habitat destruction is the primary threat to aquatic fauna within the Pasquotank River basin (NCDENR 2003). Basin waters have suffered from losses of riparian vegetation, straightening of streams, erosion of banks, and reductions of aquatic vegetation that serves as food and shelter for fish, birds, and other wildlife.

There are no interbasin transfers between the Pasquotank and other river basins. Water withdrawals, however, do occur, primarily for agricultural purposes (NCDWQ 2002).

Non-point pollution sources that degrade water quality include agriculture, animal operations, urban development, forestry, stormwater discharge, rural residential development, hydrologic modifications, and septic systems. Point-source pollution sources in the basin may include municipal waste water treatment plants, industrial facilities, reverse-osmosis water treatment facilities, and urban and industrial stormwater systems. As of 2001, there were 34 permitted wastewater discharges, 51 general stormwater permits, and 29 registered animal operations in the basin (NCDWQ 2002).

Human population is increasing throughout the basin, primarily in beach communities and particularly as a result of the formation of bedroom communities south of Chesapeake, Virginia. This type of growth will increase pressure and demand on wastewater treatment systems. High levels of fecal coliform stemming from human or animal wastes already have led to degradation of some shellfish beds (NCDENR 2003).

Historically, dioxin, a by-product of paper mill bleaching practices, degraded water quality and negatively affected aquatic biota. However, new bleaching technologies have reduced contaminants from paper plant wastewater that enter the basin (NCDENR 2003).

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

Inventory: distributional and status surveys – General surveys are needed to complete distributional status for fish priority species. Basin specific priorities include:

- Atlantic sturgeon – survey for abundance, population status, and migrations; effects of dams should be considered; should also conduct surveys for shortnose sturgeon because it could potentially use the rivers in this basin.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed

- Support genetic work on banded killifish and Lake Phelps killifish; determine genetic relationship between the two.
- Support taxonomic research for other species as needed.

Research to facilitate appropriate conservation actions – Research should generally focus on life history of priority species.

- Conduct life history studies for priority species including habitat use/preferences, spawning location and timing, fecundity, population dynamics, feeding, competition, predation, migration patterns (where applicable).
- Determine vulnerability of priority species to specific threats; relate results to permit condition and review responsibilities.

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible.

- Conduct long-term monitoring to identify population trends:
 - Establish protocol, schedule, and locations for long-term monitoring of priority species (collaborate with NC Division of Water Quality, NC Museum of Natural Sciences, US Fish & Wildlife Service).
- Conduct special purpose monitoring:
 - Performance of stream restoration projects.
 - Performance of restoration projects.
 - Performance of dam removal projects to monitor short and long-term effects on species and habitats.
- Assess non-native species impacts:
 - Establish distribution and monitoring survey protocol for non-natives, possibly incorporating strategy into long-term monitoring for native species.
 - Determine effects of non-native species on natives

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration – Provide support for land protection (e.g., property purchase, land preservation agreements, buffers) and stream restoration (collaborate with Ecosystem Enhancement Program, NC Natural Heritage Program, US Fish & Wildlife Service, US Forest Service, Natural Resources Conservation Service, The Nature Conservancy, US Army Corps of Engineers).

- Support dam removal, as appropriate for stream restoration.
- Identify priority areas for habitat protection:
 - Priority areas for freshwater conservation in the Chowan River basin include (based on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.15b):
 - o Lake Phelps
- Gain better understanding of land ownership in basin and begin prioritization of other important aquatic habitats (i.e. shoreline habitats, submerged aquatic vegetation beds in the sound).
- Promote and support conservation and restoration efforts within the Commission.
 - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, and into Game Lands and acquisitions.

Population management and restoration

- Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

Data collection, management, and dissemination among agencies

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Coordinate sampling with other resource groups.
- Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.
- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources; improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
- Develop and disseminate print media, including stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
 - Deliver oral presentations.
 - Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection – Work with regulatory agencies to minimize negative impacts on species and habitats.

- Strengthen water quality rules/issues.
 - Support clean-up efforts and stricter enforcement of animal operations in addition to promoting animal waste treatment improvements and upgrades (cooperators include NC Division of Water Quality, Natural Resources Conservation Service, Albemarle Pamlico National Estuary Program, Ecosystem Enhancement Program, private corporations).
 - Promote programs to reduce working farm-related sedimentation/erosion (using best management practices, fencing livestock out of streams, etc.) and reduce nutrient inputs (pesticide/herbicide use).
 - Support stormwater management and wastewater treatment plant improvements and upgrades.
 - Promote protection of areas with good water quality through Outstanding Resource Water and High Quality Water designations.

Land-use planning – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishment of riparian buffers along streams, implementation of low impact development and better stormwater management (e.g., secondary and cumulative impacts, NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

