Conserving the Roanoke River

Conservation Action Plan
November 2005

SOUTHEAST AQUATIC RESOURCES PARTNERSHIP
SARP
"Saving Aquatic Resources Proactively"

The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH

Preface

The Lower Roanoke River Project (LRRP) Conservation Plan consists of five elelments. The first of these elements is this summary report containing the key components of a written conservation action plan. The second is a Conservation Action Planning Workbook (developed by TNC using a Microsoft Excel platform) in which information about stresses, threats, strategies, and strategic success is routinely updated with conservation partners. The third is a GIS-based database including land-ownership maps and many kinds of spatial data for illustrating and evaluating various conservation scenarios. The fourth is a set of models (public policy, flow, flood, and ecological response) that allow us to evaluate the way different strategies for management of the system's hydrology produce ecological effects. The fifth is a site protection plan consisting of priority tract maps and a spreadsheet for tracking conservation progress on each of them, as well as all of them cumulatively.

In developing and revising the Conservation Plan for the Lower Roanoke over the past several years, The Nature Conservancy has utilized a series of workshops to address conservation strategies at the site scale. The goal of these workshops was to apply The Nature Conservancy's site conservation "5-S Framework" to the Roanoke River project area, thereby developing a conservation blueprint for action and a baseline from which to measure its success over time. Primary partners in the planning process have included the U.S. Fish and Wildlife Service (USFWS) and the NC Wildlife Resources Commission (WRC), among others. During calendar year 2005, the TNC-NC Conservation staff revised the Roanoke plan through another series of workshops in collaboration with the Southeast Aquatic Resource Partnership (SARP). The SARP chose the Roanoke River as one of four pilot watersheds in the Southeastern U.S. (the Roanoke, the Altamaha River in GA, the Duck River in TN, and the Pascagoula River in MS) to test the development of a Southeastern Aquatic Habitat Plan. TNC's "5-S Framework" is outlined below:

- **Systems**: the conservation targets occurring at a site, and the natural processes that maintain them, that will be the focus of site-based planning.
- **Stresses**: the types of degradation and impairment afflicting the system(s) at a site.
- **Sources**: the agents generating the stresses.
- **Strategies**: the types of conservation activities deployed to abate sources of stress (threat abatement) and persistent stresses (restoration).
- **Success**: measures of biodiversity health and threat abatement at a site.

Through the guidance of workshops and supplemental meetings with individual experts, the TNC-NC Roanoke team selected conservation targets (systems), analyzed and ranked stresses and sources of stress for each target, and identified conservation strategies to abate threats.

The Roanoke is an alluvial river, meaning it originates above the coastal plain and normally carries crystalline solids as sediments to the sea, or in this case, Albemarle Sound. The Roanoke is one of the largest alluvial rivers on the eastern slope of North America where it provides habitat for one of the largest and least fragmented systems of bottomland forests and one of the most diverse and numerous populations of diadromous fishes south of the St. Lawrence. The North Carolina Natural Heritage Program includes in its inventory of rare and vulnerable species and natural communities in the Lower Roanoke River, habitat for three federally listed animals (American Alligator (*Alligator mississippiensis*), Bald Eagle (*Haliaeetus leucocephalus*), Short-nosed Sturgeon (*Acipenser brevirostrum*)), 16 additional state-listed animals, and 13 state-listed plants. Thirty-one natural communities are known to occur in the LRRP of which 16 are listed as exemplary by the North Carolina Natural Heritage Program. Of 214 bird species found in the Lower Roanoke River (LRR), 88 are known to nest there, including 44 neo-tropical migrants, many of which are thriving in the LRR while they decline throughout most of the rest of their. Ecosystem conservation efforts in the LRR are focused on conserving ecological patterns and processes and the system's diversity of plants, animals, and natural communities.

Conservation planning history

The Nature Conservancy (TNC) Board of Governors designated the Lower Roanoke as one of the "Last Great Places," making it one of only 200 sites so designated in all of the Americas and parts of Asia, and the Pacific, and making it a featured site in both of the last two international capital campaigns. The Lower Roanoke River Project (LRRP) is in the Mid-Atlantic Coastal Plain ecoregion, and comprises parts of Bertie, Halifax, Martin, Northampton, and Washington counties in NC. The project includes the entire watershed of the Roanoke River downstream of the fall-line between the Piedmont and the Coastal Plain near the NC/VA line. It follows the river 137 miles to its mouth on Albemarle Sound. Our conservation emphasis is on the on the river itself and the floodplains and valley walls of the river and its tributaries. We envision that the Lower Roanoke River should be managed so that conservation of natural resources and biological diversity, recreation, flood control, economic development, and hydropower production are balanced in sustainable ways. If we are successful, the full complement of natural communities and species and ecological patterns and processes will be present and self-sustaining in the context of natural disturbances and human uses.

The Lower Roanoke River Project (LRRP) Conservation Plan consists of five components. The first of these components is a planning document that introduces the project and summarizes its main components. The second is a Conservation Action Planning Workbook in which information about stresses, threats, strategies, and strategic success is routinely updated. The Conservation Action Planning Workbook is a spreadsheet designed to facilitate conservation planning and data assimilation. The third component is a GIS-based database including land-ownership maps and many kinds of spatial data for illustrating and evaluating various conservation scenarios. The fourth is a set of models (public policy, flow, flood, and ecological response) that allow us to evaluate the way different strategies for management of the system's hydrology produce ecological effects. The fifth is a site protection plan consisting of priority

tract maps and a spreadsheet for tracking conservation progress on each of them, as well as all of them cumulatively. Collaborating with the SARP as part of the pilot rivers project allowed the Roanoke River planning team to revise and update the written conservation plan for the project utilizing a more advanced version of the Conservation Action Planning Workbook. For this iteration, the planning team was comprised primarily of TNC, U.S. Fish and Wildlife Service, and North Carolina Wildlife Resource Commission staff.

Conservation targets

Conservation targets for the Lower Roanoke River Project were chosen based on the simple notion that we needed a limited set of targets which would, if successfully managed and monitored (adaptively managed), could provide reasonable confidence that all potential targets would become and/or remain viable. Initially, we developed a list of six terrestrial communities, three wide ranging terrestrial animals, four groups of diadromous fish species, and the resident aquatic communities in each of eight river reaches, yielding 21 targets. Eventually, we reduced these to four terrestrial communities, diadromous fishes inclusively, the resident aquatic community inclusively, and two wide ranging terrestrial animals. However, it is important to note that many action and monitoring strategies for aquatic species and some terrestrial communities continue to specify one or more river reaches for implementation. The 8 primary conservation targets are listed below:

- Rich Slope Mesic Hardwood Forests
- Riverine Bottomland Hardwood Forests
- Riverine Swamp Forests
- Non-riverine Wetland Forests
- Diadromous Fishes
- Riverine Resident Aquatic Communities
- Red Wolf
- Black Bear

Under the riverine resident aquatic communities, we recognize five main reaches of the Lower Roanoke River, and one of these is then divided into three sub-reaches. The red wolf is not officially present as a breeding population in the Roanoke, although individuals from the experimental “reintroduction” population at Alligator River regularly visit the landscape. We chose this as a target because we believe that a landscape as large and productive as that of the Roanoke cannot be conserved without a top predator. The black bear, a wide-ranging, omnivorous animal was selected as a conservation target because it is intensively managed and intensively hunted in the project area. Because the focus of the SARP’s pilot planning effort is on aquatic resources, conservation objectives and strategies were not developed for the red wolf and black bear at this time.

Priority threats

The ecological process most critical to the project is the hydrological regime of the Roanoke River. This is significantly and negatively influenced by three dams at the fall line between the Piedmont and the Coastal Plain. These dams produce extended flooding in the floodplain during the growing season, thereby killing tree seedlings and insects and other invertebrates and disrupting reproduction of ground nesting birds. The reservoirs alter the connectivity of aquatic habitats for diadromous and other types of fish species. The planning partners are convinced that this can be adequately mitigated through adaptive management partnerships with the dam managers (Dominion Generation and the US Corps of Engineers).

In addition to hydrologic alteration from dams, a large silt deposit presumably developed between the mid-1800s and the construction of the dams around the 1950s. This deposit may have contributed to significant entrenchment of the river. We are not sure what kinds of impacts this silt deposit is having or will continue to have. The Roanoke is subject to all of the stresses associated with global climate change. Most notably, we expect impacts from higher temperatures, higher carbon dioxide levels, invasive species, more frequent and more powerful storms, and rising sea levels. The LRRP lies entirely within very low income counties, all of which seek actively seek business, industrial, and residential development. So far, these pressures have been mild, but poor land management, especially clear-cutting of timber on lands too wet to support natural regeneration, is a serious problem throughout the valley.

Conservation objectives and strategies

The planning partners identified 11 primary objectives directed at abating key threats and improving aquatic habitats and biological health in the Lower Roanoke River. Embedded within each objective summarized here, and articulated specifically in the LRR plan, are multiple conservation strategies aimed at achieving the stated objectives.

Objective 1: Acquire remaining industrial and private bottomland hardwood forest lands for conservation (estimated to be about 50,000 acres).

Objective 2: Assess status of fish populations and aquatic communities and develop appropriate management plans.

Objective 3: By the year 2014, change the operating policies that govern Kerr and Dominion facilities so that, growing season floods do not exceed 5 days except very rarely (e.g., in very wet years).

Objective 4: Change the operating policies that govern Kerr and Dominion facilities to mimic natural flows as closely as possible.

Objective 5: Control feral hogs in the Roanoke River valley.

Objective 6: Coordinate with universities to develop management strategies and techniques for aquatic invasive species.

Objective 7: Develop plans with USACE, FEMA, NRCS and NCDWR to leave woody debris in river when not an obstacle to navigation and to relocate to side of channel when it is an obstacle.

Objective 8: Eliminate industrial discharges as sources of toxins, color, reduced pH, and increased BOD.

Objective 9: Establish a control program to prevent the expansion of existing populations of invasive terrestrial plants on existing and newly acquired conservation lands.

Objective 10: Restore forested lands in conservation ownership through natural succession and active management.

Objective 11: Restore natural land forms/drainage.

