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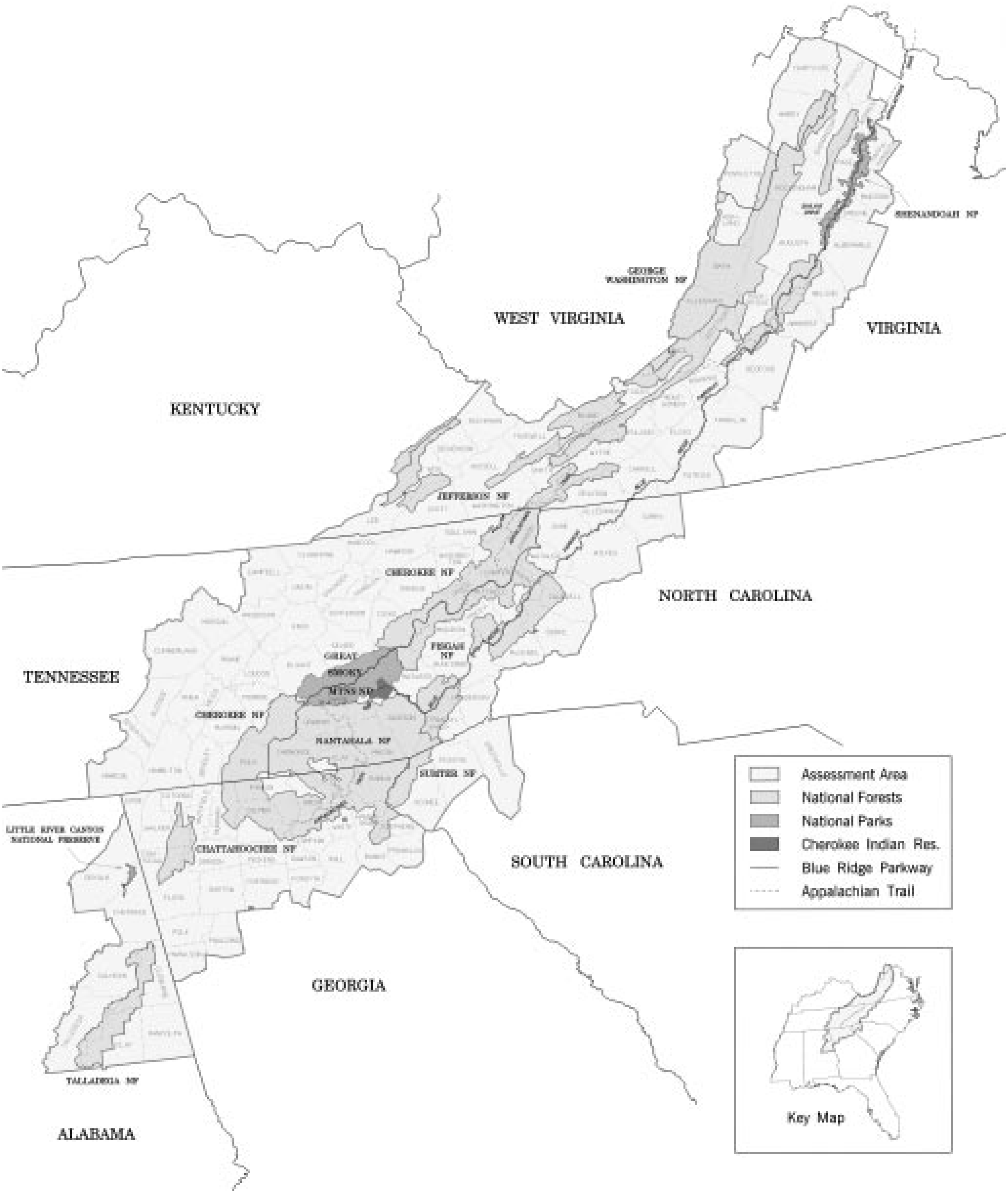
Figure 1

SOUTHERN APPALACHIAN ASSESSMENT AREA



Executive Summary

The Southern Appalachian ecosystem is widely recognized as one of the most diverse in the temperate region. The headwaters of nine major rivers lie within the boundaries of the Southern Appalachians, making it a source of drinking water for much of the Southeast.

The Southern Appalachian Assessment (SAA) area (fig.1) includes parts of the Appalachian Mountains and Shenandoah Valley extending southward from the Potomac River to northern Georgia and the northeastern corner of Alabama. It includes seven states, 135 counties, and covers approximately 37 million acres. The Southern Appalachians are one of the world's finest remaining ecological regions. Early in the 20th century, the Appalachian landscape and natural resources were being exploited; croplands, pastures, and hillsides were eroding; and timberlands were being cut with little thought for sustaining the resources. National forests and national parks were created to preserve and restore the natural resources in the region. The seven national forests in conjunction with three national parks, the Blue Ridge Parkway, and the Appalachian Trail form the largest contiguous block of public lands east of the Mississippi River.

The SAA, a comprehensive, interagency assessment, began in the summer of 1994 and was completed in May 1996. It was designed to collect and analyze ecological, social, and economic data. The information provided will facilitate an ecosystem-based approach to management of the natural resources on public lands within the assessment area.

Public participation has been, and will continue to be, an important part of the assessment. One of the first actions of the assessment was to conduct a series of town hall meetings at which the public gave suggestions on the major themes and questions to be addressed. These questions, supplemented by additional concerns expressed by land managers and policy makers, form the structure for the assessment.

The Southern Appalachian Assessment those involved with resource planning for ecosystem management. The four SAA technical reports address terrestrial resources, aquatic resources, air quality, and social/cultural/economic aspects in the Southern Appalachian Mountains. The SAA is a cooperative effort of the U.S. Environmental Protection Agency (EPA); U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior, Fish and Wildlife Service (FWS), Geological Survey (USGS), National Biological Service (NBS), and National Park Service (NPS); U.S. Department of Energy, Oak Ridge National Laboratory; Department of Commerce, Economic Development Administration; Tennessee Valley Authority (TVA); the U.S. Army Corps of Engineers (COE); and the states of Tennessee, Georgia, and North Carolina.

This SAA aquatic technical report compiles existing regionwide information on aquatic resource status and trends, riparian condition, impacts of various land management or human activities, water laws, aquatic resource improvement programs, and water uses. The report discusses the distribution of aquatic species and identifies impacts on aquatic resources and water quality. Some problems include numerous degraded streams (greater than 20 percent of stream miles impacted in 15 basins), eutrophication of lakes (approximately 38 percent), habitat stress such as loss of up to 75 percent of riparian forest in some watersheds, loss of aquatic species, and the impacts of increasing human population and development. The report further identifies cooperative opportunities for citizens, businesses, and government agencies and identifies future data needs for aquatic resources.

Diversity of aquatic species is high, with a rich fauna of fish, molluscs, crayfish, and aquatic insects. Although human activities that impair aquatic habitat have decreased, population growth and concomitant land development have the potential to increase pressure on aquatic resources. The heritage program files the SAA area. These include 26 endangered mussels and 7 endangered fish. Mussel populations may experience additional declines over the next 30 years in the Tennessee River basin. Impoundments of rivers and degradation of water quality have been implicated in the loss of these mussel species. Approximately 39 percent of the SAA area is in the range for wild trout, consisting of 33,088 miles of potential wild trout streams. The three trout species within the SAA area are vulnerable to stream acidification, which is increasing, particularly in higher-elevation streams.

While the percentage of degraded streams in the study area cannot be estimated accurately with available information, evidence documented in this aquatic resources report provides some estimates.

The states' assessments of designated use for aquatic life, drinking water, recreation, and other uses show that approximately three-quarters of all drainages in the SAA area have at least 6 percent of their streams not fully supporting uses (see section 2.2). Because most states monitoring programs cover only a small fraction of waters, and their monitoring network locations are not chosen to represent all streams in the SAA area, we can consider the range of 6 to 20 percent degraded streams to be an estimate for the larger streams. Second, studies of selected portions of the SAA area, using fish community biological samples of smaller drainages in several basins (see section 2.7), suggest that over 70 percent of locations sampled show moderate or severe fish community degradation. Third, a statistical sample of stream habitat condition overlapping the portions of the study area in Virginia and West Virginia suggests that about 50 percent of stream miles in the area studied show habitat impairment compared to relatively unimpacted reference conditions (see section 3.1).

Because these estimates are inadequate to represent the entire SAA area, a comprehensive statistical sample of streams in the SAA study area is necessary to determine the extent of degraded streams with known confidence. In the future we can expect an overall improvement in water quality. However, impacts associated with industrial and rural development are likely to continue until watershed management and planning are implemented across the

Water quality laws and regulations have been effective in controlling most point sources of pollution. In addition, widespread application of Best Management Practices (BMPs) to nonpoint sources of pollution has proven effective in protecting and maintaining water quality.

Finally, this aquatic resources assessment outlines information and data gaps which should be filled to allow evaluation of changes in aquatic conditions over time and to permit more reliable evaluation of the effectiveness of water quality protection programs. Such data gaps provide excellent opportunities for joint research and monitoring activities by federal and state agencies and other organizations. In order to document improvement in aquatic resources, techniques for using sensitive biological, physical habitat, and chemical indicators must be developed and collaboratively applied. (Intergovernmental Task Force on Monitoring Water Quality 1994)

Questions and Key Findings

The aquatic technical report addresses five questions raised during public outreach of the proposed SAA. Government agency scientists from various levels, forest planners, and concerned citizens identified the five questions as necessary to the understanding of the unique Southern Appalachian ecosystem being studied. Following is a brief summation of the key findings associated with each question.

Question 1 (Chapter 2):

What is known about the current status and apparent trends in water quality, aquatic habitat, and aquatic species within the Southern Appalachian study area?

The Southern Appalachian Mountain region, blessed with abundant rainfall and a vast network of streams, provides water supplies for foothill communities and major cities of the Eastern and southeastern United States. Information pertaining to these waterbodies is essential to understanding and managing our vital resources.

- High annual precipitation is typical for the SAA area, which includes stations

- Water is a significant part of the SAA area landscape. The mean density of stream and river channels is 12 feet per acre and would be greater if all small mountain streams could be measured.
- The SAA area contains more than 556,000 acres of flooded river and lake surface, about 1.5 percent of the total SAA area.

Evaluation of the condition of rivers and tributaries is based upon the waterbodies' ability to support designated uses – fishing, swimming, aquatic life, and drinking water. State water quality monitoring data serve as the basis for this evaluation.

- There is general agreement that water quality has improved significantly since the adoption of the Clean Water Act in 1972. In addition, in some areas, population growth and resulting landscape alterations have caused some degradation in water quality.
- Most watersheds (representing 75 percent of the river miles in the SAA) have over 80 percent of their river miles rated as partially or fully supporting their designated uses as prescribed in the Clean Water Act.
- The trophic status of lakes in the SAA area varies widely. Overall, for lakes greater than 500 acres assessed by the states, 38 percent were listed as eutrophic, 46 percent mesotrophic, and 16 percent oligotrophic.
- The Tennessee River and Alabama River basin areas include most of the significantly impacted watersheds. See Chapter 5 for a discussion of pollutant sources and their impacts on water quality.
- The Chesapeake Bay drainage area, primarily in Virginia, has the highest percentage of waterbodies meeting water quality standards for the protection of aquatic life in the study area.
- The occurrence of fecal coliform bacteria above the states' standards for human contact is evident throughout the SAA area and is probably due to wildlife, livestock operations, and municipal discharges.

In the Southern Appalachians, geologic bedrock and the associated buffering capacity of soils to neutralize acid is used to identify watersheds that are sensitive to acid deposition.

- Within the SAA area, 54 percent of stream miles have high sensitivity to acid deposition, 18 percent have medium sensitivity, and 27 percent have low sensitivity.
- Published scientific evidence indicates that some streams in the area have become increasingly acidic in recent years.
- Projections of future conditions suggest that additional streams could become more acidic in the decades to come.
- The northern part of the assessment area is more vulnerable because of climate and proximity to sources of acid deposition.
- Headwater mountain streams in rugged terrain are typically most sensitive to acid deposition.

The SAA area serves as habitat for a number of threatened, endangered, and special concern species. Threatened and endangered species have been officially listed by the FWS under the Endangered Species Act. Special concern species have limited distribution and have not been legally listed, but are recognized by the Nature Conservancy and others as globally rare.

- The heritage program lists include 190 aquatic and semiaquatic TE&SC species in the SAA area; of these, 62 are fish and 57 are mollusks.
- The state heritage program lists include 34 endangered, 10 threatened, 4 proposed endangered, and 63 former category 2 aquatic and semiaquatic species as determined by the FWS.
- Of the 34 endangered species on the state heritage program lists, 26 are mollusks and 7 are fish.
- The 10 counties with the greatest number of aquatic TE&SC species are in three areas: the Clinch and Powell River drainages of Virginia and Tennessee; the

overall pattern largely reflects patterns for fish and mollusks.

The status of trout and associated habitat in the Southern Appalachians is a major concern with many people who fish for trout. Trout are often viewed as indicators of high water quality.

- Of the 37.4 million acres in the SAA area, 14.6 million acres are in the range of wild trout. Trout also live in some areas of the Southeast that are outside the SAA area.
- Of the total 33,088 miles of potential wild trout streams in the SAA area, 7 percent are in West Virginia, 39 percent are in Virginia, 10 percent are in Tennessee, 32 percent are in North Carolina, 2 percent are in South Carolina, 10 percent are in Georgia, and none are in Alabama.
- Of the total 33,088 miles of potential wild trout streams in the SAA area, 7,975 miles are in areas under Forest Service ownership and 1,634 miles are under National Park Service ownership.
- An additional 1,337 miles of stocked trout streams are found outside the wild trout boundary. An unknown portion of the streams within the wild trout range are stocked.
- Approximately 59 percent of wild trout streams are in areas that are highly vulnerable to acidification and 27 percent are in areas that are moderately vulnerable to acidification. Most of the highly vulnerable areas are in the northern parts of the SAA area, where brook trout are more common than rainbow and brown trout.
- Most Virginia and West Virginia wild trout streams are in counties that have reported hemlock wooly adelgid infestation.
- Twenty-six reservoirs greater than about 1 square mile in the SAA contain trout: 15 are stocked with trout, primarily rainbow trout; 8 contain incidental wild trout from past stockings or tributary streams; and trout may occur in 3 additional reservoirs.

High diversity of aquatic species in the Southern Appalachian Mountain region is a risk are designated by the states as "threatened and endangered," "special concern, sensitive," or "rare," but are not listed by the FWS.

- Out of a total of 260 other aquatic species at risk in the SAA area, there are 97 fish, 25 mussels, 1 snail, 2 crayfish, 111 insects, 17 salamanders, and 7 turtles.
- Approximately 70 percent of the selected fish are at the edge of their range in one or more SAA states.
- Fish that are categorized as TE&SC species or as other aquatic species at risk (table 2.6.1) comprise about 45 percent of the total number of fish species in the SAA area.
- Mussels that are categorized as TE&SC or as other aquatic species at risk comprise about 50 percent of the total mussels found in the SAA area.

Assessment of the condition of fish communities can provide an integrated picture of the ecological integrity of the assemblages of fish species.

- Detrimental impacts on fish community integrity are evident from fish community samples conducted by state and federal agencies covering selected subsets of the SAA area.
- Of 300 subjectively selected sites in both the Ridge and Valley and Blue Ridge ecological regions, about 69 percent of streams sampled show moderate to severe degradation of habitat. A statistical sample or a much larger and more widely distributed selection of sites would be needed to completely describe fish community condition.

A monitoring program on the George Washington National Forest serves as a case study on aquatic macroinvertebrate species. This approach has potential use for the Southern Appalachian Mountain region.

- Based on this case study, about 60 percent of the streams sampled on the George Washington National Forest with low EPT scores were acidified.

Question 2 (Chapter 3):

What management factors are important in maintaining aquatic habitat and water quality? What is the extent of riparian area and composition?

Habitat condition is one of the main factors influencing the ecological integrity of aquatic resources.

- Studies of subsets of the SAA area indicate a number of streams show signs of habitat degradation.
- Qualitative visual habitat assessments of 235 sites in the Holston and Hiwassee drainages show 15 percent of the sites sampled were severely impaired, 62 percent slightly to moderately impaired, and 23 percent not impaired.
- Qualitative visual habitat assessments of 178 statistically selected sites in the Mid-Atlantic Highlands Assessment (MAHA) study area (this includes the SAA study area in Virginia and West Virginia and also some areas outside the SAA) estimates that 50 percent of stream miles have impaired physical habitat.
- Approximately 37 percent of stream miles in the Blue Ridge ecological regions of the MAHA area and 60 percent of stream miles in the Ridge and Valley ecological region of the MAHA are impaired due to habitat factors.

Natural and human activities have the potential to significantly influence water quality and aquatic ecological integrity. Much of the landscape in the Southern Appalachians has been changed by human activity.

- Land cover classes aggregated by watershed, and thought to strongly influence water resource integrity, are distributed in the study area as follows: forest – 71 percent, pasture/herbaceous – 22 percent, cropland – 3 percent, and developed/barren – 4 percent.
- Intensive human influence on landscapes in the study area ranges from 0 percent to 75 percent. Intensive human uses include the developed/barren, cropland, and pasture/herbaceous classes. Note: little or no human use.
- Those land cover classes which influence aquatic resources have distinct patterns in different ecological regions. For example, agricultural lands are predominant in the Ridge and Valley, while forests dominate the Blue Ridge.
- Federal holdings, including National Forest System land and National Park Service lands, have a lower fraction of land cover classes evidencing significant human influence than the rest of the study area.

Instream habitats for aquatic life are dependent on natural bank and riparian zone vegetation. Riparian areas serve as a food source for aquatic species and provide numerous important ecological functions.

- Aggregated land cover classes for the riparian zone of the entire SAA area are distributed as follows: forest – 70 percent, pasture/herbaceous – 22 percent, cropland – 3 percent, developed/barren – 4 percent, and wetlands – 1 percent.
- Federal holdings, including National Forest System and National Park Service land, have 90 percent forest cover in the riparian zone.
- Forest cover in the riparian zones of the study area ranges from less than 25 percent to 100 percent.
- The distribution of land cover classes in the riparian zone shows distinct patterns in different ecological regions. For example, forest cover in the riparian zone is generally much less in the Ridge and Valley than in the Blue Ridge.

Question 3 (Chapter 4):

What laws, policies and programs for the protection of water quality, streams, wetlands, and riparian areas are in place, and how do they affect aquatic resources, other resources, and human uses within the SAA?

- A number of federally funded programs exist to protect, restore, or improve the agencies, including the USDA Forest Service, Natural Resource Conservation Service, NPS, Farm Services Agency, EPA, TVA, and COE. The programs provide for cost-share technical assistance to private landowners for erosion control, the purchase of easements on private wetlands, restoration, and assistance to private landowners for riparian management.

- The last 8 years have been a turning point in water resource legislation and pollution control. Programs have been specifically designed to deal with such problems as nonpoint source pollution, toxics, and other point sources. Programs also place emphasis on some of our national treasures such as the Chesapeake Bay and Great Lakes. The water pollution regulatory program as administered by EPA has been largely successful in reducing point sources of pollution. Many of our streams and lakes have gradually recovered from years of abuse and now support abundant life for swimming and recreation. The design and implementation of BMPs have demonstrated that technology can effectively reduce nonpoint source pollution.

Question 4 (Chapter 5):

What are the current and potential effects on aquatic resources from various activities?

- Two-thirds of the reported water quality impacts are due to nonpoint sources, such as agricultural runoff, stormwater discharges, and landfill and mining leachate.
- Soil disturbance due to agriculture and its potential for generating soil erosion that might reach the aquatic system declined from 1982 to 1992. While 23 counties reduced potential soil erosion by more than 50 percent over that 10 years, another 8 counties showed an increase of more than 50 percent.
- Impacts on the hydrology of aquatic resources are greatest for land uses and increase with the proportion of watershed disturbed.
- In the majority of counties in the SAA area, less than 30 percent of the land base is devoted to agriculture. Those counties with more land in agriculture do not necessarily have greater estimated erosion potential, but often do have greater estimated nitrogen loading from fertilizer and animal manure.
- Population in the SAA area increased 19 percent from 1970 to 1980. Growth increased 7 percent more in the next 10 years. Development of housing, service facilities, and roads to serve the growing population generally increases impacts on water quality.
- Nearly 40 percent of the watersheds in the SAA have 6 percent of their stream length near and are potentially impacted by graveled or paved lower class roads. In a few counties, as much as 20 percent of their stream length is near roads.
- A total of 890 potential pollution-source sites are listed under the Comprehensive Environmental Resource Conservation Liability Act (CERCLA) within the SAA. There are 22 sites on the National Priorities List (NPL) Superfund sites, and 84 are either abandoned or closed landfills.
- At the time of this assessment, there were 170 sanitary landfills active in the SAA area that were not on the CERCLA list.
- In the state Water Quality Reports to Congress (required under CWA 305[b]), SAA states indicate that mining impacts on water quality occur predominantly in the Tennessee River basin and southwestern Virginia.
- Mining, urban/suburban development, and dams have had the largest effect on hydrology in the SAA region.
- Forest comprises the primary land cover of the region. Unlike agriculture, forestry activities that disturb soil are dispersed in both space and time. Thus, forestry has a low potential impact on aquatic resources.

- About 3,000 point sources currently discharge treated wastewater into surface waters within the Southern Appalachian region. About 7 percent of these NPDES permit sources are considered major facilities, based on volume of discharge and pollutant loading.
- The majority of permitted point sources with discharges greater than 1 million gallons per day (132 of 222) are municipal treatment facilities. Municipals constitute 40 percent of all permitted discharges.
- Urban areas are a large source of biological oxygen demand (BOD). Waters with estimated high BOD loading are often responsible for stream conditions inadequate for designated uses.
- The three industries with the largest number of point discharges are mining, textiles, and chemicals. Of those industries, 4 mining, 19 textile, and 21 chemical sites are rated as major facilities.
- According to Section 304(1) of the Clean Water Act, lists submitted by the states to EPA, 30 National Pollutant Discharge Eliminate System (NPDES) permit facilities have discharged significant levels of toxic chemicals into SAA waters.
- A total of 17 fish consumption advisories have been issued in the SAA area, with each state having at least one of these advisories. Eleven of the warnings are for Polychlorinated Biphenyl (PCB) contamination, one is due to PCB/chlordane contamination, three are due to mercury contamination, and two are due to dioxin contamination. Of the 17 advisories, 10 are located on 4 rivers and a lake that cross state lines.

Question 5 (Chapter 6):

What are the status and apparent trends in water usage and supplies within the SAA, including water rights and uses on national forest system land?

Water supplies in the Southern Appalachian

- In 1990, approximately two-thirds of the water use within the study area was industrial, with the remainder divided between commercial, domestic, and agricultural.
- Overall, water usage in the domestic, industrial, and agricultural categories decreased 20 percent between 1985 and 1990, primarily due to a 27 percent decline in industrial use. Agricultural and domestic use also decreased, whereas commercial use increased.

Water uses on National Forest System land are predominately for domestic household, irrigation, recreation, municipalities, and the maintenance of fish and wildlife.

- Water usage on national forest system lands ranges from 1,700 gallons per day in Alabama to 1,315,000 gallons per day in Virginia. The Chattahoochee National Forest uses approximately 81,000 gallons per day, and the National Forests in North Carolina use 172,000 gallons per day. Tennessee national forests use 360,000 gallons per day. Only three counties in South Carolina are included in the assessment and no water rights were recorded for this area. The national forests in South Carolina do maintain rights for 39 sites within 4 watersheds within the area.
- Of the 1,315,000 gallons per day of usage in Virginia, 1,126,000 are drawn from the Holston River. Industrial withdrawals from the Holston River for Sullivan County, TN, and Scott and Washington, VA, are the highest within the SAA area.
- Water withdrawn from the Holston River in Virginia for fish and wildlife (614,000 gallons per day) represents the largest use on National Forest System land within the SAA boundary.
- Water usage on national forest land is minuscule in comparison to county usage.

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The Aquatic Technical Report

1.0 INTRODUCTION

The Southern Appalachians serve as habitat for numerous species and headwaters for nine major rivers. Streams support three species of trout, a number of threatened and endangered species, and other aquatic species of concern. There is a growing public awareness of the importance of aquatic resources and the need to prudently manage the land in such a way that protects, maintains, and restores water quality.

The aquatic assessment addresses a number of issues identified through public participation and consultation with state, local, and federal agencies. These five questions should provide information which could be used to better manage aquatic resources across state, political, and forest boundaries. The questions relate to the basic values of water resources, the living organisms that depend on those water resources, and how these resources are being affected by human activities. The assessment is a compilation of existing data and information about the aquatic resources and, wherever possible, addresses likely future trends. The data and information have been limited by availability of data and a compressed timeframe in which to assemble the data.

The aquatic team, comprised of representatives from a number of agencies, set goals to identify and develop information that could be assimilated and analyzed using Geographic Information System (GIS) technology. GIS products were developed to answer the five questions and compiled in a unified database. The team soon determined that aquatic resource data across the SAA are lacking or may be available only in some locations that do not necessarily represent the SAA area as a whole. Consequently, the assessment has identified a number of research and data needs necessary for a comprehensive understanding of the current status and future trends of aquatic resources.

The study area boundary and the counties within that boundary are mapped in figure 1.0.1. The major drainages of the study area are shown in figure 1.0.2. River systems draining the Southern Appalachians eventually flow to

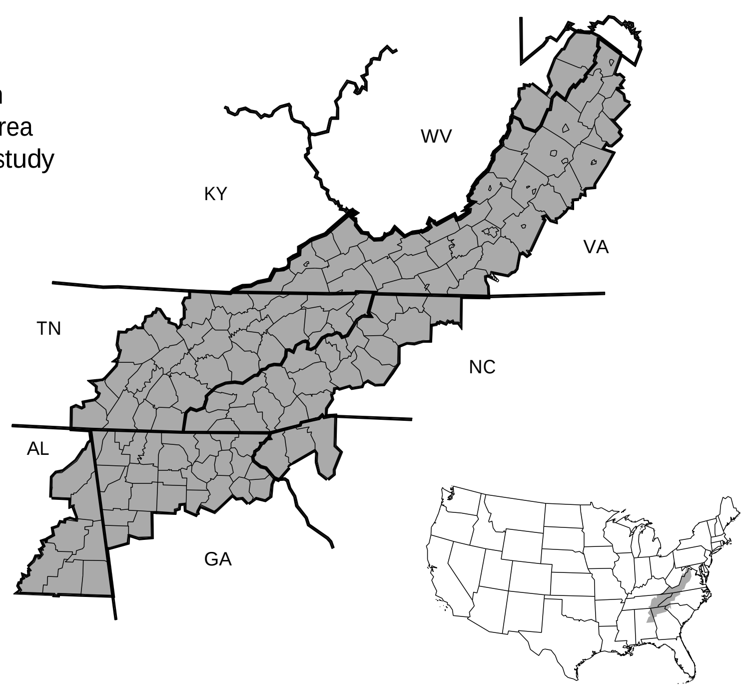


Figure 1.0.1 Southern Appalachian Assessment study area. The study area boundary and counties within the study area are shown.

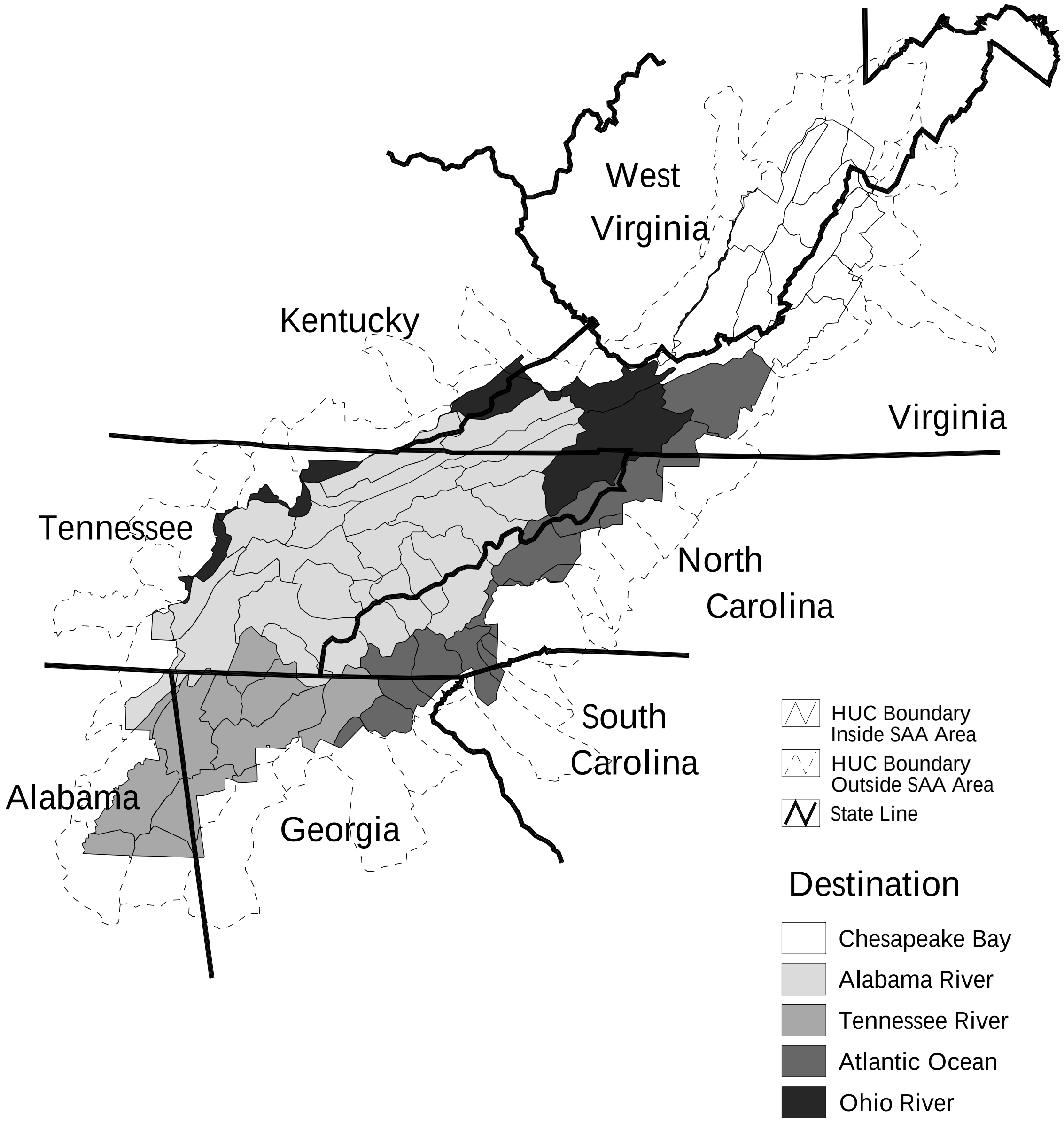
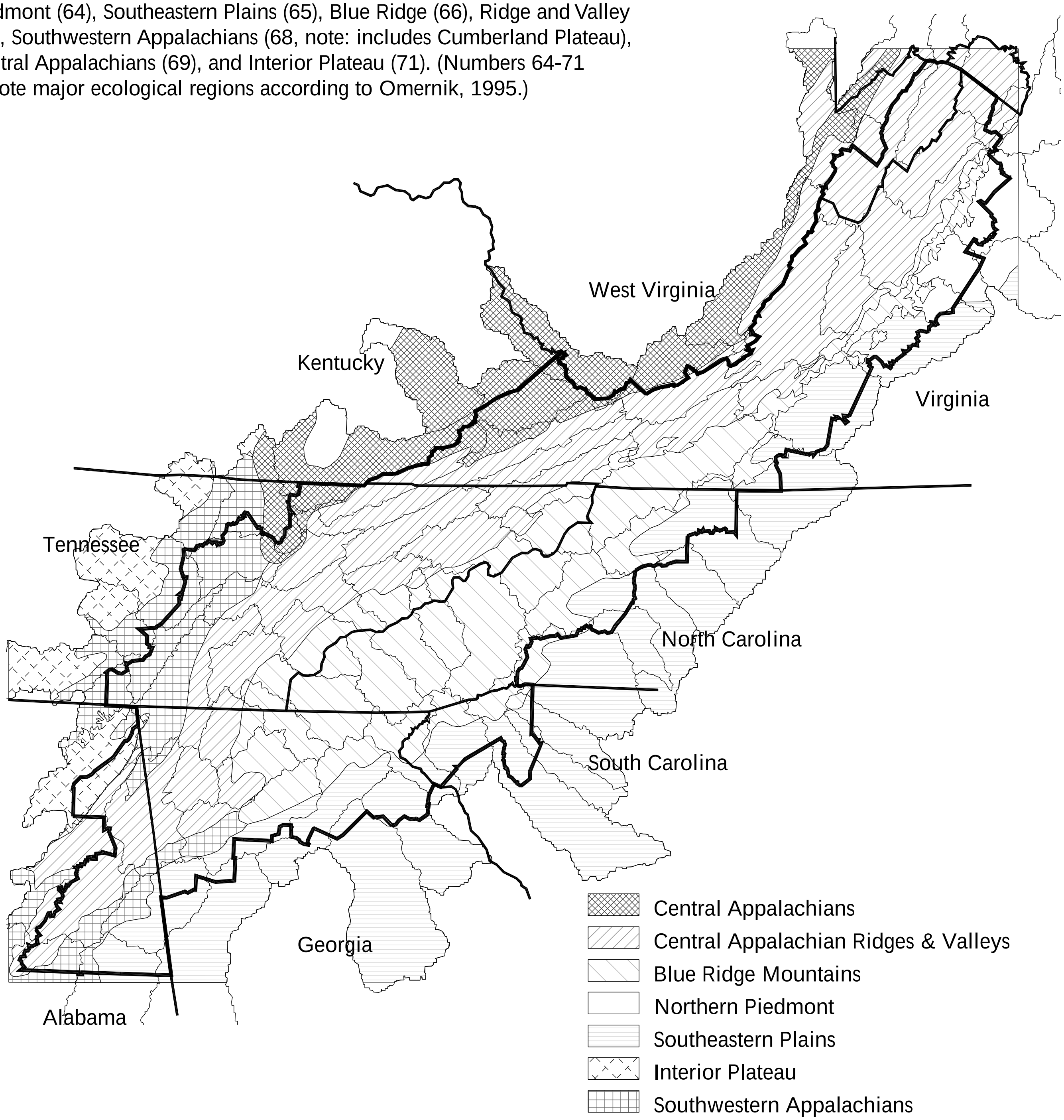


Figure 1.0.2 Major drainages of the SAA study area. Streams and rivers draining the Southern Appalachian mountains flow to the Chesapeake Bay, the Ohio River, the Atlantic Ocean, the Gulf of Mexico (via the Alabama and Chattahoochee/Appalachicola rivers), and the Tennessee River (to the Mississippi River and to the Gulf).

the Chesapeake Bay, the Ohio River (thence to the Mississippi River and the Gulf of Mexico), the Atlantic Ocean, the Tennessee River (again to the Mississippi and the Gulf), and to the Gulf of Mexico. Figure 1.0.3 shows important hydrologic areas, indicated by Hydrologic Unit Code (HUC), boundaries in conjunction with the major ecological regions within and overlapping the assessment area boundary: the Northern Piedmont, Southeastern Plains, Blue Ridge, Ridge and Valley, Southwestern Appalachians (note: includes Cumberland Plateau), and small areas of the Central Appalachians and Interior Plateau. (Omernik 1995). Watershed and ecosystem areas are useful for organizing, analyzing, and understanding data and information that describe aquatic resource integrity. Some information in this aquatic technical report relies on county or state boundaries. Generally, political lines are less useful for enhancing knowledge of aquatic systems.

Figure 1.0.3 Ecological regions of the Southern Appalachians. Major ecological regions of the study area are indicated. These include the Northern Piedmont (64), Southeastern Plains (65), Blue Ridge (66), Ridge and Valley (67), Southwestern Appalachians (68, note: includes Cumberland Plateau), Central Appalachians (69), and Interior Plateau (71). (Numbers 64-71 denote major ecological regions according to Omernik, 1995.)



This information should provide land managers and property owners with valuable information about current conditions and available data, and lend support and credence for future research that can be accomplished through cooperative interagency efforts.