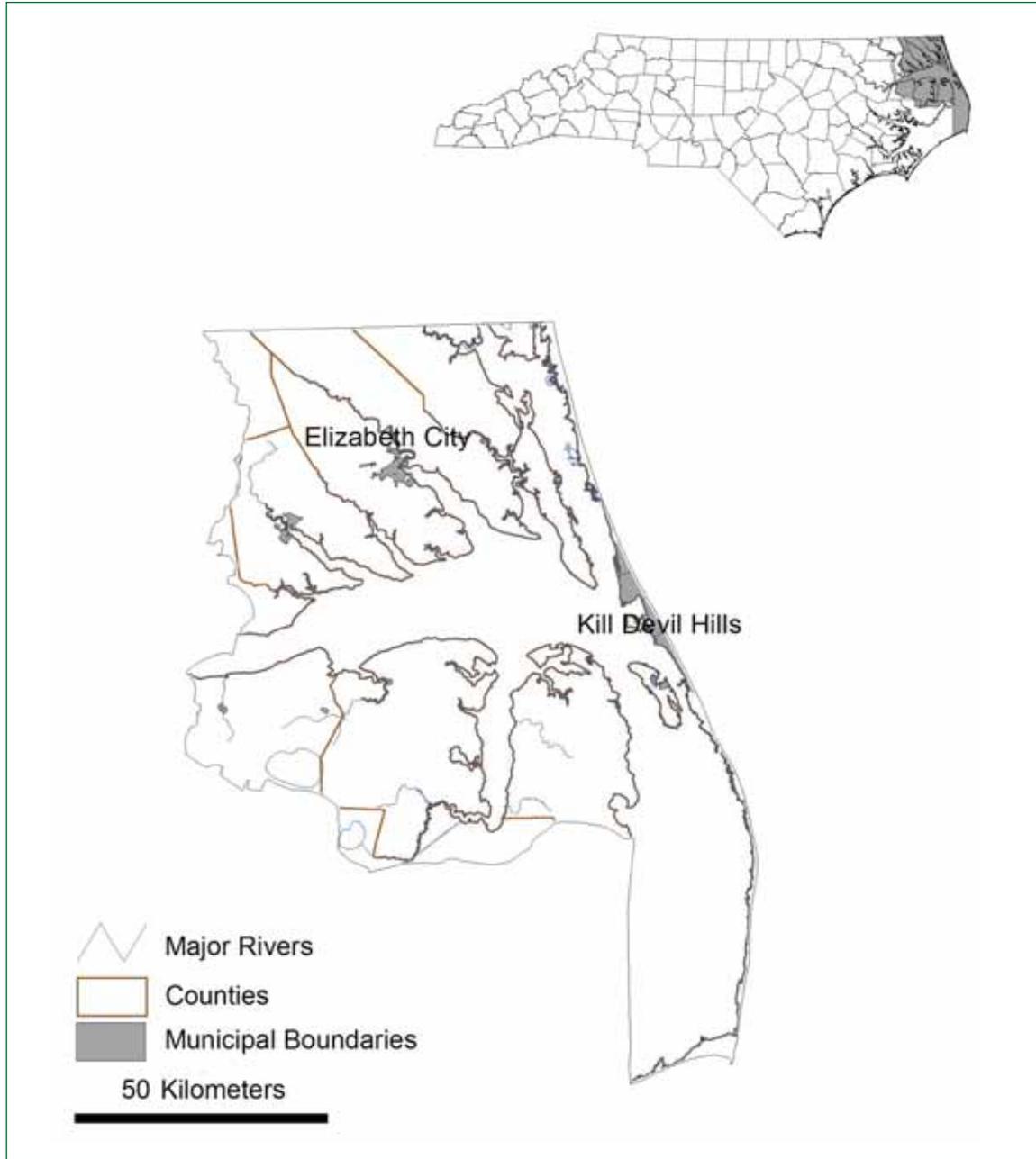
- Support federal and state species listing processes.
 - Focus analysis and synthesis of inventory and monitoring data and reporting to inform decision making pertaining to initial species listing and status revision.
 - When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

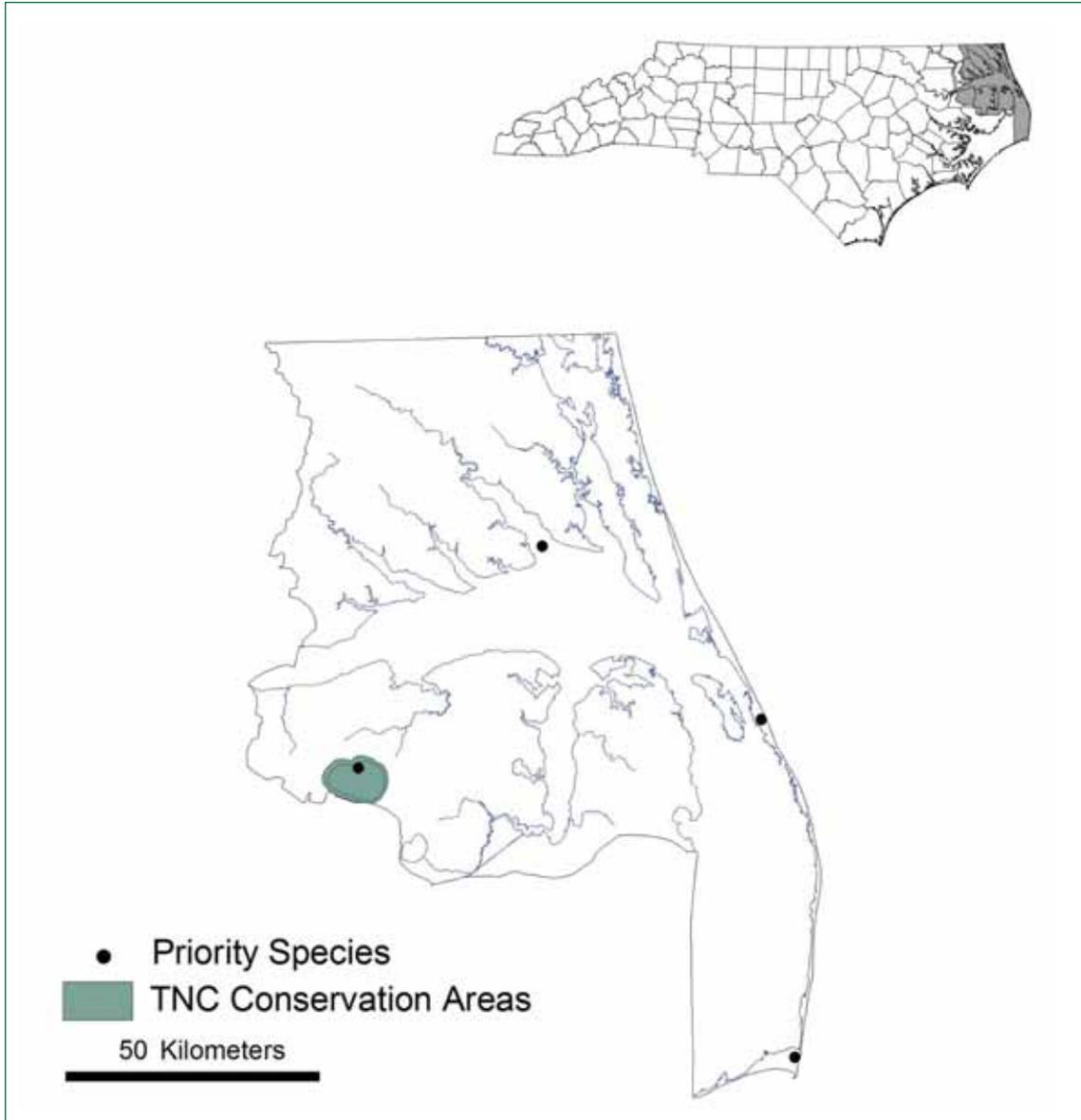
- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