Conservation success measures and adaptive management

In order to conserve keystone ecological processes, we propose to document complexity [composition, pattern (structure in time and space), and process (functions)], stresses, and sources of stresses on the Lower Roanoke River. We plan to prevent ecological simplification and support ecological restoration and resilience by adhering to the following principles of management:

1. We will reduce stresses through decisive action when we are certain and/or when decisions must be final and through adaptive management when we are uncertain and/or when decisions can be incremental;

2. We will incorporate spatial flexibility, heterogeneity, and connectivity into our conservation design; and

3. We will prevent simplification resulting from human disturbance, invasion, and fragmentation while supporting compatible economic activity.

Most of the stakeholders on the Roanoke River have committed to an Adaptive Management Partnership. The FERC license issued to Dominion Generation in 2005 contains numerous provisions for adaptive management, including requirements for monitoring tree seedling survival, fish spawning success, bank erosion, and so on. Dominion is required by its license to reduce its contribution to erosion, aquatic habitat fragmentation, growing season inundation, and other impacts incrementally over the 40-year period of its new license provided that monitoring produces data that supports the changes.

Stakeholders and Partners

The numerous conservation partners and stakeholders in the Lower Roanoke River include the U.S. Fish and Wildlife Service (USFWS), NC Wildlife Resources Commission (WRC), Georgia-Pacific Corporation, Weyerhaeuser Corporation, International Paper Corporation, local governments, hunt clubs, and private individuals. These partners are involved in the implementation of several strategies, including land protection aimed at approximately 150,000 acres of floodplain habitats; 70,000 acres of which are now conserved. As of September 2005, TNC retains ownership or conservation easements over about 25,325 acres in the floodplain of the Lower Roanoke. The U.S. Army Corps of Engineers and Dominion Generation have worked with other federal, state, and non-governmental conservation organizations to improve reservoir operations in the Lower Roanoke.

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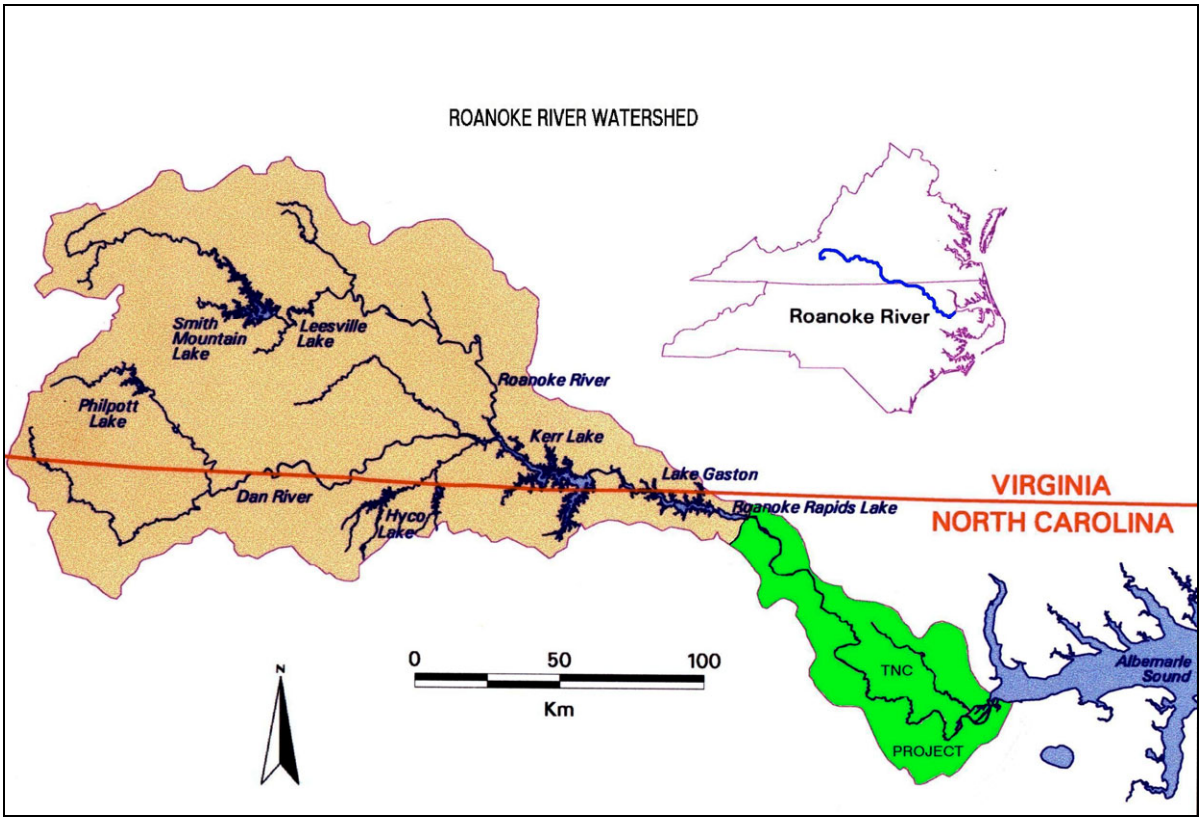


Figure 1. Map of the Roanoke River watershed in Virginia and North Carolina.

Watershed Characteristics

The Roanoke is an alluvial river, meaning it originates above the coastal plain and normally carries crystalline solids as sediments to the sea, or in this case, Albemarle Sound. The Roanoke is one of the largest alluvial rivers on the eastern slope of North America where it provides habitat for one of the largest and least fragmented systems of bottomland forests and one of the most diverse and numerous populations of diadromous fishes south of the St. Lawrence. The North Carolina Natural Heritage Program includes in its inventory of rare and vulnerable species and natural communities in the LRRP, habitat for three federally listed animals (American Alligator (*Alligator mississippiensis*), Bald Eagle (*Haliaeetus leucocephalus*), Short-nosed Sturgeon (*Acipenser brevirostrum*)), 16 additional state-listed animals, and 13 state-listed plants. Thirty-one natural communities are known to occur in the LRRP of which 16 are listed as exemplary by the North Carolina Natural Heritage Program. Of 214 bird species found in the LRRP, 88 are known to nest there, including 44 neo-tropical migrants, many of which are thriving in the LRRP while they decline throughout most of the rest of their. Ecosystem conservation efforts in the LRRP are focused on conserving ecological patterns and processes and the system's diversity of plants, animals, and natural communities.

History of Conservation Action

The TNC Board of Governors designated the Lower Roanoke as one of the "Last Great Places," making it one of only 200 sites so designated in all of the Americas and parts of Asia, and the Pacific, and making it a featured site in both of the last two international capital campaigns. The Roanoke River Project is in the Mid-Atlantic Coastal Plain ecoregion, and comprises parts of Bertie, Halifax, Martin, Northampton, and Washington counties in NC. The project includes the entire watershed of the Roanoke River downstream of the fall-line between the Piedmont and the Coastal Plain near the NC/VA line. It follows the river 137 miles to its mouth on Albemarle Sound. Our conservation emphasis is on the on the river itself and the floodplains and valley walls of the river and its tributaries.

In order to achieve The Nature Conservancy's mission in this place, we envision that the Lower Roanoke River should be managed so that conservation of natural resources and biological diversity, recreation, flood control, economic development, and hydropower production are balanced in sustainable ways. If we are successful, the full complement of natural communities and species and ecological patterns and processes will be present and self-sustaining in the context of natural disturbances and human uses. Land protection conservation partners include the US Fish and Wildlife Service (USFWS), NC Wildlife Resources Commission (WRC), Georgia-Pacific Corporation, Weyerhaeuser Corporation, International Paper Corporation, local governments, hunt clubs, and private individuals. The project is expected eventually to include about 150,000 acres of conservation land, with approximately 70,000 acres conserved at this time. TNC presently (September 2005) retains ownership or conservation easements over about 25,325 acres in the floodplain of the Lower Roanoke.

The LRRP lies entirely within very low income counties, all of which seek actively seek business, industrial, and residential development. So far, these pressures have been mild, but poor land management, especially clear-cutting of timber on lands too wet to support natural regeneration, is a serious problem throughout the valley. The chapter has established partnerships with local towns, counties, hunt clubs, and development coalitions to promote compatible economic development. TNC is helping to support, through the Roanoke River Partners, a system of canoe platforms to create a 125 mile long canoe trail, and TNC is actively engaged with the Town of Windsor and Bertie County in various community development activities.

Obviously, the conservation managers of the Roanoke River Landscape Project could not hope to develop management, monitoring, and adaptive strategies for 48 different rare species and natural communities, nor would doing so adequately address the larger system. First, unlisted but vulnerable and even common species would tend to be ignored until they were listed. Second, the matrix and large patch terrestrial communities and the instream system would be ignored. And finally, emergent properties of ecological structure and function (pattern and process) would not be protected.

In ecology, the whole really is greater than the sum of its parts. Therefore, TNC, USFWS, and WRC spent many days debating the necessary and sufficient conservation targets for the LRRP. Necessity and sufficiency were based on the simple notion that we needed a limited set of targets which would, if successfully managed and monitored (adaptively managed), could provide reasonable confidence that all potential targets would become and/or remain viable. Initially, we developed a list of six terrestrial communities, three wide ranging terrestrial animals, four groups of diadromous fish species, and the resident aquatic communities in each of eight river reaches, yielding 21 targets. Eventually, we reduced these to four terrestrial communities, diadromous fishes inclusively, the resident aquatic community inclusively, and two wide ranging terrestrial animals. However, it is important to note that many action and monitoring strategies for aquatic species and some terrestrial communities continue to specify one or more river reaches for implementation. This section of the report provides a description of the Roanoke Project Team's primary conservation targets.

Rich Slope Mesic Hardwood Forests

These are isolated forests located relatively close to the Piedmont fall line on the valley walls of the river. Many plant species normally found only in the western Piedmont and the southern Blue Ridge are found in these forests. These are large but isolated conservation targets that we will treat as local scale targets.