1.1 HISTORICAL PERSPECTIVE OF WATERSHED MANAGEMENT

The landscape of the SAA area has changed dramatically since the 1880s. Prior to this time, forests covered virtually all the area except for small openings created for agriculture or towns. The forests were a source of building material and food, as well as an impediment to development. Settlers used the land and its wildlife for their survival with little concern for the consequences. Subsistence agriculture was widespread because markets were distant and transportation difficult. Slash-, burn-, and plant-agriculture was commonly practiced, with settlers moving on as the soil lost its productivity. Trees were often deadened and crops planted under the standing dead trees.

The building of the railroads opened the mountains to the outside world. Transport of products and people into and out of the area became faster and easier. Land became a commodity, to be bought, sold, and used for a profit, particularly by outsiders. By the turn of the century, millions of acres of mountain land had been bought by developers, whose main interest was to exploit the land for profit (Eller 1985).

Throughout the Southern Appalachians, timber companies purchased vast acreage of forest land and began cutting the virgin ash, cherry, oak, spruce, and yellow-poplar. By 1910, the southern mountains yielded nearly 40 percent of the total timber production in the United States (Eller 1985). By 1919, most of the region had been logged and timber production fell to about half of its pre-war level. In the 1920s, the timber companies were abandoning their land and moving to the timberlands of Oregon and Washington.

Loggers had little regard for aquatic systems. Roads and railroads were built in many of the river and stream bottoms. They extended up the narrow mountain hollows where the stream channel itself was commonly used as the road bed. Stream crossings were numerous and were not constructed with any intent to protect the channel or its resources. Splash dams were constructed on many small streams to store water and flush logs downstream to saw mills. Riparian vegetation was often cut to clear the channel so logs would not hang up while floating downstream. Small mining operations for minerals, gems, and coal frequently used streams for disposal of waste materials. Acid runoff from some mined areas and acid deposited from smelting operations killed life in some streams.

Logging often resulted in excessive erosion and sedimentation of the channels, frequently causing braided or multichannel streams. Streams sometimes began flowing down the abandoned road instead of the natural channel. Some streams were scoured clean, while other streams were choked with logging debris. Impacts to stream biology ranged from little effect to a total change in species mix or even total elimination of fish life. Wetlands were created in places where they didn't previously exist, while other wetlands were drained so that land could be developed.

The passage of the Weeks Act in 1911 authorized the purchase of forested, cutover, or denuded private lands within watersheds of navigable streams, as necessary, to secure favorable flows of water (USDA Forest Service 1983). These lands created the national forest reserves in the East. The first acquisition under the Weeks Act was a tract of land in the Curtis Creek area of the Pisgah National Forest's Grandfather Ranger District, within the SAA area. By 1920, the Forest Service had acquired more than 2 million acres of Appalachian forest land. Nearly 70 percent of the land eventually acquired had been severely cutover or burned. By 1940, the total acreage acquired for national forests had risen to more than 5 million acres. During this same period, additional lands in the SAA area were also acquired by the National Park Service (NPS), the Tennessee Valley Authority (TVA), and other federal and state agencies.

Much land coming into federal ownership needed rehabilitation-revegetation, erosion control, and stream restoration. During the 1930s and early 1940s, the Civilian Conservation Corps labored throughout the newly acquired federal lands. They constructed hiking trails, removed weed trees and misshapen scrubs, built fire towers and fire roads, improved streams, fought fires, built picnic areas, erected bridges, and performed a host of other tasks necessary to restore and produce a bountiful and highly useful forest (Jolley 1985).

The change in forest land in the SAA area has continued to the present. The functions and processes of the natural forest ecosystem today are better understood than ever before. Both public and private land managers seek multiple goals and objectives from their lands with emphasis on sustained use rather than single-resource outputs. Public concern for the environment has resulted in a host of legislation aimed at protection and enhancement of the resources, including the Clean Water Act, the National Forest Management Act, and the National Environmental Policy Act.

The past trend of improvement in the area's water resources is likely to continue. The hydrologic conditions of the forest lands have improved steadily since widespread forest exploitation has stopped. Continuing natural restoration of area streams is slowly reducing the effects of the devastation that resulted during early logging, although evidence of the devastation is still present in many streams. Present environmental controls such as voluntary and required state Best Management Practices (BMPs), erosion and sediment pollution control regulations, and land use controls greatly reduce the likelihood of widespread land disturbance or exploitation in most areas.

The major land use change influencing SAA watersheds, now and in the future, is urban, suburban, and rural home development and its associated roads and service facilities.

1.2 HISTORICAL PERSPECTIVE OF TROUT MANAGEMENT

Trout are important gamefish in the SAA area and have been the focus of much attention throughout the history of the area. Thus, a brief history of trout management in the Southern Appalachians provides some insight into the history of aquatic resources.

The SAA area is home for three species of trout: native brook trout (*Salvelinus fontinalis*), introduced rainbow trout (*Oncorhynchus mykiss*), and introduced brown trout (*Salmo trutta*). Originally, brook trout were distributed down the spine of the Appalachian Mountains through western Virginia and North Carolina, and eastern Tennessee to northwest South Carolina and northeast Georgia, on the southern edge of the species' range (MacCrimmon and Campbell 1969). Stocking programs have not significantly extended this range. Rainbow trout and brown trout were introduced to the region in the late 19th and early 20th centuries. Historical attempts have been made to introduce other salmonids. However, none appear to have survived, except for occasional reports of kokanee (*Oncorhynchus nerka*) and lake trout (*Salvelinus namaycush*) in certain reservoirs.

Historical trends in the Great Smoky Mountains National Park have been well documented since the park was established in 1934. Park fisheries biologists have published results of survey work beginning with Willis King (1937) and continuing to the present. For the rest of the SAA area, little published information is available to document historical trends. The trends described herein are based on data from the park, with a general presumption that similar changes have occurred elsewhere, at least in the areas around the park.

Since the early 1900s, native brook trout ranges have shrunk, and rainbow and brown trout ranges have expanded in the park (King 1937; Lennon 1967; Kelly and others 1980). Several causes for loss of brook trout range have been identified: logging and associated activities, including fires that increase sediment and temperature; overfishing; and introduction of exotic rainbow trout (King 1937; Kelly and others 1980; Larson and Moore 1985).

The lower elevations where trout species are found were generally more accessible to removal of forest cover during Native American and European settlement (Pyle 1985; Williams 1989). In addition, where agricultural land uses and forest harvest practices remove streamside vegetation, stream temperature may increase. (Brown and Krygier 1970; Swift and Messer 1971). Other stream habitat alterations, such as removal of large woody debris, roadbuilding, and channelization, may accompany these land use changes. Furthermore, streams at lower elevations may be more accessible to both angling and trout stocking programs.

Trout in the SAA area have been managed by state and federal agencies at least since the early 1900s. Stocking of selected streams with trout of all sizes and all three species continues to this day. Trout habitat management has been carried out for at least 60 years and continues today, with increasing emphasis on re-creating natural habitat conditions.

Status of Aquatic Resources

2.0

Question 1:

What are the current status and apparent trends in aquatic resources within the Southern Appalachian assessment area?

Aquatic resources have been broadly defined to include streams and waterbodies, watersheds, aquatic and semiaquatic species of all kinds, water quality, and other characteristics of aquatic habitat. In effect, this question asks for a current inventory of all aquatic resources and an assessment of the historic and future trends in those resources. How much is there? In what condition are the Southern Appalachian Assessment (SAA) aquatic resources? Are they increasing or decreasing in quality or quantity?

The focus of the assessment was primarily on surface water. Although analysis of the current status and trends of aquatic resources should include the role of human activities, detailed discussions of interaction between human activities and aquatic resources have been deferred to a later section that specifically addresses this question (chapter 5). Finally, all efforts were made to ensure that resources identified in the public discussion that preceded the team's efforts were addressed. For example, trout receive considerable emphasis here and in subsequent sections because trout were the single most commonly mentioned aquatic resource in the public comments.

A number of regional inventory and monitoring efforts are underway. The U.S. Environmental Protection Agency's (EPA) Environmental Monitoring and Assessment Program (EMAP) has been operational for several years. The goals and objectives of EMAP are closely aligned with this question of status and trends, and the original sampling scheme was devised to produce relatively unbiased results for a large network of sites. However, few EMAP results were available when the SAA started, and now EMAP is undergoing major design revisions.

The U.S. Geological Survey's (USGS) National Water Quality Assessment (NAWQA) program is an integrated assessment of physical, chemical, and biological aspects of water quality, including status and trends, for the nation. Several of the study units extend into the SAA area, but NAWQA sampling does not completely cover the SAA area. Furthermore, the first round of sampling is not yet complete on any study unit, and two-thirds have not yet been initiated. Finally, the Tennessee Valley Authority's (TVA) River Action Teams (RAT) are evaluating existing physical and biological conditions of streams for the entire Tennessee River basin. This effort involves detailed sampling of hundreds of sites, organized by subbasin. At this time, sampling is not yet complete and the entire SAA area was not included in the sampling, so these data could not be used. Although use of these monitoring programs in the SAA was not extensive, some Regional EMAP (R-EMAP) and RAT data were used for the case study on fish community integrity (section 2.7). These major efforts, though not completely suitable for the SAA, are likely to be valuable for future efforts to characterize the status and trends of aquatic resources in the Southern Appalachians.

Biodiversity is not addressed in this section because existing data for the SAA area are inadequate. Nevertheless, a brief discussion of the topic, narrowly defined as species richness, is warranted. A comprehensive treatment of biodiversity in southeastern aquatic systems, including chapters on high-gradient mountain streams, ponds, and reservoirs has been published recently (Hackney and others 1992). Diversity of freshwater mussels in the Southeast is greater than any other part of the world (Williams and Neves 1995), and much of that diversity is in the SAA area. A similar claim may be made for crayfish and snails in the Southeast (Williams and Neves 1992, Taylor and others, 1996). Of the 297 mussel species in the United States, 269 (91 percent) have been found in the

11 southeastern states (Neves and others 1995). Diversity of fishes in the Southeast is also high: Out of about 800 species of fish in the United States, the Southeast has about 485 and the Southern Appalachians south of the Roanoke and New Rivers have about 350 species (Walsh and others 1995). In mountain streams, aquatic plant (i.e., algae and macrophytes) diversity may be relatively limited, but diversity of aquatic invertebrates, especially insects, is high (Wallace and others 1992). A great deal of this regional diversity is due to the presence of several physiographic provinces (e.g., mountains, piedmont, coastal plain), but diversity within the SAA area is also high.

The headwater areas of the Tennessee and Cumberland rivers on the Cumberland Plateau of southwestern Virginia, Tennessee, and Kentucky are known to be particularly rich in both fish and mussel species (Starnes and Etnier 1986; Neves 1991; Neves and others 1995). Fauna of this area, known as Cumberlandian, are diverse because the area is geologically old and streams have been isolated for a long time, fostering speciation. To some extent, this great geologic age and isolation contributes to the diversity of aquatic fauna throughout the SAA area. A warmer climate and lack of glaciation also contribute to the diverse fauna of the Southeast (Adams and Hackney 1992).

These same conditions probably contribute to high genetic and landscape diversity, as well. The genetic diversity of the southern strain of native brook trout, for example, is high because populations in adjacent streams have been isolated from each other for some time (Kriegler and others 1995). At the landscape scale, fish fauna of each drainage differ from neighboring drainages (Burkhead and Jenkins 1991). Although drainages may be adjacent to each other in the SAA area, their connectedness for aquatic species may require an impossible passage through inhospitable physiographic regions and estuarine and marine systems.

For fish, a long history of human manipulation, through stocking and introduction of exotic species, may paradoxically both increase species diversity directly and decrease diversity by eliminating native species through competition and predation. These and other human activities have resulted in a loss of species, a topic to be discussed more fully later in this document.

What follows is a discussion of eight selected topics of current status and trends of aquatic resources. In most cases, there is a topic introduction; followed by key findings; explanations of data sources; discussion of analyses, spatial patterns, and trends leading to key findings; and some speculation on future trends, although predictive models were not produced.

The selection of topics in this chapter was largely dependent on data available for the region. For example, the assessment of current status and trends for biota emphasizes three gamefish and species recognized to be imperilled or at risk. There are literally hundreds (thousands, if insects are included) of other aquatic species in the SAA area about which adequate data to produce similar analyses are lacking.

2.1 WATERBODIES: STREAMS, RIVERS, AND LAKES

Introduction

The Southern Appalachian Mountain region is blessed with abundant rainfall, which produces and maintains water flow through a vast network of perennial streams. These mountain streams serve as water supplies for mountain and foothill communities and, ultimately, major cities of the eastern and southeastern United States. Seventy-three river watersheds lie wholly or partly in the SAA area.

The waters of the SAA area support a large variety of aquatic life, and the adjacent riparian zone is home and refuge for a number of species. The expanding land uses in the South and increasing development in urban and suburban areas require an abundant supply of high-quality water. Information and data pertaining to the location of streams, rivers, and lakes are essential to understanding, analyzing, and successfully managing our vital water resources.

This section summarizes some of the hydrography data collected for the aquatic technical report. The information serves as a basis for much of the discussions that follow.

Key Findings

- Water is a significant part of the SAA area landscape. The mean density of stream and river channels is 12 feet of length per acre of land and would be greater if all small mountain streams (intermittent and first- to third-order) could be measured.

- High annual precipitation amounts are typical for the SAA area, which includes stations that record the greatest total rainfall per year in the Eastern United States.
- The SAA area contains more than 556,000 acres of flooded river and lake surface, about 1.5 percent of the total SAA area.

Data Source

Knowledge of the locations of all streams, rivers, and lakes in the SAA region is basic to successful analysis of aquatic resources. GIS files have been assembled to consolidate this waterbody information. River and stream data were taken from the EPA Reach File version 3.0 (RF3), which is based on the 1:100,000 scale USGS Digital Line Graph (DLG) data. Each stream or river is divided into segments or reaches of similar channel type. Attributes for each reach include a numeric code, stream name, reach type, reach length, and spatial location information. Lake and reservoir boundaries also came from the DLG data. Major river basins have been delineated by USGS and HUCs assigned to each. Basins are numbered in a hierarchial 8-digit code. Approximate boundaries were digitized from 1:2,000,000-scale maps.

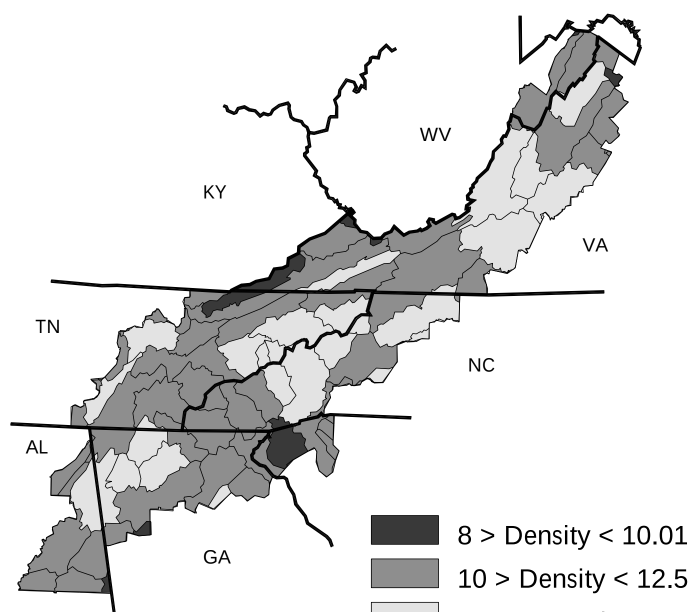
Quality and Gaps

The "blueline" representation of a headwater stream on a 1:100,000-scale map generally shows only the main fork of each actual fourth-order stream (Chow 1964) that exists on the landscape. Thus, most second- and third-order streams and nearly all first-order streams are not included in the RF3 database. The concept of stream order is described by Maidment (1993), or Chow (1964), and in many hydrology textbooks. It is estimated that as little as 30 percent of the total length of flowing streams on upper slopes is represented by the length of headwater reaches recorded in the database. Many small perennial and intermittent streams in mountain watersheds are not represented, even on the more detailed 1:24,000-scale 7.5-minute quadrangle sheets. Thus, the weakest characteristic of the RF3 database, for the purposes of the SAA, is that many miles of headwaters streams are not represented.

Parts of 73 watersheds or hydrologic units lie within the SAA. A total of 26 watersheds are wholly within the assessment region, 18 have more than 50 percent of their area within, and 29 have less than 50 percent within the region. Watershed boundaries are shown in figure 1.0.2.

Pre-analysis Preparations

The watershed boundaries, appropriate at the 1:2,000,000 scale, had insufficient detail when redrawn at the larger scale of 1:100,000. Due to the lack of an existing 1:100,000-scale digital version of watershed boundaries, a digital file was generated by the SAA team. Hydrologic unit boundaries were adjusted to fit between the ends of headwater streams and along ridgelines defined by digital elevation data for the 1:100,000-scale maps. Watersheds having less than 50 percent of their total area within the SAA region were omitted from stream density analyses. Minor portions (less



AR110

Figure 2.1.1 Stream density by watershed. Stream density in mean feet of river or stream channel per acre of land surface in river basin watersheds defined by the eight-digit Hydrologic Unit Code drainage areas.

than 10 percent) of 13 watersheds are included where county boundaries, which define the SAA area, are not coincident with watershed ridgelines.

Analyses

Stream length was totaled for counties and hydrologic units, listed in tables 2.1.1 and 2.1.2. Overall, the SAA region has a stream density of 12 feet of channel length per acre of land with somewhat higher densities around lakes in the Tennessee River system, in counties with higher, steeper slopes, and in the high-rainfall southern portion of the SAA (figs. 2.1.2 and 2.1.4). Densities were found to be less in the foothill and upper piedmont counties. Figure 2.1.3 shows the distribution of stream density by counties. Half of the SAA has a density of main streams and rivers between 11 and 13 feet per acre. If all lengths of flowing streams could have been counted, these densities would be higher. For example, the Forest Service did an intensive survey of the Chattooga River basin and recorded a stream density, including intermittent streams, of 82 feet per acre. Other National Forest lands in South Carolina have densities ranging from 64 in the piedmont to 116 feet per acre in the mountains.

Annual precipitation in the SAA ranges from a mean of about 35 inches along the West Virginia-Virginia border to nearly 100 inches along the southeastern edge of the Blue Ridge Mountains in North and South Carolina. Figure 2.1.4 shows the precipitation for 1986 and 1989 averaged over the climate zones of the SAA region (Guttman and Quayle 1996). These 2 years represent some of the driest and the wettest periods, respectively, experienced in the southern end of the mountains in the past 60 years.

Water yield from forested mountain watersheds averages 46 percent of precipitation. Most yield occurs as base or delayed flow (Woodruff and Hewlett 1970). Quickflow due to storm events comprises 4 to 12 percent of annual total streamflow.

Lakes and impoundments are a significant part of the water resources in the mid-to-southern portion of the SAA, principally because of TVA reservoirs (fig. 2.1.5). The region contains nearly 870 square miles of water surface. Table 2.1.3 lists the water surface area of each state within the SAA region.

The watershed boundaries were used to describe regional patterns for aquatic resources. The areas of each of the watersheds wholly or partly within the SAA region are listed in table 2.1.2.

Future

The hydrography database will be important to any future assessments of aquatic resources. The USGS has a program to produce digital line graph GIS files that are accurate and complete to the standard of 1:24,000-scale maps (USGS 1993, 1994). These new files will vastly improve the stream length, density, and location information over what has been available for this assessment and redefine the hydrologic unit code watershed boundaries.

2.2 CONDITION OF WATERBODIES

Introduction

The condition of waterbodies is influenced by land uses within the watershed, geology, soil erosion, vegetation, and soil nutrients. In addition, the condition of lakes and reservoirs is determined by the shape of lake basins, as well as a number of physical, chemical, and biological processes that are associated with lakes and lake sediments. The water quality of rivers and their tributaries is also determined by natural habitat features such as the riparian zone land cover and the stream bed strata, (i.e., gravel, silt, etc.). Human impacts such as direct pollutant discharges, stormwater and overland runoff, and air deposition of pollutants can significantly alter the characteristics of a waterbody.

This evaluation of the condition of the rivers and their tributaries is based upon the waterbodies' ability to support their designated uses fishing, aquatic life, swimming, drinking water. Most waterbodies in the SAA are classified as fishable and swimmable. The states are responsible for adopting water quality criteria for these waterbodies to protect the appropriate designated uses. Comparison of state water monitoring data to appropriate water quality criteria serves as the basis for the evaluation of the relative water quality condition of the hydrologic

Table 2.1.1 Stream length and density for each county in the Southern Appalachian Assessment region except for Virginia city-counties.

FIPS[1] Code	County	State	Length (miles)	Density (feet/acre)
01015	Calhoun	AL	762.66	10.28
01019	Cherokee	AL	1047.76	14.41
01027	Clay	AL	769.39	10.47
01029	Cleburne	AL	783.33	11.52
01049	Dekalb	AL	1124.82	11.92
01111	Randolph	AL	737.00	10.41
01121	Talladega	AL	891.91	9.68
13011	Banks	GA	341.47	12.05
13015	Bartow	GA	579.53	10.16
13047	Catoosa	GA	275.50	13.97
13055	Chattooga	GA	511.30	13.44
13057	Cherokee	GA	614.72	11.69
13083	Dade	GA	283.80	13.45
13085	Dawson	GA	359.18	13.85
13111	Fannin	GA	551.33	11.62
13115	Floyd	GA	828.00	13.18
13117	Forsyth	GA	294.31	9.82
13119	Franklin	GA	334.65	10.36
13123	Gilmer	GA	651.03	12.44
13129	Gordon	GA	570.98	13.17
13137	Habersham	GA	406.69	12.02
13139	Hall	GA	539.81	10.38
13143	Haralson	GA	371.19	10.81
13187	Lumpkin	GA	481.03	13.93
13213	Murray	GA	620.87	14.77
13223	Paulding	GA	316.50	8.29
13227	Pickens	GA	373.74	13.25
13233	Polk	GA	462.80	12.23
13241	Rabun	GA	498.58	10.91
13257	Stephens	GA	250.94	11.24
13281	Towns	GA	247.66	11.89
13291	Union	GA	491.32	12.31
13295	Walker	GA	718.39	13.27
13311	White	GA	355.62	12.12
13313	Whitfield	GA	441.57	12.53
37005	Alleghany	NC	309.33	10.84
37009	Ashe	NC	534.63	10.33
37011	Avery	NC	348.64	11.63
37021	Buncombe	NC	889.22	11.12
37023	Burke	NC	710.17	11.38
37027	Caldwell	NC	704.49	12.25
37039	Cherokee	NC	650.43	11.50
37043	Clay	NC	322.20	12.05
37075	Graham	NC	379.59	10.38
37087	Haywood	NC	862.85	12.83
37089	Henderson	NC	595.51	13.11
37099	Jackson	NC	617.09	10.30
37111	McDowell	NC	638.00	11.79
37113	Macon	NC	671.17	10.66
37115	Madison	NC	680.01	12.42
37121	Mitchell	NC	307.66	11.43
37171	Surry	NC	895.87	13.74
37173	Swain	NC	692.01	10.56
37175	Transylvania	NC	596.96	12.94
37189	Watauga	NC	474.51	12.52
37193	Wilkes	NC	1175.76	12.76
37199	Yancey	NC	449.28	11.84

Table 2.1.1 (cont.) Stream length and density for each county in the Southern Appalachian Assessment region except for Virginia city-counties.

FIPS[1] Code	County	State	Length (miles)	Density (feet/acre)
45045	Greenville	SC	1040.61	10.77
45073	Oconee	SC	847.89	10.38
45077	Pickens	SC	603.52	9.74
47001	Anderson	TN	438.36	10.49
47007	Bledsoe	TN	623.20	12.64
47009	Blount	TN	929.38	13.53
47011	Bradley	TN	526.18	13.10
47013	Campbell	TN	561.71	9.30
47019	Carter	TN	504.42	11.97
47025	Claiborne	TN	499.73	9.34
47029	Cocke	TN	776.76	14.46
47035	Cumberland	TN	1050.95	12.66
47057	Grainger	TN	358.81	9.79
47059	Greene	TN	1044.80	13.81
47063	Hamblen	TN	221.04	10.38
47065	Hamilton	TN	773.68	11.09
47067	Hancock	TN	295.02	10.89
47073	Hawkins	TN	699.38	11.55
47089	Jefferson	TN	340.05	8.93
47091	Johnson	TN	589.58	16.07
47093	Knox	TN	744.91	11.69
47105	Loudon	TN	343.92	11.49
47107	McMinn	TN	689.32	13.16
47115	Marion	TN	695.37	11.17
47121	Meigs	TN	300.17	11.42
47123	Monroe	TN	931.15	11.77
47129	Morgan	TN	817.08	12.90
47139	Polk	TN	667.15	12.44
47143	Rhea	TN	492.58	12.08
47145	Roane	TN	527.72	11.02
47153	Sequatchie	TN	382.44	11.86
47155	Sevier	TN	1030.55	14.22
47163	Sullivan	TN	616.06	11.83
47171	Unicoi	TN	315.73	13.97
47173	Union	TN	232.43	7.76
47179	Washington	TN	494.65	12.38
51003	Albemarle	VA	984.74	11.19
51005	Alleghany	VA	727.10	13.42
51009	Amherst	VA	768.19	13.24
51015	Augusta	VA	1507.46	12.79
51017	Bath	VA	781.40	12.06
51019	Bedford	VA	1254.38	13.45
51021	Bland	VA	489.25	11.25
51023	Botetourt	VA	850.82	12.86
51027	Buchanan	VA	685.11	11.22
51035	Carroll	VA	627.29	10.83
51045	Craig	VA	566.37	14.16
51051	Dickenson	VA	500.05	12.33
51063	Floyd	VA	516.07	11.16
51067	Franklin	VA	1075.65	12.47
51069	Frederick	VA	524.33	10.41
51071	Giles	VA	424.72	9.71
51077	Grayson	VA	620.09	11.47
51079	Greene	VA	178.68	9.39
51091	Highland	VA	596.51	11.83
51105	Lee	VA	540.67	10.20
51113	Madison	VA	407.48	10.45

Table 2.1.1 (cont.) Stream length and density for each county in the Southern Appalachian Assessment region except for Virginia city-counties.

FIPS[1] Code	County	State	Length (miles)	Density (feet/acre)
51121	Montgomery	VA	560.13	11.87
51125	Nelson	VA	745.34	12.96
51139	Page	VA	416.63	10.94
51141	Patrick	VA	658.24	11.18
51155	Pulaski	VA	369.35	9.25
51157	Rappahannock	VA	416.64	12.88
51161	Roanoke	VA	373.82	12.30
51163	Rockbridge	VA	873.31	11.99
51165	Rockingham	VA	1217.59	11.77
51167	Russell	VA	689.90	11.94
51169	Scott	VA	788.65	12.08
51171	Shenandoah	VA	823.01	13.25
51173	Smyth	VA	622.68	11.36
51185	Tazewell	VA	643.39	10.21
51187	Warren	VA	296.95	11.32
51191	Washington	VA	888.15	12.91
51195	Wise	VA	567.65	11.58
51197	Wythe	VA	643.28	11.42
54027	Hampshire	WV	933.32	11.94
54031	Hardy	WV	884.10	12.48
54071	Pendleton	WV	869.66	10.28

[1]Federal Information Processing Standard code for counties

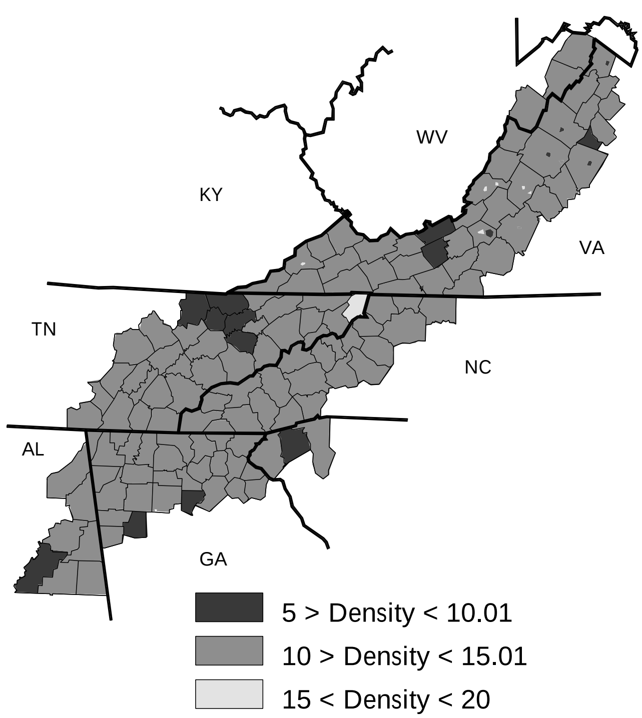


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Figure 2.1.2 Stream density by county. Stream density in mean feet of river or stream channel for each acre of land surface in each SAA county.

Table 2.1.2 Hydrologic unit watersheds that are fully or partly within the Southern Appalachian Assessment (SAA) region, grouped by major drainage basins.

Hydrologic Unit		Portion of Watershed Within SAA Region		River and Stream	
				Length	Density
Code Number	River Basin Name	(percent)	(acres)	(miles)	(feet/acre)
Chesapeake Bay Watersheds					
02070001	Potomac, South Branch	83	788172	1837.58	12.3
02070002	Potomac, North Branch	2	12363	26.67	11.4
02070003	Cacapon-Town	62	491500	1148.69	12.3
02070004	Conococheague–Opequon	13	191656	388.76	10.7
02070005	Shenandoah, South Fork	100	1064400	2604.56	12.9
02070006	Shenandoah, North Fork	100	661934	1626.00	13.0
02070007	Shenandoah	28	62407	145.74	12.3
02070008	Middle Potomac–Catoctin	<1	483	.03	–
02080103	Rapidan–Rappahannock	41	426204	948.47	11.8
02080106	Pamunkey	<1	5835	12.92	11.7
02080201	Upper James	96	1358925	3477.10	13.5
02080202	Maury	100	542047	1303.79	12.7
02080203	Middle Jame–Buffalo	63	845635	2229.40	13.9
02080204	Rivanna	76	385235	893.78	12.3
Carolina–Atlantic Watersheds					
03010101	Upper Roanoke	82	1178765	3382.25	15.2
03010103	Upper Dan	27	361261	842.26	12.3
03040101	Upper Yadkin	61	960919	2453.26	13.5
03040102	South Yadkin	9	56628	154.98	14.5
03050101	Upper Catawba	51	783966	1962.88	13.2
03050102	Catawba, South Fork	19	81399	202.26	13.1
03050105	Upper Broad	10	153986	333.93	11.5
03050107	Tyger	15	77769	166.73	11.3
03050108	Enoree	21	99927	220.29	11.6
03050109	Saluda	24	410997	981.57	12.6
03060101	Seneca	78	525143	1517.74	15.3
03060102	Tugaloo	88	573886	1589.06	14.6
03060104	Broad	36	358182	810.66	12.0
03070101	Upper Oconee	5	100221	243.72	12.8
Alabama–Apalachicola River Watersheds					
03130001	Upper Chattahoochee	70	722849	2205.51	16.1
03130002	Middle Chattahoochee	5	105562	206.13	10.3
03150101	Conasauga	100	461535	1212.40	13.9
03150102	Coosawattee	100	549452	1484.98	14.3
03150103	Oostanaula	100	361995	1072.27	15.6
03150104	Etowah	91	1085667	2823.14	13.7
03150105	Upper Coosa	100	1026919	3104.10	16.0
03150106	Middle Coosa	53	901588	2086.63	12.2
03150107	Lower Coosa	20	263886	626.73	12.5
03150108	Upper Tallapoosa	52	948014	2122.26	11.8
03150109	Middle Tallapoosa	33	341081	755.80	11.7
Ohio River Watersheds					
05020004	Cheat	<1	1513	.00	–
05050001	Upper New	100	1884269	4268.15	12.0
05050002	Middle New	52	561216	1177.70	11.1
05050003	Greenbriar	1	13718	11.15	4.3
05070201	Tug	9	96078	184.33	10.1
05070202	Upper Levisa	69	544395	1275.41	12.4
05100201	Kentucky, North Fork	<1	4	.00	–
05130101	Upper Cumberland	12	185008	384.03	11.0
05130104	Cumberland, South Fork	17	158121	326.13	10.9
05130105	Obey	1	8879	20.83	12.4
05130107	Collins	4	23604	52.39	11.7
05130108	Caney	15	175444	427.31	12.9

Table 2.1.2 (cont.) Hydrologic unit watersheds that are fully or partly within the Southern Appalachian Assessment (SAA) region, grouped by major drainage basins.

Hydrologic Unit		Portion of Watershed Within SAA Region		River and Stream	
Code Number	River Basin Name	(percent)	(acres)	Length (miles)	Density (feet/acre)
Tennessee River Watersheds					
06010101	Holston, North Fork	100	473618	1177.77	13.1
06010102	Holston, South Fork	100	755168	2063.84	14.4
06010104	Holston	100	639284	1823.41	15.1
06010105	Upper French Broad	100	1199723	3092.47	13.6
06010106	Pigeon	100	442040	1168.73	14.0
06010107	Lower French Broad	100	505139	1726.85	18.1
06010108	Nolichucky	100	1131644	2989.86	14.0
06010201	Watts Bar Lake	100	871053	2771.53	16.8
06010202	Upper Little Tennessee	100	533287	1308.98	13.0
06010203	Tuckasegee	100	472354	1073.53	12.0
06010204	Lower Little Tennessee	100	675823	1950.67	15.2
06010205	Upper Clinch	100	1252304	3192.43	13.5
06010206	Powell	100	602161	1362.84	12.0
06010207	Lower Clinch	100	407104	1158.86	15.0
06010208	Emory	98	538297	1426.28	14.0
06020001	Middle Tennessee–Chickamauga	100	1187407	3301.35	14.7
06020002	Hiwassee	100	1315229	3689.12	14.8
06020003	Ocoee	100	411737	1137.74	14.6
06020004	Sequatchie	95	361234	873.67	12.8
06030001	Guntersville Lake	30	405174	926.22	12.1
06030003	Upper Elk	<1	298	.11	1.9

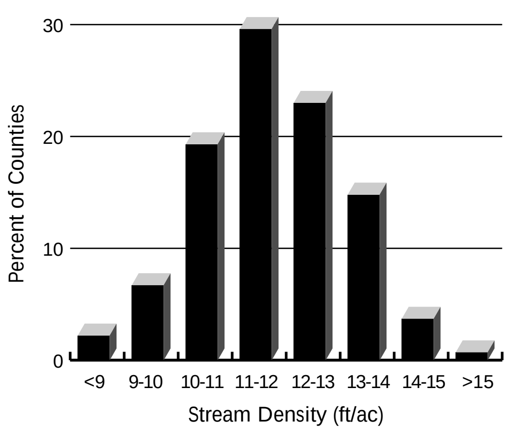

Figure 2.1.3 Distribution of stream densities for counties across the Southern Appalachian Assessment region. Virginia city-counties are not included.