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Map 5B.15a. Pasquotank River basin, political information.



Map 5B.15b. Pasquotank River basin, priority species occurrences and priority areas for freshwater conservation.

16. Lumber River/Lower Pee Dee Basin

Priority aquatic species in the Lumber River/Lower Pee Dee River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish ¹	<i>Ameiurus brunneus</i>	Snail Bullhead	
	<i>Cyprinella sp. (cf. zanema)</i>	Thinlip Chub	
	<i>Elassoma boehlkei</i>	Carolina Pygmy Sunfish	T
	<i>Elassoma evergladei</i>	Everglades Pygmy Sunfish	
	<i>Elassoma zonatum</i>	Banded Pygmy Sunfish	
	<i>Enneacanthus chaetodon</i>	Blackbanded Sunfish	
	<i>Enneacanthus obesus</i>	Banded Sunfish	
	<i>Erimyzon sucetta</i>	Lake Chubsucker	
	<i>Etheostoma mariae</i>	Pinewoods Darter	SC
	<i>Etheostoma perlongum</i>	Waccamaw Darter	T
	<i>Fundulus lineolatus</i>	Lined Topminnow	
	<i>Fundulus waccamensis</i>	Waccamaw Killifish	SC
	<i>Lepomis marginatus</i>	Dollar Sunfish	
	<i>Lepomis punctatus</i>	Spotted Sunfish	
	<i>Menidia extensa</i>	Waccamaw Silverside	T (T)
	<i>Notropis chalybaeus</i>	Ironcolor Shiner	
	<i>Notropis maculatus</i>	Taillight Shiner	
	<i>Noturus n. sp.</i>	Broadtail Madtom	SC
	<i>Poecilia latipinna</i>	Sailfin Molly	
<i>Semotilus lumbee</i>	Sandhills Chub	SC	
Mussels	<i>Elliptio cistellaeformis</i>	Box Spike	
	<i>Elliptio folliculata</i>	Pod Lance	SC
	<i>Elliptio icterina</i>	Variable Spike	
	<i>Elliptio marsupiobesa</i>	Cape Fear Spike	SC
	<i>Elliptio waccamawensis</i>	Waccamaw Spike ²	E
	<i>Lampsilis cariosa</i>	Yellow Lampmussel ²	E
	<i>Lampsilis fullerkeri</i>	Waccamaw Fatmucket ²	T
	<i>Lampsilis radiata radiata</i>	Eastern Lampmussel ²	T
	<i>Leptodea ochracea</i>	Tidewater Mucket ²	T
	<i>Villosa delumbris</i>	Eastern Creekshell ²	SR
Crayfish	<i>Procambarus ancylus</i>	Edisto Crayfish	
	<i>Procambarus blandingii</i>	Santee Crayfish	
	<i>Procambarus braswelli</i>	Waccamaw Crayfish	SC
Snails	<i>Amnicola sp.</i>	Waccamaw Snail	SC
	<i>Cincinnatia sp.</i>	Waccamaw Siltsnail	SC
	<i>Viviparus intertextus</i>	Rotund Mysterysnail ²	SR

Note: As a coastal basin, information contained in Chapter 5C (Marine Systems), especially related to the Coastal Habitat Protection Plan (Street et al. 2004), may also apply to this basin.

¹ Brook silverside (*Labidesthes sicculus*) is a native priority fish species in the Little Tennessee basin, but is a non-native in the Yadkin-PeeDee and Lumber basins. In non-native basins, this species is not a priority for conservation. Rather, monitoring and possible control of range expansion of the species should be initiated.

²Species is only found in Lake Waccamaw, not in the Lumber River basin proper.