Riverine Bottomland Hardwood (BLH) Forests

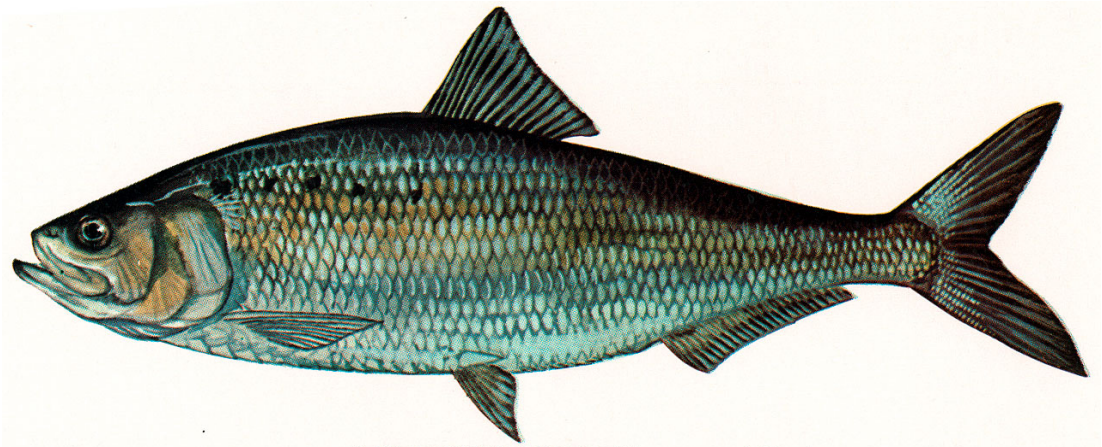
These are the second most common forests of the Roanoke River, frequently found as inter-digitated ridges between swamps (ridge and swale systems), along levees, in patches on knolls in swamps, and on low valley walls. Six sub-types are recognized: Maple-Green Ash BLH, Sweetgum BLH, Low Ridge and Flat Mixed BLH, High Levee Mixed BLH, Mixed Mesic BLH, and Beech-Mixed BLH. All are affected by artificially extended growing season floods. Individually, forest patches can be thought of as local targets, but we focus on the full suite of alluvial bottomland hardwood forests, seeking to conserve diversity of composition, structure, and spatial pattern.

Riverine Swamp Forests (Swamps)

These are the most common forests of the Roanoke River, frequently found as inter-digitated swamps between ridges (ridge and swale systems), as back swamps between ridge and swale systems and the valley walls, and as deep swamps near the mouth of the river. In this last case, Tupelo and Cypress are generally dominant on mineral soils while Swamp-Black Gum and pocosin vegetation with rare Atlantic White Cedar stands occupy deep organic soils. Ten sub-types are recognized: Atlantic White Cedar, Bay Pine Forest, Bay Forest, Bay Swamp Black Gum, Swamp Black Gum, Mixed Forested Peat Land, Non-alluvial Black Gum, Open Tupelo-Cypress, and Tupelo-Cypress, and Mixed Swamp Forest. In general, these forests are also affected by artificially extended growing season floods and by the absence of dry-downs during dry years. Individually, forest patches can be thought of as local targets, but we focus on the full suite of alluvial bottomland hardwood forests, seeking to conserve diversity of composition, structure, and spatial pattern.

Non-riverine Wetland Forests

In the Roanoke system, the only major example of this type is Roquist Pocosin which is not a pocosin but a large Carolina Bay containing a mosaic of Non-riverine Wet Hardwood forests and Non-riverine Swamps. Much of the former has recently been cut-over, and is now succeeding to fresh marsh. Roquist Pocosin functions as a single conservation target, now mainly in Department of Transportation ownership as a wetland restoration and mitigation site.



AMERICAN SHAD *Alosa sapidissima*

Diadromous Fishes

The US Fish and Wildlife Service has advised TNC that the Roanoke and Chowan Rivers support the most diverse and some of the largest populations of diadromous fishes (those that migrate between fresh and salt water) in the eastern US. We recognize four main groups of diadromous fishes: 1) Striped Bass and American Shad (anadromous, main channel broadcast spawners, eggs semi-buoyant and not adhesive); 2) Hickory Shad, Alewife, and Blueback Herring (anadromous, small tributary substrate spawning, eggs adhesive on submerged vegetation); 3) Atlantic and Short-nosed Sturgeon (anadromous), and 4) American Eel (catadromous). These species range over thousands of miles of fresh and salt water habitats.

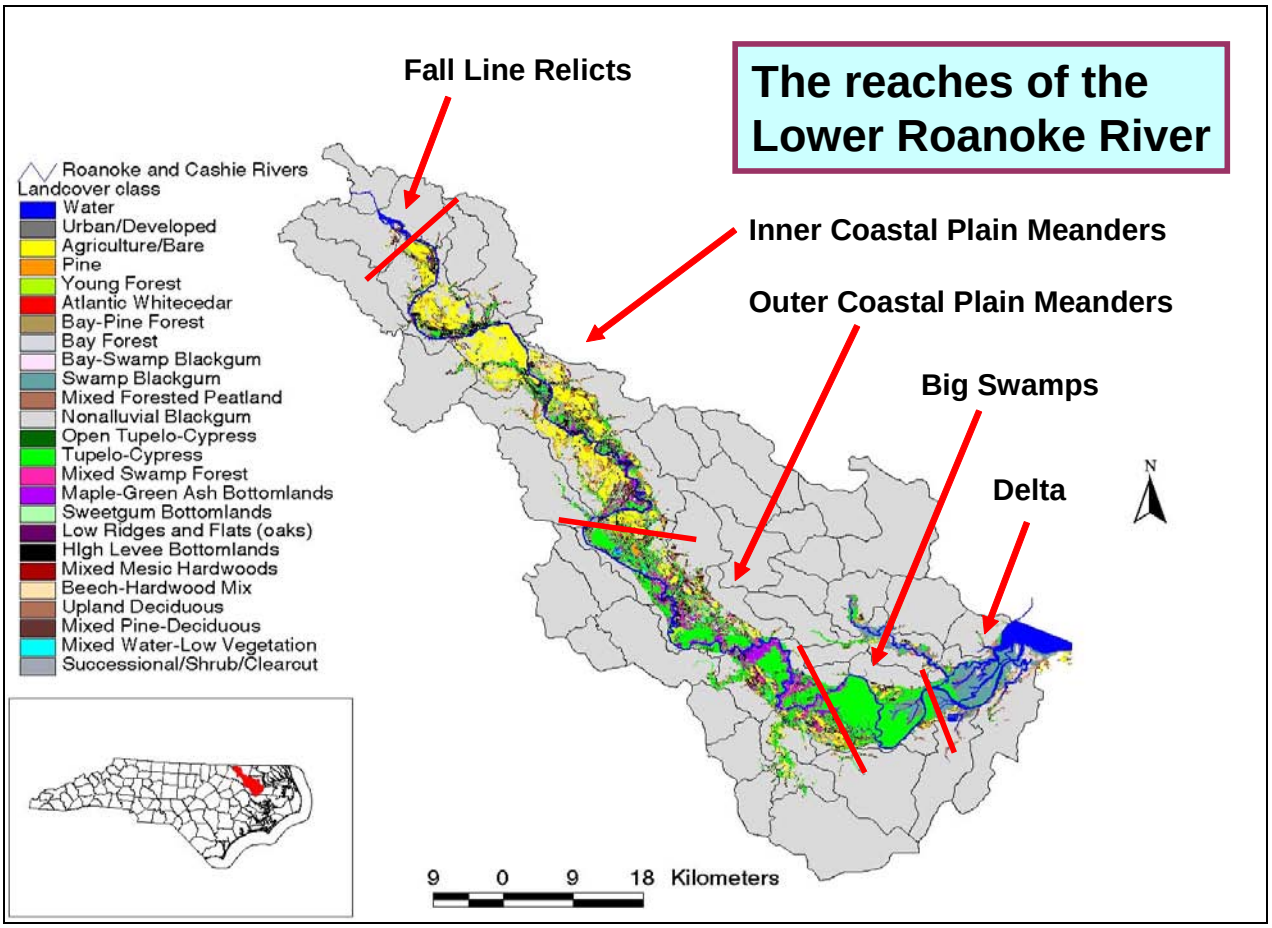


Figure 2. Aquatic system reaches of the Lower Roanoke River.

Riverine Resident Aquatic Communities

We recognize five main reaches of the Lower Roanoke River (Figure 2), and one of these is then divided into three sub-reaches (Figure 3).

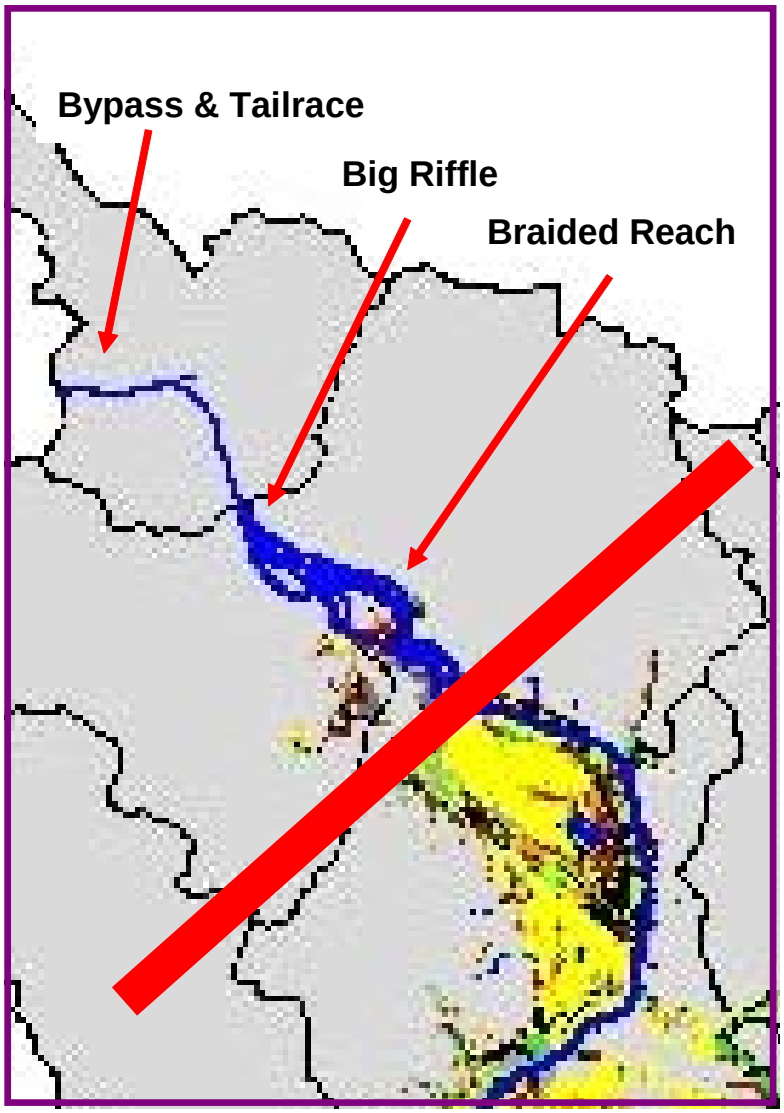


Figure 3. Subsections of the Fall Line Relicts system reach.