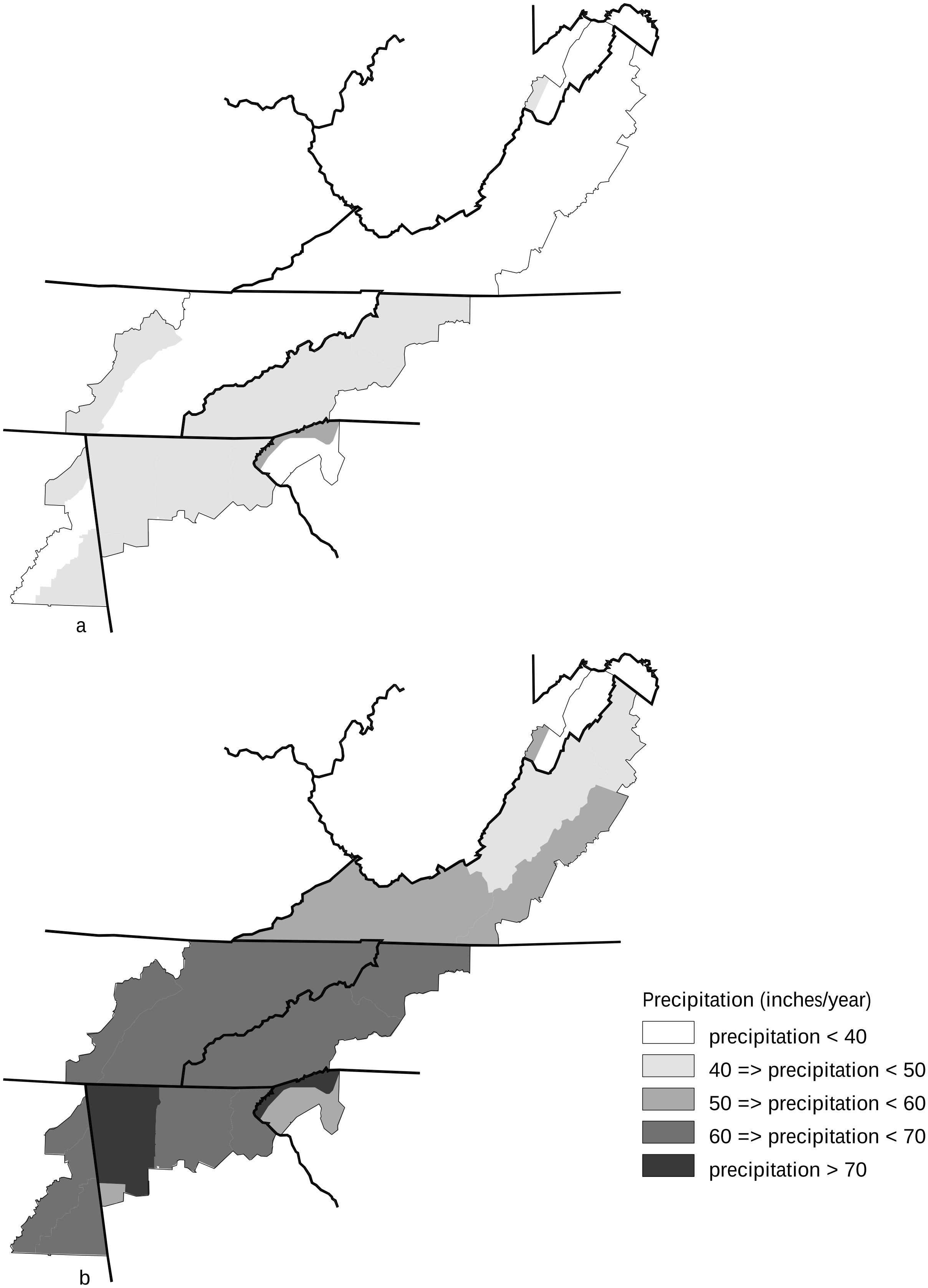

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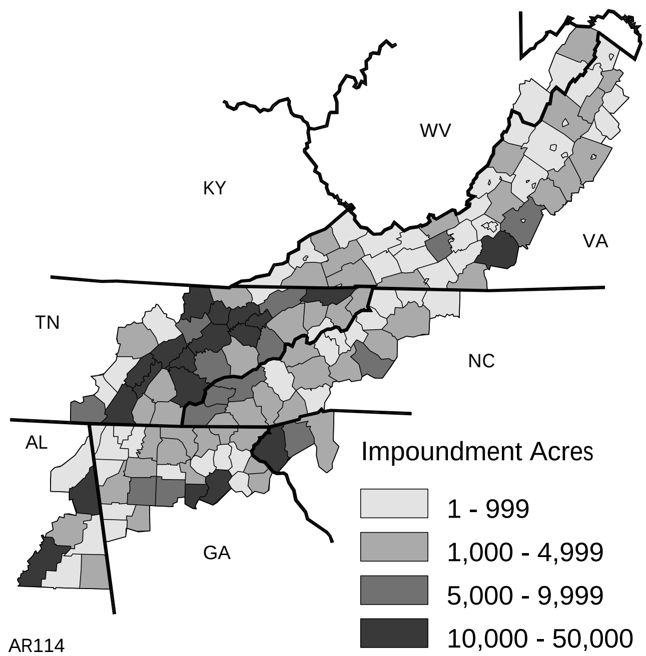
Figure 2.1.4 Precipitation averaged over the climate zones of the SAA region: a.) 1986, an unusually dry year, and b.) 1989, an unusually wet year.

Table 2.1.3 Water surface area of flooded rivers and lakes in the Southern Appalachian Assessment region.

State	Acres
Alabama	66,368
Georgia	89,888
North Carolina	47,664
South Carolina	38,915
Tennessee	248,776
Virginia	61,537
West Virginia	3,090
Total	556,238

Figure 2.1.5 Acres of lake or reservoir surface for counties in the SAA area showing influence of TVA impoundments



units (HUCs) or watersheds in the study areas.

A commonly used method to assess the condition of lakes and reservoirs is to determine their trophic state. The trophic state classification of lakes is based on divisions of their trophic progression from low to high primary productivity. Traditionally, the progression is divided into three classes: oligotrophic, mesotrophic, and eutrophic. Low nutrient (nitrogen and phosphorous) levels, low algal densities, clear water, oxygen concentrations in the hypolimnion (the deeper portions of lakes) sufficient to support aquatic life and good water quality are characteristic of oligotrophic water. As lakes age or inputs of pollutants from human activities increase, the trophic progression of lakes continues. Increased nutrient levels, increased algal densities, decreases in water clarity, and decreases in hypolimnetic oxygen concentrations occur as a lake progresses from a mesotrophic to a eutrophic state. Mesotrophic lakes are moderately productive and show little, if any, signs of water quality problems. Eutrophic lakes may be so productive, with high nutrient levels, poor clarity, and low oxygen, that a high potential for water quality degradation exists. Continued increases of nutrients can lead to hypereutrophic conditions. This deteriorated condition can result in fish kills due to oxygen depletion and jeopardize the use of lakes for drinking water supplies and recreation.

Fecal coliform concentrations are used to indicate the likely presence of pathogenic organisms and the potential for water-based disease outbreaks.

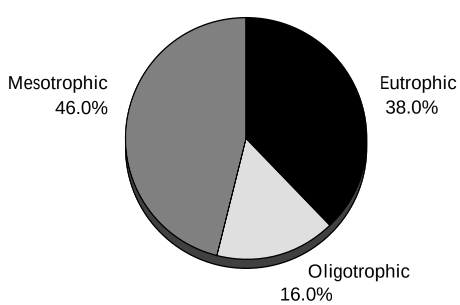


Figure 2.2.1 Lake and reservoir trophic condition. A summary of the trophic condition of lakes and reservoirs within the Southern Appalachian Assessment region is portrayed as percent of total lake acres assessed.

Key Findings

- The trophic status of lakes in the SAA area varies widely. Overall, for lakes greater than 500 acres assessed by the states, 38 percent of total lake acres were assessed as eutrophic, 46 percent mesotrophic, and 16 percent oligotrophic (fig. 2.2.1).

- There is general agreement that water quality has improved significantly since the adoption of the Clean Water Act in 1972. In addition, in some areas, population growth and resulting landscape alterations have caused some degradation in water quality.
- An association may exist between the water quality condition of rivers and their tributaries in the study area and the extent of urbanization and resource extraction. See chapter 5 for a discussion of pollutant sources and their impacts on water quality. Figure 2.2.2 illustrates the miles of impaired waterbodies by watershed, and figure 2.2.3 ranks the watersheds by the percentage of stream miles not supporting designated uses. These figures indicate that the Tennessee River and Alabama River basin areas include most of the significantly impacted watersheds.
- The Chesapeake Bay drainage area, primarily in Virginia, has the highest percentage of waterbodies that meet water quality standards for the protection of aquatic life in the study area.
- The occurrence of fecal coliform bacteria above the states' standards for human contact is evident throughout the study area

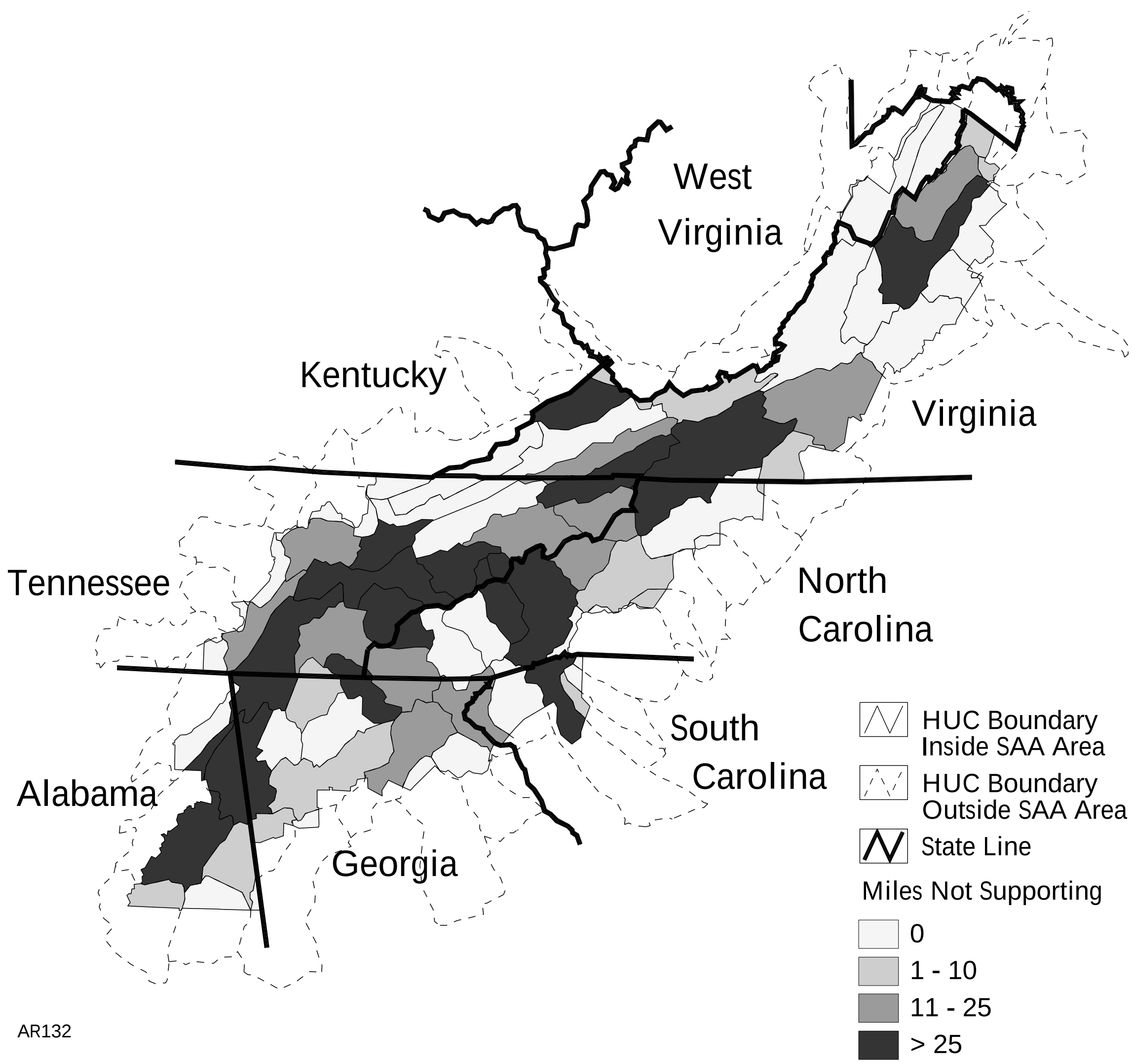


Figure 2.2.2 Miles of streams not supporting water uses by hydrologic unit. Miles of streams with severe degradation are shown by hydrologic unit based on states' 1994 water quality reports to Congress.

(fig. 2.2.4). Contamination from fecal coliform is likely due to natural deposition from wildlife, livestock operations, and municipal discharges.

- There are 15 watersheds with areas of widespread water quality degradation (greater than 20 percent impairment) (fig. 2.2.3).
- More than 80 percent of river miles in most watersheds or hydrologic areas (which represent 75 percent of the river miles in the SAA) are rated as fully supporting their designated uses.

Data Sources

The primary sources of information for this assessment were the 1994 Water Quality Reports to Congress (state water quality reports to Congress, as required under section 305[b] of the Clean Water Act) from the states within the SAA (Alabama Department of Environmental Management 1994; Denton and others 1994; Georgia Department of Natural Resources 1994; North Carolina Department of Environment, Health, and Natural Resources 1994; South Carolina Department of Health and Environment 1994; Virginia Department of Environmental Quality 1994). West Virginia's 1994 full report was not completed in time for

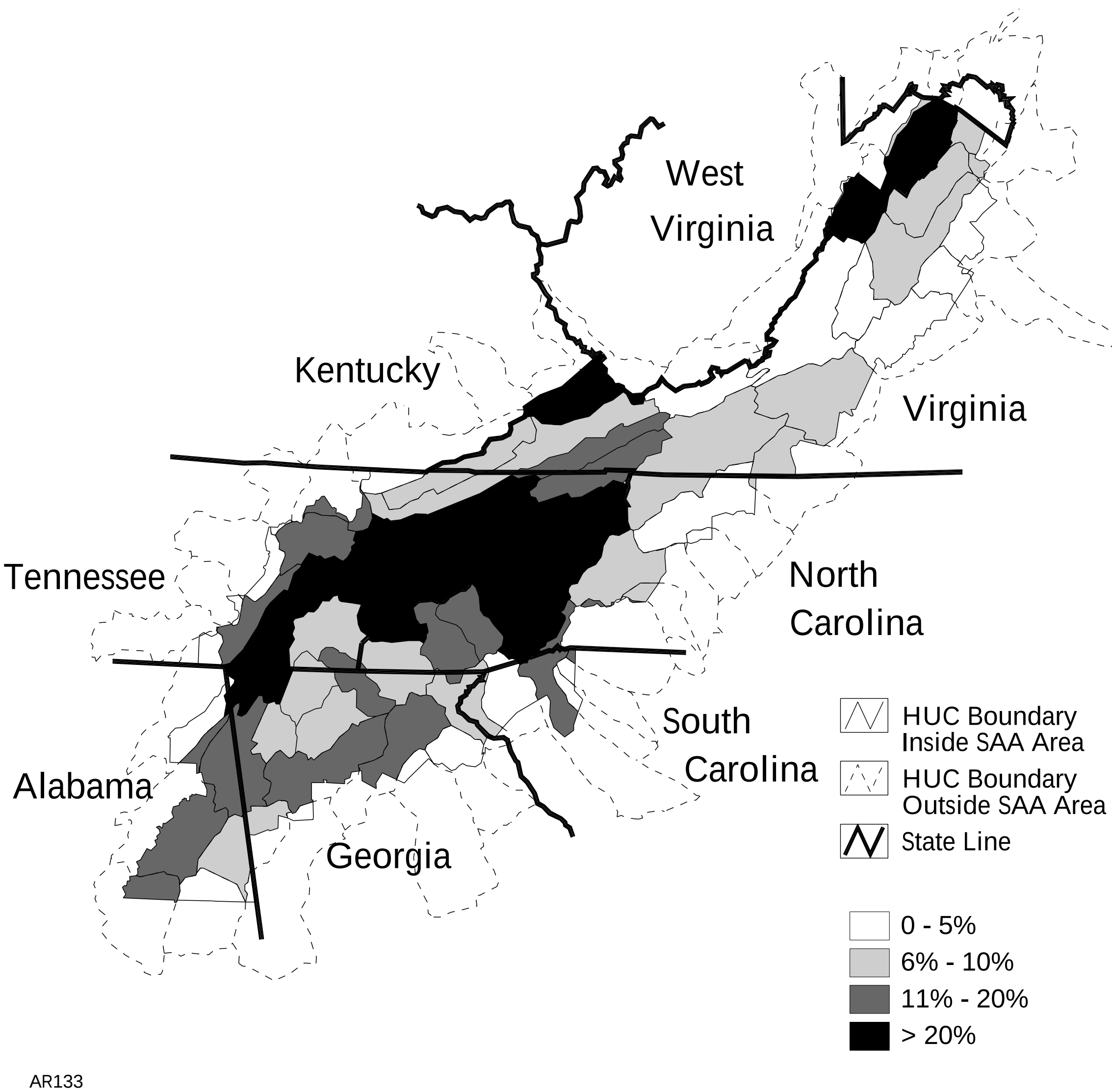
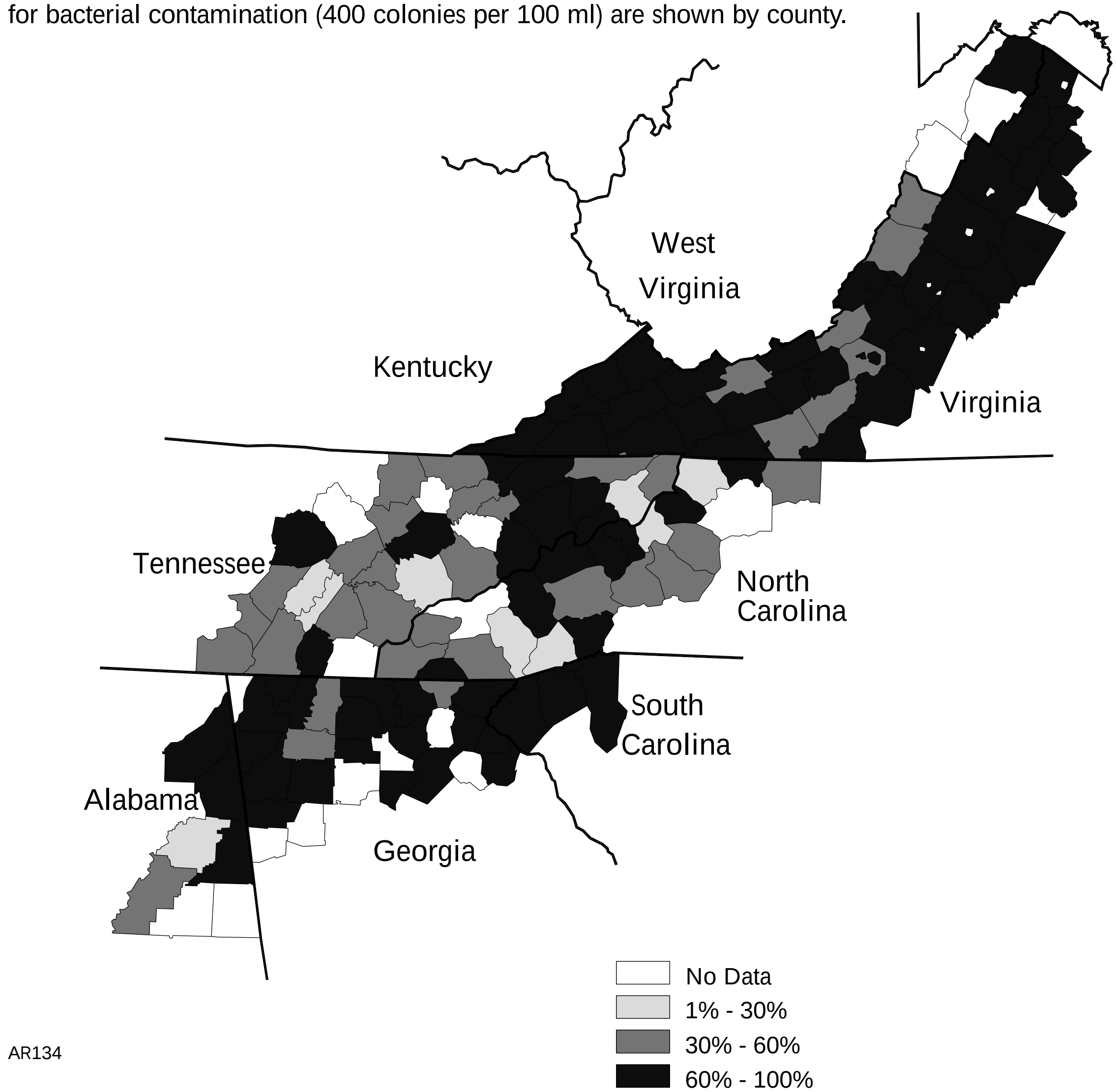


Figure 2.2.3 Percent of stream miles not fully supporting water use shown by hydrologic unit. Percent of stream miles not fully supporting designated water uses such as fishing/aquatic life, swimming, and drinking water are shown by hydrologic unit based on states' 1994 water quality reports to Congress.

Figure 2.2.4 Fecal coliform violations. Percent of stations exceeding standards for bacterial contamination (400 colonies per 100 ml) are shown by county.



this assessment. These reports are produced biennially by the states and describe statewide water quality conditions for the previous 2-year period. Additional information was obtained from the "River Pulse" documents produced by the TVA (TVA 1993; TVA 1994b; TVA 1995a).

Information concerning the trophic state of lakes in the SAA was also obtained from the state Water Quality Reports to Congress. Each of the states in the region uses a form of a trophic state index based on measurement of water quality parameters. Although the methods vary somewhat, each of the indices used by the states is based on similar factors, such as water clarity, chlorophyll a, and nutrient levels (nitrogen and phosphorous).

Information concerning the attainment of water quality standards in rivers and streams was aggregated by hydrologic units and watersheds described in section 2.1. The percentage of the waterbodies that fully supported, partially supported, and did not support their designated uses, based on water quality factors, was derived from the data presented in each state's Water Quality Report to Congress. The RF3 database of streams in the study area was used to obtain the numbers of river miles in a hydrologic unit/watershed. Fully supporting waters are defined as those waterbodies where water quality samples meet the water quality criteria more than 90 percent of the time. Partially supporting waters are defined as those that meet water quality criteria 75 to 90 percent of the time, and nonsupporting waters are those that meet water quality criteria less than 75 percent of the time (EPA 1993a).

Water quality monitoring frequency and extent varies from state to state. The data used in this analysis include both monitored and evaluated water quality as documented by each state. Monitored means having site-specific survey data less than 5 years old. Evaluated means not having current site-specific information; rather, data older than 5 years, other information such as land use data, modeling using estimated parameters, or data from sources or studies with less rigorous analyses (EPA 1993a). For example, of the total stream miles in EPA's Southeastern Region, 15 percent were monitored and 15 percent were evaluated, as reported in the states' 1994 Water Quality Reports to Congress (Section 305[b] Reports). These percentages for monitored and evaluated stream miles are probably similar in the SAA area. Because the states present their assessments in different formats, the information in the state Water Quality Reports to Congress was aggregated by hydrologic unit/watershed. In some cases supplemental information, such as the total river miles in a hydrologic unit or watershed was obtained from the RF3 database files.

Water quality standards also vary between states. In addition, several limitations of assessments based on legally enforceable state standards are important. First, not all chemical stressors are covered by standards; some chemicals lack sufficient toxicity data to establish standards. Next, some criteria that are available may not include toxicity data pertinent to sensitive life-stages of some organisms (freshwater mussels and amphibians, for example). Thus, how well the criteria protect untested organisms isn't fully known. Finally, federal criteria recommendations and state standards are generally not available for important stresses such as habitat degradation or for the biological integrity of aquatic communities, perhaps the best integrative measure of the condition of aquatic systems.

To provide a more complete picture of the water quality conditions of the rivers and streams, the data were summarized two ways by hydrologic unit/watershed: first, using the stream miles not supporting water uses (fig. 2.2.2), and second by percentage of stream miles not fully supporting designated uses (fig. 2.2.3).

The fecal coliform data were obtained from the EPA STORET database of water quality data. This information was aggregated by county to illustrate the geographic areas susceptible to exposure above the states' standards for human contact (fig. 2.2.4).

Trends and Spatial Patterns

There is general agreement that water quality has improved significantly since the adoption of the Clean Water Act in 1972. Recently, the rate of water quality improvement has slowed since most of the municipal and industrial discharges currently control pollution and protect water quality, while the remaining sources of pollution, such as storm water runoff, sediment contamination, and spills are more difficult and expensive to control. In addition, in some areas, population growth and resulting landscape alterations have caused some degradation in water quality.

Portions of five major river basins originate in the SAA area (fig. 1.0.2). Based on the states' Water Quality Reports to Congress, the Tennessee River basin is the most severely impacted basin in the study area. The most severe impacts are found in the French Broad and Holston river watersheds and in the main stem of the Tennessee River. These impacts are attributed to urbanization, resource extraction, and hydrologic modification of the Tennessee River system.

The Alabama River basin, especially the Coosa River watershed, is impacted by point sources and agricultural runoff, as discussed further in chapter 5. The basin has impacts associated with high fecal coliform counts (fig. 2.2.4).

The Ohio River basin portion of the study area includes the New River watershed in North Carolina and Virginia, which appears to be in above-average condition (fig. 2.2.2). However, a significant number of miles are not supporting designated uses due to impacts from mining operations (fig. 2.2.2, fig. 5.1.5).

The Atlantic basin contains parts of several headwater watersheds that generally yield high-quality water. The notable exception is Greenville County, South Carolina, which has 76 miles of streams that do not fully support the aquatic life designated uses and have significant fecal coliform-related impacts (fig. 2.2.2, 2.2.4).

The Chesapeake Bay basin area appears to be the least impacted of the river basins in the study area. The most impacted area in this basin is in the south branch of the Potomac River watershed. While the aquatic life uses are fully supported in more than 99 percent of the James River watershed (fig. 2.2.2), there are elevated levels of fecal coliform contamination in the eastern portion of this watershed (fig. 2.2.4).

Likely Future Trends

Because of expected population growth and associated development, future water quality in some areas may be at risk to impairment. Maintaining the water quality gains of the past and continuing to improve water quality of impacted waterbodies, will require control of sources of pollution and siltation, remedies for past damage to sediments and riparian zones, and land use practices and patterns designed to minimize the impact on water resources. Such an approach would maintain the integrity of streams, rivers, lakes, and reservoirs in the SAA area.

Waterbodies in the SAA area are extremely important to area residents for a variety of reasons. For example, the waterbodies are heavily used for recreation, drinking water, transportation routes, livestock watering, irrigation, and flood control. Reservoirs also provide hydroelectric power and most lakes support excellent populations of both sport and commercial fishes. The lakes, reservoirs, and streams also provide habitat opportunities and enhancement for wildlife and offer prime real estate sites for human habitation and second home or vacation sites.

Monitoring water quality, trophic condition, biological, and habitat condition of each waterbody is important in determining the status and trends of water quality and health in waterbodies in the region. Monitoring will aid in the detection of developing and existing water quality problems that may occur within the SAA area. With this knowledge, problem areas can be identified and corrected.

2.3 SENSITIVITY OF STREAMS TO ACID DEPOSITION

Introduction

Acidic deposition is the process by which acidic compounds move from the atmosphere to the earth's surface. Sulfur and nitrogen oxides are released into the atmosphere from sources such as factories, automobiles, and fossil-fueled power plants. These emissions react with other chemicals in the atmosphere to produce sulfate and nitrate. When mixed with water, they become sulfuric and nitric acids and are delivered to watersheds in rain or snow or as particulate matter, aerosol particles, or dust.

The Mid-Atlantic Highlands has one of the highest rates of acidic deposition in the nation (Herlihy and others 1993). The natural resources that appear most sensitive to and at greatest potential risk from acidic deposition are aquatic ecosystems, aquatic dependant species, and high-elevation red spruce forests. Research conducted under the auspices of the National Acid Precipitation Assessment Program (NAPAP) concluded that regions in the United States most at risk from continued acidic deposition are located along the Appalachian Mountain chain stretching from the Adirondacks in New York to the southern Blue Ridge in Georgia.

The acidity and buffering capacity of streams are determined by the amount and type of acidic compounds deposited and the chemical, biological, and physical processes in the watershed. Soil performs an important function in this process. Microbial activity in soil organic matter can produce significant buffering action (Fitzgerald and others 1988). In soils, silicate and carbonate minerals provide the base cations needed to buffer the soils and neutralize acidity in the streams. The ability of soils to assimilate or neutralize acid compounds is limited. As the supply of base cations from soils is exhausted and the neutralizing capacity is diminished, acidic inputs are no longer neutralized and surface waters become acidic. As soils become saturated with sulfate compounds, the chemical passes through to surface waters. Acidic deposition into a watershed reduces the alkalinity of soils and causes leaching or export of the base cations in soils, further reducing the ability of soils to neutralize acid deposition.

In the Southern Appalachians, soil composition is determined almost exclusively by bedrock geology. Soils derived from quartz sandstone, for example, provide little to no base cations and, therefore, have limited buffering capacity. Conversely, soils derived from limestone have an abundance of base cations that readily buffer acid deposition. It follows that bedrock geology can be used to identify specific watersheds that are sensitive to acidification (Herlihy and others 1993; Cosby and others 1991).

Key Findings

- Within the SAA area, 54 percent of stream miles have high sensitivity to acid deposition, 18 percent have medium sensitivity, and 27 percent have low sensitivity.
- Published scientific evidence indicates that some streams in the area have become increasingly acidic in recent years.
- Projections for the future suggest that many additional streams could become more acidic in the decades to come.
- The northern part of the assessment area is more vulnerable than the southern part because of its location relative to sources of acid deposition and also because of climate factors such as length of growing season.
- Headwaters mountain streams in rugged terrain are typically most sensitive to acid deposition.

Data Sources and Methods of Analysis

A generalized bedrock geology map of the crystalline and sedimentary rocks of the Southern Appalachian Mountains, compiled by Peper and others (1995), provides the basis for assignment of lithology-based acid deposition sensitivity ratings. The generalized geologic map groups rocks by their dominant lithology using mineralogical, petrographic, and other characteristics that influence the composition and texture of the rocks without regard to specific age or stratigraphic name. Thus, for example, all quartz sandstones are mapped as a single rock type. Broad areas are generalized by dominant rock type and aerial significance at 1:1,000,000 scale. The map units are useful for regional considerations but are not detailed enough for site-specific work.

The chemical composition of stream water is largely a function of watershed bedrock geology. Webb and others (1994) developed a watershed classification that relates bedrock geology to various parameters of stream chemistry and is based on the Virginia Trout Stream Sensitivity Study (VTSSS) database. These data represent the result of chronic high levels of acid deposition and the resultant effect on stream chemistry. Stream water chemistry from spring season samples at 70 sites was used to differentiate between the various rock types and group them by similar chemical characteristics.

Each rock unit on the generalized geologic map was assigned a sensitivity rating based on the VTSSS classification. For rock units not included in the VTSSS classification, sensitivities were assigned by collaboration among experts. A key factor is the expected ability of the rock types to release acid-neutralizing calcium upon weathering and thus produce an acid-neutralizing soil in the watershed of the stream.

Rocks composed of mostly calcium or calcium-magnesium carbonate (limestones, dolomites, marbles, and calcareous rocks), are rated as low susceptibility, as are most mafic rocks (gabbros, mafic paragneisses and schists, and amphibolites), predominantly mafic volcanic rocks, diabase, and ultramafic rocks and mafic-ultramafic complexes. These latter groups of rocks generally contain sufficient calcium-rich feldspar or other calcium-magnesium silicate minerals to generate acid-neutralizing soils upon weathering. In addition, many of these mafic rocks have undergone low-grade metamorphism and have dispersed carbonate minerals within their altered matrices.

Dominantly siliceous clastic rocks (sandstones, shales) were shown by Webb and others (1994) to be associated with areas of high acid precipitation susceptibility. These rocks release little or no acid-neutralizing components; indeed, sulfitic shales and sulfitic schists may be acid generators. These and their metamorphic equivalents, as well as siliceous mylonites, were rated as high-susceptibility areas.

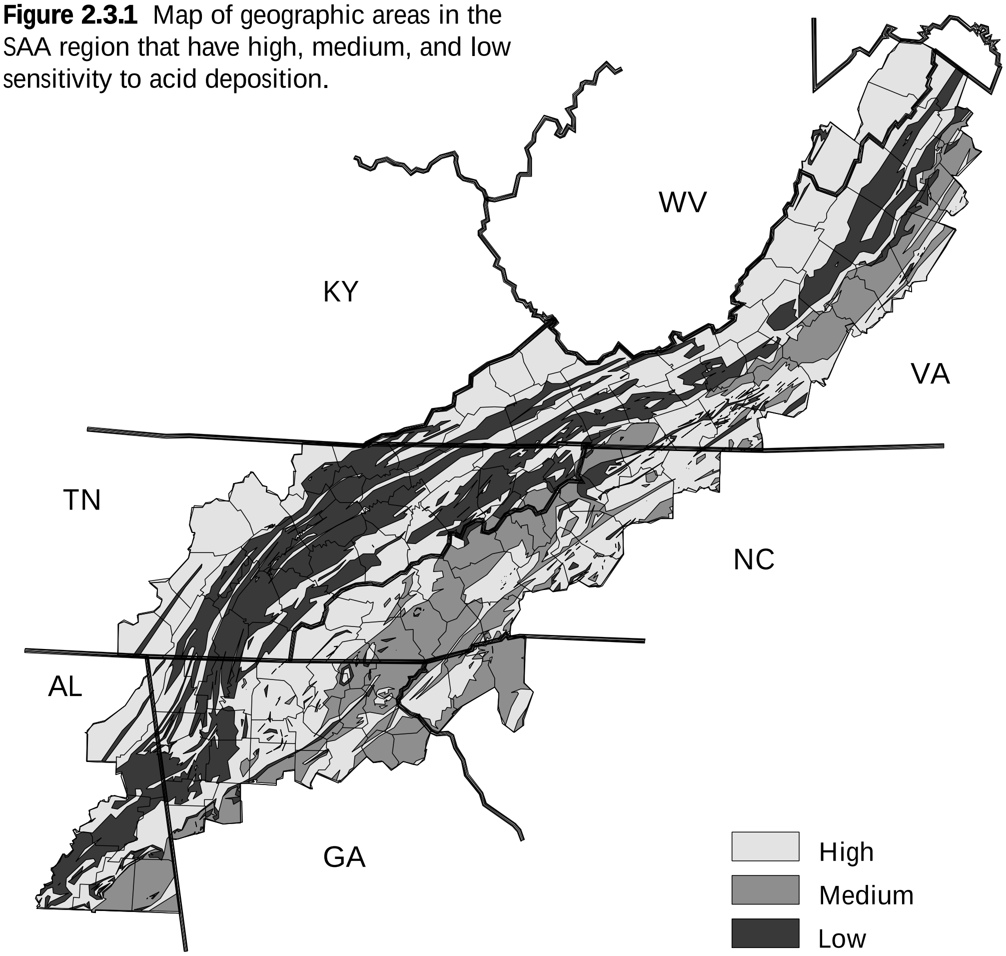
Areas of felsic volcanic rocks, granitic rocks (granite, granodiorite, quartz diorite), volcanic and volcaniclastic rocks, felsic paragneiss and schist, alkalic rocks, and anothosite are characterized by the presence of alkali (potassium and sodium), feldspars, and slightly calcareous plagioclase feldspar. Based on rock composition alone, most geologists would consider large areas of inclusion-free potassium feldspar-rich granite to have little acid neutralizing capacity (ANC) and resultant high acid deposition sensitivity rating. However, most granites in the map area are granodioritic and contain inclusions. Areas dominated by these rocks, as expected and as evidenced by Webb and others (1994), were designated to be of medium sensitivity.

The product is a GIS-generated map of geographical areas within the SAA area that have high, medium, or low sensitivity to acid deposition (fig. 2.3.1). When combined by overlay with a map of stream reaches, the result is an estimate of miles of stream by sensitivity level. These are shown in the following table:

Sensitivity Level	Miles	Percent
High	52,086	54.3
Medium	17,986	8.7
Low	25,860	27.0

These sensitivity ratings are based on a generalized map of bedrock geology. As a result, there can be significant local variations from the rating shown on the acid deposition sensitivity map (fig. 2.3.1). For example, in parts of the Valley and Ridge province in Virginia, some of the narrow limestone valleys do not display at the scale of the generalized bedrock geology map (1:1,000,000 scale). Consequently, these low acid deposition sensitivity areas are not indicated on the acid deposition sensitivity map. In addition, the VTSSS data are restricted to streams associated with forested ridges and may not provide information concerning the less extensive area of other rock types and alluvial deposits within the map areas. The VTSSS data may be further biased toward more extreme (low ANC) conditions because the VTSSS sites were selected from the least disturbed wild land watersheds in the region. These tend to be the base-poor lands that have been unsuitable for cultivation or timber production.

Figure 2.3.1 Map of geographic areas in the SAA region that have high, medium, and low sensitivity to acid deposition.



Trends and Spatial Patterns

The table above depicts the relative sensitivity and not the current condition of stream chemistry in the assessment area. For a stream to be at risk, it must be sensitive to acid deposition. It must also have an actual or reasonable possibility of exposure to acid deposition in amounts sufficient to cause an adverse effect. Sensitive streams are at high risk when located where acidic deposition loads are currently above (or are projected to remain above) thresholds likely to cause adverse effects. As reported in the Atmospheric Technical Report (SAMAB 1996a), the northern part of the SAA area is the recipient of much higher loadings of acid deposition than the southern portion.