A. Location and condition of basin (see Maps 5B.16a, 5B.16b):

The Lumber basin is located in the southeastern corner of North Carolina and the northeast corner of South Carolina. The headwaters of the Lumber River originate in the Sandhills region (a notable center of endemism) in the northwest corner of the Lumber basin. The remaining portion of the basin occurs in the Coastal Plain region. The Lumber River, Little Pee Dee, Waccamaw and Carolina-Coastal constitute four major hydrological units within the basin. The basin can be divided into two types of waters based upon physiographic attributes (NCDWQ 2003):

- 1) Sandhills Region – waterbodies are typified by flowing sandy streams, supplied by groundwater and rainfall, and are primarily located in the northwestern portion of the basin (constituting one-third of the basin).
- 2) Coastal Plain – waterbodies are typically meandering and are associated with swamps, hardwood bottoms, wetland communities, peatlands (these waterbodies also have low assimilation, i.e., ability to handle any oxygen consuming wastes).

In the Lumber River basin, all but two rivers flow into the Pee Dee River in South Carolina. The Shallote and Lockwoods Folly Rivers drain directly to the Atlantic Ocean. The Lumber River mainstem is the only North Carolina blackwater river designated as a National Wild and Scenic River.

The total area of the basin is 3,336 sq. miles, with 2,232 freshwater stream miles and 8,965 freshwater lakes acres (NCDWQ 2003). There are 4,305 total estuarine acres and 25 coastline miles. The Lumber basin contains 51 municipalities, with the cities of Lumberton, Laurinburg, and Whiteville being the largest urban areas. Population size in 2000 was 304,579 corresponding to a density of 92 persons/sq. mile (NCDWQ 2003). The population is expected to increase by 45% before 2010 (NCDWQ 2003).

Land use in the basin is 60% forest land, 25% agricultural/cultivated cropland, 7.1% urban, and 8% other (rural transport., small water areas, lake, and estuaries; NCDWQ 2003). Two thirds of the forest land in the basin is held by non-industrial private landowners. The remaining third of the forest land is owned by the forest industry. Impaired streams in the Lumber basin total 252 miles (NCDWQ 2003). Causes of impairment include mercury and fecal coliform (NCDWQ 2003). Sources of pollutants contributing to impairment include industrial and municipal emissions, municipal wastewater outfalls, urban runoff/storm sewers, and discharges from animal farms. Despite the impairments in the basin, the Lumber River basin contains three Outstanding Resource Waters (NCDWQ 2004), including Naked Creek, Rocky Ford Branch, and Lake Waccamaw. Lake Waccamaw is a notable center of endemism in the southeast (Smith et al. 2002).

B. Problems affecting species and habitats:

Numerous problems affect species and their habitats within the Lumber River basin. Sources of non-point pollution in the basin include agriculture, forestry, construction, and stormwater discharges. The major pollutant in this group is sedimentation. Activities that contribute to stream habitat degradation in the basin include land-clearing (forestry, urban development), agriculture activities, and wetland fills. The Lumber basin has a high concentration of swine farms. Poor or improper management of animal discharges contributes to organic pollution in the basin and results in high concentrations of fecal coliform. Other point sources include industrial and municipal discharges that contribute toxic compounds and elements such as ammonia, chlorine, and mercury.

Our knowledge of aquatic species distributions in the basin is inadequate; general surveys are needed throughout much of the Lumber River basin. We also have a poor understanding of life history and habitat use for many species, knowledge that is critical for managing these populations. We have difficulty monitoring known populations of rare species at regular intervals, which is needed to track changes in abundance and habitat quality. In addition, there are few long-term data sets or monitoring sites. Distributional surveys of invasive species (e.g., flathead catfish, red swamp crayfish) are also needed.

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

Inventory: distributional and status surveys – General surveys are needed to complete the distributional status of fish, mussels, crayfish, and snails (in order of need).

- Basin specific priorities include *Elassoma spp.* (pygmy sunfish species), the broadtail madtom, Sandhills chub.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions are needed for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms.

- Support genetic studies to help improve our understanding of the mussel genus *Elliptio*.
- Support completion of species descriptions for undescribed taxa.

Research to facilitate appropriate conservation actions

- Research should focus on life history studies of priority species and for taxa which little information is known.

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible.

- Conduct long-term monitoring to identify population trends:
 - Establish protocol and schedule for long-term monitoring of priority species (collaborate with the NC Division of Water Quality, NC Museum of Natural Science, and the US Fish & Wildlife Service).
 - Monitor populations of fishes and mussels occurring in Lake Waccamaw (e.g., Waccamaw darter, Waccamaw killifish, Waccamaw silverside, Waccamaw spike, Waccamaw fatmucket) to assess the effect of land use changes and practices in the surrounding watershed.
- Conduct special purpose monitoring:
 - Performance of stream restoration projects.
- Assess non-native species impacts:
 - Determine distribution of non-native species in the Lumber River basin and their potential effects on native species

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration – Provide support for land protection (e.g., acquisition, easements, buffers).

- Work with local conservation and watershed groups to promote and protect the Lumber watershed (e.g., NC Natural Heritage Program, US Fish & Wildlife Service, Natural Resources Conservation Service, Ecosystem Enhancement Program, Lumber River Conservancy, Friends of Lake Waccamaw State Park, The Nature Conservancy, Winyah Rivers Foundation, Waccamaw Riverkeeper, Lumber River Consortium).
- Identify priority areas for habitat protection (areas with high species diversity, rare species, and endemic species). Identify specific areas that are critical to the survival of species (e.g., spawning areas) and/or diverse communities.
 - Priority areas for freshwater conservation in the Lumber River basin include (based in part on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.16b): :
 - o Lumber River and sandhills tributaries
 - o Ashpole Creek/Hog Swamp

- o Little Pee Dee River sandhills tributaries
- o Waccamaw Lake and River/Juniper Swamp
- o Royal Oak Swamp
- Promote and support conservation and restoration efforts within the Commission.
 - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, and into Game Lands and acquisitions.