Red Wolf

This species is not officially present as a breeding population in the Roanoke, although individuals from the experimental "reintroduction" population at Alligator River regularly visit the landscape. We chose this as a target because we believe that a landscape as large and productive as that of the Roanoke cannot be conserved without a top predator. The Roanoke actually would provide better, more appropriate habitat for red wolf than does Alligator River. When red wolf are present in the landscape, they will transcend the boundaries of the landscape and extends across several adjacent landscapes from the Green Sea and the Chowan to the Roanoke and then east to the end of the Albemarle Peninsula. We have not completed conservation strategies for this target.

Black Bear

This wide-ranging, omnivorous animal was selected as a conservation target because it is intensively managed and intensively hunted in the project. We have not completed conservation strategies for it at this time.

Key Ecological Attributes and Indicators

Key ecological attributes and indicators were developed by panels of experts over several meetings (Table 1). These experts, in turn, drew on resources within their agencies and at academic institutions as needed. Even so, we frequently found that, while we were reasonably confident about where the ends of the continuum were for indicator ranges (poor and very good), we were unable to assign values to the intermediate values of "fair and good" without being completely subjective. Blank cells in Table 1 reflect this challenge. Table 2 summarizes the viability status of the conservation targets. The viability rankings in Table 2 are a summary of the condition of the key ecological attributes identified for each target. Conservation strategies aimed at improving the condition of the attributes listed in Table 1 will improve the viability of the targets over time.

The ecological process most critical to the project is the hydrological regime of the Roanoke River. This is significantly and negatively influenced by three dams at the fall line between the Piedmont and the Coastal Plain (Pearsall et al. 2005). These dams produce extended flooding in the floodplain during the growing season, thereby killing tree seedlings and insects and other invertebrates and disrupting reproduction of ground nesting birds. The Roanoke Planning team is convinced that this can be adequately mitigated through adaptive management partnerships with the dam managers, Dominion Generation and the US Army Corps of Engineers.

Table 1. Key ecological attributes of the conservation targets in the Lower Roanoke River.

Conservation Target		Category	Key Attribute	Indicator	Bold = Current Indicator Ratings			*Italics = Desired*	Current Rating	Desired Rating	Date of Current Rating	Date for Desired Rating
					Poor	Fair	Good	Very Good				
1	Rich Slope Mesic Forest	Landscape Context	Soil / sediment stability & movement	Slope stability	Ruts and gullies common, hardwood tree seedlings and forbes absent, successional pines present	Ruts and gullies less common, HW seedlings and forbes present, successional pines not common	**Ruts and gullies rare, HW seedlings and forbes dominant on floor, successional pines rare**	*Ruts and gullies absent; HW seedlings and forbes ubiquitous*	Good	Very Good	Sep-04	Sep-14
1	Rich Slope Mesic Forest	Landscape Context	Soil / sediment structure & chemistry	Soil pH	soil acidified <5 and nutrients not available	soil moving toward low pH <6, and nutrient inavilibity	**soil retrains nutrient availability, pH <6.5**	*soil pH is still high and stabile ~7, nutrients available*	Good	Very Good	Sep-04	Sep-14
1	Rich Slope Mesic Forest	Condition	Presence / abundance of keystone species	Presence of spring ephemerals (camassia, larkspur)	Dominated by privet and honeysuckle. Ephemerals suppressed or absent.			*Privet and honeysuckle absent. Ephemerals abundant.*	Fair	Very Good	Jan-05	Sep-14
1	Rich Slope Mesic Forest	Size	Landscape pattern (mosaic) & structure	Community fully occupies all potential sites	< 25% potential sites occupied by this community	25-50% potential sites occupied by this community	**50-75 % potential sites are occupied by this community**	*>75% potential sites occupied by this community*	Good	Very Good	Sep-04	Sep-14
2	Riverine Bottomland Hardwood Forest	Landscape Context	Hydrologic regime - (timing, duration, frequency, extent)	Duration of growing season floods (between 1 March and 30 September)	**Growing season floods exceed 10 consecutive days 3 consecutive years**	Growing season floods exceed 5 days 3 consecutive years	Growing floods exceed 5 days 2 consecutive years	*Growing floods do not exceed 5 days except very rarely (e.g., in very wet years)*	Poor	Very Good	Sep-04	Sep-14

2	Riverine Bottomland Hardwood Forest	Landscape Context	Size / extent of characteristic communities / ecosystems	Acres in conservation	<50% protected	**>50% protected**	>75% protected	*All BLHFs protected from destructive forestry and/or conversion.*	Fair	Very Good	Sep-05	Sep-15
2	Riverine Bottomland Hardwood Forest	Condition	Soil / sediment stability & movement	Bank stability	Concoidal slips and collapse common enough to cause severe erosion along most of the shore	**Some banks vegetated and convex, serving as brown water snake basking habitat**	Most banks vegetated and convex, and serving as brown water snake basking habitat	*Banks vegetated, convex, brown water snakes use as excellent basking habitat*	Fair	Very Good	Sep-04	Sep-14
2	Riverine Bottomland Hardwood Forest	Condition	Soil / sediment stability & movement	Rate of sediment deposition in bottomland hardwoods	**Current rate (several centimeters per year).**			*Sedimentation approaching 0.*	Poor	Very Good	Jan-05	Feb-15
2	Riverine Bottomland Hardwood Forest	Condition	Species composition / dominance	Forbe composition, herp community structure, and reproductive success of ground nesting birds	**forbes bsically absent, herps that breed in isolated bodies of water are supressed by fish predation, box turtles drown, turkey production is zero**	forbes rare, herps that breed in isolated bodies are stressed, box turtles stressed, turkey production is low	forbes mainly present, herps survive, box turtles not stressed, turkey production is good	*forbes cover the forest floor, herps abundant, box turtles abundant, turkey production is excellent*	Poor	Very Good	Sep-04	Sep-15

2	Riverine Bottomland Hardwood Forest	Condition	Successional dynamics	Germination and seedling survival of key tree species (extend apical meristem above local flood stage defined by sustained releases of 20,000 cfs)	**Tree seeds don't germinate**	Tree seeds germinate, but few cohorts survive.	Tree seeds germinate and seedlings survive in sufficient numbers for some cohorts to make it to the canopy. Stand replacement is not reliable. Stands will be patchy and easily invaded.	*Tree seeds germinate and seedlings survive in sufficient numbers to replace the canopy. Trees reach canopy at the same rate as canopy trees die.*	Poor	Very Good	Sep-04	Sep-15
2	Riverine Bottomland Hardwood Forest	Condition	Trophic structure	Presence of terrestrial crayfish (esp. Procambarus) and rates of recovery from inundation	**Crayfish kills follow growing season floods most years**	Crayfish kills common, post flood recovery is very slow	Crayfish kills rare and post flood recovery is rapid.	*Crayfish kills very rare, restricted to very wet years.*	Poor	Very Good	Sep-04	Sep-15
2	Riverine Bottomland Hardwood Forest	Size	Size / extent of characteristic communities / ecosystems	Wood thrush production	Wood thrush population is low and parasitism is high	Wood thrush population is low and parasitism is low	Wood thrush populaiton is high enough to support emmigration, parasitism is low	***Wood thrush population is high enough to support emmigration, parasitism is rare***	Very Good	Very Good	Sep-04	Sep-15

3	Riverine Swamp Forest	Landscape Context	Hydrologic regime - (timing, duration, frequency, extent)	Frequency and duration of extended dry-down	Swamps never dry out.	**Swamps become dry from 1 March to 30 September during dryest XX% of all years.**	Swamps become dry from 1 March to 30 September during dryest XX% of all years.	*Swamps become dry from 1 March to 30 September during dryest XX% of all years.*	Fair	Very Good	Jan-05	Feb-15
3	Riverine Swamp Forest	Condition	Soil / sediment stability & movement	Rate of sediment deposition in the back swamps	**Current rate (several centimeters per year).**			*Sedimentation approaching 0.*	Poor	Very Good	Jan-05	Feb-15
3	Riverine Swamp Forest	Condition	Species composition / dominance	Abundance and diversity of aquatic invasive plant species	Dominant in ground story.	**Abundant but not dominant.**	Occasional	*Absent*	Fair	Very Good	Jan-05	Feb-15
3	Riverine Swamp Forest	Condition	Species composition / dominance	Dominance of cypress saplings (apical meristem above high water).	**No cypress saplings**			*75-80% cypress and 20-25% tupelo or black gum*	Poor	Very Good	Jan-05	Feb-15
3	Riverine Swamp Forest	Size	Landscape pattern (mosaic) & structure	Percentage of potential sites occupied by riverine swamp forest	Absent	33%	67%	***100%***	Very Good	Very Good	Jan-05	Jan-05
4	Non-Riverine Wetland Forest	Landscape Context	Hydrologic regime - (timing, duration, frequency, extent)	Soil saturation					Poor	Very Good	Jan-05	Feb-10