Temporal Trends

There are indications that stream acidification is already occurring. Very few streams have a long enough history of chemical and biological monitoring to identify trends over time. However, indirect evidence from specific watersheds provides compelling evidence that acidification is occurring. One excellent example is the St. Mary's River, which flows from the western slopes of Virginia's Blue Ridge Mountains. Its watershed was given federal wilderness status in 1984. Historical information on stream insects dates back to the 1930s when Eugene Surber worked on the river. The decrease in the number and diversity of aquatic insects from 1936 to 1988, the disappearance of acid-sensitive mayfly genera, and increases in abundance of acid-tolerant stonefly and midge species are all indicative of stream water acidification (Kauffman and others, 1993). The St. Mary's River is discussed further in the Atmospheric Technical Report (SAMAB 1996a) and in sections 2.5 and 2.8 of this report.

Data from the Great Smoky Mountains National Park in Tennessee and North Carolina indicate a poor buffering capacity for most of the park's streams and lower pH in the higher-elevation watersheds. The National Stream Survey researchers (Kaufmann 1988) were able to infer significant historical decline of ANC and pH. They concluded that chronic acidification of surface waters has occurred in the Southern Blue Ridge.

Spatial Trends

Within the SAA area, higher-elevation lands such as mountain ridges are made up of more resistant bedrock that is usually lacking in buffering capacity. The valleys are often underlain by more weatherable rock with abundant buffering capacity. Surface waters most sensitive to acidic deposition are often located in watersheds having shallow acidic soils with rapid, shallow subsurface flows. Acidic lakes and streams tend to occur in smaller watersheds with steep terrain or at the higher elevations (e.g., watersheds less than 30 km2 and elevations greater than 300 m in the Mid-Appalachian region [Herlihy and others 1993]). These small watersheds have additional attributes that provide favorable habitat for native trout. As discussed in section 2.5, many of the trout populations in these streams are thus at risk.

Forested watersheds are the most likely places to find acidic streams. Almost all of the acidic streams in the Mid-Appalachians were in forested watersheds along ridges. The highly weatherable and more base-rich valley bottoms which have more buffering capacity have generally been cleared for agriculture and settlement.

Nitrogen Saturation

Nitrate is not only an important acid anion in acidic deposition, it is also an essential nutrient in high demand by biological processes and organisms. An expanding body of recent research shows that nitrate deposition is an important component and increasing cause of present and future acidification in some environments. Specifically, there are limits to the amount of nitrate that can be incorporated into organic matter by biological processes in watersheds. When these processes are saturated, nitrate losses from the watershed will increase, principally in the form of nitrate leaching. Excess nitrate in watersheds can lead to depletion of base cations and surface water acidification.

Episodes of storm flow or snowmelt runoff can expose organisms to short-term acutely lethal acidic water. Episodic events occurring during spring snowmelt or storm runoff often tend to be most acidic. Nitrate tends to be more mobile in watershed soils at this time of year because most plants are dormant. Snowmelt or storm runoff can flush nitrate through the watershed at flow rates that exceed the capacity of plants to capture the nutrient. Nitrate can thus be a significant seasonal cause of episodic acidification in some regions.

Present scientific knowledge does not allow a precise estimate of the number of years it will take for a watershed to reach nitrogen saturation. Times to saturation vary among geographic regions. Watersheds in the northern portion of the SAA area with cooler annual temperatures, shorter growing seasons, lower inherent productivity potentials, and long histories of elevated deposition rates of sulfur and nitrogen will have the shortest time to nitrogen saturation. Some estimates indicate this will happen in less than 100 years. Watersheds in the southern portion of the SAA area, with warmer annual temperatures, longer average growing seasons, relatively higher inherent productivity potentials, faster decomposition rates, and historically lower nitrogen deposition rates will have longer times to nitrogen saturation.

The progressive infestation of the gypsy moth (SAMAB 1996 b) may also accelerate the nitrogen saturation process. Webb and others (1994) report large increases in nitrate concentrations in stream waters where gypsy moth infestation and severe defoliation have occurred.

Future Trends

The potential for future change is addressed by Herlihy and others (1993). They state: "Our analyses of net annual sulfur retention in the Mid-Atlantic Highlands indicate the effect that atmospheric sulfur deposition is having in the region. Increased sulfur deposition has resulted in increased fluxes of sulfate to surface waters. This, in turn, has caused stream acidification to the point that some reaches have become acidic. Our analyses further indicate that soils and surface waters of the region have not yet realized the full effects of elevated sulfur deposition. Net annual sulfur retention undoubtedly will continue to decrease in the future resulting in increasing stream sulfate concentrations and further loss of stream ANC."

In a report to Congress, EPA (1995a) discusses the use of models to predict stream ANC and pH in the year 2040 under various scenarios of air quality regulation. For the Mid-Appalachian region, they predict that if "...average time to watershed nitrogen saturation approximates 100 years or less, the MAGIC (Model for Acidification of Groundwater in Catchments) model (Cosby and others 1985) predicts that reducing either sulfur or nitrogen deposition by about 25 percent below projected Clean Air Act Amendments reductions, or some lesser combined deposition reduction for both chemicals, could be necessary to maintain proportions of target stream reaches in the year 2040 near their 1985 conditions."

Webb and others (1994) have modeled projected changes in stream chemistry for their six response classes. They project that: "For the Blue Ridge siliciclastic streams, the observed present and estimated future percentage of streams with pH less than or equal to 5.0 on a chronic basis is 5 percent and 68 percent (respectively). For the Allegheny Ridge's siliclastic streams, these percentages are 8 percent and 100 percent. For the Allegheny Ridge's minor carbonate streams, these percentages are 0 percent and 20 percent."

Long-range projections of the responses of surface waters in the Southern Blue Ridge to changes in acidic deposition are limited. Elwood and others (1991) suggest that "some acidification of surface waters in this region has already occurred," and that "increases in acid anion mobility will result in major declines in the ANC and pH of most surface waters in the region."

2.4 THREATENED, ENDANGERED, AND SPECIAL CONCERN AQUATIC SPECIES

Introduction

Threatened and endangered species are those that have been officially listed by the U.S. Fish and Wildlife Service (FWS) under the Endangered Species Act (ESA) of 1973. Under this law, the term "species" includes species, subspecies, other smaller taxonomic units (stocks, varieties), and certain populations; that convention will be followed in this document. Additional species may be of special concern because of their limited distributions, but the legal listing process has not been completed. This section concerns distribution of threatened, endangered, and special concern species (TE&SC), defined broadly as those species listed as threatened (T), endangered (E), proposed endangered or threatened (PE, PT), category 1 (C1), or formerly known as category 2 (C2) (a designation since eliminated by the FWS), or ranked as G1, G2, or G3 (or a variant) by the state heritage programs and The Nature Conservancy (see glossary).

Key Findings

- The state heritage program lists include 190 aquatic and semiaquatic TE&SC species in the SAA area; of these, 62 are fish and 57 are molluscs.
- The state heritage program lists include 34 endangered, 10 threatened, 4 proposed endangered, and 63 former (C2) aquatic and semiaquatic species, as determined by the FWS; an additional 79 species are ranked as G1, G2, or G3 by The Nature Conservancy.
- Of the 34 endangered species on the state heritage program lists, 26 are molluscs and 7 are fish.
- The 10 counties with the greatest number of aquatic TE&SC species on the state heritage program lists are in three areas: the Clinch and Powell river drainages of Virginia and Tennessee; the area around Knoxville and Oak Ridge, TN; and Monroe County, Tennessee. This overall pattern largely reflects patterns for fish and molluscs.
- According to the FWS, 46 threatened and endangered aquatic species are known to occur and 7 others possibly occur in SAA area counties. The nine counties known by FWS to have the greatest number of threatened and endangered aquatic species include the same six counties in the Clinch and Powell river drainages of Virginia and Tennessee that were identified in the heritage program data set as harboring the most TE&SC species and two counties in Georgia, which are primarily in the Conasauga River drainage.

Data Sources

We obtained Element Occurrence Record (EOR) data from the seven state heritage programs with all sample locations assigned to counties. Some records were rather old, although about 60 percent were dated in the last 20 years; no attempt was made to select by date of record. (Late in the process, it was discovered that Virginia had neglected to send data for Montgomery and Buchanan Counties).

With the aid of standard references, fish, mussels, and only aquatic and semiaquatic species of amphibians (salamanders), and reptiles (turtles) (Conant 1975; Martof and others 1980), insects (Merritt and Cummins 1984), snails (Hubricht 1985; Burch 1989), and other invertebrates were selected (Pennak 1989). There were no truly aquatic plants (e.g., *Utricularia*) in the database that met the TE&SC criteria. The relatively few amphibians and reptiles were combined as "herptiles." Also combined were the few crustaceans, flatworms, and annelid worms as "other invertebrates."

Errors were corrected using the same references, consulting the FWS (1994a, 1994b, 1994c, 1994d, 1994e) lists first, followed by standard references (Conant 1975; Robins and others 1991), to resolve differences in scientific names. Where different global rankings were given by different states. The Nature Conservancy office in Boston was consulted to reconcile differences. FWS (1994a, 1994b, 1994c, 1994d, 1994e) rankings were assigned manually to the corrected EOR data. Finally, the TE&SC species were selected that met the above criteria. The resulting data set had 2,633 observations of 190 species.

Analysis, Spatial Patterns, and Trends

Before discussing the analysis results and spatial patterns, some limitations of the EOR data should be considered. The state heritage programs are largely dependent on sharing of data from state and federal agencies, often collected for specific reasons at particular sites (e.g., bridge sites). With these data, patterns may be a function of where the search took place rather than patterns of species distribution. Analysis of the distribution of EOR locations revealed that greater effort was probably expended on lands owned by entities other than the federal government, the states, or the Cherokee Nation. Nonetheless, there appears to be no better source of data for the SAA region as a whole.

Another concern is that there is some ambiguity in the identification of a particular county as having few or many TE&SC species. Consider a county that has many TE&SC species in the EOR data set: Is that so because much of the county is managed by an agency for protection of TE&SC species, because the county once had many endemic species that are now imperiled by poor conditions, because it's a large county, or because someone spends a lot of time looking for TE&SC species? Although it is tempting to think that counties with many TE&SC species are places where degraded conditions imperil many species, in many cases these are areas that provide refuge for species.

The EOR data set had information on 190 aquatic TE&SC species: 62 were fish, 57 molluscs (mussels and aquatic snails), 6 herptiles, 26 insects, and 39 other invertebrates (table 2.4.1). Most (111) species had some kind of FWS ranking (E, T, PE, C2) in addition to a global ranking. A similar data set of known and possible occurrences of species, obtained from FWS files (Herrig 1995), had 53 federally listed (E, T) or proposed (PE, PT) species, compared to 48 in the EOR data set. There were more observations of species within the SAA area in the EOR data set; therefore, most analyses were of this data set.

The species in the EOR data set were distributed among taxonomic groups and

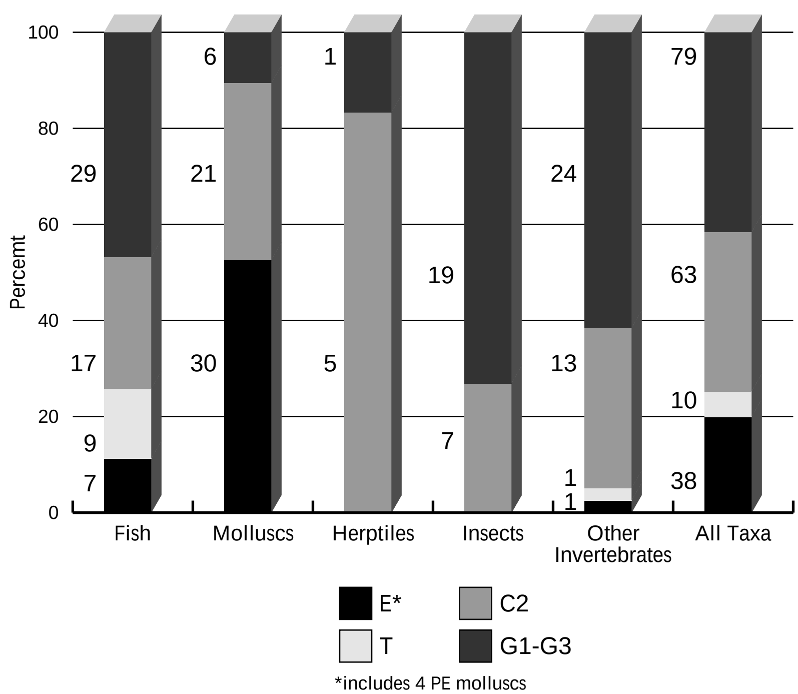


Figure 2.4.1 Distribution of number of species in each taxonomic group among federally listed endangered and proposed endangered (E), threatened (T), former category 2 (C2), and globally ranked (G) classes of TE&SC species. Globally ranked species are those that are ranked G1, G2, or G3 and are not also federally ranked in one of the above classes. Numerals are numbers of species, and the proportion of each section of bar reflects the percentage of total TE&SC species in the corresponding class. (Based on Element Occurrence Records from state heritage programs)

Table 2.4.1 Threatened, endangered, and special concern (TE&SC) species used in section 2.4 of this report. These species are either federally listed as endangered (E), threatened (T), proposed endangered (PE), category 1 (1) candidate, or former category 2 (2) candidate or globally ranked as G1, G2, G3, or a variant (see glossary for descriptions of global ranks) by The Nature Conservancy. All species were in the heritage programs database and occur within the Southern Appalachian Assessment (SAA) area boundary.

Scientific Name	Common Name	Global Rank	Federal Rank
Fish			
Acipenser fulvescens	Lake sturgeon	G3	2
Ambloplites cavifrons	Roanoke bass	G3	
Ammocrypta clara	Western sand darter	G3G4	
Clinostomus funduloides ssp 1	Little Tennessee River rosyside dace	G5T2	
Cottus baileyi	Black sculpin	G2	
Cottus pygmaeus	Pygmy sculpin	G1	T
Cycleptus elongatus	Blue sucker	G3	2
Cyprinella caerulea	Blue shiner	G2	T
Cyprinella callitaenia	Bluestripe shiner	G2	2
Cyprinella monacha	Spotfin chub	G2	T
Cyprinella zanema pop 1	Santee chub - piedmont population	G3?T3	
Erimystax cahni	Slender chub	G2	T
Erimystax insignis	Blotched chub	G3G4	
Etheostoma acuticeps	Sharphead darter	G3	
Etheostoma cinereum	Ashy darter	G2G3	2
Etheostoma ditrema	Coldwater darter	G2	2
Etheostoma kanawhae	Kanawha darter	G2	
Etheostoma maculatum	Spotted darter	G2	2
Etheostoma nigrum susanae	Cumberland Johnny darter	G5T1	2
Etheostoma podostemone	Riverweed darter	G3	
Etheostoma sagitta	Arrow darter	G3G4	
Etheostoma scotti	Cherokee darter	G?	T
Etheostoma sp 3	Duskytail darter	G1	E
Etheostoma tallapoosae	Tallapoosa snubnose darter	G2?Q	
Etheostoma tippecanoe	Tippecanoe darter	G3	
Etheostoma trisella	Trispot darter	G2	2
Etheostoma vulneratum	Wounded darter	G3	
Hemitremia flammea	Flame chub	G4	2
Hypentelium roanokense	Roanoke hog sucker	G3	
Ichthyomyzon bdellium	Ohio lamprey	G3G4	
Luxilus zonistius	Bandfin shiner	G3	
Moxostoma ariommum	Bigeye jumprock	G2	
Moxostoma lachneri	Greater jumprock	G3?	
Moxostoma robustum	Robust redhorse	G3G4	2
Notropis ariommus	Popeye shiner	G3	
Notropis hypsilepis	Highscale shiner	G3	2
Notropis lineapunctatus	Lined chub	G3	
Notropis semperasper	Roughhead shiner	G3	2
Notropis sp 3	Palezone shiner (S. Fk. Cumberland)	G2	E
Noturus baileyi	Smoky madtom	G1	E
Noturus flavipinnis	Yellowfin madtom	G2	T
Noturus gilberti	Orangefin madtom	G2	2
Noturus munitus	Frecklebelly madtom	G3	
Noturus stanauli	Pygmy madtom	G1	E
Percina antesella	Amber darter	G2	E
Percina aurantiaca	Tangerine darter	G3G4	
Percina aurolineata	Goldline darter	G2	T
Percina burtoni	Blotchside darter	G2	
Percina jenkinsi	Conasauga (=reticulate) logperch	G1	E
Percina lenticula	Freckled darter	G2	
Percina macrocephala	Longhead darter	G3	2
Percina palmaris	Bronze darter	G3	

Table 2.4.1 (cont.) Threatened, endangered, and special concern (TE&SC) species used in section 2.4 of this report. These species are either federally listed as endangered (E), threatened (T), proposed endangered (PE), category 1 (1) candidate, or former category 2 (2) candidate or globally ranked as G1, G2, G3, or a variant (see glossary for descriptions of global ranks) by The Nature Conservancy. All species were in the heritage programs database and occur within the SAA area boundary.

Scientific Name	Common Name	Global Rank	Federal Rank
Percina rex	Roanoke logperch	G2	E
Percina squamata	Olive darter	G3	2
Percina tanasi	Snail darter	G2	T
Phenacobius crassilabrum	Fatlips minnow	G3	
Phenacobius teretulus	Kanawha minnow	G3	2
Phoxinus cumberlandensis	Blackside dace	G2	T
Phoxinus tennesseensis	Tennessee dace	G2G3	
Polyodon spathula	Paddlefish	G4	
Thoburnia hamiltoni	Rustyside sucker	G2	2
Typhlichthys subterraneus	Southern cavefish	G3	
Molluscs			
Alasmidonta marginata	Elktoe	G5	2
Alasmidonta raveneliana	Appalachian elktoe	G1	E
Alasmidonta varicosa	Brook floater	G3	2
Athearnia anthonyi	Anthony's river snail	G1T1	E
Conradilla caelata	Birdwing pearlymussel	G1	E
Cumberlandia monodonta	Spectacle case	G2G3	2
Cyprogenia stegaria	Fanshell	G1	E
Dromus dromas	Dromedary pearlymussel	G1	E
Elimia bellula	Walnut elimia	G?	2
Elimia crenatella	Lacey elimia	G?	2
Elliptio lanceolata	Yellow lance	G3	2
Epioblasma brevidens	Cumberlandian combshell	G2	PE
Epioblasma capsaeformis	Oyster mussel	G2	PE
Epioblasma florentina florentina	Yellow-blossom	G1TX	E
Epioblasma torulosa gubernaculum	Green-blossom pearlymussel	G2TX	E
Epioblasma torulosa torulosa	Tubercled blossom	G2TX	E
Epioblasma triquetra	Snuffbox	G3	2
Epioblasma turgidula	Turgid-blossom	GH	E
Epioblasma walkeri	Tan riffleshell	G1T1	E
Fusconaia barnesiana	Tennessee pigtoe	G2G3	
Fusconaia cor	Shiny pigtoe	G1	E
Fusconaia cuneolus	Fine-rayed pigtoe	G1	E
Fusconaia masoni	Atlantic pigtoe	G2	2
Hemistena lata	Cracking pearlymussel	G1	E
Holsingeria unthanksensis	An aquatic cavesnail	G1	
Io fluvialis	Spiny riversnail	G2	2
Lampsilis abrupta	Pink mucket	G2	E
Lampsilis cariosa	Yellow lampmussel	G4	2
Lampsilis virescens	Alabama lamp mussel	G1	E
Lasmigona holstonia	Tennessee heelsplitter	G2G3	2
Lasmigona subviridis	Green floater	G3	2
Leptoxis praerosa	Onyx rocksnail	G1G3	2
Leptoxis taeniata	Painted rocksnail	G?	2
Lexingtonia dolabelloides	Slabside pearlymussel	G2G3	2
Lithasia geniculata	Ornate rocksnail	G1G3	2
Lithasia verrucosa	Varicose rocksnail	G?	2
Pegias fabula	Little-wing pearlymussel	G1	E
Plethobasus cicatricosus	White wartyback	G1	E
Plethobasus cooperianus	Orange-foot pimpleback	G1	E
Plethobasus cyphyus	Sheepnose	G3	
Pleurobema collina	James spinymussel	G1	E

Table 2.4.1 (cont.) Threatened, endangered, and special concern (TE&SC) species used in section 2.4 of this report. These species are either federally listed as endangered (E), threatened (T), proposed endangered (PE), category 1 (1) candidate, or former category 2 (2) candidate or globally ranked as G1, G2, G3, or a variant (see glossary for descriptions of global ranks) by The Nature Conservancy. All species were in the heritage programs database and occur within the SAA area boundary.

Scientific Name	Common Name	Global Rank	Federal Rank
Pleurobema cordatum	Ohio River pigtoe	G3	
Pleurobema oviforme	Tennessee clubshell	G2G3	2
Pleurobema plenum	Rough pigtoe	G1	E
Pleurobema rubrum	Pyramid pigtoe	G2G3	
Pleurocera showalteri	Upland hornsnail	G?	2
Pyrgulopsis ogmoraphe	Royal snail	G1G3	E
Quadrula cylindrica strigillata	Rough rabbitsfoot	G4T2T3	PE
Quadrula intermedia	Cumberland monkeyface	G1	E
Quadrula sparsa	Appalachian monkeyface	G1	E
Toxolasma cylindrellus	Pale lilliput	G1	E
Toxolasma lividus	Purple liliput	G1G2	2
Tulotoma magnifica	Tulotoma livebearing snail	G2?	E
Villosa fabalis	Rayed bean	G2	2
Villosa nebulosa	Alabama rainbow	G3	
Villosa perpurpurea	Purple bean	G1 PE	
Villosa trabalis	Cumberland bean	G2	E
Herptiles (Amphibians and Reptiles)			
Aneides aeneus	Green salamander	G4	2
Clemmys muhlenbergii	Bog turtle	G3	12
Cryptobranchus alleganiensis	Hellbender	G4	2
Desmognathus santeetlah	Santeetlah dusky salamander	G3Q	
Eurycea junaluska	Junaluska salamander	G2Q	2
Gyrinophilus palleucus	Tennessee cave salamander	G2	2
Insects			
Aeshna mutata	Spring blue darner	G3G4	
Arrhopalites clarus	A cave springtail	G1?	
Calopteryx amata	Superb jewelwing	G3G4	
Ceraclea alabamae	Caddisfly	G1	
Cheumatopsyche helma	Helma's cheumatopsyche caddisfly	G1G3	2
Gomphus consanguis	Cherokee clubtail	G2G3	2
Gomphus quadricolor	Rapids clubtail	G3G4	
Gomphus ventricosus	Skillet clubtail	G3	
Gomphus viridifrons	Green-faced clubtail	G3	
Hydraena maureenae	Maureens hydraenan minutemoss beetle	G1G3	2
Hydroptila cheaha	Caddisfly	G1	
Hydroptila choccolocco	Caddisfly	G1	
Hydroptila micropotamis	Caddisfly	G1	
Hydroptila patriciae	Caddisfly	G1	
Hydroptila setigera	Caddisfly	G1	
Macromia margarita	Margaret's river cruiser	G2G3	2
Ophiogomphus aspersus	Brook snaketail	G3G4	
Ophiogomphus howei	Pygmy or midget snaketail	G3	2
Ophiogomphus incurvatus incurvatus	Piedmont snaketail	G3G4T3	
Ophiogomphus mainensis	Twin-horned snaketail	G3G4	
Polycentropus carlsoni	Carlson's polycentropus caddisfly	G1G3	2
Pseudosinella hirsuta	A cave springtail	G1	
Stenelmis gammoni	Gammon's stenelmis riffle beetle	G1G3	2
Stylurus amnicola	Riverine clubtail	G3G4	
Stylurus laurae	Laura's clubtail	G3G4	
Stylurus scudderi	Zebra clubtail	G3	

Table 2.4.1 (cont.) Threatened, endangered, and special concern (TE&SC) species used in section 2.4 of this report. These species are either federally listed as endangered (E), threatened (T), proposed endangered (PE), category 1 (1) candidate, or former category 2 (2) candidate or globally ranked as G1, G2, G3, or a variant (see glossary for descriptions of global ranks) by The Nature Conservancy. All species were in the heritage programs database and occur within the SAA area boundary.

Scientific Name	Common Name	Global Rank	Federal Rank
Other Invertebrates			
Antrolana lira	Madison Cave isopod	G1	T
Caecidotea carolinensis	Bennett's Mill Cave water slater	G?	2
Caecidotea henroti	Henrot's cave isopod	G2	
Caecidotea holsingeri	Greenbriar Valley cave isopod	G3	
Caecidotea incurva	Incurved cave isopod	G2	
Caecidotea pricei	Price's cave isopod	G3	
Caecidotea richardsonae	Tennessee Valley cave isopod	G3G5	
Caecidotea sinuncus	An isopod	G1	2
Caecidotea vandeli	Vandel's cave isopod	G2	
Cambarus chasmodactylus	New River riffle crayfish	G3G4	
Cambarus crinipes	Bouchard's crayfish	G3?	
Cambarus extraneus	Chickamauga crayfish	G3	2
Cambarus obeyensis	Obey crayfish	G3?	2
Cambarus reburrus	French Broad crayfish	G2G3	2
Lirceus culveri	Rye Cove isopod	G1	2
Lirceus usdagalun	Lee County cave isopod	G1	E
Macrocotyla hoffmasteri	Hoffmaster's cave flatworm	G3	
Sphalloplana chandleri	Chandler's planarian	G1	
Sphalloplana consimilis	Powell Valley planarian	G1G2	
Sphalloplana virginiana	Rockbridge County cave planarian	G1	2
Stygobromus abditus	James cave amphipod	G1	
Stygobromus baroodyi	Rockbridge County cave amphipod	G2	
Stygobromus biggersi	Bigger's cave amphipod	G1G2	2
Stygobromus carolinensis	Yancey sideswimmer	G?	2
Stygobromus conradi	Burnsville Cove cave amphipod	G1G2	2
Stygobromus cumberlandus	Cumberland cave amphipod	G2	
Stygobromus ephemerus	Ephemeral cave amphipod	G1	
Stygobromus estesi	Craig County cave amphipod	G1	
Stygobromus gracilipes	Shenandoah Valley cave amphipod	G2	
Stygobromus hoffmani	Alleghany County cave amphipod	G1	2
Stygobromus interitus	New Castle Murder Hole amphipod	G1	
Stygobromus leensis	Lee County cave amphipod	G1	
Stygobromus morrisoni	Morrison's cave amphipod	G2	2
Stygobromus mundus	Bath County cave amphipod	G1G2	2
Stygobromus pseudospinosus	Luray Caverns amphipod	G1	
Stygobromus sp 7	Sherando spinosoid amphipod	G2	
Stygobromus spinosus	Blue Ridge Mountain amphipod	G2	
Stygobromus stegerorum	Madison Cave amphipod	G1	
Stylodrilus beattiei	A cave lumbriculid worm	G1G2	

federal and global rankings (fig. 2.4.1). Nearly 90 percent of mollusc and 53 percent of fish TE&SC species were ranked by FWS. Among insects, only 27 percent were ranked by FWS, and they were all formerly C2, not enough persuasive information was available to warrant FWS listing as threatened or endangered. The number of herptile species was limited because only aquatic salamanders and turtles were included and because relatively little effort is directed to these groups. The herptiles that had FWS ranks were all formerly C2, and more persuasive information is needed for FWS listing as threatened or endangered.

Molluscs and fish had the largest number of FWS -listed species, reflecting both higher effort and higher numbers of species at risk. Both of these groups exhibit high degrees of endemism in the SAA area, a major factor in species endangerment (Williams and others 1989; Neves 1991; Warren and Burr 1994; Flather and others 1994). In the United States, out of about 800 fish species, 254 species that are rare enough to warrant protection have been identified (Williams and others 1989). In the Southern Appalachians (defined to include more than the SAA area, but to exclude SAA areas north of the Roanoke and New Rivers), there are about 350 fish species, 64 of which are imperiled (Walsh and others 1995). Among the molluscs, the freshwater mussel fauna is of particular concern: of 297 native mussel species in the United States and Canada, 21 are believed extinct, 77 endangered, 43 threatened, and 72 of special concern (Williams and others 1993). Diversity of mussels in the Southeast is not only the highest in the world, but the percentage of species now imperiled exceeds 50 percent for all SAA states except West Virginia, where 46 percent are imperiled (Williams and Neves 1995).

To determine regional patterns of distribution, numbers of TE&SC species observed in the EOR data set for each county were counted and results plotted on maps (fig. 2.4.2). Similar plots were produced for fish and molluscs separately (figs. 2.4.3, 2.4.4). The four categories in figures 2.4.2-2.4.4 were selected to identify the 8 to 10 counties with the greatest number of TE&SC species.

Ten counties had 16 to 41 TE&SC species in the EOR data set: 6 counties in the Powell and Clinch river drainages; Knox, Anderson, and Roane Counties, Tennessee; and Monroe County, Tennessee, (fig. 2.4.2). The Clinch, Holston, and Powell river drainages have large numbers of TE&SC species of all kinds, and consequently, these are also areas of much scrutiny. These areas in the upper portions of Tennessee River drainage, on the Cumberland Plateau, are geologically old and isolated, a condition that favors speciation. These areas continue to have a rich fauna of both fish and mussels (Starnes and Etnier 1986; Neves 1991). Knox and Anderson, and to a lesser extent, Roane Counties in Tennessee include both urban areas of Knoxville and Oak Ridge and impounded portions of the Tennessee River drainage (e.g., Watts Bar Lake). In these counties, some of the EORs are of historical sightings, and some species are no longer found there. Nonimpounded portions of the Tennessee River drainage above impoundments and in the Clinch and Powell river drainages may be important locations of TE&SC species. Monroe County, Tennessee, is a largely rural

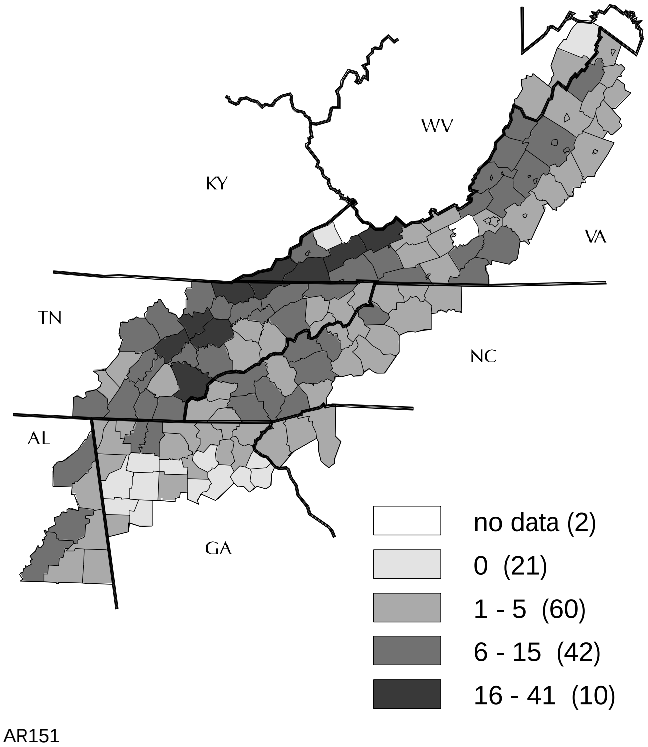


Figure 2.4.2 Spatial distribution of all TE&SC species among counties. Numbers in parentheses denote the number of counties in the given occurrence class.

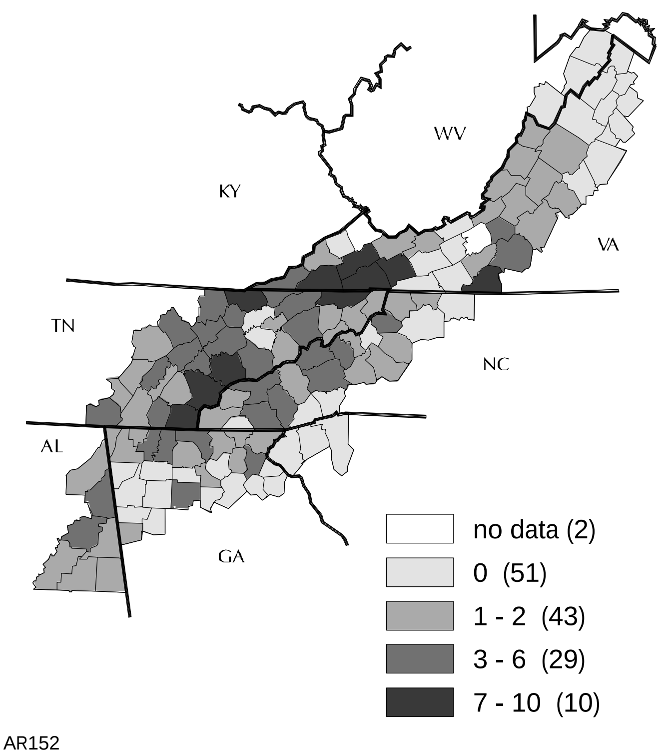


Figure 2.4.3 Spatial distribution of TE&SC fish species among counties. Numbers in parentheses denote the number of counties in the given occurrence class.

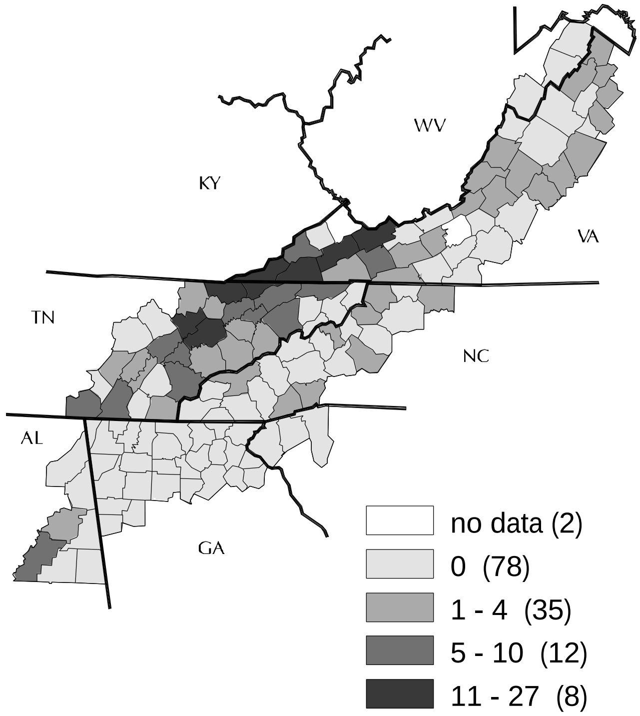


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Figure 2.4.4 Spatial distribution of TE&SC mollusc species among counties. Numbers in parentheses denote the number of counties in the given occurrence class.

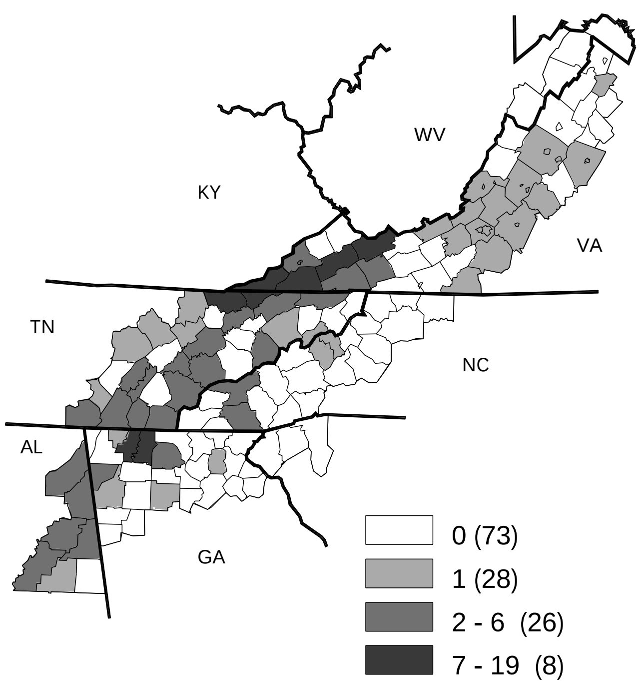

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Figure 2.4.5 Spatial distribution of federally listed threatened and endangered aquatic species known to occur in the SAA-area counties. Numbers in parentheses denote the number of counties in the given occurrence class.

area which includes portions of the Cherokee National Forest and upper portions of Tellico Lake.