Population management and restoration

- Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

Data collection, management, and dissemination among agencies

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Coordinate sampling with other resource groups.
- Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.
- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources; improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
- Develop and disseminate print media, including stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
 - Deliver oral presentations.
 - Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection – Work with regulatory agencies (e.g., US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, US Fish & Wildlife Service, etc.) to conserve and restore water and habitat quality.

- Support strengthening of water quality protection.
 - Support water quality rules and watershed designations that conserve habitats for priority aquatic species. Outstanding Resource Water and High Quality Water designations should be supported wherever the criteria for designation are met, especially in watersheds that support priority species.

- Support incentive and information programs that help reduce sedimentation/erosion (e.g., fencing livestock from streams, improve tilling practices), minimize pesticide and herbicide use, modernize wastewater treatment facilities, etc.
- Specific issues needing to be addressed in this basin include:
 - o Secondary and cumulative impacts upon water quality
 - o Buffer ordinances
 - o Water supply watershed protection
 - o Ordinances more stringent than state requirements
 - o Protect headwaters

Land-use planning – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishment of riparian buffers along streams, implementation of low impact development and better stormwater management (e.g., secondary and cumulative impacts, NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

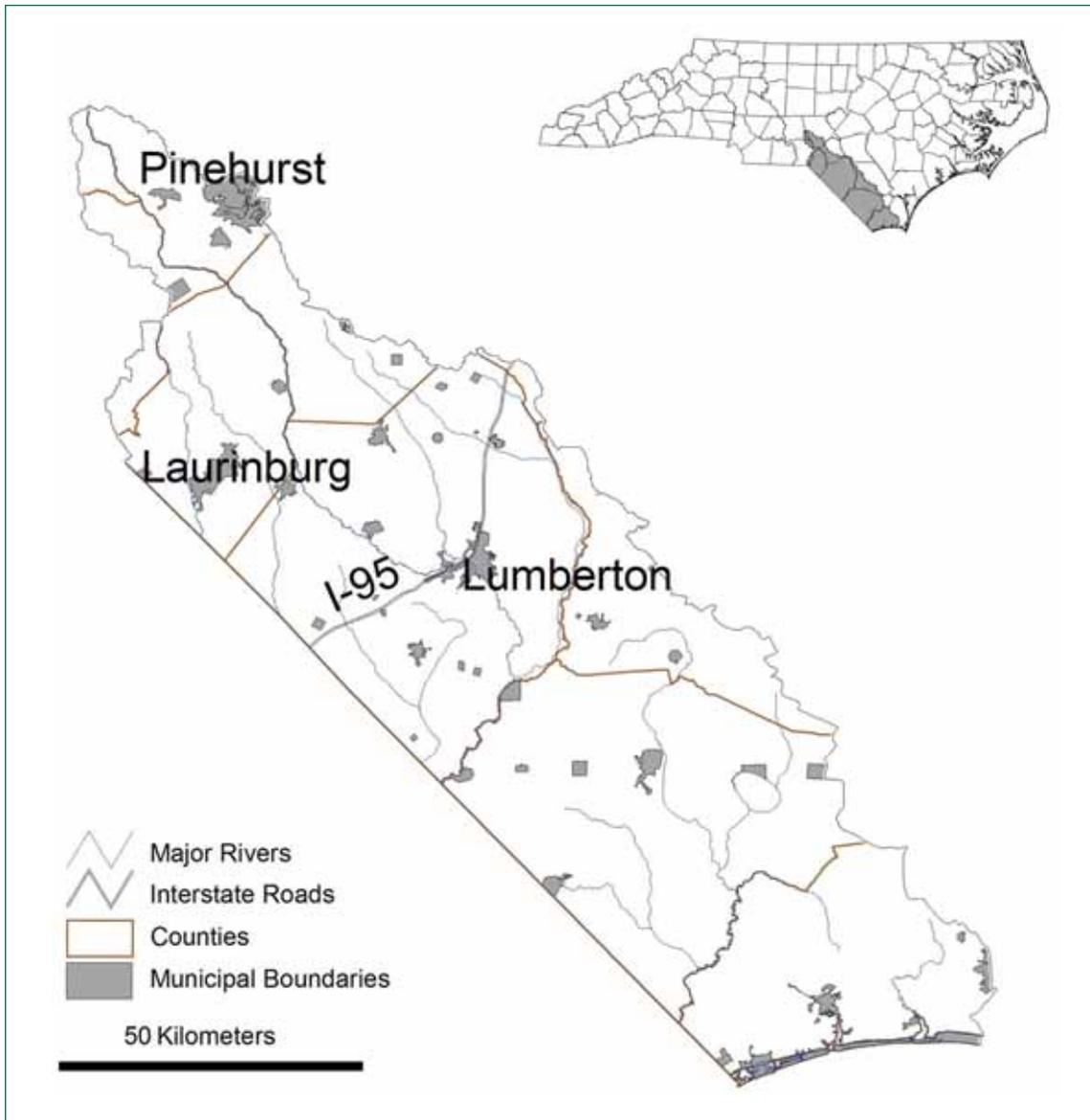
- Support federal and state species listing processes.
 - Focus analysis and synthesis of inventory and monitoring data and reporting to inform decision making pertaining to initial species listing and status revision.
 - When warranted, make recommendations for state listing to the Commission’s Nongame Wildlife Advisory Committee.