4	Non-Riverine Wetland Forest	Condition	Species composition / dominance	Abundance and distribution of feral hogs	Widespread throughout system.			*Absent*	Fair	Very Good	Jan-05	Jan-15
4	Non-Riverine Wetland Forest	Condition	Successional dynamics	Percent of site restored to non-riverine wetland via natural succession	**0%**	50%	75%	*100%*	Poor	Very Good	Jan-05	Jan-15
4	Non-Riverine Wetland Forest	Size	Size / extent of characteristic communities / ecosystems	Relative area of forest type versus its potential area at Roquist Pocosin	Occupies less than 25%	**25-50%**	50-75%	*75-100%*	Fair	Very Good	Sep-04	Sep-15
5	Diadromous Fishes	Landscape Context	Connectivity among communities & ecosystems	Access to full range of spawning habitat	**< 25% of historic habitat available**	*50 % of historic habitat availble*	75% of historic habitat available	100% of historic habitat available	Poor	Fair	Feb-05	Feb-15
5	Diadromous Fishes	Landscape Context	Hydrologic regime - (timing, duration, frequency, extent)	Difference between run of river and current operations	**Highly altered**	*AM experiments w/ ROR to gain better understanding*	Run of river during spawning	Run of river	Poor	Fair	Feb-05	Feb-15

5	Diadromous Fishes	Landscape Context	Soil / sediment structure & chemistry	Degree of displacement of cobble/gravel by finer sediments (embededness), and degree of contamination by toxic substance	**< 25% of uncontaminated cobble/gravel habitat available**	50% available	*75% available*	100% of uncontaiminated cobble/gravel habitat available	Poor	Good	Feb-05	Feb-05
5	Diadromous Fishes	Condition	Population structure & recruitment	Percentage of population above the appropriate age (i.e., 8 years for striped bass; each species will have its own age)	**100 % of population at young ages**			25% of population is above appropriate old age	Poor	Good	Feb-05	Feb-05
5	Diadromous Fishes	Size	Population size & dynamics	Population within range of known variability for each diadromous species	Population at or below historic low range.	**Population is below the historic mean.**	*Population is above the historic mean.*	Population is at or rises above the historic high end of the range.	Fair	Good	Feb-05	Feb-15
6	Riverine Resident Aquatic Communities	Landscape Context	Community architecture	Presence of bankside vegetation along Upper and Lower Meanders	**Absent**	Present along 10 - 33% of banks	Present along >33% of banks	*>75% of banks covered with complex, layered woody and herbaceous community.*	Poor	Very Good	Apr-05	May-15

6	Riverine Resident Aquatic Communities	Landscape Context	Hydrologic regime	Duration of swamp inundation in lower reaches	**Growing season floods exceed 10 consecutive days in 3 consecutive years**	Growing season floods exceed 5 days in 3 consecutive years	Growing floods exceed 5 days in 2 consecutive years	*Growing floods do not exceed 5 days except very rarely (e.g., in very wet years)*	Poor	Very Good	May-05	Sep-14
6	Riverine Resident Aquatic Communities	Landscape Context	Hydrologic regime	Peaking frequency and ramping rate at Roanoke Rapids dam	**I = 0**			*I = 1*	Poor	Very Good	Apr-05	May-15
6	Riverine Resident Aquatic Communities	Landscape Context	Hydrologic regime	Hydrographic range in Bypass and Tailrace	0 mininum flow - 0 maximum flow	**325 minimum flow - 500 maximum flow**		*325 minimum flow - 15,000 maximum flow*	Fair	Very Good	Apr-05	May-15
6	Riverine Resident Aquatic Communities	Condition	Abundance of food resources	Zooplankton density in Big Swamp and Delta	Sparse			*Dense*	Good	Very Good	Apr-05	May-15
6	Riverine Resident Aquatic Communities	Condition	Biological legacies	Amount of woody debris in river channel along Upper and Lower Meanders	**Absent or scarce**			*Abundant woody debris*	Poor	Very Good	Apr-05	May-15

6	Riverine Resident Aquatic Communities	Condition	Population structure & recruitment	Age-structured catch per unit of sampling effort in Bypass and Tailrace (e.g., redbreast sunfish, darter spp., sucker spp.)	**Truncated age structure and low numbers**			*All species age classes present in sufficient numbers to indicate a healthy population.*	Poor	Very Good	Apr-05	May-15
6	Riverine Resident Aquatic Communities	Condition	Presence / abundance of keystone species	Native mussels per square meter in Bypass and Tailrace	**Absent**			*Most species present in sufficient numbers to indicate a healthy population*	Poor	Very Good	Apr-05	May-15
6	Riverine Resident Aquatic Communities	Condition	Presence of spawning habitat	Species richness of spawning fish in Braided Reach and Upper Meanders	Only species tolerant of degraded conditions			*Full complement of expected species*	Good	Very Good	Apr-05	May-15
6	Riverine Resident Aquatic Communities	Condition	Soil / sediment stability & movement	Rate of riverbank erosion along Upper and Lower Meanders	**Excessive rate above natural baseline.**			*Nothing more than would occur under run of river conditions*	Poor	Very Good	Mar-05	May-15

6	Riverine Resident Aquatic Communities	Condition	Species composition / dominance	Species richness of native mussels in Bypass,Tailrace, Big Riffle and Braided Reach	**0**			*12 species present (including 3-4 common spp. and 3-4 rare)*	Poor	Very Good	Apr-05	May-15
6	Riverine Resident Aquatic Communities	Condition	Trophic structure	Diversity and abundance of ground-level macrointebrates on floodplain of Lower Meanders	Low diversity and low abundance			*High diversity and high abundance*	Fair	Very Good	Mar-05	May-15
6	Riverine Resident Aquatic Communities	Condition	Water chemistry	Dissolved oxygen saturation in all reaches	0-25 percent	26-50 percent	**51-75 percent**	*>75 percent*	Good	Very Good	Apr-05	May-15
6	Riverine Resident Aquatic Communities	Size	Population size & dynamics	Population within range of known variability for each resident species	Population at or below historic low range.	**Population is below the historic mean.**	*Population is above the historic mean.*	Population is at or rises above the historic high end of the range.	Fair	Good	Feb-05	Feb-15

Table 2. Viability status of Lower Roanoke River conservation targets.

	Conservation Targets	Landscape Context	Condition	Size	Viability Rank
1	Rich Slope Mesic Forest	Good	Fair	Good	**Good**
2	Riverine Bottomland Hardwood Forest	Poor	Poor	Very Good	**Fair**
3	Riverine Swamp Forest	Fair	Poor	Very Good	**Fair**
4	Non-Riverine Wetland Forest	Poor	Poor	Fair	**Poor**
5	Diadromous Fishes	Poor	Poor	Fair	**Poor**
6	Riverine Resident Aquatic Communities	Poor	Poor	Fair	**Poor**

Threats to Conservation Targets

The Roanoke River Project Team evaluated stresses and the sources of stress for each of the six targets for which conservation planning is well advanced. Tables 3 through 8 summarize the results for each of the six primary conservation targets. Table 9 summarizes the threats for all the targets across the project area together. Following Tables 3 through 9 are descriptions of those threats with high or very high rankings. The Project Team discussed two main threats for which it was difficult to assess the scope or severity of the problem. First, a large silt deposit presumably developed between the mid-1800s and the construction of the dams about 50 years ago. This deposit may have contributed to significant entrenchment of the river. We are not sure what kinds of impacts this silt deposit is having or will continue to have. Secondly, The Roanoke is subject to all of the stresses associated with global climate change. Most notably, we expect impacts from higher temperatures, higher carbon dioxide levels, invasive species, more frequent and more powerful storms, and rising sea levels. However, addressing the potential effects of global climate change was beyond the scope of this update to the conservation action plan.

Table 3. Threats to Rich Slope Mesic Forests

Viability Summary	Landscape Context	Condition	Size	Viability Rank
	Good	Fair	Good	Good

	Stresses - Altered Key Ecological Attributes	Severity	Scope	Stress	User Override
1	Slopes unstable and eroding.	Low	Low	Low	
2	Soils becoming acidified.	Low	Low	Low	
3	Community absent from key potential sites.	Low	Low	Low	
4	Keystone species declining or absent.	Medium	Medium	Medium	

	Threats - Sources of Stress		Slopes unstable and eroding.	Soils becoming acidified.	Community absent from key potential sites.	Keystone species declining or absent.	-	Threat to System Rank
1	Rich Slope Mesic Forest		*Low*	*Low*	*Low*	*Medium*	-	
1	Forestry practices	Contribution	Medium	Low	Low	Medium		Low
		Irreversibility	High	Medium	High	High		
		Override						
		Source	Medium	Low	Medium	Medium	-	
		Combined Rank	Low	-	Low	Low	-	
2	Crop production practices	Contribution	Low	Low	-	Medium		Low
		Irreversibility	High	Low	-	Low		
		Override						
		Source	Medium	Low	-	Low	-	
		Combined Rank	Low	-	-	Low	-	
3	Recreational vehicles	Contribution	Very High	-	-	High	High	Medium
		Irreversibility	Very High			High	High	
		Override						
		Source	Very High	-	-	High	High	
		Combined Rank	Low	-	-	Medium	-	
4	Atmospheric deposition	Contribution	-	Medium	Medium	Medium	Medium	Medium
		Irreversibility	-	Very High	Very High	Very High	Very High	
		Override						
		Source	-	High	High	High	High	
		Combined Rank	-	Low	Low	Medium	-	

5	Invasive/alien species	Contribution	-	-	High	High	Very High	Medium
		Irreversibility	-	-	High	High		
		Override						
		Source	-	-	High	High	-	
		Combined Rank	-	-	Low	Medium	-	
6	Primary home development	Contribution	Medium	-	High	Low		Low
		Irreversibility	Very High	-	Very High	Very High		
		Override						
		Source	High	-	High	Medium	-	
		Combined Rank	Low	-	Low	Low	-	

Table 4. Threats to Riverine Bottomland Hardwood Forests

Viability Summary	Landscape Context	Condition	Size	Viability Rank
	Poor	Poor	Very Good	Fair