A closer look at the heritage program EOR data reveals that the EOR observation dates and sampling effort may influence the overall pattern in figure 2.4.2. The year each species was last observed in each county can be identified. Had this analysis been restricted to only the most recent dates, useful patterns would not have been detectable because the data set would be too small. For Anderson County, Tennessee, only 2 out of 17 species were last observed in the past 20 years (1975 to 1995). Likewise, only 4 out of 21 species in Knox County, Tennessee; 7 out of 16 species in Roane County, Tennessee; and 6 out of 16 species in Monroe County, Tennessee, have been observed in the past 20 years. In the six counties in the Powell and Clinch river drainages with at least 16 TE&SC species, at least two-thirds of the TE&SC species have been observed in the past 20 years. Thus, some of the TE&SC species may have been extirpated from these counties, especially in the areas around Knoxville. However, this conclusion is by no means certain, because sampling effort is not uniform through time and space. For example, one species in Anderson County was observed in 1995, but in Hancock County, Tennessee, 24 out of 26 species (92 percent) have been observed since 1975 and none have been observed since 1980. Which county currently has more TE&SC species? Which has more extirpated species? Have people given up looking for TE&SC species around Knoxville because the area is so urbanized and it seems a wasted effort? Has anyone sampled in remote Hancock County in the past 15 years? Without additional information about how sampling effort was expended over time and across the region, these results should be taken with some caution. Those seeking to focus conservation efforts should examine all available evidence.

The FWS files on known and possible occurrences of threatened, endangered, and proposed threatened or endangered aquatic species were compiled by Herrig (1995) into a data set that identifies these species for each county. This data set contains information on 46 species known to occur in the SAA area and 7 additional species whose occurrence is “possible.” As was done with the TE&SC species in the EOR data set, numbers of known threatened, endangered, and proposed threatened or endangered species were counted for each county and the results plotted on a map (fig. 2.4.5). Although all 135 SAA counties had at least one known or possible occurrence, only 62 counties had known occurrences of these species (fig. 2.4.5). Eight counties had 7 to 19 known occurrences (fig. 2.4.5). Six of these counties were the same counties in the Powell and Clinch river drainages that were identified in the EOR data set (figs. 2.4.2 and 2.4.5). The other two counties, Murray and Whitfield in Georgia, are primarily in the Conasauga River drainage, another area known for its diversity. The urban areas around Knoxville, TN, identified in the EOR data set, do not have large numbers of known species occurrences in the FWS data set. But, if possible occurrences in the FWS data set are also included, Knox County has the second or third highest (tie) count of species in the SAA area. Further comparison of the distribution patterns from the EOR and FWS data sets, as well as another published by Flather and others (1994), is beyond the scope of this report and will be reported separately.

Ten counties with 7 to 10 TE&SC fish species in the EOR data set were scattered in four areas: the Clinch River, VA, and upper Holston River, VA and TN; Patrick County, Virginia; Claiborne County, Tennessee, in the Powell River drainage; and Polk, Monroe, and Blount Counties, Tennessee (fig.2.4.3). Patrick County, Virginia, is a largely rural area on the east slope of the Blue Ridge. Polk County, Tennessee, was the site of historically intense copper mining and soil and water acidification due to processing of mined copper. Blount County, like Monroe County, Tennessee, has some rural areas near the Great Smoky Mountains National Park, but also has urban areas around Maryville. About one-third of Blount County is in the Great Smoky Mountains National Park, where efforts are underway to restore several federally listed species in at least one stream (Moore 1995). But these concentrations of species may simply represent greater collecting effort: Streams in these four counties (Patrick, Polk, Blount, and Monroe) are known to be frequently surveyed for fish by several individuals because streams harbor species of intense interest or have many endemic species. Warren and others (1995) provide further discussion of fish imperilment patterns for the Southeast.

Eight counties with 1 to 27 TE&SC mollusc species in the EOR data set were in two areas: six counties in the Powell and Clinch river drainages of Virginia and Tennessee and Knox and Anderson counties, the urban area of Knoxville and Oak Ridge, TN (fig. 2.4.4). The Tennessee River drainage, in general, has a large number of mollusc species (Neves and others 1995). These areas still have highly diverse and endemic fauna, harboring a number of TE&SC mussel species (Neves 1991; Neves and others 1995). The Clinch Valley Bioreserve (encompassing the Pendleton Island Reserve on the Clinch River) is one of The Nature Conservancy's Last Great Places, because it harbors mussels and other fauna.

Causes of species loss are difficult to sort out because several factors contribute to each lost species, the factors differ for each species, and we rarely observe the extinction of a species. Some extinctions are gradual over time and space. Other losses go unnoticed because so little is known about many species. Anthropogenic factors have been implicated, including loss and degradation of physical habitat, sedimentation, impoundments and other physical barriers, chemical pollution, introduction of exotic species, and overexploitation of species. Ecological attributes of individual species, like diadromy (species migrate from fresh to salt water or vice versa), limited geographic range, limited range of stream size, and ecological specialization, also contribute to loss of species (Angermeier 1995). Catastrophic events also can contribute, especially where a species has a limited geographic range (some species are limited to single springs or seeps).

The Powell River drainage is an area in which coal mining and associated effects of acid mine drainage and increased sedimentation have contributed to endangerment of molluscs (Neves and others 1995). Impoundment of rivers and degradation of water quality have been implicated in the loss of mussel species in the Tennessee River (Neves and others 1995). Other factors that may cause loss of mussels and freshwater snails include nonpoint pollution, especially sediments; waste discharge, especially toxics that accumulate in mussel tissue over time; reduced stream flow; loss of host fish species (an early life stage of mussels must live attached to the gills of a particular fish species); habitat loss and degradation, including loss of riparian buffer strips; and dredging and channelization (Neves and others 1995). In the SAA area, exotic zebra mussels (*Dreissena polymorpha*) have been seen in the Tennessee River up to Knoxville and in the lower 2 miles of the French Broad River. Zebra mussels can be expected to contribute to mollusc declines in the future as they spread to other areas (Neves and others 1995). Zebra mussels attach themselves to native molluscs, preventing them from respiring and feeding, and eventually kill the mollusc.

Likely Future Trends

Certain future trends are obvious. But, with the analysis of the current situation, trends that reflect the process of species imperilment, per se, must be separated from trends that represent the human process of identifying imperiled species.

Both the FWS and heritage program lists will tend to grow longer over time – new species are identified more rapidly than other species are removed from lists. Between 1979 and 1989, none of the 251 North American fish species identified by the American Fisheries Society as threatened, endangered, or of special concern was removed from their list because recovery was successful, 16 were removed because of better information, and 10 became extinct (Williams and others 1989). In that same time, 139 new species were added (Williams and others 1989). In the Southeast, the number of imperiled fish species recognized by the FWS has risen from 3 in 1974 to 84 in 1994 (Walsh and others 1995). All states in the SAA area have a backlog of species recognized by fisheries professionals as threatened or endangered, but which are not federally listed (Warren and Burr 1994). These historical trends will probably continue. If the Endangered Species Act is not reauthorized, of course new species will not be listed by the FWS (there is already a moratorium on listing new species after March 1995, and the C2 list was eliminated in July 1995). But, species will be no less endangered by not being federally listed, and they will still be of concern to heritage programs and others.

Will more species in the SAA area become endangered over time? Probably. Extinctions and endangerment, have always occurred, although not at the current rate (Wilson 1988), and they will probably continue. But, to speculate further on the future trend of endangerment patterns requires complex considerations of biological, cultural, economic, and political concerns well beyond the scope of the analysis we conducted.

2.5 STATUS OF TROUT POPULATIONS

Introduction

The status of trout and trout habitat in the Southern Appalachians, where trout are near the southern edge of their range, is a major concern raised during the SAA public comment period. Many people want to fish for native brook trout, naturalized rainbow and brown trout, or stocked individuals of all three species. Others find the native brook trout to be a beautiful fish and want assurances that its continued existence is secure. Still others see trout as indicators of high water quality.

Three species of trout live in the SAA area: the native brook trout (*Salvelinus fontinalis*), introduced rainbow trout (*Oncorhynchus mykiss*), and introduced brown trout (*Salmo trutta*). Originally, brook trout were distributed down the spine of the Southern Appalachian Mountains through western Virginia and North Carolina, and eastern Tennessee to northwest South Carolina, and northeast Georgia, which is the southern edge of the range of the species (MacCrimmon and Campbell 1969). Stocking programs have not significantly extended this range. Rainbow trout and brown trout were introduced to the region in the late 19th and early 20th centuries. Historical attempts have been made to introduce other salmonids, but other than occasional reports of kokanee (*Oncorhynchus nerka*) and lake trout (*Salvelinus namaycush*) from certain reservoirs, none of these attempts appear to have succeeded.

In the Great Smoky Mountains and neighboring areas of Tennessee, introduced rainbow trout have been successful at lower elevations. Between the 1900s and the present, brook trout have been increasingly restricted to upper headwater reaches (King 1937; Kelly and others 1980; Bivens and others 1985; Larson and Moore 1985). Brook trout now occur at the highest elevations and rainbow and brown trout at lower elevations with up to several kilometers of sympatric coexistence between the allopatric sections (Bivens and others 1985; Larson and Moore 1985).

These patterns do not hold completely for the region–trout tend to be distributed along latitudinal and elevational gradients (Meisner 1990; Flebbe 1994). Brook trout generally live at higher elevations than rainbow or brown trout; however, proceeding north, the average elevation at which brook trout live declines more rapidly than that for the other two species (Flebbe 1994). In the northern portions of the SAA area, around Shenandoah National Park, brown trout are quite rare, rainbow trout are only marginally successful, and brook trout are widely distributed and abundant (Lennon 1961; Mohn and Bugas 1980; Flebbe 1994). Sympatry of trout species becomes less common to the north (Flebbe 1994). Allopatric brook trout, the native condition, remains most common and abundant in the SAA region as a whole (Flebbe 1994).

Stocking programs are largely run by the states and very few streams in the SAA have never been stocked. Stocking of fingerlings and adult trout of all three species continues into the present.

Recently, two putative strains of brook trout have been recognized in the Southern Appalachians: a southern form and a northern form introduced through hatcheries and stocking (Stoneking and others 1981; McCracken and others 1993). The two forms can be distinguished with modern genetic methods. In at least some streams where northern brook trout were stocked on top of existing southern brook trout, hybridization between the two has been found (McCracken and others 1993). Current research efforts are aimed at determining geographic patterns in distribution of the northern, southern, and hybrid forms (Kriegler and others 1995; Strange and Habera 1995; McCracken 1995). In Tennessee, northern brook trout appear to be more common in streams located near hatcheries (Strange and Habera 1995). However, stocking records have not proven to be reliable predictors of genetic status of brook trout in individual streams (Kriegler and others 1995).

Key Findings

- Of the 37.4 million acres in the SAA area, 14.6 million acres are in the range of wild trout. Trout also live in some areas of the Southeast outside the SAA area.
- Of the total 33,088 miles of potential wild trout streams in the SAA area, 7 percent are in West Virginia, 39 percent are in Virginia, 10 percent are in Tennessee, 32 percent are in North Carolina, 2 percent are in South Carolina, 10 percent are in Georgia, and none are in Alabama.
- Of the total 33,088 miles of potential wild trout streams in the SAA area, 7,975 miles are in areas under Forest Service management and 1,634 miles are under National Park Service management.
- Of the total 33,088 miles of potential trout streams in the SAA area, 2,431 miles are in roadless areas and 846 miles are in wildernesses.
- An additional 1,337 miles of stocked trout streams are found outside the wild trout range boundary. An unknown portion of the streams within the wild trout range are stocked.
- Approximately 59 percent of wild trout streams are in counties that are highly vulnerable to acidification and 27 percent are in areas moderately vulnerable to acidification. Most of the highly vulnerable areas are in the northern parts of the SAA area, where brook trout are more common than rainbow and brown trout.
- Most Virginia and West Virginia wild trout streams are in counties that have reported hemlock wooly adelgid infestation.
- Twenty-six reservoirs greater than about 1 square mile in the SAA area contain trout: 15 are stocked with trout, primarily rainbow trout; 8 contain incidental wild trout from past stockings or tributary streams; and trout may occur in 3 additional private reservoirs.

Data Sources

No existing data sets were adequate for producing a GIS map that depicts current status of trout for the whole SAA area and could be the basis for analysis. States use various criteria based on fish sampling programs and water quality criteria to delineate “trout waters.” Waters meeting states’ water quality criteria for trout water are generally acknowledged by fisheries biologists to include waters that cannot and do not currently support trout, because the criteria often include only water temperature, and possibly dissolved oxygen, measured at limited points in time and space. Other habitat characteristics and interactions with other species preclude trout where temperature might be adequate. State fish and wildlife agencies, which have primary responsibility for fish on national forest lands, conduct stream inventories. However, their methods and timing differ, and states sample only a small, nonrandom portion of their total stream mileage (Mohn and Bugas 1980; Bonner 1983; Strange and Habera 1995). Streams on private lands are rarely inventoried. The Great Smoky Mountains National Park has conducted surveys of its trout streams since the 1930s (King 1937; Lennon 1967; Kelly and others 1980; Larson and Moore 1985; Moore 1995). These data sources were starting points for drawing the maps.

Two maps were constructed for trout at the 1:2,000,000 scale because data and resource constraints prevented a more detailed map. Both maps represent potential trout distribution. Also, because of this broad scale and the sometimes patchy nature of distributions of individual species, all three trout species were combined into single distributions.

State inventory data (Fatora and Beiser 1980; Mohn and Bugas 1980; Bonner 1983; Strange and Habera 1995), state water-quality data, and expert opinion were used to draw a boundary around the wild trout area.

Table 2.5.1 Summary statistics for trout in the Southern Appalachian Assessment (SAA) area. In this table, "wild trout streams" refers to potential wild trout streams in this report and to actual wild trout (unstocked) streams in the other reports cited.

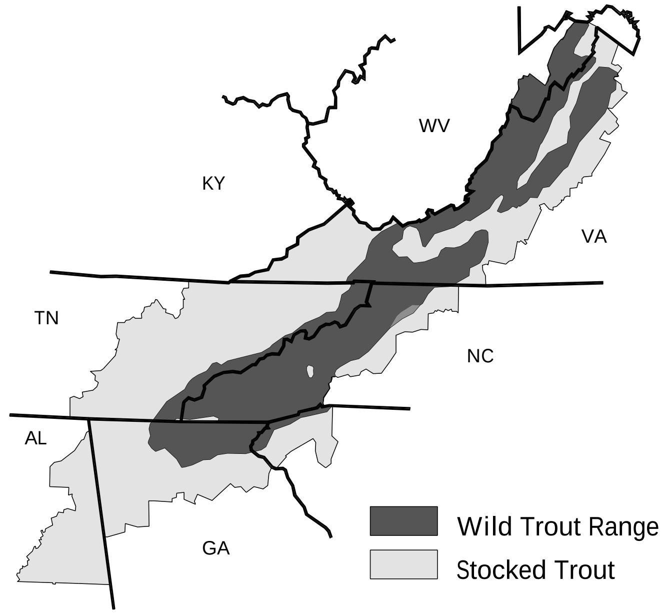
	This Report	Other Reports
Total Miles		
Total square miles in SAA	58,477	
Total square miles in wild boundary	22,785	
Total stream miles in SAA	83,614	
Potential wild trout stream miles	33,088	6,189[1]
Additional stocked trout stream miles	1,337	5,044[1]
Wild Trout Streams by Ownership		
Wild trout stream miles in Forest Service ownership	7,975	
Wild trout stream miles in National Park Service ownership	1,634	
Wild trout stream miles in Native American (Cherokee) ownership	102	
Wild trout stream miles in state ownership	345	
Wild trout stream miles in DOE or military ownership	1	
Wild trout stream miles in other ownership	23,031	
Wild Trout Streams by State		
West Virginia wild trout stream miles	2,230	
Virginia wild trout stream miles	12,980	977[1]
Tennessee wild trout stream miles	3,273	583[1]
		839[2]
North Carolina wild trout stream miles	10,543	1,319[1]
South Carolina wild trout stream miles	632	181[1]
Georgia wild trout stream miles	3,429	2,393[1]
Wild Trout Streams by Acid Sensitivity		
Wild trout stream miles, high sensitivity to acidification	19,503	
Wild trout stream miles, medium sensitivity to acidification	9,046	
Wild trout stream miles, low sensitivity to acidification	4,534	
Wild trout stream miles where no data on sensitivity to acidification	4	
Wild Trout Streams in Protected Areas		
Wild trout stream miles in roadless areas	2,431	
Wild trout stream miles in wildernesses	846	

[1](Source: Habera and Strange, 1993 [North Carolina and Tennessee figures don't include 736 miles in Great Smoky Mountains National Park])

[2](Source: Strange and Habera, 1995)

Whenever possible, a consensus on all boundaries was achieved among experts. To identify additional wild and stocked streams outside the wild trout boundary, the same experts and several state publications were consulted (West Virginia Division of Natural Resources (WVDNR) 1989; Tennessee Wildlife Resources Agency (TWRA) 1994; Georgia Department of Natural Resources (GADNR) 1995; Mohn 1995).

Reservoirs and lakes in the SAA area also have trout. Many small impoundments and one or two natural lakes occur within the SAA area; for these, the assumption was that if they are within the wild trout boundary, they potentially have wild trout. Outside the trout boundary, we assumed that small impoundments lack trout. Reservoirs in the SAA area that are greater than about 500 acres (about 1 square mile) and have trout were identified from maps, publications (TWRA 1989; Mohn 1995), and experts.



AR160

Figure 2.5.1 Wild trout range boundaries in the SAA area. Stocked streams and a few isolated wild trout streams exist outside this boundary. The wild distribution extends northward to Maryland and beyond and westward into West Virginia from the SAA area.

Analysis, Spatial Patterns, and Trends

Two GIS layers were produced: 1) a wild trout range map with a boundary that encompasses areas in which trout populations are reproducing, generally without stocking supplementation at this time (fig. 2.5.1); and 2) a trout stream map in which individual streams in the RF 3 file (sec. 2.1) were identified as either occurring within the wild trout boundary (wild) or as additional wild or stocked streams outside the boundary. Some streams within the wild trout area are stocked from time to time, a few streams are stocked regularly (usually "put and take"), and some do not have trout. However, most streams within the area have reproducing trout populations. Even so, if a stream in the RF 3 file is within the wild trout boundary, it was identified as wild. The wild trout streams in this layer are properly called potential wild trout streams. Identified stocked streams are all outside the wild boundary and are maintained by stocking programs. No wild trout are known in Alabama, and all stocked trout fisheries in Alabama are outside the SAA area.

The wild trout range map layer (fig. 2.5.1) provides an estimate of the total land area in which self-sustaining trout may be found (table 2.5.1). Approximately 39 percent of the SAA area is in the range of wild trout (table 2.5.1). Nearly 40 percent of all streams in the SAA area potentially support wild trout and an additional 2 percent outside the wild trout boundary and within the SAA boundary are stocked (table 2.5.1). All estimates of potential wild trout stream mileage are overestimates of actual wild trout stream mileage because estimates are based on the range map we produced and not on inventories. Stocked mileage are underestimates because stocked streams within the wild trout boundary were not identified.

Most reservoirs in the SAA area are managed for warm or cool water fisheries, not trout. Of the reservoirs that have trout, most are stocked. Others have incidental wild trout (table 2.5.2), usually because they were stocked in the past or because tributaries to the reservoir have trout (Borawa 1995). The only evidence that trout live in some of these reservoirs is occasional reports of anglers (Borawa

Table 2.5.2 Reservoirs in the Southern Appalachian Assessment (SAA) area greater than about 500 acres (about 1 square mile) with trout. Other reservoirs in the SAA area without trout are not listed.

State	Reservoir/Lake	Species[1]	Status[2]
Virginia	John Flannagan Reservoir	RBT, BNT	S
Virginia	Lake Moomaw	RBT, BNT	S
Virginia–Tennessee	South Holston Reservoir	RBT	S
Tennessee	Tellico Reservoir	RBT	S
Tennessee	Watauga Reservoir	RBT, LT	S
Tennessee	Patrick Henry Reservoir	RBT	S
Tennessee	Chilhowee Reservoir	RBT	S
Tennessee	Parksville Lake	RBT	S
Tennessee	Wilbur Reservoir	RBT	S
Tennessee–North Carolina	Calderwood Reservoir	RBT, BNT	S
North Carolina	Nantahala Lake	RBT, BNT, KOK	IW
North Carolina	Lake Santeetlah	RBT	IW
North Carolina	Fontana Lake	RBT, BNT	IW
North Carolina	Lake Cheoah	RBT, BNT, BKT	S
North Carolina	Glenville Reservoir (Thorpe Lake)	RBT	IW
North Carolina	Bear Creek Lake	RBT, BNT, BKT	S
North Carolina	Lake Toxaway	RBT	P
North Carolina	Wolf Creek Reservoir	RBT	S
North Carolina	Lake James	RBT	IW
North Carolina–Georgia	Chatuge Lake	RBT	IW
South Carolina	Lake Jocassee	RBT, BNT	S
South Carolina	Table Rock Lake	RBT	P
South Carolina	North Saluda Reservoir	RBT	P
South Carolina–Georgia	Tugaloo Lake	BNT	S
Georgia	Lake Lanier	RBT	IW
Georgia	Lake Burton	RBT	IW

[1]BKT = brook trout
BNT = brown trout
KOK = kokanee
LT = lake trout
RBT = rainbow trout

[2]Status:
S = presently stocked
IW = Incidental “wild”, often migrating from tributary streams
P = private, status not known

(Source: Information obtained from TWRA, 1994, Borawa, 1995, Durniak, 1995, Geddings, 1995, and Mohn, 1995)

1995). Reservoirs managed for trout by active stocking are usually well-publicized (TWRA 1994; Mohn 1995). Trout status was not determined in the small number of private reservoirs (table 2.5.2).

For analysis, the trout stream layer was used to provide stream mileage estimates (table 2.5.1) only for potential wild trout streams. Many of the identified additional stocked streams are in extremely marginal areas where survival of trout beyond a few days or a single season is not expected.

First, the total mileage of potential wild trout was partitioned among ownerships: Forest Service, National Park Service, other federal, Native American, state, and all other ownerships (mostly private). Most (70 percent) potential wild trout streams were on private lands; only 24 percent were on Forest Service and 5 percent were on National Park Service lands (table 2.5.1). Second, the total mileage was partitioned among the six states. North Carolina (32 percent) and Virginia (39 percent) had the greatest mileage of potential wild trout streams. Mileages from this analysis were generally higher than mileages cited from other studies in table 2.5.1 because those studies were concerned with actual rather than potential wild trout stream miles, and many privately owned streams were not included in the estimates. Habera and Strange (1993) reported a different proportion of the total stream mileage in each state because their estimates were based on criteria that differed for each state. For example, the estimate for Georgia was based on stream temperature (Fatora and Beisser 1980) while estimates for the other states were expanded from inventories of public waters. Thus, although the SAA estimate of potential wild trout stream mileage was much higher than actual wild trout stream mileage would be, the allocations among the states were probably more accurate than previous reports.

A number of analyses could be produced to illustrate how these two GIS layers can be used with others in the assessment to answer questions about effects on trout. Other analyses might also address effects of current trout distribution on other resources (e.g., recreational opportunities). To illustrate, three such analyses will be discussed: areas vulnerable to acidification, defoliation by gypsy moth, and infestation by hemlock wooly adelgid.

The SAA area was partitioned into areas of high, medium, and low sensitivity to acidification (section 2.3). The resulting GIS polygons were used to partition the wild trout stream mileage into the same categories of sensitivity (table 2.5.1). A map (fig. 2.5.2) was produced to show the distribution of these sensitivity categories within the wild trout range. Most of the highly sensitive streams were in the northern portion of the wild trout range in the SAA area (fig. 2.5.2). The primary concern for trout is that acidification causes aluminum in soils to be more soluble in water. When the soluble inorganic aluminum reaches streams, trout and other fish are exposed to this aluminum, which is toxic to them. At least one fish kill of recently stocked rainbow trout due to acid precipitation has been documented in the SAA area (Hudy 1994). Brown and rainbow trout are sensitive at slightly higher pH values than are brook trout. Although brook trout are more common in the areas highly sensitive to acidification, their greater tolerance of acidification is too slight to make a real difference in survival over the long term.

Gypsy moth and hemlock wooly adelgid are two insect pests that are invading the SAA area (see Terrestrial Technical Report [SAMAB 1996b]). These two pests are of concern to trout for different reasons. The gypsy moth causes widespread defoliation in watersheds, including riparian areas, because its preferred food source is oak, common in the mountain forests of the region, and the moth easily switches to other tree species when oak is not available. Hemlock wooly adelgid is specific to hemlock, but hemlock is a major component of riparian areas in the mountains.

Whether activities of these two pests are detrimental to trout or not depends on a variety of complex interactions, including increased water temperatures because more sunlight reaches streams, changes in timing and amount of trout food, and increased large woody debris habitat after trees die and fall into the stream. Gypsy moths have defoliated increasing amounts of Virginia forests since 1986. Projections are that gypsy moths will move southwestward through the SAA area, potentially affecting more and more of the watersheds that have trout in them (see Terrestrial Technical Report [SAMAB 1996b]. Hemlock wooly adelgid has been reported in nearly all counties of West Virginia and Virginia and in Surry County, North Carolina within the SAA area and in other counties outside the SAA area (see Terrestrial Technical Report [SAMAB 1996b]). The SAA counties in Virginia that do not yet have hemlock wooly adelgid are in the far southwest, beyond the range of wild trout. Hemlock wooly adelgid is moving south at a rate of 20 to 40 miles per year and perhaps more slowly to the west (Brown 1995). Eventually, this pest could affect the entire SAA area. Hemlock is a dominant and long-lived resident of riparian areas, and the effects of hemlock loss on stream systems and trout are potentially complex.

Likely Future Trends

Future trends for trout are difficult to predict from historical and current patterns because past practices that contributed to the present situation are unlikely to occur. These practices include wholesale stocking of exotic species and clearing of forest land for conversion to agriculture. The following discussion is not intended to be complete nor to imply that predictions can be made from these analyses, but to speculate on trout responses to certain recent or predicted regional trends.

Allocation of forested land to second and retirement home communities has increased in the past few years and may be expected to continue into the future as the “baby boom” generation reaches retirement age. On a regional scale, relative abundance of trout is higher in watersheds with large areas in hardwood forest more than 50 years old and small areas in human and crop land uses (Flebbe and others 1988). In addition to declines in trout habitat that may accompany land use conversions, expectations are for the growing population that occupies these homes to exert greater angling pressure on trout–those who are retired or visiting second homes will have more time to fish than those who must earn a living, and there will be more of them.

Fine sediment has been implicated as a cause of low trout productivity because fine sediment may suffocate or trap developing eggs and embryos in the substrate, alter the amount and kind of food organisms that live in the substrate, limit the amount of habitat available for cover and nest building, or inhibit visual feeding by trout. Brook trout seem especially susceptible to these effects. If ongoing efforts to limit the amount of fine sediment that reaches streams become successful, increased trout abundance in streams is possible. In addition, brook trout might return to stream sections from which they have been eliminated by an excess of fine sediment. Significant extensions of the overall range of trout are unlikely because other factors probably limit trout at the range boundary.

If the trend for increasing acidification noted above (section 2.3) continues, greater impacts on trout might be expected. Brown and rainbow trout are slightly more vulnerable than brook trout to acidification, therefore some streams might regain allopatric brook trout status. But the differences are small, and these streams may also lose their brook trout. Loss of brown and rainbow trout, with concomitant decline in brook trout abundance and shifts in trout food resources, have been noted in Virginia’s acid-sensitive St. Mary’s River (Mohn and others 1989; Flebbe, 1995). A number of mitigation efforts involving treatments with lime are underway, but would be costly on a regional scale.

If predictions for global climate changes due to greenhouse gases are realized, there may be changes in temperature, precipitation, and streamflow. Regional estimates of effects of global change are highly speculative; but, if it is assumed that temperatures in the Southern Appalachians may increase, minimum elevations at which brook trout can live would probably increase for much of the SAA area (Meisner 1990). Habitat for brook trout would become more fragmented as the range shrinks into “island” near the tops of mountains (Flebbe 1993). Further, with increasing elevation, streams branch into smaller streams that may be too small for brook trout, further limiting and fragmenting the brook trout distribution. Brook trout restoration – the reintroduction of native brook trout to streams that now have either exotic trout species or northern-form brook trout – has been attempted in several streams (Moore and others 1986; Strange and Habera 1995). Restoration has already increased Tennessee’s trout resource over the last three decades (Strange and Habera 1995). Particular interest has developed in restoration with native

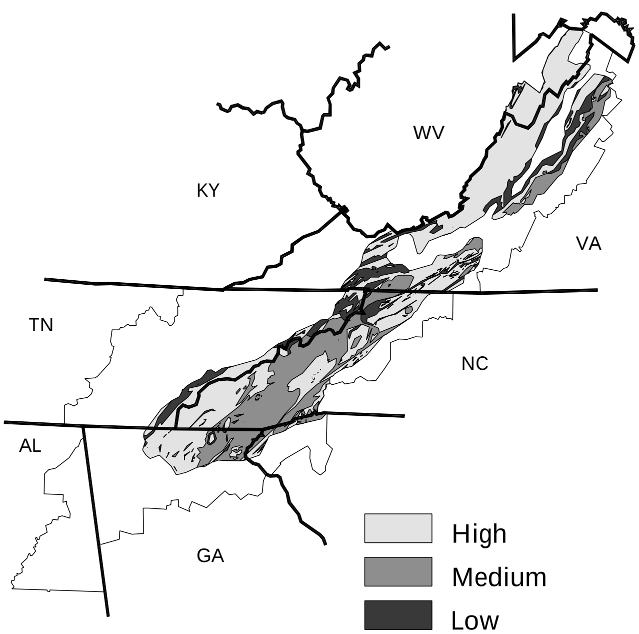


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Figure 2.5.2 Areas within the SAA area wild trout range of high, medium, and low sensitivity to acidification.

southern brook trout. The southern, native brook trout shows substantial genetic variation, even between nearby streams (McCracken and others 1993; Kriegler and others 1995). But, with the assistance of modern genetic tools, prudent restoration can be conducted, restoring populations in target streams from sources most likely to be genetically appropriate (Kriegler and others 1995). These restoration efforts may achieve success in some individual streams, possibly mitigating negative effects of other trends, but they will not extend the range of trout in general.

2.6 OTHER AQUATIC SPECIES AT RISK

Introduction

The Southern Appalachian Mountain region has one of the richest aquatic faunas in the country. The high diversity of species is a result of the unique geological, climatological, and hydrological features of the region. Information relative to aquatic species has always been available on an individual state basis, but not collectively for the SAA area. This report broadens the scope by analyzing current status for the region and determining a base for future trends within the SAA area.

"Other aquatic species" is a collective term that includes species designated by states as "threatened and endangered," "special concern," "sensitive," or "rare," but which are not listed by the FWS as threatened, endangered, proposed, or candidate (C1 or C2); nor ranked by The Nature Conservancy as G1, G2, or G3; nor are trout species. These species are addressed in sections on TE&SC aquatic species (section 2.4) and trout (section 2.5). Other aquatic species at risk – fish, molluscs, aquatic insects, aquatic crustaceans, and aquatic and semiaquatic salamanders and turtles are included in this section. The list of other aquatic species is a selective one and by no means represents all species in the SAA area. A complete analysis of all aquatic species was not possible.

Key Findings

- Out of a total of 260 selected other aquatic species in the SAA area, there are 97 fish, 25 mussel, 1 snail, 2 crayfish, 111 insect, 17 salamander, and 7 turtle species.
- Approximately 70 percent of the selected fish species occur at the edge of their range in one or more SAA states.
- Fish that are categorized as TE&SC species (table 2.4.1) or as other aquatic species (table 2.6.1) comprise about 45 percent of the total number of fish species in the SAA area.
- Mussels that are categorized as TE&SC (table 2.4.1) or as other aquatic species (table 2.6.1) comprise about 50 percent of the total number of mussel species found in the SAA area.
- Location information is sparse for aquatic insects.

Data Methods and Analysis

A species list was compiled from the following sources: each of the SAA state natural heritage programs; USDA Forest Service databases for sensitive species; the USDA Forest Service Southern Region Aquatic Species Being Reviewed for Sensitive Species Designation that Occur on the SAA National Forests; and The Nature Conservancy Endemics and Near-Endemics of the Southern Blue Ridge of North Carolina, Virginia, Tennessee, Georgia, and South Carolina. The TE&SC species (table 2.4.1) and trout were removed from this list of other aquatic species. The list was distributed to 47 reviewers familiar with fauna in the SAA area for comments, and species were added and deleted from the list based on the 22 responses received. Additional insect species were included from a study, Southern Appalachian Streams at Risk: Implications for Mayflies, Stoneflies, Caddisflies, and Other Aquatic Insects (Morse and others 1993).

Table 2.6.1 contains the scientific and common name of each species, the SAA states where the species is included on range maps, and The Nature Conservancy global rank (see rank) of each species, where applicable. Fish and mollusc scientific and common names follow American Fisheries Society publications (Turgeon and others 1988; Robins and others 1991), except for species described after publication dates.

Table 2.6.1 Other aquatic species in the Southern Appalachian Assessment area.

Scientific Name	Common Name	Occurrence	Global Rank
Fish			
Anguilla rostrata	American eel	AL,GA,NC,SC,TN,VA,WV	G5
Aplodinotus grunniens	Freshwater drum	AL,GA,NC,TN,VA	G5
Carpiodes carpio	River carpsucker	GA,NC,TN	G5
Carpiodes velifer	Highfin carpsucker	NC,TN	G4G5
Cottus carolinae	Banded sculpin	AL,GA,NC,TN,VA	G5
Cottus cognatus	Slimy sculpin	VA,WV	G5
Cyprinella analostana	Satinfin shiner	NC,VA,WV	G5
Cyprinella galactura	Whitetail shiner	AL,GA,NC,SC,TN,VA	G5
Cyprinella gibbsi	Tallapoosa shiner	AL,GA	G4
Cyprinella nivea	Whitefin shiner	GA,NC,SC	G4
Cyprinella spiloptera	Spotfin shiner	Al,GA,NC,TN,VA	G5
Cyprinella whipplei	Steelcolor shiner	AL,TN,VA	G5
Erimyzon oblongus	Creek chubsucker	VA,WV	G5
Esox masquinongy	Muskellunge	NC,TN,VA	G5
Ethestoma baileyi	Emerald darter	TN	G4G5
Etheostoma blenniodes gutselli	Tuckseegee darter	TN	
Etheostoma caeruleum	Rainbow darter	GA,TN,VA	G5
Etheostoma camurum	Bluebreast darter	TN,VA	G4
Etheostoma chlorobranchium	Greenfin darter	NC,TN,VA	G4
Etheostoma chuckwachatee	Lipstick darter	GA	
Etheostoma coosae	Coosa darter	AL,GA,TN	G4
Etheostoma duryi	Black darter	AL,GA,TN	
Etheostoma flabellare	Fantail darter	NC,SC,TN,VA	G5
Etheostoma inscriptum	Turquoise darter	GA,NC,SC	G4
Etheostoma jessiae	Blueside darter	AL,GA,NC	G4Q
Etheostoma jordani	Greenbreast darter	AL,GA,TN	G4
Etheostoma rufilineatum	Redline darter	AL,GA,NC,TN,VA	G5
Etheostoma rupestre	Rock darter	AL,GA,TN	G4
Etheostoma simoterum	Snubnose darter	AL,GA,TN,VA	G5
Etheostoma sp. cf coosae	Cherokee darter	GA	
Etheostoma sp. cf jordani	Etowah darter	GA	
Etheostoma stigmaeum	Speckled darter	AL,GA,NC,TN,VA	G4
Etheostoma swannanoa	Swannanoa darter	NC,TN,VA	G4
Etheostoma variatum	Variegate darter	VA	
Etheostoma zonale	Banded darter	GA,NC,SC,TN,VA	G5
Exoglossum laurae	Tonguetied minnow	NC,VA	G4
Fundulus bifax	Stippled studfish	GA	
Fundulus catenatus	Northern studfish	AL,GA,TN,VA	
Fundulus diaphanus	Banded killifish	VA,WV	G5
Hiodon tergisus	Mooneye	NC,TN	G5
Hybognathus regius	Eastern silvery minnow	GA,NC,SC,VA,WV	G5
Ichthyomyzon castaneus	Chestnut lamprey	AL,GA,TN	G5
Ichthyomyzon gagei	Southern brook lamprey	AL,GA,TN	G5
Ictiobus bubalus	Smallmouth buffalo	NC,TN	G5
Labidesthes sicculus	Brook silverside	GA,TN,VA	G5
Lampetra aepyptera	Least brook lamprey	AL,GA,TN	G5
Lampetra appendix	American brook lamprey	NC,TN,VA	G5
Lepomis megalotis	Longear sunfish	AL,GA,SC,TN,VA	G5
Luxilus chrysocephalus	Striped shiner	AL,GA,NC,TN,VA	G5
Luxilus coccogenis	Warpaint shiner	GA,NC,SC,TN,VA	
Lythrurus ardens	Rosefin shiner	GA,TN,VA	G5
Lythrurus bellus	Pretty shiner	AL,GA	G5
Lythrurus lirus	Mountain shiner	GA,TN,VA	G4
Macrhybopsis aestivalis	Speckled chub	AL,GA,TN	G5
Macrhybopsis storeriana	Silver chub	GA,TN	G5
Margariscus margarita	Pearl dace	VA,WV	G5
Micropterus coosae	Redeye bass	AL,GA,NC,SC,TN	G5
Moxostoma carinatum	River redhorse	AL,GA,NC,SC,TN,VA	G4T1
Notropis amblops	Bigeye chub	GA,NC,TN,VA	G4?