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

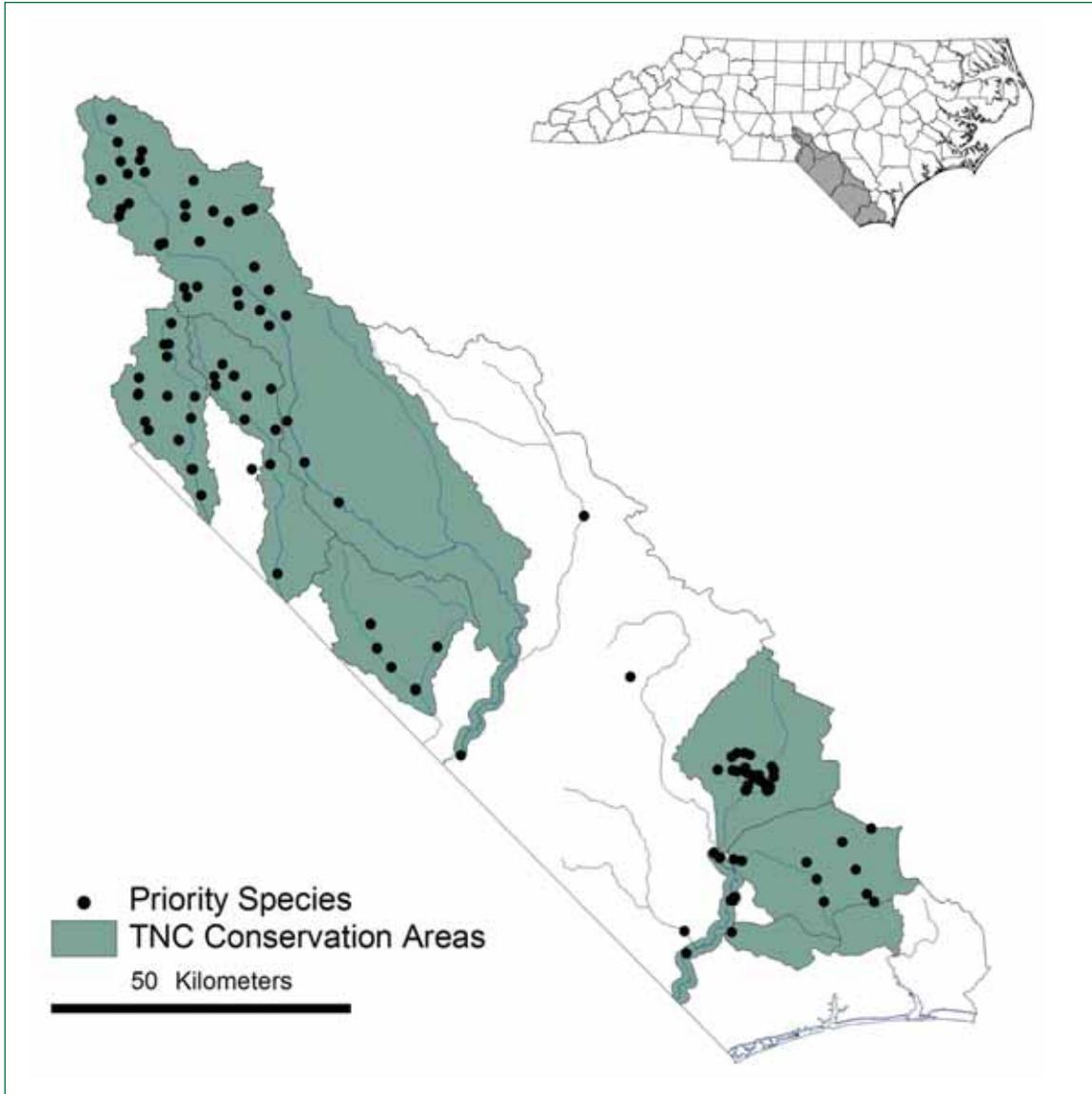
- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

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Map 5B.16a. Lumber River basin, political information.



Map 5B.16b. Lumber River basin, priority species occurrences and priority areas for freshwater conservation.

17. White Oak River Basin

Priority aquatic species in the White Oak River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish	<i>Acipenser oxyrinchus</i>	Atlantic Sturgeon	SC
	<i>Enneacanthus chaetodon</i>	Blackbanded Sunfish	
	<i>Enneacanthus obesus</i>	Banded Sunfish	
	<i>Erimyzon sucetta</i>	Lake Chubsucker	
	<i>Fundulus lineolatus</i>	Lined Topminnow	
	<i>Notropis chalybaeus</i>	Ironcolor Shiner	
Mussels	<i>Elliptio icterina</i>	Variable Spike	
Crayfish	<i>Procambarus plumimanus</i>	Croatan Crayfish	SR

Note: As a coastal basin, information contained in Chapter 5C (Marine Systems), especially related to the Coastal Habitat Protection Plan (Street et al. 2004), may also apply to this basin.

A. Location and condition of basin (see Maps 5B.17a, 5B.17b):

This basin lies entirely within the Coastal Plain, and includes four small separate river systems (New River, White Oak River, Newport River, and North River). The White Oak River basin encompasses 1,264 sq. miles, 446 stream miles, and 130,009 estuarine acres (NCDWQ 2001). Sixteen municipalities are located in whole or in part of the basin.

Land use in the basin is 49% forest and wetlands, 8% urban and built-up, and 6% agriculture. From 1982-1997 there was an 81.6% increase in the amount of developed land (NRCS 2001). Public lands make up a large portion of this basin and include: Croatan National Forest, Hoffman State Forest, and Camp Lejeune. The estimated 1990 human population was 149,032 and is predicted to increase to 188,403 by 2015 (NCDWQ 2001).