	Stresses - Altered Key Ecological Attributes	Severity	Scope	Stress	User Override
1	River banks are prone to collapse and severe erosion.	Very High	Very High	Very High	
2	Sediments are being deposited on the floodplain.	Medium	Low	Low	
3	Reproductive failure and mortality for species confined to the forest floor, including herps that reproduce in normally isolated ponds.	Very High	Very High	Very High	
4	Artificially extended growing season floods.	Very High	Very High	Very High	
5	Forests fragmented with reduced patch sizes.	High	Medium	Medium	
6	Tree seeds fail and tree seedlings are drowning.	Very High	High	High	
7	Soil invertebrates and crayfish are drowning.	High	High	High	

Threats - Sources of Stress			River banks are prone to collapse and severe erosion.	Sediments are being deposited on the floodplain.	Reproductive failure and mortality for species confined to the forest floor, including herps that reproduce in normally isolated ponds.	Artificially extended growing season floods.	Forests fragmented with reduced patch sizes.	Tree seeds fail and tree seedlings are drowning.	Soil invertebrates and crayfish are drowning.	Threat to System Rank
2	Riverine Bottomland Hardwood Forest		*Very High*	*Low*	*Very High*	*Very High*	*Medium*	*High*	*High*	
1	Presence and operation of dams or reservoirs	Contribution	Very High	Medium	Very High	Very High		Very High	Very High	Very High
		Irreversibility	Medium	Medium	Medium	Medium		Medium	Medium	
		Override								
		Source	High	Medium	High	High	-	High	High	
		Combined Rank	Very High	Low	Very High	Very High	-	High	High	
2	Conversion to agriculture or silviculture	Contribution	Medium	High			Very High			High
		Irreversibility	Medium	Medium			High			
		Override								
		Source	Medium	Medium	-	-	Very High	-	-	
		Combined Rank	High	Low	-	-	Medium	-	-	
3	Forestry practices	Contribution	High	-			-			High
		Irreversibility	Medium	-			-			
		Override								
		Source	Medium	-	-	-	-	-	-	

		Combined Rank	High	-	-	-	-	-	-	
4	Invasive/alien species	Contribution			Very High					Very High
		Irreversibility			Very High					
		Override								
		Source	-	-	Very High	-	-	-	-	
		Combined Rank	-	-	Very High	-	-	-	-	
5	Presence of artificial ditches and levees	Contribution		Medium	High	High		High	High	High
		Irreversibility		Very High	Medium	Medium		Medium	Medium	
		Override								
		Source	-	High	Medium	Medium	-	Medium	Medium	
		Combined Rank	-	Low	High	High	-	Medium	Medium	
6	Historic slug of sediment in river	Contribution		Very High						Low
		Irreversibility		Very High						
		Override								
		Source	-	Very High	-	-	-	-	-	
		Combined Rank	-	Low	-	-	-	-	-	

Stresses and Threats

Table 5. Threats to Riverine Swamp Forests

Viability Summary	Landscape Context	Condition	Size	Viability Rank
	Fair	Poor	Very Good	Fair

	Stresses - Altered Key Ecological Attributes	Severity	Scope	Stress	User Override
1	Sediment deposition in back swamps.	Very High	Medium	Medium	
2	Cypress seedlings not surviving to sapling stage.	Very High	High	High	
3	Community being extirpated from potential sites.	Medium	Medium	Medium	
4	Flooding rarely allows for dry-down.	Very High	Very High	Very High	
5	Native species composition being changed by invading aquatic plants.	High	Low	Low	

	Threats - Sources of Stress		Sediment deposition in back swamps.	Cypress seedlings not surviving to sapling stage.	Community being extirpated from potential sites.	Flooding rarely allows for dry-down.	Native species composition being changed by invading aquatic plants.	Threat to System Rank
3	Riverine Swamp Forest		*Medium*	*High*	*Medium*	*Very High*	*Low*	
1	Crop production practices	Contribution	Low	-	Low	-		Low
		Irreversibility	Very High		Very High			
		Override						
		Source	Medium	-	Medium	-	-	
		Combined Rank	Low	-	Low	-	-	
2	Presence and operation of dams or reservoirs	Contribution	High	Very High	Very High	Very High		Very High
		Irreversibility	Very High	Medium	Medium	Medium		
		Override						
		Source	High	High	High	High	-	
		Combined Rank	Medium	High	Medium	Very High	-	

3	Forestry practices	Contribution	High	Low	Very High	-		Medium
		Irreversibility	Very High	Low	Medium			
		Override						
		Source	High	Low	High	-	-	
		Combined Rank	Medium	Low	Medium	-	-	
4	Historic slug of sediment in river	Contribution	Very High	-	Very High	-		Medium
		Irreversibility	Very High		Very High			
		Override						
		Source	Very High	-	Very High	-	-	
		Combined Rank	Medium	-	Medium	-	-	
5	Invasive/alien species	Contribution					Very High	Low
		Irreversibility					High	
		Override						
		Source	-	-	-	-	Very High	
		Combined Rank	-	-	-	-	Low	
6	Presence of artificial ditches and levees	Contribution	Medium	High		High		High
		Irreversibility	High	Medium		Medium		
		Override						
		Source	Medium	Medium	-	Medium	-	
		Combined Rank	Low	Medium	-	High	-	

Stresses and Threats

	Table 6. Non-Riverine Wetland Forests						
Viability Summary		Landscape Context	Condition	Size	Viability Rank		
		Poor	Poor	Fair	Poor		
Stresses - Altered Key Ecological Attributes				Severity	Scope	Stress	
1	Site hydrology severely altered.			Very High	Very High	Very High	
2	Much of site has been recently clear cut.			Very High	Very High	Very High	
3	Growing feral hog population suppressing native species.			Very High	Medium	Medium	
4	Size / extent of characteristic communities / ecosystems			Very High	High	High	
Threats - Sources of Stress			Site hydrology severely altered.	Much of site has been recently clear cut.	Growing feral hog population suppressing native species.	Size / extent of characteristic communities / ecosystems	Threat to System Rank
4	Non-Riverine Wetland Forest		*Very High*	*Very High*	*Medium*	*High*	
1	Presence of artificial ditches and levees	Contribution	Very High	Low		Very High	Very High
		Irreversibility	Medium	Medium		Medium	
		Override					
		Source	High	Low	-	High	
		Combined Rank	Very High	Medium	-	High	
2	Forestry practices	Contribution	Medium	Very High		Very High	Very High
		Irreversibility	Medium	Medium		Medium	
		Override					
		Source	Medium	High	-	High	
		Combined Rank	High	Very High	-	High	

3	Invasive/alien species	Contribution			Very High		Medium
		Irreversibility			High		
		Override					
		Source	-	-	Very High	-	
		Combined Rank	-	-	Medium	-	

Stresses and Threats

	Table 7. Threats to Diadromous Fishes							
Viability Summary		Landscape Context	Condition	Size	Viability Rank			
		Poor	Poor	Fair	Poor			
Stresses - Altered Key Ecological Attributes				Severity	Scope	Stress	User Override	
1	Hydrologic regime altered.			High	High	High		
2	Populations are reduced below historic levels.			Medium	Very High	Medium		
3	Species do not have access to historic spawning habitat.			High	Very High	High		
4	Populations are dominated by young age classes with few old fish present.			High	Very High	High		
5	Cobble/gravel habitat subject to sedimentation and contamination.			Medium	Very High	Medium		
Threats - Sources of Stress			Hydrologic regime altered.	Populations are reduced below historic levels.	Species do not have access to historic spawning habitat.	Populations are dominated by young age classes with few old fish present.	Cobble/gravel habitat subject to sedimentation and contamination.	Threat to System Rank
5	Diadromous Fishes		*High*	*Medium*	*High*	*High*	*Medium*	
1	Presence and operation of dams or reservoirs	Contribution	Very High	Medium	Very High	Very High	Very High	Very High
		Irreversibility	High	Medium	Very High	Medium	Very High	
		Override						
		Source	Very High	Medium	Very High	High	Very High	
		Combined Rank	High	Low	High	High	Medium	
2	Industrial discharge	Contribution		Medium		Medium		Medium
		Irreversibility		High		High		
		Override						
		Source	-	Medium	-	Medium	-	
		Combined Rank	-	Low	-	Medium	-	

3	Invasive/alien species	Contribution		Medium		Medium		High
		Irreversibility		Very High		Very High		
		Override						
		Source	-	High	-	High	-	
		Combined Rank	-	Medium	-	High	-	
4	Management of/for certain species	Contribution		High		High		Medium
		Irreversibility		Medium		Medium		
		Override						
		Source	-	Medium	-	Medium	-	
		Combined Rank	-	Low	-	Medium	-	
5	Overfishing or overhunting	Contribution		Very High		Very High		High
		Irreversibility		Low		Low		
		Override						
		Source	-	High	-	High	-	
		Combined Rank	-	Medium	-	High	-	
6	Parasites/pathogens	Contribution		Low		Low		Medium
		Irreversibility		Very High		Very High		
		Override						
		Source	-	Medium	-	Medium	-	
		Combined Rank	-	Low	-	Medium	-	
7	Presence of artificial ditches and levees	Contribution		Medium		Medium	High	Medium
		Irreversibility		Medium		Medium	Medium	
		Override						
		Source	-	Medium	-	Medium	Medium	
		Combined Rank	-	Low	-	Medium	Low	

Stresses and Threats

Table 8. Threats to Riverine Resident Aquatic Communities

Viability Summary	Landscape Context	Condition	Size	Viability Rank
	Poor	Poor	Fair	Poor

Entry assistance ON

	Stresses - Altered Key Ecological Attributes	Severity	Scope	Stress	User Override
1	Hydrologic regime altered.	High	Very High	High	
2	Low levels of DO, higher than normal levels of BOD, and reduced pH.	High	High	High	
3	Increased river bank erosion and loss of bankside vegetation.	Very High	Very High	Very High	
4	Woody debris absent from river channel.	Very High	High	High	
5	Reduced presence of spawning habitat.	Medium	Medium	Medium	
6	Simplified species composition and trophic structure/dominance.	High	High	High	
7	Reduced presence and abundance of keystone species.	High	High	High	
8	Diminished population structure and recruitment.	Medium	High	Medium	