Table 2.6.1 (cont.) Other aquatic species in the Southern Appalachian Assessment area.

Scientific Name	Common Name	Occurrence	Global Rank
Notropis asperifrons	Burrhead shiner	GA,TN	G4
Notropis atherinoides	Emerald shiner	AL,GA,TN,VA	G5
Notropis buccatus	Silverjaw minnow	GA,TN,VA	G5
Notropis chrosomus	Rainbow shiner	AL,GA,TN	G4
Notropis leuciodus	Tennessee shiner	GA,NC,SC,TN,VA	G5
Notropis lutipinnis	Yellowfin shiner	GA,NC,SC	G4
Notropis photogenis	Silver shiner	GA,NC,TN,VA	G5
Notropis procne	Swallowtail shiner	NC,VA,WV	G5
Notropis rubellus	Rosyface shiner	NC,TN,VA	G5
Notropis rubellus rubellus	Northern rosyface shiner	VA	
Notropis rubescens	Rosyface chub	GA,NC,SC	G4
Notropis rubricroceus	Saffron shiner	NC,TN,VA	
Notropis scabriceps	New River shiner	NC,VA	G4
Notropis scepticus	Sandbar shiner	GA,NC,SC	G4
Notropis spectrunculus	Mirror shiner	GA,NC,SC,TN,VA	G4
Notropis stilbius	Silverstripe shiner	AL,GA,TN	G4?
Notropis telescopus	Telescope shiner	GA,NC,TN,VA	G5
Notropis volucellus	Mimic shiner	AL,GA,NC,TN,VA	G5
Noturus eleutherus	Mountain madtom	GA,TN,VA	G5
Noturus flavus	Stonecat	NC,TN,VA	G5
Noturus funebris	Black madtom	AL,GA	G5
Noturus nocturnus	Freckled madtom	GA	G5
Percina (Alvordius) sp.	Bridled darter	AL,GA,TN	
Percina caprodes	Logperch	AL,GA,NC,TN,VA	G5
Percina copelandi	Channel darter	TN,VA	G5
Percina crassa	Piedmont darter	NC,SC,VA	G4
Percina evides	Gilt darter	GA,NC,TN,VA	G4
Percina maculata	Blackside darter	GA,TN,VA	G5
Percina oxyrhynchus	Sharpnose darter	NC,VA	G4
Percina sciera	Dusky darter	GA,NC,TN,VA	G5
Percina shumardi	River darter	GA,TN	G5
Percina sp. cf macrocephala	Muscadine darter	GA	
Phenacobius catostomus	Riffle minnow	AL,GA,TN	G4?
Phenacobius uranops	Stargazing minnow	GA,TN,VA	G4
Pimephales notatus	Bluntnose minnow	AL,GA,NC,TN,VA,WV	G5
Rhinichthys atratulus	Blacknose dace	AL,GA,NC,SC,TN,VA,WV	G5
Stizostedion canadense	Sauger	GA,NC,TN,VA	G5
Thoburnia rhothocea	Torrent sucker	VA,WV	G4
Molluscs			
Actinonais pectorosa	Pheasantshell	TN,VA	
Alasmidonta undulata	Triangle floater	NC,VA,WV	G4
Alasmidonta viridis	Slippershell mussel	NC,TN,VA	G4
Cyclonaias tuberculata	Purple wartyback	NC,TN,VA	
Ellipsaria lineolata	Butterfly	AL,GA,TN	
Elliptio arca	Alabama spike	AL,GA,TN	
Elliptio arctata	Delicate spike	AL,GA,TN	
Elliptio crassidens	Elephant-ear	AL,TN,VA	G5
Elliptio dilatata	Spike	GA,NC,TN,VA	G5
Elliptio fisheriana	Northern lance	VA,WV	G4
Fusconaia subrotundata	Long-solid	NC,TN,VA	
Lampsilis fasciola	Wavy-rayed lampmussel	NC,TN,VA	G4
Lampsilis ovata	Pocketbook	NC,TN,VA	
Leptodea fragilis	Fragile papershell	AL,GA,TN,VA	G5
Leptoxis dilatata	Seep mudalia	NC,VA	G?
Ligumia recta	Black sandshell	AL,TN,VA	G5
Medionidus conradicus	Cumberland moccasinshell	GA,NC,TN,VA	
Ptychobranchus subtentum	Fluted kidneyshell	TN,VA	G4
Quadrula pustulosa pustulosa	Pimpleback	NC,TN,VA	G5
Strophitus connasaugaensis	Alabama creekmussel	AL,GA,TN	
Strophitus undulatus	Squawfoot	NC,VA,WV	

Table 2.6.1 (cont.) Other aquatic species in the Southern Appalachian Assessment area.

Scientific Name	Common Name	Occurrence	Global Rank
Tritogonia verrucosa	Pistolgrip	AL,GA,NC,TN,VA	G4
Truncilla truncata	Deertoe	NC,TN,VA	G4
Villosa constricta	Notched rainbow	NC,VA	
Villosa vanuxemensis v.	Mountain creekshell	NC,TN,VA	G4
Villosa villosa umbrans	Coosa creekshell	AL,GA,TN	
Crustaceans			
Cambarus georgiae	Little Tennessee crayfish	GA,NC	3C
Cambarus sp 1	Emory River crayfish	TN	G?
Insects			
Aeshna canadensis	Canada darner	VA	G5
Aeshna constricta	Lance-tailed darner	TN,VA	G5
Aeshna tuberculifera	Black-tipped darner	VA	G4
Aeshna verticalis	Green-stripped darner	NC,VA	G5
Acroneuria petersi			
Acroneuria arida			
Agapetus vireo			
Allocapnia brooksi			
Allocapnia fumosa			
Amphiagrion saucium	Eastern red damsel	SC,VA	G5
Amphinemura mockfordi			
Anax longipes	Comet darner	AL,NC,SC,VA	G5
Argia bipunctulata	Seepage dancer	SC,VA	G4
Arigomphus furcifer	Lilypad clubtail	VA	G5
Baetisca carolina			
Barbaetis benfieldi			
Beloneuria georgiana			
Beloneuria stewarti			
Brachycentrus etowahensis	Caddisfly	GA,TN	G?
Callibaetis pretiosus			
Calopteryx angustipennis	Appalachian jewelwing	AL,VA	G4
Ceraclea alabamae			
Cheumatopsyche bibbensis			
Cheumatopsyche cahaba			
Chimarra augusta	Caddisfly	SC,VA	G?
Chromagrion conditum	Aurora damselfly	AL,VA	G5
Cordulegaster erronea	Erroneous biddie	NC,SC,TN,VA	G4
Cordulegaster obliquua	Arrowhead spiketail	VA	G4
Cordulia shurtleffi	American emerald	VA,WV	G5
Dolophilodes sisko			
Drunella allegheniensis			
Drunella conestee			
Drunella longicornis			
Drunella walkeri			
Drunella waya			
Ephemera blanda			
Ephemerella catawba			
Ephemerella floripara			
Gomphaeschna antilope	Taper-tailed darner	VA	G4
Gomphus borealis	Beaverpond clubtail	VA	G4
Gomphus fraternus	Midland clubtail	VA	G5
Gomphus parvidens	Piedmont clubtail	AL,NC,SC,VA	G4
Gomphus rogersi	Sable clubtail	AL,NC,SC,TN,VA	G4
Heterocloen petersi			
Homoplectra flinti			
Hydropsyche carolina	Caddisfly	NC,SC,VA	
Hydroptila anisoforficata			
Hydroptila lagoi			
Hydroptila talladega			
Iron dispar			
Iron pleuralis			

Table 2.6.1 (cont.) Other aquatic species in the Southern Appalachian Assessment area.

Scientific Name	Common Name	Occurrence	Global Rank
Iron rubidus			
Iron subpallidus			
Isoperla bellona			
Isoperla distincta			
Isonychia georgiae			
Isonychia serrata	Mayfly	VA	
Ladona julia	Chalk-fronted skimmer	VA	G5
Lepidostoma etnieri			
Lepidostoma flinti			
Lepidostoma glenni			
Lepidostoma griseum	Caddisfly	AL,NC,TN,VA	G?
Lepidostoma lobatum			
Lepidostoma mitchelli			
Lestes congener	Spotted spreadwing	VA	G5
Lestes eurinus	Amber-winged spreadwing	VA	G4
Lestes forcipatus	Sweetflag spreadwing	VA	G5
Leucorrhinia frigida	Frosted whiteface	NC,VA	G5
Leucorrhinia hudsonica	Hudsonian whiteface	VA,WV	G5
Leucorrhinia intacta	Dot-tailed whiteface	VA,WV	G5
Leucorrhinia proxima	Variable whiteface	VA	G5
Megaleuctra williamsae			
Neophylax auris			
Neophylax etnieri			
Neophylax mitchelli			
Neophylax stolus			
Neophylax toshioi			
Oconoperla innubila			
Ophiogomphus carolus	Riffle snaketail	VA,WV	G5
Oropsyche howellae			
Paragnetina ichusa			
Polycentropus nascotius	Caddisfly	AL	G?
Procloeon quaesitum			
Procloeon rivulare			
Protoptila cahabensis			
Pycnopsyche virginica	Caddisfly	AL,NC,SC,VA	G?
Rhithrogena amica			
Rhithrogena exelis			
Rhithrogena fuscifrons			
Rhithrogena rubicunda			
Rhyacophila accola			
Rhyacophila amicis			
Rhyacophila montana			
Rhyacophila mycta			
Rhyacophila teddyi	Caddisfly	AL,NC,TN	G?
Serratella carolina			
Serratella serrata			
Somatochlora elongata	Slender emerald	NC,VA	G5
Somatochlora williamsoni	Williamson's bog skimmer	TN,VA	G5
Stactobiella cahaba			
Stenonema carlsoni			
Strophopteryx inaya			
Stylurus spiniceps	Arrow clubtail	NC,TN,VA	G5
Sweltsa urticae			
Tallaperla elisa			
Theliopsyche corona			
Theliopsyche epilonis			
Tramea onusta	Red-mantled glider	AL,NC,VA	G5
Triaenodes taenia	Cold spring triaenodes	AL	G?
Wormaldia mohri			
Wormaldia shawnee	Caddisfly	AL,SC	G?

Table 2.6.1 (cont.) Other aquatic species in the Southern Appalachian Assessment area.

Scientific Name	Common Name	Occurrence	Global Rank
Salamanders			
Ambystoma jeffersonianum	Jefferson salamander	VA	G5
Ambystoma talpoideum	Mole salamander	GA,NC,TN	G5
Ambystoma tigrinum tigrinum	Eastern tiger salamander	AL,TN,VA	G5
Desmognathus imitator	Imitator salamander	NC,TN	
Desmognathus ochrophaeus	Mountain dusky salamander	AL,GA,NC,SC,TN,VA,WV	G5
Desmognathus quadramaculatus	Blackbelly salamander	GA,NC,SC,TN,VA	G5
Desmognathus welteri	Black mountain salamander	TN,VA	G4
Desmognathus wrighti	Pigmy salamander	NC,TN,VA	G4
Eurycea longicauda longicauda	Longtail salamander	AL,GA,NC,TN,VA,WV	G5T5
Eurycea lucifuga	Cave salamander	AL,GA,TN,VA	G5
Eurycea wilderae	Blue Ridge two–lined salamander	GA,NC,TN,VA	
Gyrinophilus porphyriticus danielsi	Blue Ridge spring salamander	NC,TN	
Hemidactylium scutatum	Four-toed salamander	Al,GA,NC,SC,TN,VA,WV	G5
Leurognathus marmoratus	Shovelnose salamander	GA,NC,SC,TN,VA	
Necturus maculosus	Mudpuppy	AL,GA,NC,TN,VA	G5
Pseudotriton ruber nitidus	Blue Ridge red salamander	NC,TN,VA	
Pseudotriton ruber schencki	Blackchin red salamander	GA,NC,SC,TN	
Turtles			
Apalone spinifera spinifera	Eastern spiny softshell	AL,NC,TN,VA	G5T5
Clemmys guttata	Spotted turtle	VA	G5
Clemmys insculpta	Wood turtle	VA,WV	G4
Graptemys geographica	Map turtle	AL,GA,TN,VA	G5
Graptemys pulchra	Alabama map turtle	AL,GA	G4
Pseudemys rubriventris	Redbelly turtle	VA,WV	G5
Sternotherus minor peltifer	Stripeneck musk turtle	AL,GA,NC,TN,VA	G5

Known locations of selected species were recorded by county, with the exception of molluscs, which were recorded by hydrological unit. A location table can be found in the supporting database that is available in the SAA CD-ROM database (TVA 1995). Species location data were obtained from published books, journal articles, natural heritage programs, and personal communications with faunal group experts in each state. The location data are based on present distributions (within the past 20 years) and do not include historical distributions. The fish data are more complete than data for other faunal groups because published books are available (Menhinick 1991; Etnier and Starnes 1993; Jenkins and Burkhead 1994). However, there are missing data for some species in Alabama, Georgia, and South Carolina. Mollusc data are missing for some hydrological units. Insect data were especially difficult to obtain without contacting experts for each insect taxonomic order. Since several experts questioned the validity of salamander subspecies on the list, the ranges are fairly subjective. The location data may be used in a GIS to produce maps showing counties in which each of the 260 species is known to occur. Managers who plan activities may consult the location data to identify state-listed species that may occur in the management activity area.

Trends and Spatial Patterns

The list of other aquatic species had a total of 260 species. Of these, there were 97 fish, 25 mussel, 1 snail, 2 crayfish, 111 insect, 17 salamander, and 7 turtle species. Many of the species were included because they are considered rare in states where they occur at the edge of their range. These species may be abundant and have wide distributions outside the state where they are listed. For instance, northern insects, such as *Aeshna canadensis* and *Gomphus borealis*, are found at the southern end of their range in Highland County, Virginia. Other species, such as the mussel *Elliptio* *dilatata*, are common throughout much of the SAA area but are rare enough in North Carolina to be included on the list. The SAA area also includes many endemic species that have small distributions and populations.

Most of the fish (70 percent) were listed by states where the species was at the very edge of its range. A particular species may be abundant in number and distribution, but of questionable status within a portion of the SAA. The black-nose dace (*Rhinichthys atratulus*) is an example of a state-listed fish species that is found at the edge of its range in one SAA state. This species is abundant in Appalachian streams, but it is considered rare in South Carolina because habitat occurs in only the three most northern counties of the state.

Approximately one-third of the fish species exhibited more limited distributions. The majority of these were darters and minnows. Etnier and Starnes (1991) suggest that the large number of jeopardized species of darters in Tennessee, which are restricted to medium-sized rivers and springs, may be due to habitat alteration (impoundments, sediment increases, and water supply usage). Assuming that there are about 350 fish species in the Southern Appalachians (Walsh and others 1995), the 62 TE&SC fish species (section 2.4) plus the 97 other aquatic species (table 2.6.1) comprise about 45 percent of the Southern Appalachian fish fauna.

The 111 insect species were listed by SAA states or in a paper by Morse and others (1993). Streams in the SAA area contain some of the highest aquatic insect species diversity and one of the highest concentrations of endemic aquatic insect species on the continent (Morse and others 1993). Species of mayflies, stoneflies, and caddisflies were identified as rare and vulnerable to extirpation in the Southern Appalachian Mountains. These species are susceptible to sedimentation, improper forest management practices, drought, acid rain, and development. Location information for insect species is not complete because few publications are available for reference. Most references are specific to a particular state or insect taxonomic order.

Within North America, most species of freshwater decapod crustaceans reside in the Southeast (Bouchard 1994). Some 36 percent of the crayfish in the United States are ranked as extinct or imperiled by The Nature Conservancy (Warren and Burr 1994). Only two endemic crayfish species were included on the list (table 2.6.1) and five crayfish listed as TS&SC species (section 2.4), possibly because distribution data are lacking for many species.

Nine species of salamanders in table 2.6.1 are widely distributed, but their ranges are peripheral in the SAA area. The remaining eight salamander species are regarded as either endemic or near-endemic to the Southern Blue Ridge or are a subspecies. They have limited distribution and are vulnerable to habitat degradation and loss.

Of the 26 molluscs identified, 25 were mussels and 1 was an aquatic snail. Mussel distribution information within the SAA is incomplete. Some historical data exist; however, only data describing the current distributions were used for this assessment. Mussels do not inhabit as many areas today as they did in the past. The combined total of 45 TE&SC mussel species (section 2.4) and 25 mussel species in table 2.6.1 comprise about 50 percent of the total mussel species in the SAA area (McDougal 1995).

The common factors affecting the status of aquatic species populations in the Southern Appalachians are habitat degradation and loss. Major threats to aquatic habitats and aquatic fauna include dams and the resulting reservoirs, channelization, sedimentation, and mining. Point source pollution, such as industrial waste, livestock feed lots, human sewage, and water treatment waste; and nonpoint source contaminants like fertilizer, pesticides, septic system leakage, household chemical waste, roadwash residues, and urban area runoff also contribute to the degradation and loss of aquatic resources.

Dams and their associated reservoirs create adverse habitat conditions for many species of mussels and other aquatic fauna that are adapted to flowing water. Most of the medium and large rivers in the SAA area have been dammed. Few species can adapt to the new habitat conditions that are caused by the resulting changes in water depth, temperature, current, substrate, and dissolved oxygen levels. Jeopardized species of molluscs and fish that once occurred in SAA rivers have disappeared with the loss of their habitat and now only occur in the remnant sections of free-flowing rivers. The Coosa River system in Alabama and Georgia is a good example of a drainage that once contained a rich mussel and snail fauna now decimated by dams (Van der Schalie 1981; Neves and others 1994). Many species now inhabit only small rivers and headwater streams not dammed or altered by human activities (McDougal 1995).

Sedimentation is another serious, pervasive threat to aquatic habitats and affects many streams and rivers in the Appalachian area. Sedimentation can result from almost any surface clearing such as mining, agriculture, grazing, construction, urban development, and forestry, if methods are not used to prevent runoff and protect riparian areas. Rivers in the SAA area have also been devastated by industrial discharges. For example, aquatic species in the South Fork of the Shenandoah River (Neves 1991), the North Fork Holston River (Stansberry and Clench 1975; Neves 1991) in Virginia, and the Etowah River (U.S. Fish and Wildlife Service 1994) in Georgia were severely impacted by mercury releases into the rivers.

Likely Future Trends

Many of the species listed in table 2.6.1 will not be federally protected and, indeed, many are quite common through much of their range. Protected status is not always necessary throughout the range of a species, but population monitoring and range shrinkages are important in tracking the status of these species. Some of these species (table 2.6.1) may be useful in monitoring environmental changes. For example, even though the blacknose dace is abundant throughout the SAA area, recent studies have shown that this fish is a good species to monitor because it is sensitive to acidic water conditions (Newman 1995). From 1989 to 1994, the blacknose dace population in the St. Mary's River of Virginia declined 90 percent (Flebbe 1995). The St. Mary's River was identified as one of the most endangered and threatened rivers in the United States by American Rivers, a national conservation organization. The pH has declined, soils are poor in buffering capacity, and the watershed is subject to acid precipitation. Because acid precipitation is a concern in much of the SAA area, blacknose dace population declines may reflect acid conditions.

The likely future trend of these aquatic species within the SAA area will be highly dependent on the quality of the aquatic habitat. Human populations in the area will continue to grow, putting more pressure on the aquatic systems in the form of increased nonpoint source pollution and water-use demands. In North Carolina, Alderman and others (1992) predict that only 51 of the 147 mussel populations are likely to maintain viable populations over the next 30 years. Mussel species within the entire Tennessee River basin are in severe decline (Neves and others 1994) and are likely to continue to decline. Introduced species, such as the zebra mussel (*Dreissena polymorpha*), will play a major role in determining the composition and decline of native aquatic communities in the future.

Some advances have been made to protect and restore aquatic habitats in the SAA area. A number of groups have formed to address problems in many river drainages. Throughout the SAA, citizen groups are actively interested in protecting and restoring the aquatic habitats for the Conasauga River in Georgia and Tennessee; the Little Tennessee River in North Carolina; the Cowpasture River in Virginia; and the Chattooga River in Georgia, North Carolina, and South Carolina. The Nature Conservancy has broadened its scope from managing small parcels of land to planning on the ecosystem level. Areas like the Clinch Valley Bioreserve are the result of this change in philosophy. Federal agencies such as the USDA Forest Service and U.S. Fish and Wildlife Service are moving toward ecosystem management based on drainage areas rather than arbitrary boundaries.

Conclusion

Other aquatic species in the SAA area are of concern in one or more states, but they represent a range of conditions. At one extreme are species that have a limited distribution in a single state but are common elsewhere. At the other extreme are species of quite limited distribution within the SAA area, such as endemics, that should perhaps be protected from further declines.

State and federal laws, such as the Clean Water Act and Endangered Species Act, help to protect fragile aquatic habitats in the SAA area. However, survival of aquatic species will be dependent on the cooperation of a variety of interests. Future viability of aquatic species will require a commitment from industrial, commercial, and residential developers; cooperative interaction between local, county, and state agencies; and involvement of residents and visitors to the area.

2.7 FISH COMMUNITY INTEGRITY

Introduction

Scientifically sound assessments of the condition of fish communities can provide an integrated picture of the ecological integrity of the assemblages of fish species (Karr 1991) inhabiting Southern Appalachian streams. For this approach, the fish community as a whole is characterized, rather than the population of a single species (Davis and Simon 1995). The result is a comprehensive description of the fish community at a site which can be compared to unimpaired or least impacted sites in the same ecological region (Hughes and others 1986; EPA 1991).

Widely recognized ecological regions within the Southern Appalachians include the Blue Ridge, Ridge and Valley, and Cumberland Palteau/Mountains areas (Omernik 1995; Omernik and Griffith 1991; McNab and Avers 1994). State and federal resource agencies have sampled fish communities at some unimpared and relatively unimpacted reference sites representing portions of both the Blue Ridge and Ridge and Valley ecoregions in the Southern Appalachians. This reference area sampling provides a partial description of the range of desirable and attainable condition for a healthy fish community appropriate to each ecological region (Gallant and others 1989).

Measures of fish community condition or integrity consider a wide range of ecological attributes of fish species present at a site (Karr 1993) These measures include fish species composition, trophic composition, abundance, and condition (diseases and anomalies). Responsible agencies have tailored summary fish community measures of 9 to 12 metrics into indices that describe the overall biological integrity of the fish community.

Fish community integrity indices commonly used in the Southern Appalachians are refinements of the original Index of Biotic Integrity developed by Dr. James Karr for use in Midwestern streams. The IBI has been extensively tested and successfully modified for use in many regions around the United States (Plafkin and others 1989; Gibson 1994).

Key Findings

- Numerous detrimental impacts on fish community integrity may be likely (fig. 2.7.2). Based on fish community samples conducted by state and federal agencies covering subsets of the SAA area (fig. 2.7.1), 300 subjectively selected sites in both Ridge and Valley, and Blue Ridge ecological regions, 65 percent of streams sampled show moderate to severe degradation.
- A statistical sample or a much larger and more widely distributed selection of sites would be needed to completely describe fish community condition in the study area.
- Only 9 percent of streams sampled were not impaired.

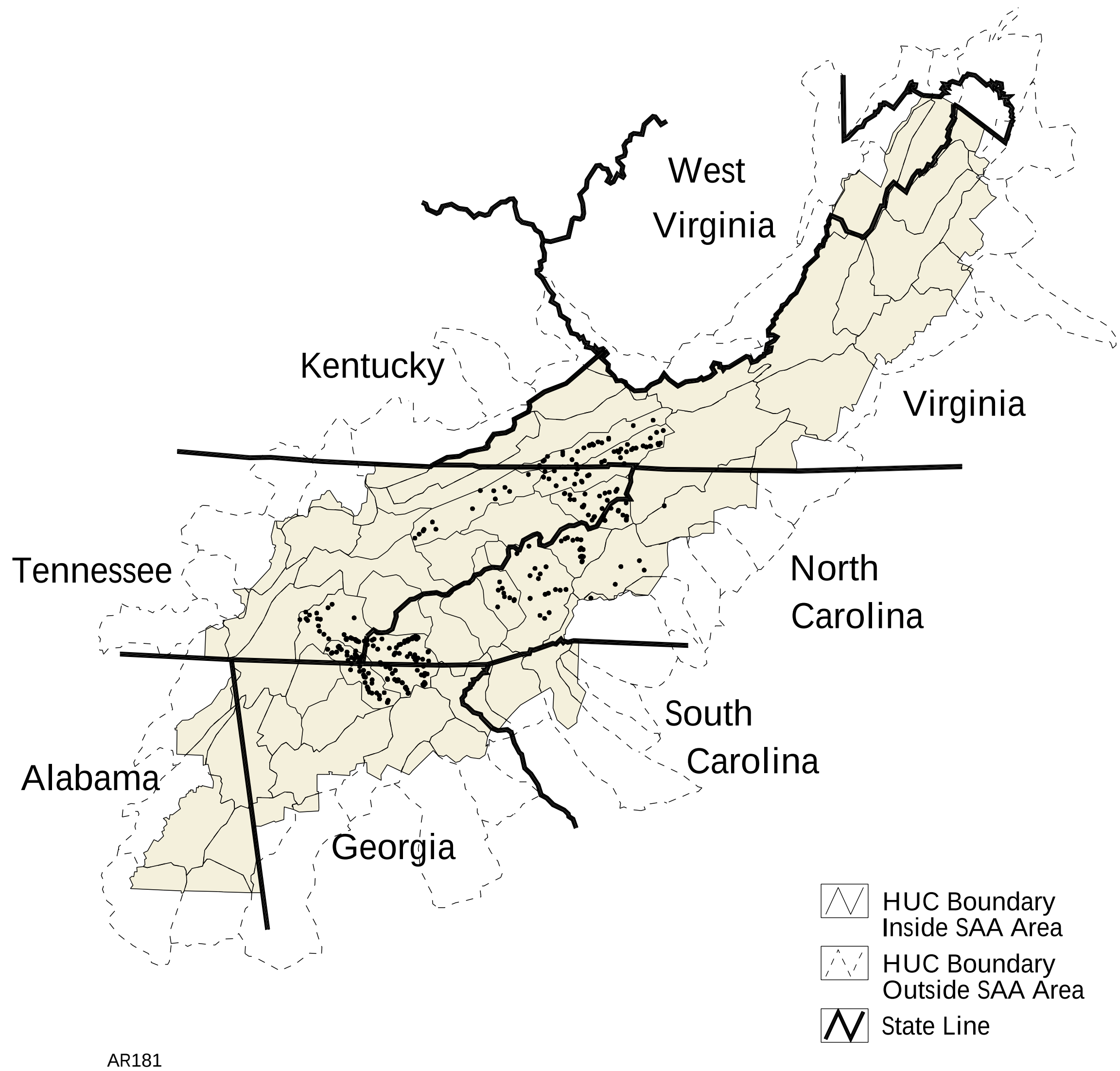
Data Sources

The North Carolina Department of Environment, Health, and Natural Resources (NCDEHNR), Division of Environmental Management, Biological Assessment Group provided a summary of Index of Biological Integrity (IBI)-based fish community assessments at 46 mountain sites (50 total samples) in the Blue Ridge of western North Carolina. Most samples were collected by NCDEHNR personnel during 1992 to 1993; several collections were compiled by other agencies or organizations and assessed by NCDEHNR (Schneider 1995).

The TVA Holston River Action Team provided a summary report on IBI-based fish community assessments for 101 sites. About 10 percent of these sites were in the Blue Ridge, and the remainder were in the Ridge and Valley (TVA 1994a). Summary data on fish community and habitat assessments for 153 sites in the Hiwassee River drainage were also provided by TVA (Cox 1995). Most of these were in the Blue Ridge.

The IBI-based sampling and assessment methods used by North Carolina and TVA are more fully described in North Carolina Department of Environment, Health, and Natural Resources (1995) and TVA (1994).

Figure 2.7.1 Fish community condition sample sites. The geographic distribution of 300 fish community condition sampling sites is focused on watersheds near the center of the SAA region. All sites have at least one fish community condition determination based on the Index of Biological Integrity (IBI).



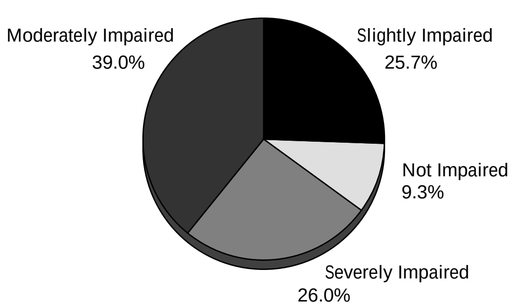


Figure 2.7.2 Fish community condition at some sites in the Southern Appalachians. Of 300 subjectively selected sites in the study area, 65 percent show moderate to severe degradation of fish communities.

Analysis, Spatial Patterns, and Trends

For this assessment, the fish community condition classes (or levels of quality) used by the agencies that contributed data to the assessment have been aggregated into four classes. These classes describe the difference in condition between a site of interest and the unimpaired reference condition range. The four condition classes used are not impaired, slightly impaired, moderately impaired, and severely impaired. Not impaired includes the agencies' "excellent" and "good to excellent" classes; slightly impaired includes the "good" and "fair to good" classes; moderately impaired includes the "fair" and "poor to fair" classes; and severely impaired includes the "poor", "very poor to poor", and "very poor" quality classes. The "not impaired" and "slightly impaired" classes include a range of the best quality classes used by the agencies that provided data. Both "not impaired" and "slightly impaired" approximate an attainable condition (Polls 1994) rather than a strictly "pristine" condition.

Fish IBI measurements conducted by TVA at 101 subjectively selected stream sites in the Holston River drainage show 4.0 percent of sites not degraded, 18.8 percent slightly degraded, 48.5 percent moderately degraded, and 30.0 percent severely degraded. Fish IBI measurements conducted by TVA at 153 subjectively selected sites in the Hiwassee River drainage show 5 percent of sites not degraded, 25.8 percent slightly degraded, 40.3 percent moderately degraded, and 28.9 percent severely degraded. Fish IBI measurements at 46 locations in North Carolina show 34.8 percent not degraded, 45.7 percent slightly degraded, 15.2 percent moderately degraded, and 4.3 percent severely degraded.

Likely Future Trends and Implications

Increased degradation of fish communities in the region could result from continued growth of population, along with expanding urban and second home development, and other human activities on the landscape. If there are no compensating improvements in management practices to reduce both point and nonpoint sources, impacts to aquatic resources could result.

The EPA Region 3's Environmental Services division has organized an ongoing multistate Regional Environmental Monitoring and Assessment (R-EMAP) study (the Mid-Atlantic Highlands Assessment or MAHA) consisting of a statistical sample of more than 200 sites in the Blue Ridge and Ridge and Valley ecoregions (Preston 1995). These data are now being analyzed.

A very incomplete picture of fish community integrity in the Southern Appalachians and a lack of long-term trend information for fish and overall aquatic community integrity present a unique opportunity. A strong interagency effort could establish a comprehensive aquatic biological community monitoring system that builds on current state and federal agency efforts (Intergovernmental Task Force on Monitoring Water Quality 1994). A carefully designed study should be capable of estimating the status of fish community condition with known confidence. Continued monitoring at regular intervals would allow construction of reliable estimates of fish community integrity trends. Ideally, the system should use an IBI modified specifically for Southern Appalachian streams. Each ecological region and stream size should be calibrated cooperatively among the states and federal agencies. This approach will ensure that condition measures for each ecological region are equivalent (Jackson and Davis 1994). Common definitions and boundaries for the ecological regions would ensure that restoration of stream ecosystems can be evaluated over time (Kondolf 1995).

2.8 A CASE STUDY OF BENTHIC MACROINVERTEBRATES IN THE SAA AREA

Introduction

Aquatic macroinvertebrate species are generally defined as animal species that lack backbones and can be seen with the naked eye, larger than about 0.01 to 0.02 inches. Benthic macroinvertebrates live on bottom substrates of streams, rivers, lakes, and ponds. Bottom substrates include logs, plants, rocks, gravel, and sediments. In streams of the SAA area, immature insects make up most of the benthic macroinvertebrate fauna.

Increasingly, benthic macroinvertebrate species are the object of biological monitoring efforts to detect change in aquatic systems (MacDonald and others 1991; Rosenberg and Resh 1993; Dissmeyer 1994; Gurtz 1994; Firehock and West 1995). The benthic macroinvertebrate fauna is composed of many genera and species that are more or less sensitive to toxins and effects of such impacts as acidification and sedimentation. Various indices have been devised, such as number of taxa (either species, genera, or families) or presence of certain tolerant or intolerant taxa (e.g., *Baetis*) that are sensitive to particular impacts. Benthic macroinvertebrates may be better for biological monitoring than are fish because macroinvertebrates are easier to sample and, as a group, may be more sensitive to impacts.

The most widely used benthic macroinvertebrate monitoring methods are those of EPA's rapid bioassessment protocols (RBPs), particularly levels II and III. Level II RBP can be carried out by minimally trained staff, while level III RBP requires more extensive training in identification of insect genera. Several well-known monitoring programs that involve extensive use of volunteers, for example, the Isaak Walton League's Save our Streams (SOS) program, are at RBP level I (Dissmeyer 1994; Firehock and West 1995).

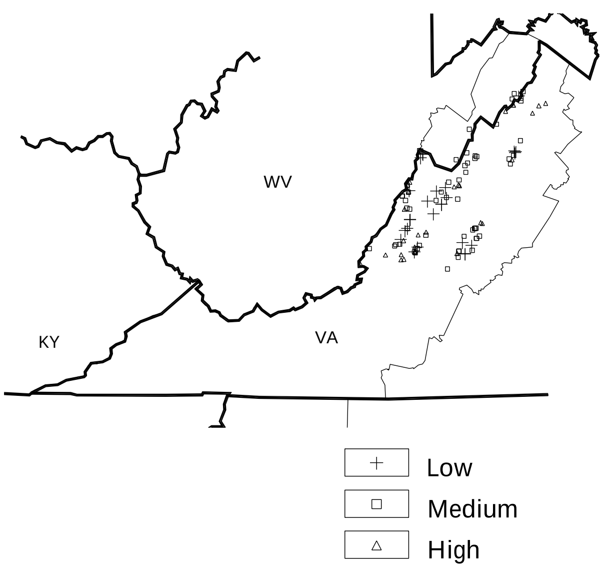


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Figure 2.8.1 Distribution of 110 reference streams on the George Washington National Forest according to EPT scores classified as high (>13 families; 26 streams), medium (9 to 13 families; 57 streams), or low (<9 families; 27 streams).

To demonstrate the potential use of benthic macroinvertebrate monitoring for regional assessments of current status and trends, we selected as a case study a monitoring program conducted on the George Washington National Forest by Mark Hudy (1995). Other data sets could be combined with this data set to provide a more complete analysis of the SAA area.

Key Finding

- Based on a case study in the SAA area, about 60 percent of the streams sampled on the George Washington National Forest with low EPT scores were acidified.

Data Sources

Data were obtained for 110 reference sites located on streams on the George Washington National Forest. These stream sites had been sampled between 1992 and 1995 and benthic macroinvertebrates identified to the level of family, closely following the RBP level II (Hudy 1995).