There are a number of impaired (303 d list) streams in this drainage, totaling 169.3 miles (NCDWQ 2001). There are 58 waterbodies (stream reaches, intercoastal waterways, bays) that have a NC Division of Water Quality Outstanding Resource Waters (ORW) classification and 174 waterbodies that have High Quality Waters (HQW) classification.

B. Problems affecting species and habitats:

Our knowledge of aquatic species distribution is inadequate within the White Oak River basin and general surveys are needed in most areas. We have a poor understanding of life history and habitat use for many species which is critical for managing these populations. It is difficult to monitor known populations of rare species at regular intervals which is needed to track changes in abundance and habitat quality. In addition, there are few long term data sets or monitoring sites. Invasive species have become established in the White Oak River basin, which may negatively impact native species populations (Fuller et al. 1999).

Water quality is degraded by excessive nutrient input (such as waste water treatment plants, industry, agriculture, and hog/chicken farms; NCDWQ 2001). In the White Oak River basin there are 50 permitted discharges (four of which are major discharges with ≥ 1 million gallons per day; NCDWQ 2001).

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

Inventory: distributional and status surveys – General surveys are needed to complete the distributional status for fish, mussels, crayfish, and aquatic snails. Areas where distributional surveys should be focused can be identified using the Commission's aquatic nongame database and NC Natural Heritage Program data.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed

- Support genetic studies to help improve our understanding of the mussel genus *Elliptio*.

Research to facilitate appropriate conservation actions – Research should generally focus on life history of priority species.

- Conduct life history studies of priority species to address habitat use/preferences, spawning location and timing, fecundity, population dynamics, feeding, competition, predation.
- Determine vulnerability of priority species to guide permit regulations (moratoria).

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible.

- Conduct long-term monitoring to identify population trends:
 - Establish protocol, schedule, and locations for long-term monitoring of priority species (collaborate with NC Division of Water Quality, NC Museum of Natural Sciences, US Fish & Wildlife Service).
- Conduct special purpose monitoring:
 - Performance of stream restoration projects.
- Assess non-native species impacts:
 - Examine distribution of exotics in the White Oak River basin and their effects on native species.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration – Provide support for land protection and stream restoration (acquisition, easements, and buffers).

- Support stream protection/restoration by working collaboratively with other organizations including: Ecosystem Enhancement Program, NC Natural Heritage Program, Natural Resource Conservation Service; The Nature Conservancy, other non-profits, and the US Forest Service (Croatan National Forest).
- Identify priority areas for habitat protection by locating areas with high species diversity, rare species, and endemic species. Identify specific areas that are critical to the survival of priority species (e.g., particular streams or spawning sites), such as ironcolor shiner, blackbanded and banded sunfish, Croatan crayfish):
 - Priority areas for freshwater conservation in the White Oak basin include (based in part on Smith et al. 2002) (see Map 5B.17b):
 - o White Oak River
 - o Newport River
- Promote and support conservation and restoration efforts within the Commission.
 - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, and into Game Lands and acquisitions.

Data collection, management, and dissemination among agencies

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Coordinate sampling with other resource groups.
- Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.
- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources; improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
- Develop and disseminate print media, including stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
 - Deliver oral presentations.
 - Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, Federal Energy Regulatory Commission, US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection – Work with regulatory agencies (US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, US Fish & Wildlife Service, etc.) to conserve and restore water and habitat quality.

- Support strengthening of water quality protection.
 - Promote programs that help farmers reduce sedimentation/erosion (install fences to keep live stock out of streams and improve tilling practices) as well as reduce pesticide and herbicide use.
 - Promote programs to help modernize wastewater treatment facilities and inform public about proper upkeep of septic systems.
 - Protect existing good water and habitat quality throughout the basin (ORW and HQW streams).
 - Promote programs to upgrade hog and chicken farms waste treatment.

Land-use planning – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishing riparian buffers along streams, implement low impact development, and better stormwater management (e.g., secondary and cumulative impacts, NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