Threats - Sources of Stress			Hydrologic regime altered.	Low levels of DO, higher than normal levels of BOD, and reduced pH.	Increased river bank erosion and loss of bankside vegetation.	Woody debris absent from river channel.	Reduced presence of spawning habitat.	Simplified species composition and trophic structure/dominance.	Reduced presence and abundance of keystone species.	Diminished population structure and recruitment.	Threat to System Rank
	Riverine Resident Aquatic Communities		*High*	*High*	*Very High*	*High*	*Medium*	*High*	*High*	*Medium*	
1	Presence and operation of dams or reservoirs	Contribution	Very High	High	Very High	Medium	Very High	High	High	Medium	Very High
		Irreversibility	Very High	Very High	Very High	Very High	Very High	Very High	Very High	Very High	
		Override									
		Source	Very High	High	Very High	High	Very High	High	High	High	
		Combined Rank	High	High	Very High	High	Medium	High	High	Medium	
2	Presence of artificial ditches and levees	Contribution	Very High	Very High	-	-	Medium	-	-	-	High
		Irreversibility	High	Very High	-	-	High	-	-	-	
		Override									
		Source	Very High	Very High	-	-	Medium	-	-	-	
		Combined Rank	High	High	-	-	Low	-	-	-	
3	Water withdrawal	Contribution	-	-	-	-	-	High	Medium	Very High	High
		Irreversibility	-	-	-	-	-	High	High	High	
		Override									
		Source	-	-	-	-	-	High	Medium	Very High	
		Combined Rank	-	-	-	-	-	High	Medium	Medium	

4	Industrial discharge	Contribution	-	High			High	Very High	Very High	High	Very High
		Irreversibility	-	High			High	High	High	High	
		Override									
		Source	-	High	-	-	High	Very High	Very High	High	
		Combined Rank	-	High	-	-	Medium	High	High	Medium	
5	Management of/for certain species	Contribution	High	-	-	-	-	Low	-	Low	High
		Irreversibility	High	-	-	-	-	Low	-	Low	
		Override									
		Source	High	-	-	-	-	Low	-	Low	
		Combined Rank	High	-	-	-	-	Low	-	Low	
6	Woody debris removal	Contribution				Very High					High
		Irreversibility				Very High					
		Override									
		Source	-	-	-	Very High	-	-	-	-	
		Combined Rank	-	-	-	High	-	-	-	-	
7	Parasites/pathogens	Contribution							Medium	Medium	High
		Irreversibility							Very High	Very High	
		Override									
		Source	-	-	-	-	-	-	High	High	
		Combined Rank	-	-	-	-	-	-	High	Medium	
8	Invasive/alien species	Contribution					High	Medium	Very High	High	High
		Irreversibility					Very High	Very High	Very High	Very High	
		Override									
		Source	-	-	-	-	High	High	Very High	High	

		Combined Rank	-	-	-	-	Medium	High	High	Medium	
9	Atmospheric deposition	Contribution		High						Medium	High
		Irreversibility		Very High						Very High	
		Override									
		Source	-	High	-	-	-	-	-	High	
		Combined Rank	-	High	-	-	-	-	-	Medium	

Table 9. Summary of Threats

Lower Roanoke River Landscape

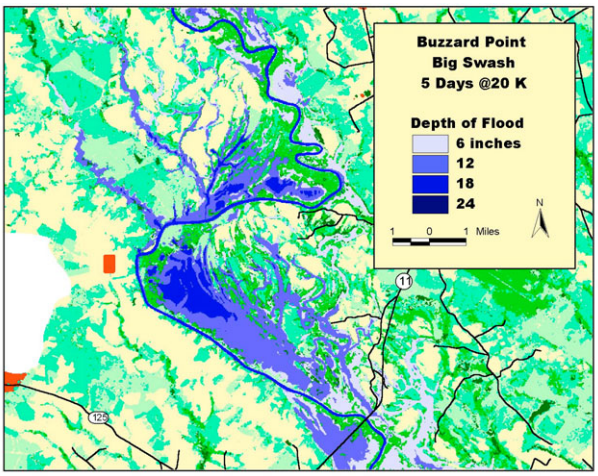
	Threats Across Systems	Rich Slope Mesic Forest	Riverine Bottomland Hardwood Forest	Riverine Swamp Forest	Non-Riverine Wetland Forest	Diadromous Fishes	Riverine Resident Aquatic Communities	Overall Threat Rank
1	Presence and operation of dams or reservoirs	-	Very High	Very High	-	Very High	Very High	Very High
2	Presence of artificial ditches and levees	-	High	High	Very High	Medium	High	Very High
3	Invasive/alien species	Medium	Very High	Low	Medium	High	High	High
4	Forestry practices	Low	High	Medium	Very High	-	-	High
5	Industrial discharge	-	-	-	-	Medium	Very High	High
6	Parasites/pathogens	-	-	-	-	Medium	High	Medium
7	Atmospheric deposition	Medium	-	-	-	-	High	Medium
8	Conversion to agriculture or silviculture	-	High	-	-	-	-	Medium
9	Woody debris removal	-	-	-	-	-	High	Medium
10	Management of/for certain species	-	-	-	-	-	High	Medium
11	Overfishing or overhunting	-	-	-	-	High	-	Medium
12	Water withdrawal	-	-	-	-	-	High	Medium
13	Historic slug of sediment in river	-	Low	Medium	-	-	-	Low
14	Recreational vehicles	Medium	-	-	-	-	-	Low
15	Management of/for certain species	-	-	-	-	Medium	-	Low
16	Crop production practices	Low	-	Low	-	-	-	Low
	THREAT STATUS FOR TARGET AND SITE	Medium	Very High	High	Very High	High	Very High	Very High

In order to conserve all the targets identified in the Lower Roanoke River, adaptive management strategies are required for immediate implementation to address all threats ranked medium or higher. The top two threats on the Roanoke are both directly related to the alteration of hydrology and to the establishment of artificial connections and barriers in aquatic habitat. The presence and operation of dams is by far the major source of these stresses.

Dam Operations

John H. Kerr Dam is a US Army Corps of Engineers facility operated in partnership with the Southeast Power Administration of the US Department of Energy. Kerr's existence severs upstream and downstream habitat for diadromous fishes, and Kerr operations account for the majority of downstream longer term (between-day) hydrological alterations, most notably the artificial extension of growing season inundation (Pearsall et al. 2005)

Lake Gaston Dam (shown here) and Roanoke Rapids Dam (just downstream) are owned and operated by Dominion Generation under a recently renewed license from the Federal Energy Regulatory Commission. These two dams are much smaller than Kerr, and while they provide additional mileage to the severance of upstream and downstream habitats, they contribute relatively little to the longer-term alteration of the hydrological regime. On the other hand, within-day fluctuation ("peaking" or "load-following") is entirely attributable to operations at Roanoke Rapids (see following page).



Buzzard Point – Big Swash Area after 5 Days of 20,000 CFS continuous release

Hardwood Inundation in April 2003

Bank Collapse Thought to Result from Continuous Saturation

Bank Undercutting and Abrasion Thought to Result from Peaking

Artificial ditches and levees

Artificial ditches (guts) and artificial levees create altered connections between the floodplain and the river. Each altered landform results in locally unique modification of the local hydrological regime. Artificial guts can increase the speed with which water enters and exits the floodplain, while artificial levees that were built to prevent water from inundating the floodplain may actually work to impound water that is in the floodplain, whether from river-based inundation or precipitation. Water is much less likely to enter or leave the floodplain as the result of over-bank flows and much more likely to be confined to both natural and artificial guts.

Invasive and alien species

Invasive and alien species are rapidly becoming universal problems in nature reserves, and that is certainly the case on the Roanoke. Several species are of particular concern because they are agents for simplification of the system, displacing native species by competition or predation.

Asiatic Clams

Microstegium

Parrot Feather

Nutria

Red Swamp Crayfish

Incompatible Foresty Practices

Incompatible forestry practices are a severe threat mainly for non-riverine swamp forests and riverine bottomland hardwoods. In both cases, aggressive harvesting of timber in the presence of an altered hydrological regime results in forest conversion, generally to non-forest.

This experimental shelter-wood cut was intended to stimulate the restoration of bald cypress in an area that, as the result of selective logging, had converted to tupelo dominance. However, almost no recruitment of either species is occurring, probably as the direct result of extended growing season inundation. Note the standing water in the clearing.

In this case, at Roquist Pocosin, a non-riverine bottomland hardwood forest was cut and artificial ditches and berms (the road itself) created a permanently wet environment that is likely to succeed to marsh rather than return to the non-riverine hardwood community.

Cypress logs about to be chipped for mulch.

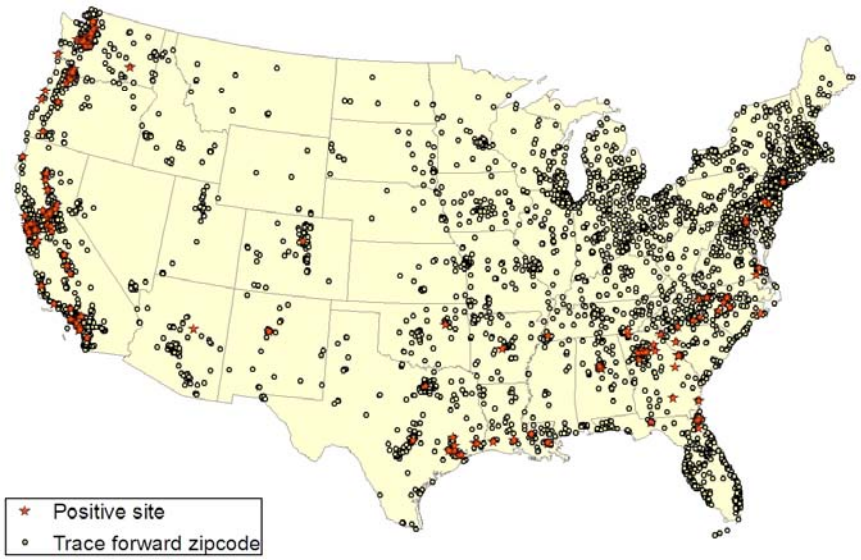
Industrial discharges

Industrial discharges represent a moderate threat for diadromous fishes, but severely threaten resident aquatic communities in the main stem.