Analysis, Spatial Patterns, and Trends

Several metrics can be calculated from these data, but only the EPT scores are reported here to illustrate their use. The EPT score is a count of the number of families in three insect orders, the Ephemeroptera (mayflies), Plecoptera (stoneflies), and Tricoptera (caddisflies); many species in these three orders are particularly sensitive to environmental impacts, including stream acidification. Each site was assigned to high (more than 13 EPT families), medium (9 to 13 EPT families), or low (fewer than 9 EPT families) EPT classes and plotted (fig. 2.8.1). The EPT classes were selected so that the high and low classes would each have about 25 percent of the sites and the medium class would have the remaining 50 percent: 26 sites were classified as high, 57 as medium, and 27 as low EPT score sites.

Of the 27 stream sites that had low EPT scores, approximately 60 percent were acidified (ANC < 100) (Hudy 1995). The spatial interspersion of some low EPT score sites among the medium and high sites (fig. 2.8.1) is a reminder that the predictive capability of the acidification map (section 2.3) is limited to general large-scale patterns. The remaining low EPT score sites were on small headwater streams or streams with other impacts such as fine sediment (Hudy 1995). Some low headwater ANC sites had medium and high EPT scores. Clearly, multiple factors contributed to the EPT scores for all sites.

The St. Mary's River in Virginia is an example of a stream that has experienced serious stream acidification and a concomitant decline in macroinvertebrate fauna. This stream was sampled in the 1930s by Surber (1951) and in the 1970s and 1980s by the Virginia Department of Game and Inland Fisheries (VDGIF). While pH declined from 6.8 in 1936 to 5.2 in 1988, the number of insect taxa declined from 31 to 18, and EPT score (genus) declined from 17 to 10 (Kauffman and others 1993). Acid-sensitive genera had disappeared or declined dramatically by 1976, and moderately sensitive genera had declined by 1986 and 1988 (Kauffman and others 1993). Taxa like leuctrids and chironomids, which actually thrive under moderate acidification, have increased dramatically over this same time (Kauffman and others 1993). Today, the St. Mary's River has a low EPT score (fig. 2.8.1).

Aquatic macroinvertebrates, especially the insects, are often sensitive to insecticides used in agricultural and silvicultural treatments. Low-elevation streams in the SAA area are often surrounded by agricultural land, sometimes with little or no riparian buffer strip. In forested areas of the SAA, treatments for gypsy moth and other pests could affect macroinvertebrates in mountain streams. These effects may have further implications for fish, such as trout and some threatened, endangered, and special concern (TE&SC) fishes, who depend on macroinvertebrates for food.

Excesses of fine sediment are detrimental to aquatic macroinvertebrates, many of which live in the interstices of gravel and rocks that make up the stream bed. Fine sediment also tends to collect in these interstices; and, when fine sediment covers over the stream bed, aquatic macroinvertebrates may be smothered.

Likely Future Trends

Benthic macroinvertebrates will continue to be used as monitoring tools. In the future, more data and a better understanding of what various indices mean will expand our ability to document historic changes in these taxa and to predict future trends. To the extent that streams are subject to impacts of acidification, sedimentation, and pesticides, concomitant loss of certain macroinvertebrate taxa can be expected. Under certain favorable conditions, when these impacts are halted, streams may be recolonized with some missing taxa, especially those with highly mobile aerial life stages.

Stream Habitat and Riparian Land Cover

3.0

Question 2:

What management factors are important in maintaining aquatic habitat and water quality? What are the extent and composition of riparian areas?

Diverse instream habitat for fish and other aquatic life is essential for healthy aquatic systems. Numerous stresses on aquatic habitat have the potential to impair the integrity of our water resources. Evaluation of instream habitat changes and the associated stresses is a growing scientific and monitoring activity. Thus, we are developing a better understanding of the role of habitat in aquatic systems.

Human activities on the landscape can adversely affect aquatic habitats in many ways. Sediment from erosion and loss of vegetation from denuded stream banks are prime examples. Initial assessments of aquatic habitat in the Southern Appalachian Assessment (SAA) area are based on satellite data of human and natural land uses important to aquatic systems. A comprehensive inventory of land cover for the riparian zone landscape within 30 meters of watercourses, also based on satellite data, is presented.

Limited on-the-ground monitoring information indicates that aquatic habitat in a significant fraction of waters in the SAA area may be stressed. Landscape and riparian information also indicates that many waters are likely to be impacted due to riparian zone disturbance and by intensive human activities on the landscape in some areas. The limited availability of information for this study points to the need for more comprehensive, systematic assessments of habitat effects and stresses as part of cooperative efforts to monitor the condition of aquatic systems. Increased attention to instream habitats, riparian areas, and landscape influences on aquatic ecosystems will be essential to guide and evaluate continued efforts to restore and maintain the integrity of aquatic systems.

3.1 STREAM HABITAT CONDITION

Introduction

Habitat condition along with chemistry, flow, energy sources, and biotic interactions is one of the main factors influencing the ecological integrity of aquatic resources (Karr 1993). Stream habitat for fish and other groups of aquatic organisms, such as bottom-living benthic macroinvertebrates, is critical for healthy aquatic systems (Gibson 1994). Stream habitat destruction, reduction, and simplification result from widespread processes and human activities. These processes and activities include sedimentation, riparian area destruction (National Association of Conservation Districts 1994), road building and maintenance (Swift 1987; Van Lear and others 1995), and urbanization, which have significant potential to degrade aquatic ecological systems (Allan and Flecker 1993). Long-term ecosystem changes caused by global change may have potentially significant effects on aquatic habitats (Eaton and Scheller 1995; Mulholland and others 1995). The historical loss of the American chestnut tree (Smock and MacGregor 1988) also substantially influenced stream ecosystem integrity.

Stream habitat assessments use a variety of both qualitative and quantitative approaches. These methods focus on stream substrates; organic matter essential to stream food chains; such as leaf litter; large woody debris; stream form (geomorphology); and riparian and bank structure. Hankin and Reeves (1988), Plafkin and others (1989), Meador and others (1993), Dolloff and others (1993), Harrelson and others (1994), and Rosgen (1994) provide representative examples of stream habitat assessment methodologies. State and federal resource agencies are increasing emphasis on habitat assessment as one essential component that characterizes the condition of stream systems (Fausch and others 1988; Rankin 1995; North Carolina Department of Environment, Health, and Natural Resources 1995; Dissmeyer 1994).

Key Findings

- A significant portion of streams in the SAA area are likely to evidence habitat degradation, based on studies of subsets of the SAA area.
- Qualitative visual habitat assessments of 235 sites in the Holston and Hiwassee drainages show 15 percent of the sites sampled were severely impaired, 62 percent slightly to moderately impaired, and 23 percent not impaired (fig. 3.1.1).
- Qualitative visual habitat assessments of 178 statistically selected sites in the Mid-Atlantic Highlands Assessment (MAHA) area (including the SAA area in Virginia and West Virginia and some areas outside the study area in Pennsylvania, Maryland, and West Virginia) estimate that 50 percent of stream miles have impaired physical habitat (Gerritsen and others 1995).
- Approximately 37 percent of stream miles in the Blue Ridge ecological region of the MAHA area and 60 percent of stream miles in the Ridge and Valley ecological region of the MAHA are impaired, due to habitat factors.

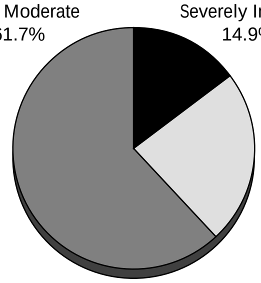


Figure 3.1.1 Distribution of habitat condition for 235 stream sites in the Holston and Hiwassee drainages. Based on qualitative visual assessments, 35 sites were severely impaired, 145 were slightly to moderately impaired, and 55 were not impaired.

Data Sources

The Tennessee Valley Authority (TVA) (1994a) provided a summary report on fish community assessments for 101 sites, and habitat assessments for 92 sites, in the Holston River watershed. About 10 percent of these sites were in the Blue Ridge and the remainder were in the Ridge and Valley (TVA 1994a). Summary data on fish community assessments for 159 sites in the Hiwassee River drainage; 14 in the Ridge and Valley and 145 in the Blue Ridge were also provided by TVA (Cox 1995).

The U.S. Environmental Protection Agency (EPA), provided preliminary data from an ongoing multistate Regional Environmental Monitoring and Assessment (R-EMAP) study (the MAHA) of a statistical sample of 178 sites in the Blue Ridge and Ridge and Valley ecoregions of Virginia, West Virginia, Maryland, and Pennsylvania (Gerritsen and others 1995).

Analysis, Spatial Patterns, and Trends

A habitat index scoring system involving seven factors was used by TVA for the Holston and Hiwassee drainages. The seven factors are instream cover, sedimentation, bank stability, bottom scouring, canopy cover, riparian zone, and habitat diversity. Scoring for each factor was as follows: 5 – optimal, 3 – mediocre, 1 – minimal, with a maximum score of 35 for each site (TVA 1994a). Site scores (sum of scores for 7 factors) for this summary were classed as follows: <20 – severely impaired, 20 to 29 – slightly to moderately impaired, and 30 to 35 – not impaired (fig. 3.1.1).

The MAHA habitat assessments used a modification of EPA's qualitative rapid bioassessment protocols involving 12 factors: channel alteration, channel flow, bank condition, embeddedness, substrate, riffle frequency, vegetation disturbance, instream cover, riparian width, sediment deposition, velocity-depth, and bank vegetation (Gerritsen and others 1995).

The MAHA preliminary habitat data assessment results indicate substantial differences in habitat impacts among ecological regions and subregions. Habitat impairment estimates for the Blue Ridge ecoregion were 63 percent non-impaired and 37 percent impaired (Gerritsen and others 1995). Corresponding estimates for the Ridge and Valley ecoregion were 40 percent nonimpaired and 60 percent impaired (Gerritsen and others 1995). Subregions within the Ridge and Valley also showed substantial differences in habitat impacts with greater fractions impaired in the Limestone and Shale valleys (82 percent and 62 percent, respectively) than in the Shale and Sandstone ridges (both 43 percent) (Gerritsen and others 1995). These estimates should not be interpreted to apply directly to the SAA area but may be indicative of similar patterns in the corresponding ecoregions and subregions that are shared by the Southern Appalachians and the Mid-Atlantic Highlands. Generally, areas that have similar patterns of stresses to stream habitat, such as agricultural use, urban development, and riparian pressures, and similar resilience due to common natural factors, such as soils, geology, and natural vegetation, should react comparably.

More quantitative habitat techniques that involve numerous measurements of stream transects are being tested by EPA and the states using a subset of the MAHA sites (Klemm and Lazorchak 1994). These and similar methods are also being tested on more than 900 additional sites in different areas of the country and show great promise as reliable predictors of instream biological condition (Kaufmann and others 1995). Other quantitative methods being tested by federal agencies include those for stream channel reference sites (Harrelson and others 1994) and the riffle stability index (Kappesser 1993). Promising methods to address hydrologic changes are under development and testing in the Clinch-Powell River drainages and other areas of the United States (Richter and others 1995).

Trends cannot be addressed with currently available data.

Likely Future Trends and Implications

Stresses to aquatic habitats in the SAA area are considered substantial. Growth of urban areas, agricultural activities, road building, and other human activities have the potential to increase the extent and severity of aquatic habitat degradation for streams.

A consistent and comprehensive picture of aquatic stream habitat condition is not currently available for the SAA area. Also, much of the habitat condition data now available are based on qualitative visual estimates with different agencies that use incomparable methods. Reliable aquatic habitat status and trend information will be necessary to successfully protect and restore stream systems in the Southern Appalachians. Hydrologic changes that result in alterations in the amounts, duration, timing, frequency, and rate of change of stream flows should also be addressed as a critical component of stream habitat condition (Richter and others 1995).

These factors argue strongly for cooperative interagency efforts to establish a comprehensive aquatic habitat condition monitoring system that builds on current state and federal agency efforts (Intergovernmental Task Force on Monitoring Water Quality 1994). The design of this monitoring system should be capable of estimating the status of stream habitats with known confidence and should continue at regular future intervals to allow construction of reliable estimates of stream habitat integrity trends. Ideally, this system should use comparable methods for each ecological region and should be calibrated cooperatively among the states and federal agencies.

3.2 LAND COVER AND AQUATIC SYSTEMS

Introduction

Natural and human activities on the landscape have the potential to significantly influence water quality and aquatic ecological integrity (Hunsacker and others 1993). Humans currently manage or otherwise have changed most of the landscape of the SAA area. The entire landscape of a watershed can affect aquatic resources (Hunsacker and Levine 1995). Additionally, areas close to streams and other watercourses can dominate important factors that influence aquatic ecosystem integrity, such as vegetation along streams and erosion from stream banks (Steedman 1988). Landscape information for the SAA area, developed from satellite imagery, provides part of the basis for relating important landscape factors to instream conditions of chemistry, habitat integrity, and ecological condition (Roth and others 1995). Geographic Information Systems (GIS) have the potential to integrate these and other data, which can provide improved management of nonpoint source pollution (Lee and others 1991). Modeling tools have been recently developed which can estimate nonpoint source pollutant loads by drainage basin, based on landscape factors, such as cover, slope, and land management practices. Among these tools are the GIS-based Better Assessment Science Integrating Point and Nonpoint Sources (BASIN model), recently developed by EPA to support watershed screening and assessment, and others, such as the Agricultural Nonpoint Source Model (AGNPS).

Key Findings

- Aggregated land cover classes thought to strongly influence water resource integrity are distributed in the study area as follows: forest – 70.7 percent, pasture/herbaceous – 21.8 percent, cropland – 3.5 percent, developed/barren – 3.8 percent, and wetlands – 0.2 percent. (fig 3.2.1)
- Intensive human influence on landscapes in the study area ranges from 0.0 percent to 74.6 percent. Intensive human uses include the developed/barren, cropland, and pasture/herbaceous classes. Small areas of rock outcrops and mountain top balds may be included in the barren and herbaceous classes, respectively. Figure 3.2.2 shows subdivisions of the SAA area that are defined by portions of hydrologic units within ecological regions. Each area is classed according to its potential for aquatic resources integrity problems based on the relative level of intensive human influence across the landscape.
- The distribution of land cover classes that are important to aquatic resources shows distinct patterns in different ecological regions. Agricultural lands are more predominant in the Ridge and Valley, while forests dominate the Blue Ridge. (fig 3.2.3)
- Federal holdings, including national forests and national parks, have a higher fraction of classes that indicate less human influence than the rest of the study area. (fig 3.2.4).

Data Sources

Key base data for this water resources related land cover summary include the land cover analysis of remotely sensed Landsat Thematic Mapper scenes into 17 classes of land cover, which was provided by Pacific Meridian for the SAA. Hydrologic areas and watersheds are defined by the 8-digit Hydrologic Unit Code (HUC) areas (adjusted to include all streams in the appropriate drainage near the edge of the SAA boundary), and ecological regions (Omernik SAA 1995; Omernik and Griffith 1991), defined by Omernik's Ecoregions of the Continental United States, revised in 1994. Omernik's ecoregions were used here because, at this scale, they provide the most precise boundaries that match the usually sharp

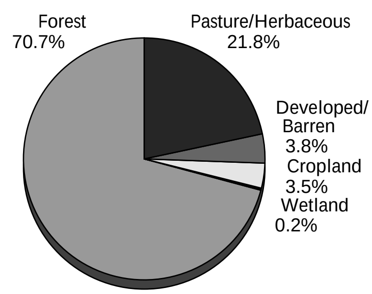


Figure 3.2.1 Distribution of aggregated land cover classes important for water resource integrity in the study area.

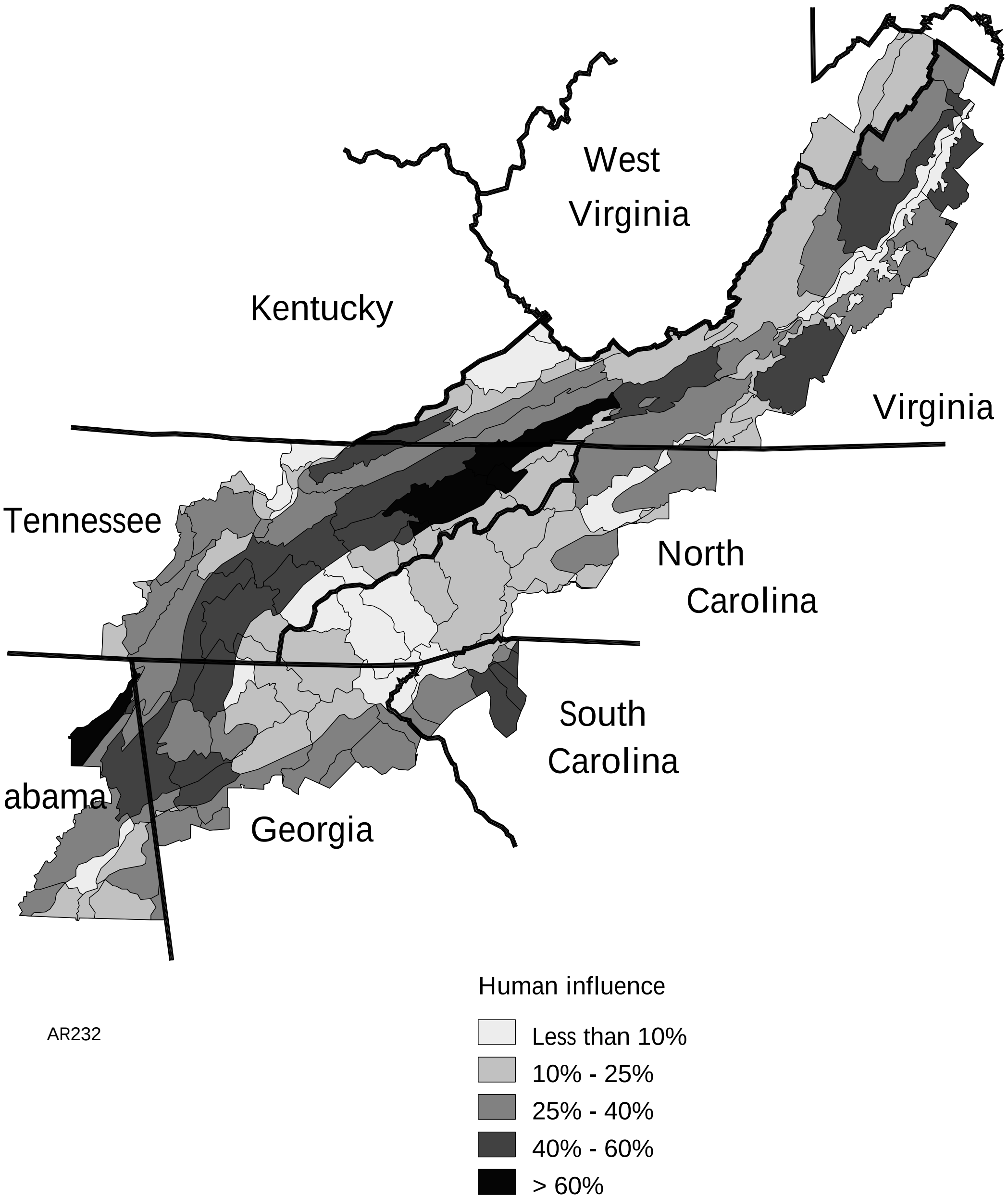


Figure 3.2.2 Intensive human influence on landscapes in the study area. Intensive human uses include the developed/barren, cropland, and pasture/herbaceous classes. Subdivisions of the SAA area defined by portions of hydrologic units within ecoregions are ranked according to potential for aquatic resource integrity problems based on relative level of human influence across the landscape. Intensive human influence ranges from 0.0 percent ot 74.6 percent. Small areas of balds and rock outcrops may be included in the pasture/herbaceous and developed/barren classes, respectively.

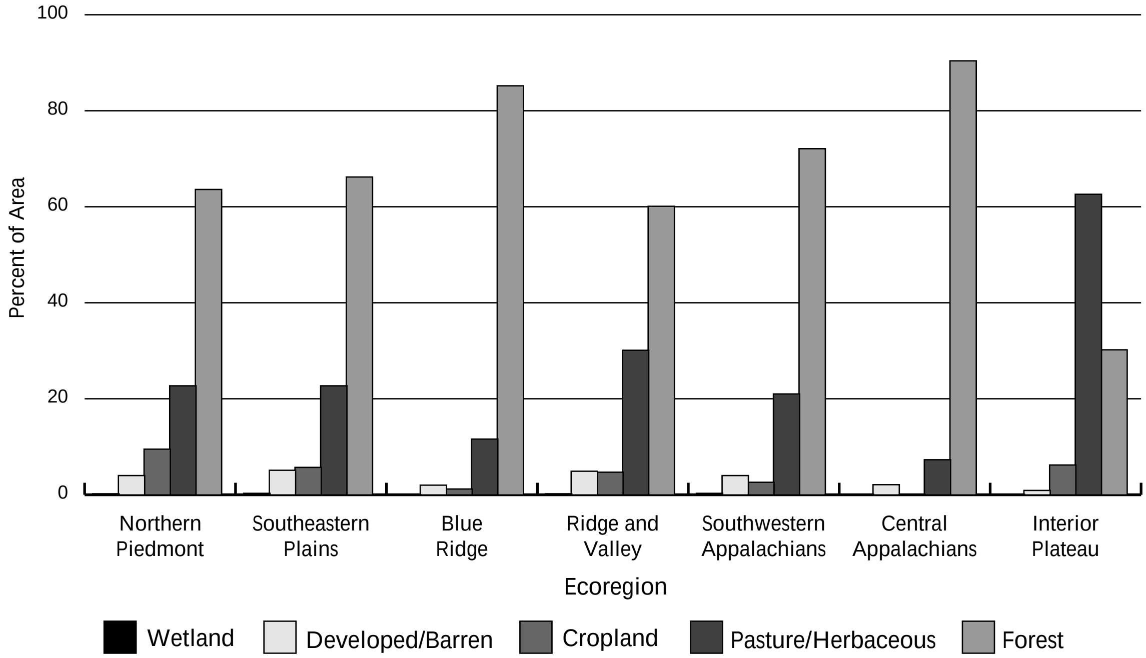


Figure 3.2.3 Distribution of land use/land cover classes by ecological region. Agricultural land uses are more predominant in the Ridge and Valley, while forests dominate the Blue Ridge. Ecoregions are as follows with the number in parentheses indicating the percent of Southern Appalachian Assessment land area: 64 - Northern Piedmont (2.2 percent), 65 - Southeastern Plains (14 percent), 66 - Blue Ridge (30.5 percent), 67 - Ridge and Valley (40.3 percent). 68 - Southwestern Appalachians (8.3 percent, note: includes Cumberland Plateau), 69 - Central Appalachians (4 percent), and 71 - Interior Plateau (0.8 percent).

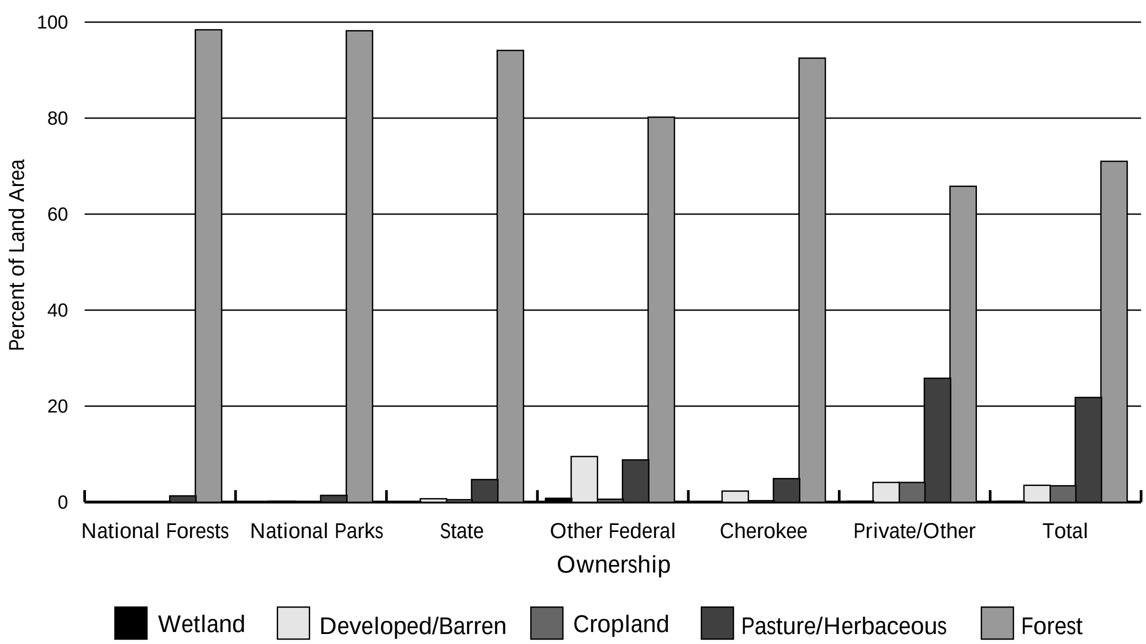


Figure 3.2.4 Land cover by ownership. Federal holdings, including national forests and national parks, have a higher percentage of classes evidencing less human influence than the rest of the study area.

demarcations between most regions in the study area. These ecoregions are broadly similar to the ecological regions and subsections defined by McNab and Avers (1994).

Analysis, Spatial Patterns, and Trends

The 17 classes in the original land cover analysis are aggregated into the following 7 classes that are believed to have the greatest utility for discerning influences of landscape on water resource integrity: forest, wetlands, agriculture-pasture and herbaceous, agriculture-crops, developed and barren, water, and indeterminate (clouds, shadows, etc.). The area that was covered by each of these aggregated classes was calculated using analysis boundaries with the most relevance to aquatic systems. These include ecoregions, hydrologic units, and smaller areas defined by the overlap of ecoregions and hydrologic units; for example, the Ridge and Valley within the French Broad drainage.

The distribution of land cover classes that are important to aquatic resources shows distinct patterns in different ecological regions (fig. 3.2.3). This is not surprising, since land use is one of the factors used to define the ecoregions. Agricultural land uses are more predominant in the Ridge and Valley, while forests are more dominant in the Blue Ridge.

Likely Future Trends and Implications

Additional research is needed on the integration of landscape, stream and riparian habitat, instream biological integrity, and water chemistry. Such research, tested with real world data covering wide areas such as large watersheds and ecological regions, can potentially refine existing approaches for the protection of aquatic resources using Best Management Practices (BMP) (Levine and others 1993). This work will be invaluable for predicting and evaluating the success of aquatic ecosystem restoration efforts. Use of the SAA land cover information base to describe small areas within the SAA area (watersheds less than 100 square miles, for example) should be done with caution until a complete accuracy assessment is available for this land cover classification (Luman and Hilton 1991). Ongoing land cover assessments, administered at regular future intervals, have the potential to construct reliable trends for landscape change in the study area.

3.3 RIPARIAN INVENTORY

Introduction

Instream habitats for aquatic life are very dependent on natural bank and riparian zone vegetation. Riparian zones are areas adjacent to streams that may have vegetation especially suited to occasional flooding. Intact riparian zones provide numerous critical ecological functions (Gregory and others 1991). They stabilize stream banks and prevent bank erosion while providing inputs of organic matter that constitute the base of stream food chains. They provide structure for important habitat types, such as undercut banks, root cover, and large woody debris for fish and other organisms. They provide essential shade and temperature regulation for many fish, such as trout. If properly planned and managed, they can serve as filters to reduce sediment input from upland erosion (Barling and Moore 1994). Managed and regularly harvested forested zones near streams but beyond the intact zone of natural vegetation, can also potentially reduce nutrient inputs (National Association of Conservation Districts 1994). Recommendations and regulations for stream bank and riparian area protection (BMPs) vary widely from state to state as do recommended riparian zone sizes. All streams need well-established riparian buffers of natural vegetation to attain and maintain their biological integrity (National Association of Conservation Districts 1994).

Assessments of riparian zones covering large geographic areas are not generally available. Remote sensing (satellite data) and GIS technologies now make wide area inventories of riparian conditions practical (Hunsaker and Levine 1995; Roth and others 1995; Steedman 1988). Such assessments of large areas should be correlated with on-the-ground measurements to yield reliable, predictive tools for water resources management.

Key Findings

- Aggregated land cover classes for the riparian zone of the entire study area are distributed as follows: forest – 69.9 percent, pasture/herbaceous – 22.0 percent, cropland – 3.1 percent, developed/barren – 4.3 percent, and wetlands – 0.7 percent. Figure 3.3.1 shows the distribution of land cover classes for riparian areas within 100 feet (30 meters) of watercourses for the entire study area.
- Forest cover in the riparian zones of the study area ranges from less than 25 percent to 100 percent. Figure 3.3.2 shows subdivisions of the SAA study area that are defined by portions of hydrologic units within ecological regions. Each area is classed according to the fraction of forest cover in the riparian zone.
- Land cover in the riparian zone differs by ownership in the study area. Federal holdings, including national forests and national parks, have more than 90 percent forest cover in the riparian zone versus 69 percent for the rest of the study area. Figure 3.3.3 shows the different pattern of land cover in the riparian area between federal holdings and lands in private and other ownerships.

Data Sources

The results of the land cover analysis for aquatic systems provided most of the information base for this product. Additionally, the streams GIS coverages based on the EPA river reach database (RF3) and a 100-foot (30-meter) buffer surrounding watercourses, constructed using established GIS techniques, were utilized to estimate the location of the near-stream zone for the entire study area. A 100-foot buffer was chosen for this riparian inventory due to the limit of resolution of the base data. Also, sensitivity analyses in published studies indicate that buffers of (100-160 feet) should be useful for potential correlation of riparian landscape factors with stream habitat and biological integrity measures (Roth and others 1995).

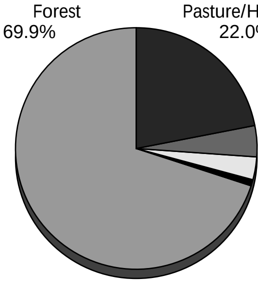


Figure 3.3.1 Riparian zone land cover. Aggregated land cover classes for the riparian zone of the entire study area. The riparian zone is defined as land areas within 100 feet of watercourses.

Analysis, Spatial Patterns, and Trends

Since the land cover classification was produced using satellite data with 30-meter resolution, only larger watercourses are detected. The location of all smaller waterways is assumed to correspond to the reach file stream tracings (section 2.1). The GIS coverages were combined to define riparian zones within the ecoregion and hydrologic unit boundaries. The aggregated land cover classes are summarized within the 100-foot (30-meter) buffer zone for a combination of ecoregion and hydrologic boundaries (fig. 3.3.2). Drainages with less than 75 percent forest cover in the riparian zone may be likely to have multiple areas with significant localized stream habitat degradation due to loss of natural riparian vegetation. Drainages with less than 60 percent forest cover in the riparian zone may be likely to have widespread stream degradation. More detailed riparian and stream habitat evaluation should be a high priority for these areas.

Forest cover in the 100-foot (30-meter) riparian zone varies greatly across the study area from more than 90 percent forest to less than 25 percent. The Ridge and Valley ecoregion tends to have less forest cover in the riparian zone than the Blue Ridge and other ecoregions. Lands in federal ownership, such as national forests and national parks, have significantly more forest cover in the riparian zone than do lands in other ownerships (fig. 3.3.3).

Likely Future and Implications

Additional scientific input is needed on the critical functions and structure of riparian areas, as well as their sizes and configurations that are necessary for aquatic ecosystems protection. This research and additional predictive modeling should be integrated with other landscape

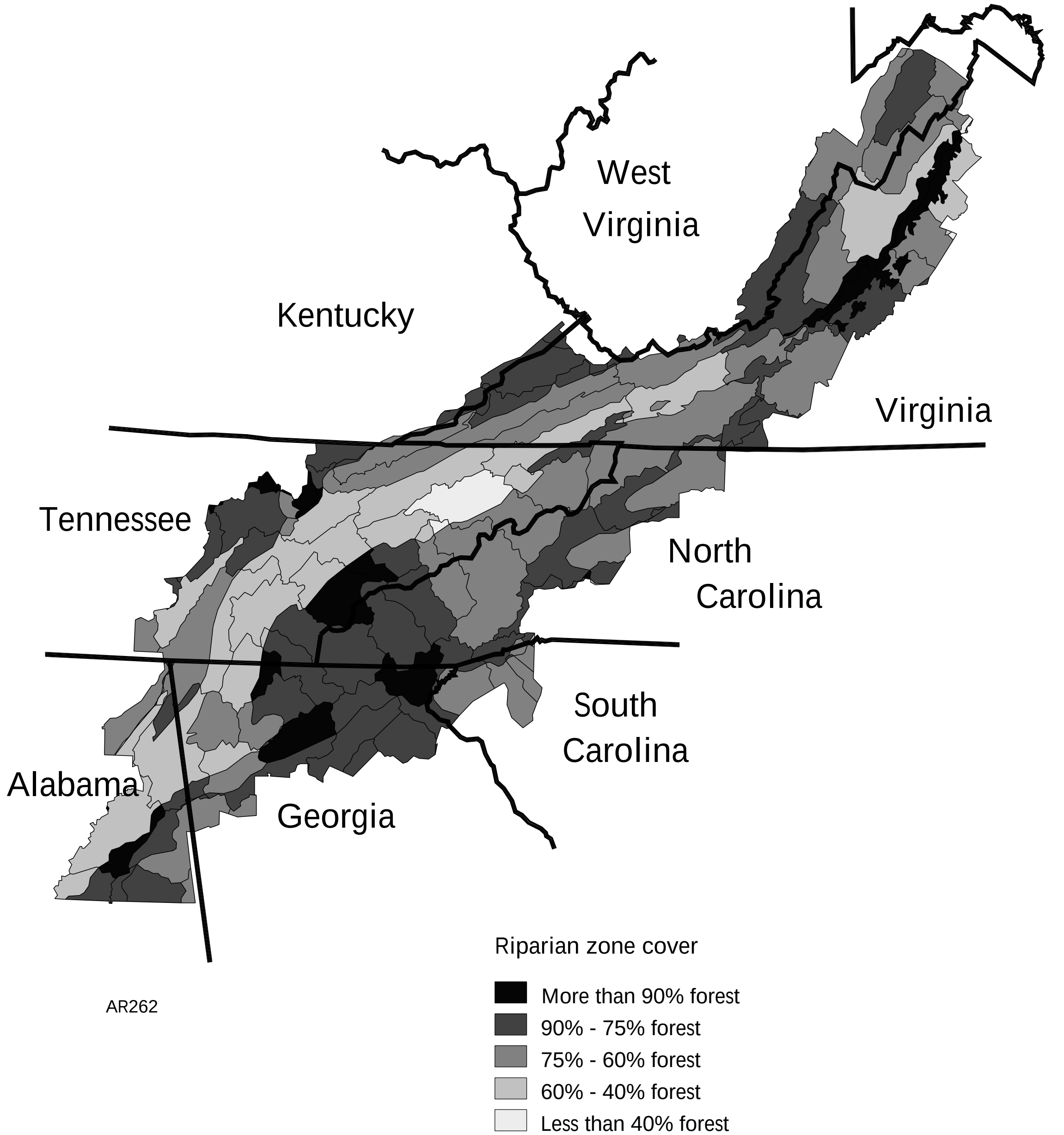


Figure 3.3.2 Riparian zone forest cover by ecoregion and hydrologic unit/watershed combined. Forest cover in the riparian zones of the study area ranges from less than 25 percent to 100 percent. This map shows subdivisions of the SAA area defined by portions of hydrologic units within ecological regions. These areas are ranked according to the fraction of forest cover in the riparian zone.