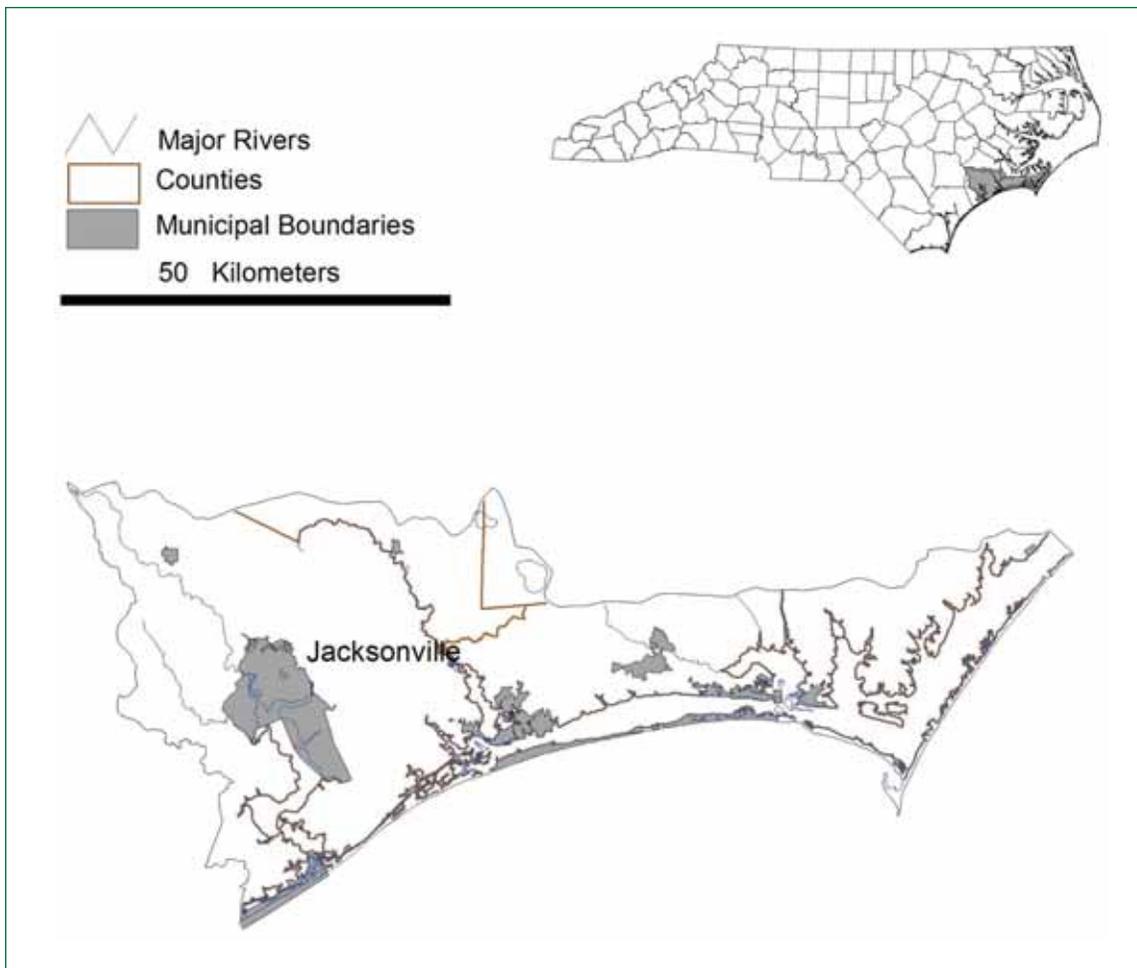
- Support federal and state species listing processes.
 - When warranted, make recommendations for state listing to the Commission’s Nongame Wildlife Advisory Committee.

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

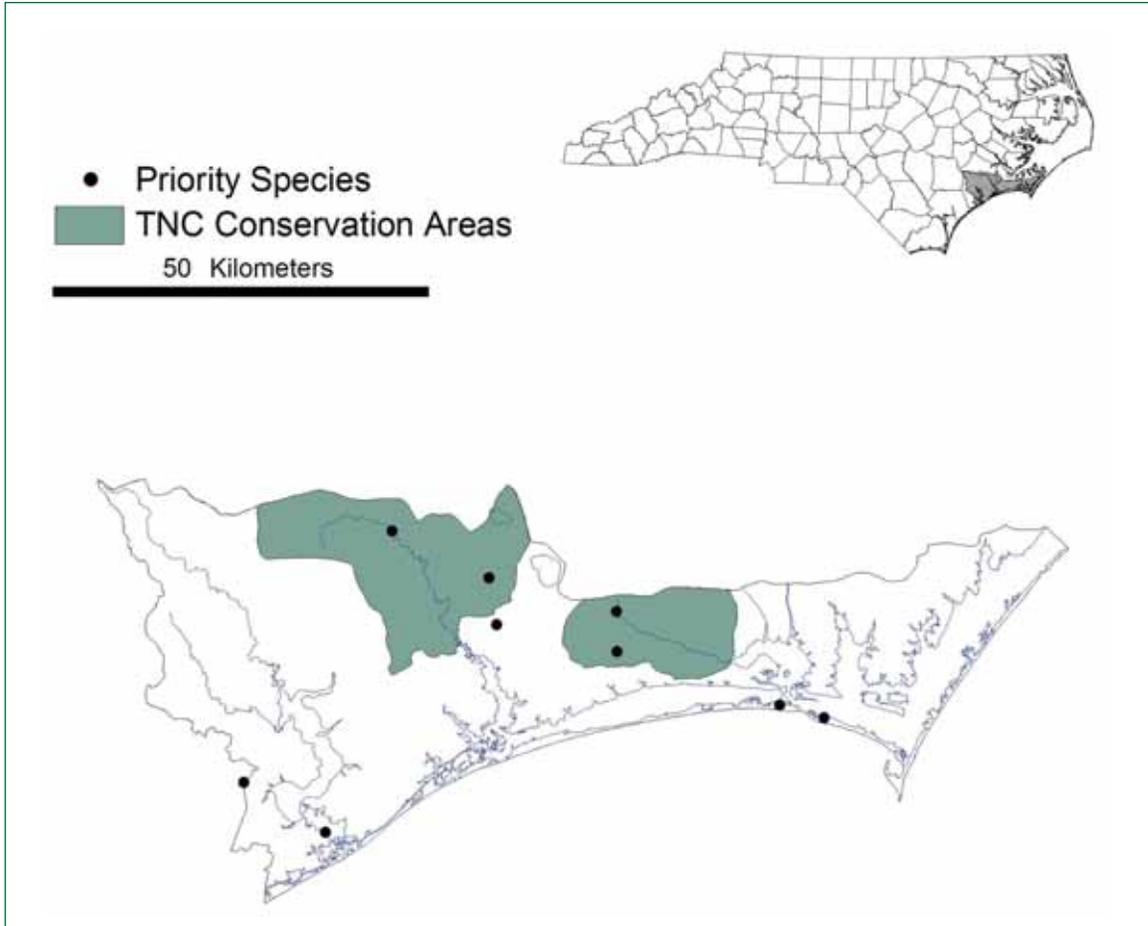
- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

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Map 5B.17a. White Oak River basin, political information.



Map 5B.17b. White Oak River basin, priority species occurrences and priority areas for freshwater conservation.