Parasites and Pathogens

Anguillicola crassus (an Asiatic nematode shown here in the swim bladder of an American Eel) is one sort of parasite that represents a significant threat on the Roanoke.

Sudden Oak Death, a fungus (of Asiatic origin?) now found across the United States is not yet found in the Roanoke valley, but it is likely to appear there soon. It is spread by nursery stock that is poorly regulated.



Red stars indicate known locations for Sudden Oak Death disease.

Atmospheric deposition

Atmospheric pollution that originates far from the Roanoke results in atmospheric deposition of acidifying compounds of sulfur and nitrogen (acid precipitation). Mercury from coal fired power plants arrives by the same means. In general, atmospheric deposition is considered to be a medium threat for the rich slope mesic forest that depends on low soil acidity and a high threat for the resident aquatic community that is damaged both by acidification and by mercury deposition.

Conversion of land to agriculture or silviculture

Former Riverine Bottomland Hardwood Forests converted to Agriculture

Woody debris removal

The USACE Snell removes woody debris, impacting in-stream habitat for substrate spawning anadromous fishes and for the resident aquatic community.

Management for certain species & Overfishing

Managing the hydrological regime to support optimum spawning flows for diadromous fishes during their spawning season sometimes results in surplus water stored in the upstream reservoirs, especially in very wet years. When this water is released over the rest of the summer, it can contribute to the artificial extension of growing season inundation downstream. Over-fishing at sea and in the sounds is thought to contribute to impacts on the populations of diadromous fishes in the Roanoke.

Water withdrawals

This intake for the Lake Gaston Pipeline is the source of an inter-basin transfer of up to 60 million gallons per day to the City of Virginia Beach. Normally, this pipeline does not create significant impacts on the resident aquatic community, but during times of drought, the potential for such impacts exists. A greater threat exists in the possibility that other cities in NC and VA will look to the Roanoke for water in the near future.

Table 10 summarizes the objectives and strategic actions for most of our most critical threats. Note however, that some threats have no associated objectives and strategic actions. These include atmospheric deposition, for which we think we cannot develop a local solution, and most of the invasive species, for which we were simply unable to develop strategies to support even the simplest objectives at this time.

Table 10. Conservation Objectives and Strategic Actions for the Roanoke River Project.

Objective 1:	**Acquire remaining industrial and private bottomland hardwood forest lands for conservation (estimated to be about 50,000 acres).**
Strategic action:	Direct acquisition with CWMTF and private funds.
Strategic action:	Implement private landowner incentive programs, e.g., CREP.
Strategic action:	Assist hunt clubs with acquisition encumbered by conservation easements.
Strategic action:	Partner with TIMO in combination with riparian and working forest easements.
Objective 2:	**Assess status of fish populations and aquatic communities and develop appropriate management plans.**
Strategic action:	Play leadership role in transition from species to ecosystem management.
Strategic action:	Provide political support for management agencies that attempt to conservatively manage fish populations, aquatic communities and water quality.

Strategic action:	Work with state and federal agencies to develop and implement recovery plans for imperiled species.
Strategic action:	Work with NC DMF, WRC, and USFWS and NMFS to develop appropriate Fisheries Management Plans for commercially and recreationally important species.
Strategic action:	Build adaptive management into the USACE 216 study and the resulting water control plan.
Strategic action:	Complete models and research that establish direct links between dam operating policies and ecological and economic consequences.
Strategic action:	Map and assess invasive species populations.
Strategic action:	Negotiate with NC DWQ and EMC to relieve assimilation pressure on the Roanoke (without impinging on efforts to mimic natural flows).
Objective 3:	**By the year 2014, change the operating policies that govern Kerr and Dominion facilities so that, growing season floods do not exceed 5 days except very rarely (e.g., in very wet years).**
Strategic action:	Build adaptive management into the 216 study and the resulting water control plan.
Strategic action:	With Dominion, participate in, provide leadership for, and provide matching funds for the adaptive management processes agreed to in the settlement.
Strategic action:	Complete models and research that establish direct links between dam operating policies and ecological and economic consequences.

Strategic action:	TNC provides USACE with a legal brief demonstrating that USACE operations have absolute precedence over SEPA operations re dispatch from Kerr.
Objective 4:	**Change the operating policies that govern Kerr and Dominion facilities to mimic natural flows as closely as possible.**
Strategic action:	Complete models and research that establish direct links between dam operating policies and ecological and economic consequences.
Strategic action:	Build adaptive management into the 216 study and the resulting water control plan.
Strategic action:	With Dominion, participate in, provide leadership for, and provide matching funds for the adaptive management processes agreed to in the settlement.
Strategic action:	TNC provides USACE with a legal brief demonstrating that USACE operations have absolute precedence over SEPA operations re dispatch from Kerr.
Objective 5:	**Control feral hogs in the Roanoke River valley.**
Strategic action:	Map and assess invasive species populations.
Strategic action:	Eliminate hog population at Roquist Pocosin by 2015.
Strategic action:	Contract with EEP to begin hog eradication program beginning in FY05 (actions to include tracking and trapping).
Strategic action:	Develop public information and landowner contact program to discourage hog releases.

Strategic action:	Coordinate DOT, EEP and consultants to restore Roquist Pocosin.
Objective 6:	**Coordinate with universities to develop management strategies and techniques for aquatic invasive species.**
Strategic action:	Organize aquatic invasives workshop on Roanoke to include researchers and potential funding agencies.
Strategic action:	Map and assess invasive species populations.
Objective 7:	**Develop plans with USACE, FEMA, NRCS and NCDWR to leave woody debris in river when not an obstacle to navigation and to relocate to side of channel when it is an obstacle.**
Strategic action:	Develop and implement woody debris removal management plan.
Objective 8:	**Eliminate industrial discharges as sources of toxins, color, reduced pH, and increased BOD.**
Strategic action:	Negotiate with NC DWQ and EMC to relieve assimilation pressure on the Roanoke (without impinging on efforts to mimic natural flows).
Strategic action:	Seek Outstanding Resource Water classification for the Roanoke and/or selected tributaries.
Objective 9:	**Establish a control program to prevent the expansion of existing populations of invasive terrestrial plants on existing and newly acquired conservation lands.**
Strategic action:	Hire staff to supervise volunteers to conduct intensive on-the-ground invasives control program.

Objective 10:	**Restore forested lands in conservation ownership through natural succession and active management.**
Strategic action:	Control invasives (including feral hogs) in hardwood succession in bottomland hardwood forests.
Strategic action:	Coordinate DOT, EEP and consultants to restore Roquist Pocosin.
Strategic action:	Create light gaps in tupelo-cypress forests at Bull Run Island.
Strategic action:	Selectively manage hardwood plantations to restore bottomland hardwoods, primarily on former Union Camp land.
Objective 11:	**Restore natural land forms/drainage.**
Strategic action:	Breach half of artificial levees on Roanoke.
Strategic action:	Map all artificial guts and implement plugging.
Strategic action:	Replace culverts with fords on conservation lands in Roanoke floodplain.

In order to conserve keystone ecological processes, we propose to document complexity (composition, pattern (structure in time and space), and process (functions)), stresses, and sources of stresses on the Lower Roanoke River. We plan to prevent ecological simplification and support ecological restoration and resilience by adhering to the following principles of management:

a) We will reduce stresses through decisive action when we are certain and/or when decisions must be final and through adaptive management when we are uncertain and/or when decisions can be incremental;

b) We will incorporate spatial flexibility, heterogeneity, and connectivity into our conservation design; and

c) We will prevent simplification resulting from human disturbance, invasion, and fragmentation while supporting compatible economic activity.

Most of the stakeholders on the Roanoke River have committed to an Adaptive Management Partnership (Manring and Pearsall, in press). The FERC license issued to Dominion Generation in 2005 contains numerous provisions for adaptive management, including requirements for monitoring tree seedling survival, fish spawning success, bank erosion, and so on (Dominion 2003). Dominion is required by its license to reduce its contribution to erosion, aquatic habitat fragmentation, growing season inundation, and other impacts incrementally over the 40-year period of its new license provided that monitoring produces data that supports the changes.

Funds for this monitoring activity are secured. At this writing, negotiations are underway to establish protocols and duties for all monitoring detailed in the settlement. We expect these negotiations to be completed and contracts to be signed by the end of 2005. On the terrestrial side, we expect to place over 50 water level gages and vegetation plots in an existing system of about 70 existing sedimentation and erosion monitoring transects to jointly monitor tree seedling survival, water levels, sedimentation and erosion. These transects will be placed mainly in reaches two and three where bottomland hardwood forests and bank stability are most threatened by the altered hydrological regime. A Remote Active Weather-station will be installed in the center of the project. Monitoring for spawning success and for resident fish species in the by-pass sub-reach of reach one is already underway.

In addition to this settlement agreement, The US Army Corps of Engineers is presently engaged with the stakeholders in the development of a Section 216 study for the purpose of establishing adaptive management of its operations. All of the details of the USACE long-term monitoring program will be determined by the outcome of the 216 study which is still several years away.

Our largest challenge in the hydrological regime impacts monitoring arena is to develop protocols that distinguish between the contributions to altered hydrology produced by Dominion

Generation, the USACE, and SEPA. We will monitor the success of landform restoration by monitoring water levels in the floodplain, using the aforementioned gages. The removal of woody debris remains a challenge, and we do not have a strategy for monitoring this threat at this time. It will be incorporated in the plan we propose to coordinate among the agencies. Water quality, industrial discharges, and water withdrawals are monitored by the State of NC, USACE, and EPA. Their data are available to us, and we will use them to monitor for success. All permits for outfalls, intakes, and fill deposits issued on the Roanoke are reviewed by the stakeholders. Forest practices and land-use transitions (e.g., conversion) will be monitored using remote sensing. We are presently committed to developing a new land-cover map of the project to monitor changes since the last one done in 1995. Finally, as previously mentioned, conservation strategies have not been developed for the red wolf and black bear, which should be addressed in subsequent iterations of this plan.

Literature Cited

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