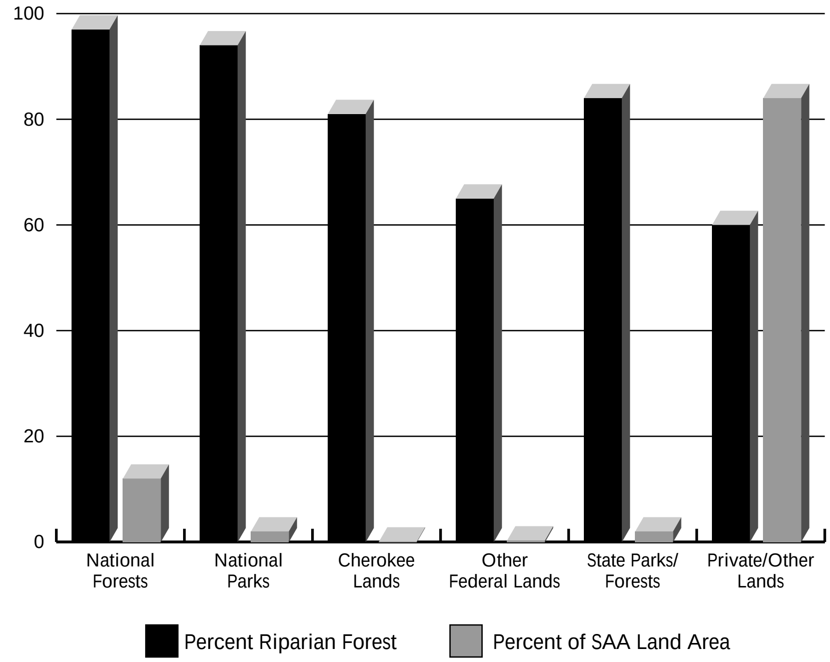


Figure 3.3.3 Riparian zone land cover by ownership. Land cover in the riparian zone differs by ownership in the study area. Federal holdings, including national forests and national parks, have over 90 percent forest cover in the riparian zone.

factors, stream habitat, instream biological integrity measures and water chemistry indicators. Testing of empirical data that cover wide areas (both watersheds and ecological regions) will help to refine BMPs for riparian zones and will be useful to predict and evaluate the success of aquatic ecosystem restoration efforts. More detailed land cover classes that are available as part of the remote sensing information base should be used with caution until a complete accuracy assessment is available for this land cover classification (Luman and Hilton 1991). If continued in the future, ongoing riparian land cover assessments will also have the potential to construct reliable trends for riparian change.

Water Laws and Restoration Programs

4.0

Question 3:

What laws, policies, and programs for the protection of water quality, streams, wetlands, and riparian areas are in place? How does the implementation of these laws and policies affect aquatic resources, other natural resources, and human uses (both land and water) within the assessment area?

The laws and policies for protection of aquatic resources provide a legal mandate to ensure that all human activities are conducted with consideration for protection, preservation, and restoration for our nation's water resources. The Clean Water Act (CWA) (1987) clearly stated an objective to restore and maintain the chemical, physical, and biological integrity of the nation's waters. Further legislation enacted for other purposes address the protection of water quality. Examples include the Safe Drinking Water Act; the Coastal Zone Management Act; and executive orders for the protection of floodplains and wetlands. Numerous federally funded programs exist to protect, restore, or improve aquatic resources within the Southern Appalachian Assessment (SAA) area. Additionally, many citizen and volunteer groups have been formed to focus on the cleanup of local streams, with many counties and local governments providing support for these efforts.

Section 4.1 discusses and summarizes many of the laws and policies that are in effect and reviews the success of these regulations to date. Topics specifically addressed include the National Pollutant Discharge Elimination System (NPDES); Nonpoint Source Pollution control; nationwide permits; and section 404 of the CWA that require permits for dredge-and-fill operations. Best Management Practices (BMPs) for control of nonpoint source pollution are also discussed.

Section 4.2 discusses and summarizes many of the federally funded programs that exist for the protection and or restoration of aquatic resources within the SAA area.

4.1 LAWS AND REGULATIONS

Introduction

In recent years, the nation and Congress have shown increased concern about the protection and restoration of aquatic resources by giving greater attention to the goals of the CWA. Passage of the Water Quality Act of 1987 over President Reagan's 1986 veto is an example of this commitment. The 1977 act had expired in 1982, and for 5 years Congress, the U.S. Environmental Protection Agency (EPA), industry, environmentalists, and the Administration struggled to produce an acceptable document. President Reagan's veto of the act in 1986 was arguably the result of the inclusion of $18 billion in grants and loans for the construction of sewer and wastewater treatment plants (Liebesman 1988). Override of the Presidential veto in 1987 is testimony to strength of the environmental movement and has set the stage for the future course in water legislation and the nation's water pollution control efforts.

The Water Quality Act of 1987 continued the basic structure set forth in the 1972 and 1977 acts but strengthened existing mandates and created new programs to protect water resources. Programs were established to control nonpoint sources of pollution and tighter controls were established for toxic pollutants (sec. 304). Nonpoint source pollution is that which originates from diffuse sources, such as runoff from construction activities. Additionally, other legislation, such as the Safe Drinking Water Act of 1986 and the development of Superfund programs, have interacted with the CWA to provide even greater protection for aquatic resources. A number of statutes have been enacted for other purposes, yet address the protection of water quality, as referenced in table 4.1.1.

The purpose of this report is to briefly discuss and summarize some of the laws germane to the protection of aquatic resources. Sections of the CWA addressed in this report include the NPDES; nonpoint source pollution control; nationwide permits; and section 404 permits for dredge-and-fill operations. BMPs, developed for the prevention and control of nonpoint source pollution, will also be discussed as they pertain to states within the SAA area. Application of these regulations resulted in the data and information discussed in chapter 5.

The Clean Water Act Legal Background

The protection of aquatic resources is governed by the Federal Water Pollution Control Act (FWPCA), which dates back to 1948. Now known as the CWA, the FWPCA was largely shaped by the comprehensive 1972 amendments, which are often viewed as the starting point for modern water pollution control law (Fogarty 1988). The 1972 amendments established a regulatory system for point sources of pollution – from an identifiable point such as a pipe from a facility – and set as a national goal that all streams should be fishable and swimmable by 1983. Section 208 of the 1972 law also recognized water quality problems associated with nonpoint source pollution and required states to develop management plans for the control of nonpoint source pollution. The CWA has undergone several amendments with the most recent passage of the Water Quality Act of 1987.

The clear objective stated in the CWA is to "restore and maintain the chemical, physical, and biological integrity of the nation's waters" (CWA 101[a]). The CWA of 1987 explicitly reaffirmed the national goal to eliminate discharges of pollutants into navigable waters of the United States and to achieve wherever attainable, water quality that provides for the protection and propagation of fish, shellfish, and wildlife. Propagation speaks to the full range of biological conditions necessary to support reproducing populations of all native forms of aquatic life (EPA 1990). The CWA of 1987 further states as a national goal that programs be developed and implemented for the control of nonpoint source pollution. The primary mechanism for controlling nonpoint source pollution is through the adoption and implementation of BMPs.

Reauthorization of the 1987 CWA plus a number of other bills is currently being considered in Congress. Considerable debate and concern continue over the implications of making changes in current water resource legislation. Water pollution issues often become polarized, as opposing interest groups advocate fewer or greater environmental controls.

Under the mandate of the current CWA, water quality standards and a system of permit requirements serve largely to regulate water pollution. The predominant mechanism is the NPDES.

National Pollutant Discharge Elimination System

At the heart of the CWA is the NPDES, which regulates both direct and indirect discharges of pollutants into U.S. waters. The act makes unlawful the discharge of any pollutant from a point source into U.S. waters without a permit. Thus, the pollution of water is not a right and is not allowed, except as provided by the act. Therefore, the bulk of the CWA can be viewed as a highly regulated exception to the no discharge rule as set forth in section 301 (Fogarty 1988).

Under the CWA, two types of regulations control the discharge of pollutants–those that are "water quality-based" and those that are "technology-based". Water quality-based requirements limit permissible amounts of pollutants allowed in a defined water body or segment of a water body. The amount of allowable pollution is based on the capacity of a receiving water to accept or absorb a pollutant and varies according to beneficial use of the water. A beneficial use is defined as use for recreation, industrial, or public drinking water (CWA sec. 303[c]). The ability of a receiving water to accept pollution is a function of the size and flow of a stream, existing water quality condition, the type of pollutant, and other factors related to a particular stream.

Technology-based standards tend to dominate the CWA's regulatory system. These

Table 4.1.1 A summary of statutes that have included provisions for the protection or maintenance of water quality.

Popular Name/General Cite	Specific Cite/Topic	Purpose With Respect to Water Quality
Federal Insecticide, Fungicide, and Rodenticide Act Sec.2 [7 U.S.C. 136]	1499 [7 U.S.C.5506] Water Policy with Respect to Agrichemicals	To develop programs for the users and dealers of agrichemicals to insure that agrichemical users, dealers and the general public understand the implications of their actions and the potential effects on water.
Clean Air Act Sec. 101 [42 U.S.C. 7401]	103[42 U.S.C. 7403] Air Pollutant Monitoring, Analysis, Modeling and Inventory Research	To conduct a research program to improve understanding of the short-term and long-term causes, effects, and trends of ecosystem damage from air pollutants on ecosystems. Part of this program will include an evaluation of the effects of air pollution on water quality with an assessment of the ecological effects of acid deposition and other atmospherically derived pollutants on surface water, (including wetlands and estuaries) and groundwater.
Federal Water Pollution Control Act Sec. 101 [33 U.S.C. 1251]	101 [33 U.S.C. 1251] Declaration of Goals and Policy	To restore and maintain the chemical, physical, and biological integrity of the nation's waters.
Resource Conservation and Recovery Act Sec. 1001 [42 U.S.C. 6901]	Sec.1003 [42 U.S.C. 6902(10)] Research Grant Program	To promote the protection of health and the environment and to conserve valuable material and energy resources by promoting the demonstration, construction, and application of solid waste management, resource recovery, and resources conservation systems which preserve and enhance the quality of water and land resources.
Safe Drinking Water Act Sec. 1401 [42 U.S.C. 300f]		To maintain the quality of the nation's drinking water supply by setting water quality standards.
Soil and Water Resources Conservation Act Sec. 2 [16 U.S.C. 2001 (4)]	Sec. 2 [16 U.S.C. 2001]	To indentify and evaluate alternative methods for the conservation, protection, environmental improvement, and enhancement of soil and water resources, in the context of alternative time frames and a recommendation of the preferred alternatives and the extent to which they are being implemented.
Surface Mining Control and Reclamation Act Sec. 101[30 U.S.C. 1201]	Sec. 102 [30 U.S.C. 1202] Statement of purpose	To establish a nationwide program to protect society and the environment from the adverse effects of surface coal mining operations and to assure that surface coal mining operations are so conducted as to protect the environment.
Coastal Zone Management Act Sec. 302 [16 U.S.C. 1451]	Sec. 303 [16 U.S.C. 1452] Congressional Declaration of Policy	To protect natural resources, including wetlands, floodplains, estuaries, beaches, dunes, barrier islands, coral reefs, and fish and wildlife and their habitat, within the coastal zone.
Wild and Scenic Rivers Act Sec. 1 [16 U.S.C. 1271]	P.L. 90-542, Sta. 906 Declaration and Purpose	To preserve in free–flowing condition, certain select rivers of the Nation which possess outstandingly remarkable, scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values.

Table 4.1.1 (cont.) A summary of statutes that have included provisions for the protection or maintenance of water quality.

Popular Name/General Cite	Specific Cite/Topic	Purpose With Respect to Water Quality
National Forest Management Act of 1976 [16 U.S.C. 1600]	P.L. 93-378, Sec. 6 National Forest System Resource Planning Findings	Provides for protection of streams, streambanks, shorelines, lakes, wetlands, and other waterbodies during timber harvest operations to the extent that detrimental changes do not occur in water temperatures, blockage of water courses and sediment that would adversely affect water conditions or fish habitat.
Marine Protection, Research, and Sanctuaries Act Sec. 2 [33 U.S.C. 1401]	Sec. 2 [33 U.S.C. 1401] Finding, Policy, and Purpose	To regulate the dumping of all types of materials into ocean waters and to prevent or strictly limit the dumping into ocean waters of any material which would adversely affect human health, welfare or amenities, or marine environment, ecological systems, or economic potentialities.
Solid Waste Disposal Act 42 U.S.C. 6901	42 U.S.C. 6902 (10) Objectives and National Policy	To promote the demonstration, construction, and application of solid waste management, resource recovery, and resource conservation systems which preserve and enhance the quality of air, water, and land resources.
Executive Orders for Floodplain and Wetland Management 11988 and 11990	E.O. 11988 and 11990	Insures that wetlands and floodplain values are considered during the planning and implementation of all federal actions and potential effects are evaluated. Alternatives will be considered to avoid adverse impacts and if no practical alternative is available, mitigation measures will be implemented to minimize impacts.
National Environmental Policy Act 42 U.S.C. 4371-4375	NEPA 42 U.S.C. 4321–4370d Declaration of Purpose	Declares a national policy to promote efforts which will prevent or eliminate damage to the environment and biosphere. Requires analysis and disclosure of environmental impacts for all federal proposed actions. Impacts on soil and water resources must be considered.
Endangered Species Act 50 CFR PART 17		The ESA requires the Secretary of the Interior, through the Fish and Wildlife Service and National Marine Fisheries Service, to identify endangered and threatened species and to develop plans for recovering such species. It requires that all Federal agencies work in cooperation with State and local agencies to resolve water resource issues in concert with the conservation of endangered and threatened species. The ESA also provides a mechanism for providing Federal assistance to States and foreign countries to assist them in implementing conservation activities for endangered and threatened species, and species likely to become endangered or threatened.

standards focus on the treatment of a pollutant before it is discharged into a stream and define a level of effluent quality that is achievable using the best available pollution control technology. All dischargers must meet minimum treatment requirements. Additionally, toxics, a recognized harmful class of pollutants, are singled out for special treatment by the CWA and regulated by the EPA.

Water quality standards (designated beneficial uses and the criteria to protect those uses) are implemented and enforced through compliance with the NPDES permit system as administered by the EPA. Under section 402 of the CWA, a discharger must obtain an NPDES from the EPA or from a state that has an EPA-certified program (CWA sec. 402 [b]). Water quality standards (both water quality-based and technology-based) are written into permits according to the particular situation that exists at a given site. The standards consider the type of pollutant and the condition and beneficial use of the receiving waters. NPDES permits are issued for 5 years and may include requirements for monitoring and reporting of discharge effluents. Discharging of pollution without a permit or violation of the terms or standards of an issued permit may result in civil and criminal penalties.

Compliance with the terms of an NPDES permit is deemed in compliance with almost all of the CWA's regulatory provisions and may be accomplished under state authority. A delegated state program is bound by many of the same statutory requirements applicable to the federal program. There is a goal to turn over to the states the authority to administer and enforce the NPDES program in its entirety. All of the states within the SAA area have NPDES permitting authority.

Specific requirements for issuance of a NPDES permit are described in CWA 402(a) 1. The NPDES permit system is an effective means of controlling point source discharge wastes such as those from a discrete point that are easily identifiable. The most common point discharges are industrial facilities, municipal treatment plants, and combined sewers.

Even though the CWA recognizes that states have authority to set their own water quality standards, standards must be reviewed by EPA, which has the authority to supersede standards that do not meet minimum requirements. For example, waters of the states must have a use designation such as fishable/swimmable that is consistent with criteria established in the CWA. Furthermore, state water quality criteria must be shown to be protective of the designated uses, and the criteria must be at least as stringent as federal guidelines. An antidegradation policy must also be included which includes a provision that designated uses cannot be removed to allow greater discharge of pollutants. States are allowed to designate Outstanding National Resource waters, which prohibit a lowering of existing water quality (Antidegration policy 40 CFR, Part 131).

While the requirements for use designations and water quality criteria result in fairly uniform water quality standards among states, actual implementation of standards varies considerably. This is due to provisions in some state standards for mixing zones to dilute pollution, variances from standards, and results in considerable variability between states. This can result in variability in NPDES permit limit requirements, as well.

Nonpoint Source Pollution Control

Nonpoint source pollution is defined as diffuse sources of pollution not regulated as point sources (EPA Nonpoint Source Pollution Guidance 1987). Nonpoint sources of pollution include atmospheric deposition, contaminated sedimentation, and many land-disturbing activities that generate polluted runoff. Examples are agricultural activities, logging operations, and onsite sewage disposal. The control of nonpoint source pollution is somewhat more difficult than point sources regulated under the NPDES system. Nonpoint source pollution is less visible and thus more difficult to control through pre-established criteria.

Siltation and nutrients are most often associated with nonpoint source impacts to water resources. In 1992 the EPA reported, currently, less visible nonpoint sources of pollution are more widespread and introduce vast quantities of pollutants into our nation's waters (EPA 1992). As shown in figure 4.1.1, reporting states pointed out that siltation and nutrients affected 45 percent and 35 percent of impaired stream miles, respectively. Figure 4.1.2 shows that the originating source was predominantly agriculture, accounting for 72 percent of the nation's rivers that were impaired. Silviculture and hydrologic modification each were shown as

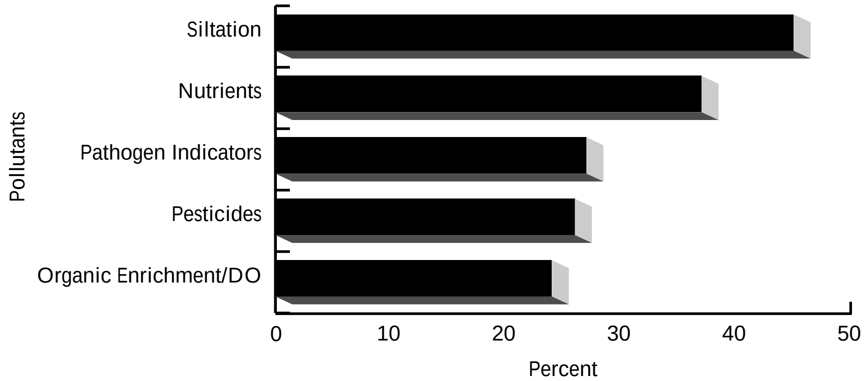


Figure 4.1.1 The percent of assessed river miles impaired by pollutants based on 222,370 assessed river miles impaired. (Source: Based on 1992 state section 305 (b) reports from National Water Quality Inventories 1992 Report to Congress, EPA, 841-R-94-001, March 1994 Washington DC 20460, Appendix A, Table A-1)

causing approximately 8 percent of the rivers to be impaired by nonpoint source pollution.

Such a national survey obscures regional differences where there may be considerable variability in land-use activities. For example, a region that is predominantly industrial and urban would produce a much different type of nonpoint source pollution than one dominated by agricultural or forestry activities. Furthermore, because it is impractical for states to report on the quality of all streams, only 18 percent of the nation's 3.5 million miles of rivers were assessed. Notwithstanding the limitations of such a survey, it is generally recognized by the scientific community and regulatory agencies that nonpoint source pollution is one of the major water pollution issues to contend with in the future (EPA 1989b). In contrast, point sources of pollution are more easily recognized and regulated under state water standards and the NPDES system.

As early as 1972, Congress recognized the need to establish a nationwide program to control nonpoint sources (section 208 FWPCA), and in 1987 enacted section 319 of the CWA. The following language was added to CWA section 101(a) 7: "It is the national policy that programs for the control of nonpoint sources be developed and implemented in an expeditious manner so as to enable the goals of this Act to be met through the control of both point and *nonpoint sources of pollution*" (emphasis added).

Section 319 requires states to assess their waters and to develop nonpoint source pollution management programs to control and reduce specific nonpoint source pollution. The nonpoint source pollution action program further authorizes federal loan and grant funds to assist states, units of local government, conservation districts, individuals, farmers, and foresters to manage nonpoint source pollution. Consistent with section 319, states are completing their assessments and management programs which, after review by EPA, will serve as the cornerstone for the national nonpoint source pollution program well into the future (EPA 1989b). All states within the SAA area have implemented or are designing programs to implement BMPs to control nonpoint source pollution.

Nationwide and Section 404 Permits

Established under the FWPCA of 1972, the section 404 regulatory program makes it unlawful to discharge dredged or fill material into waters of the United States without first receiving a permit from the Corps of Engineers. The term "waters of the United States" defines the extent of geographic jurisdiction of the section 404 program. The term includes such waters as rivers, lakes, streams, intermittent streams, mud flats, and wetlands (33 CFR sec. 328.3, 1995).

A discharge of fill material involves the physical placement of soil, sand, gravel, dredged material, or other material into these

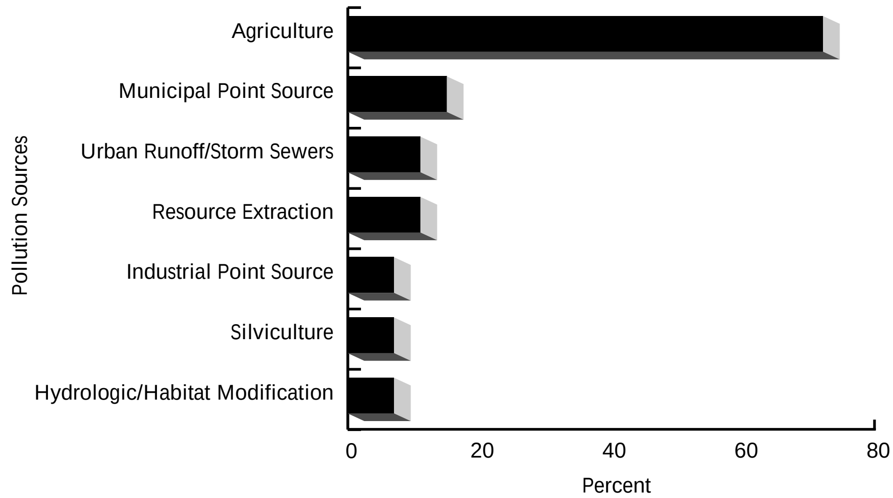


Figure 4.1.2 The percent of river miles impaired by sources of pollution based on 221,877 assessed river miles impaired. (Source: Based on 1992 state section 305 (b) reports from National Water Quality Inventories 1992 Report to Congress, EPA, 841-R-94-001, March 1994 Washington DC 20460, Appendix A, Table A-1)

waters. Exemptions were added to section 404 in 1977 to exclude normal farming activities, ranching, and forestry activities that have been active and "ongoing" (33 CFR 323.4, 1995). For example, if a farmer has been plowing, planting, and harvesting in wetlands, he or she can continue to do so without the need for a section 404 permit so long as the wetland is not converted to dry land. Activities which convert a wetland that has not been used for farming or forestry or are not part of an ongoing program are not exempt from section 404 permit requirements. The conversion of a bottomland hardwood wetland to crop production, for example, would not be exempt. Activities that do not involve discharge of dredged or fill material into U.S. waters never require a permit. However, excavation of materials may require a permit.

Nationwide permits are a general type of permit authorized by the U.S. Army Corps of Engineers for activities on a nationwide basis unless they are specifically restricted (33 CFR 330.2 [b]). Nationwide permits are designed to regulate, with little delay, certain activities that have little or minimal impact on water resources. For example, a bank stabilization activity that is less than 500 feet in length, and does not exceed an average of 1 cubic yard of material per running foot of bank, may be accomplished without a specific permit. Minor road crossings, fill material, and minor discharges are also permitted under the provisions of the nationwide permit system (33 CFR app.[b]). Activities that are not specifically authorized under the nationwide permit system may require an individual permit, regional general permit, or a dredge-and fill permit under section 404 of the CWA.

Debate continues on the definition of "wetlands" and activities that fall under the section 404 exemptions. Currently, jurisdictional wetlands are defined by the Corps of Engineers as "those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support and that under normal circumstances do support a prevalence of vegetation typically adapted for life in saturated soils". Wetland identification methodology is outlined in the current approved 1987 Corps delineation manual on the basis of the above criteria.

Most silvicultural activities are exempt from section 404 permit requirements provided they meet BMP requirements for activities related to road construction and other impacts that may cause degradation of water quality or impair aquatic habitat. Specific requirements for BMP application are outlined in 33CFR, section 323.4. For example, the design, construction,

Table 4.1.2 A summary of Southern Appalachian Assessment area state water quality laws including Best Management Practice (BMP) programs.

State	Type of BMP Program	Lead Agency	Water Quality Statutes	Special Rules
AL	Voluntary	ADEM Alabama Dept. of Environmental Management	Alabama Water Pollution Control Act	No
GA	Voluntary	GDNR–EPD Georgia Dept. of Natural Resources, Environmental Protection Division	Georgia Water Quality Control Act[1]	Yes–Georgia Comprehensive Planning Act
NC	Mandatory	NCDEHNR North Carolina Dept. of Environmental Health and Natural Resources	North Carolina Water and Air Resources Act, Sediment Pollution Control Act, and North Carolina Stream Obstruction Statutes	No
SC	Voluntary– (limited Regulations for Silviculture)	SCDHEC South Carolina Dept. of Health and Environmental Control	South Carolina Pollution Control Act	No
TN	Voluntary	TDEC Tennessee Dept. of Environment and Conservation	Tennessee Water Control Act, Scenic Rivers Act	No
VA[2]	Voluntary	Virginia Water Control Board	Virginia Water Control, Erosion and Sediment Control, Forest Water Quality, Debris in Streams and Scenic Laws	No

[1]Georgia Comprehensive Planning Act of 1989 has formulated a series of special rules for environmental planning criteria, four of which have been formulated for the protection of water supply watersheds, wetlands, river corridors, and mountains. These rules are intended as minimum planning standards and procedures to be adopted by local governments.

[2]Although Virginia has no special rules, there are very specific laws to address special resource areas. No other state in the SAA has as many specific water quality statutes under the umbrella of the main water protection statute.

and maintenance of a road crossing shall not disrupt the migration or other movement of those species of aquatic life inhabiting the water body (33 CFR 323.4 [6 vii]). BMPs have been developed for silvicultural activities in all states within the SAA area.

Best Management Practices in the Southern Region

The primary mechanism for regulating nonpoint source pollution is through the adoption and application of BMPs for forestry activities. The EPA describes BMPs as follows: "Methods, measures, or practices selected by an agency to meet its nonpoint control needs." BMPs include but are not limited to structural and nonstructural controls and operation and maintenance procedures. BMPs can be applied before, during, and after pollution-producing activities to reduce or eliminate the introduction of pollutant into receiving waters.

Specific examples of BMPs include stabilization and treatment of disturbed ground during road construction or the proper placement of waterbars on skid trails during timber harvesting operations. State water quality agencies may certify BMPs for federal agencies conducting land-disturbing activities. This can lead to delegation of responsibility to federal agencies to protect and restore those waters under their jurisdiction. The Forest Service has memoranda of understanding or letters of certification with all states within the SAA area which confirm that Forest Service management practices meet current requirements of respective state BMPs. Forest Service Standards and Guidelines for management activities are designed to meet or exceed all state BMPs.

The implementation of forestry BMPs is voluntary in all states within the SAA area, with the exception of North Carolina. The implementation of BMPs has been largely successful through education, training, and guidance provided by the state forestry programs. All forestry activities must comply with water quality regulations, and implementation of BMPs has been shown to be an effective means of controlling and preventing nonpoint source pollution.

Table 4.1.2 summarizes information regarding nonpoint source pollution control for the states within the SAA.

In a 1994 study of regional BMPs for the South, it was found that as a whole, forestry represents a relatively minor source of nonpoint source pollution compared to other nonpoint source pollution sources, such as agriculture, urban development, hydrologic alterations such as dams, and mining activities (NCASI 1994b). A caveat to this generalization, however, is that forestry activities can be a significant source of nonpoint source pollution if BMPs are not properly implemented. Two examples of BMP compliance programs are Virginia and South Carolina. A study of BMP effectiveness in South Carolina found that during 1990 and 1991 silvicultural BMPs were implemented on 84.7 percent of the harvesting operations (Adams 1993). A survey of BMP implementation in the state of Virginia during 1994 indicated that BMP implementation averaged 91 to 96 percent on related timber harvest activities (Austin 1994). Both studies concluded that improper implementation of BMPs or a lack of awareness of sensitive areas were the major problems with the implementation and effectiveness of the BMP programs.

Both knowledge and technology are available to apply BMPs that can curtail nonpoint source pollution. For example, Swift (1988) found that proper design of forest roads can reduce sediment input into streams by more than 90 percent. Swift has pointed out that guidelines are available for road design which minimize the impacts of construction and use of roads on water quality. It is important that technology transfer from researchers reaches those involved in forest management as well as those in industrial, urban, and rural development (Hackney and others 1992).

Summary

In the last 8 years, the nation has witnessed a significant turning point in water resource legislation and pollution control. With the passage of the 1987 Water Quality Act, Congress acknowledged the need, on a national basis, to strengthen existing laws and create new programs in order to address protection of our nation's most precious resource. Programs specifically designed to deal with such problems as nonpoint source pollution, toxics, and other point sources and the protection of national treasures such as the Chesapeake Bay and the Great Lakes are examples of this newfound emphasis on protecting aquatic resources.

The water pollution regulatory program as administered by EPA has been largely successful in reducing pollution and destruction of our nation's aquatic resources. Many of our streams and lakes have gradually recovered from years of abuse and now support abundant aquatic life and provide for swimming and recreation–the ultimate goal of the CWA. However, recent evidence shows that we have much work to do in protecting and enhancing aquatic resources.

Ultimately, responsibility for meeting the mandates of the Clean Water Act through pollution control and needed improvement programs falls on our society as a whole. Private citizens, various levels of state and federal government, and private businesses must all share in this important endeavor.

4.2 AQUATIC RESTORATION PROGRAMS

INTRODUCTION

Numerous federally funded programs exist to protect, restore, or improve the aquatic resources of the SAA area. Some programs have a long history of application in the area; others are still in the planning stage. A variety of agencies are involved, including the USDA Forest Service (FS), Natural Resource Conservation Service (NRCS) and Farm Services Agency (FSA), the National Park Service (NPS) and U.S. Fish and Wildlife Service (FWS), EPA, Tennessee Valley Authority (TVA), and the U.S. Army Corps of Engineers (COE).

Each program is unique and is oriented toward improving specific aspects of the aquatic resource. Some involve specific non-federal partners and state cooperators; others are available to the general public. All are nonregulatory.

A brief synopsis of these programs follows, as well as a summary on table 4.2.1 at the end of this section. More detailed information is available from sources listed as points of contact, as well as individual national forest and state headquarters offices of the respective agencies.

Agriculture Conservation Program

Administered by the FSA, this program provides cost-sharing and technical assistance to private agricultural landowners chiefly for erosion control and water pollution prevention. Cost-share rates are set by local county committees established by the FSA, as are activities that are eligible for funding. Contact: county FSA office.

Wetlands Reserve Program

The Wetlands Reserve Program (WRP), administered by the NRCS, funds the purchase of permanent easements on private wetlands and follow-up wetland restoration and revegetation. Eligible lands include altered but restorable wetlands and adjacent, critical non-wetlands. Management plans are developed by the NRCS and FWS, and agreed to by the landowner. Landowners are responsible for 25 percent of the restoration cost and maintenance. Land use is restricted to activities compatible with maintaining wetland functions. All 50 states are eligible for the program. Contact: NRCS area offices.

National Riparian Strategy

Provides FS assistance to state foresters servicing private landowner riparian area management requests, as well as the inventory and restoration of degraded riparian areas on the national forests. The inventory of all riparian areas was to be completed by 1995 and 75 percent of the degraded areas restored by 2000. Funds appropriated for national forest watershed improvement and operations programs are utilized for this purpose. Contact: individual national forests.

Rise to the Future

Initiative utilizes national forest fisheries funding to encourage partnerships between the national forests and others for the purpose of managing and improving fish habitat on forest streams. Activities can also include riparian and wetlands restoration. Contact: national forest supervisor's offices.

Table 4.2.1 Federal assistance programs for aquatic resource improvement in the Southern Appalachian Assessment area.

Program Name	Lead Federal Agency	Type of Program	Applicable Lands/Streams	Sample/Eligible Activities
Agricultural Conservation Program (ACP)	USDA Farm Services Agency	Cost–Share (variable rate) and Technical Assistance	Private	Streambank Stabilization Livestock Exclusion from Streams Stream Crossing Construction Buffer Strip Planting
Wetlands Reserve Program	USDA Natural Resources Conservation Service	Cost–Share (75–25) Technical Assistance	Private	Wetland Restoration and Reforestation– Riparian Area Restoration
National Riparian Strategy	USDA Forest Service	Initiative	National Forests	Riparian Area Improvement
Rise to the Future	USDA Forest Service	Initiative	National Forests	Riparian Restoration Wetlands Restoration Fish Habitat Improvement
Stewardship	USDA Forest Service	Technical Assistance and Cost–Share (variable)	Private	Forest Stewardship Plans Wetland Improvement Riparian Improvement Erosion Control
Conservation Technical Assistance Program	Natural Resources Conservation Services	Technical Assistance and Planning	Private	Soil and Water Conservation Plans
Clean Water Initiative	Tennessee Valley Authority	Technical Assistance, Planning and Cost-Share (variable)	Public and Private	Agriculture, Best Management Plan Installation
Section 1135 Program	U.S. Army Corps of Engineers	Cost–Share (75–25)	Public or Private	Fish Ladders Channel Restoration Streambank Plantings
Bring Back the Natives	USDA Forest Service USDI Bureau of Land Management & National Fish and Wildlife Foundation	Challenge Cost–Share (50–50)	Public	Stream Habitat Restoration for Native Fish
Fisheries Across America	U.S. Fish and Wildlife Service	Cost–Share (50–50)	Public	Aquatic Habitat Improvement/ Information and Education
Partners for Wildlife	U.S. Fish and Wildlife Service	Tehnical Assistance and Cost–Share	Private Farmer Home Administration Easement and Fee–Title Transfer of Lands	Wetland Restoration Channel and Riparian Restoration

Table 4.2.1 (cont.) Federal assistance programs for aquatic resource improvement in the Southern Appalachian Assessment area.

Program Name	Lead Federal Agency	Type of Program	Applicable Lands/Streams	Sample/Eligible Activities
Rivers, Trails, and Conservation Assistance Program	National Park Service	Planning and Technical Assistance	Public or Private	River Corridor Assessment Conservation Strategies Greenway Development
Section 319 Non-Point Source Program	Environmental Protection Agency	Grants (60–40)	Public or Private	Riparian Restoration Upland Runoff Control Pollution Prevention Streambank Restoration
P.L. 566 Small Watershed Program	USDA Natural Resources Conservation Service	Planning and Cost–Share (Variable Rate)	Private	Erosion Control Stream Restoration Riparian Area Protection
Emergency Watershed Protection Program Conservation Service	USDA Natural Resources (By Local Government)	Cost–Share	Public or Private	Stream Channel Restoration Flood Control Landslide Recovery
River Basin Planning Program	USDA Natural Resources Conservation Service	Planning	Public or Private	Watershed Analysis Identification of Treatment Needs/ Funding Sources

Stewardship

The Forest Stewardship program, administered by the FS but delivered at the state level by state forestry agencies, provides funds for the development of stewardship plans for private landowners. These plans provide for such activities as timber and wildlife management, recreational use, and water quality improvement. Landowners agree to carry out practices compatible with the plan and can receive cost-share assistance for approved practices. State forestry agencies establish most of the terms of the cost-shared practices. These can include such activities as wildlife habitat improvement, reforestation, and erosion control. An interagency stewardship committee guides the program statewide. Contact: local county forester.

Conservation Technical Assistance Program (CTAP)

The NRCS offers technical assistance through district conservationist offices to private agricultural landowners. Farm plans are prepared with recommendations for erosion control, stream channel improvement, stream crossings, and riparian area protection. The NRCS identifies cost-share options and other programs that the landowner may wish to pursue to implement the plan. Contact: NRCS district conservationist.

Section 1135 Program

The COE program, aimed at cost-sharing with local sponsors to improve degraded fish and wildlife habitat, is associated with COE water projects, such as impoundments and channel maintenance activities. Reconnection of former oxbows and construction of fish ladders to facilitate migration above dams are examples of actions cost-shared with 1135 funds. Contact: COE district offices.

Bring Back the Natives

This 50-50 challenge cost-share program targets native fish habitat restoration. National forests match with cooperators, such as Trout Unlimited, to improve in-stream conditions for the restoration of native fish populations. The National Fish and Wildlife Foundation and the USDI Bureau of Land Management receive federal appropriations which it cost-shares with public and private partners for the same purpose. Contact: national forest supervisor's offices, Trout Unlimited chapters, and the Fish and Wildlife Foundation.

Fisheries Across America

This FWS cost-share program provides for aquatic habitat improvement with emphasis on information and education. Contact: regional FWS office in Atlanta.

Partners for Wildlife

Offers technical and financial assistance to private landowners of degraded wetlands or other wildlife habitat. The FWS provides the funds for restoration work administered under cooperative agreement with the landowner. Lands received by easement or fee-title transfer by the FSA are also eligible for habitat restoration using these funds. Contact: regional FWS office.

Rivers, Trails and Conservation Assistance Program

This NPS planning and technical assistance program is oriented toward local and state governmental agencies to assist in carrying out statewide river assessments, wild and scenic river studies, and river conservation strategies. Contact: NPS regional office.

Section 319 Nonpoint Source Program

This EPA program provides grants to state water quality agencies to carry out nonpoint source pollution planning and management activities. Approximately half of the grant is used to manage the overall nonpoint source program; the remainder is intended to demonstrate practices, termed BMPs on the ground. While grants are provided by EPA to states primarily, cooperators and subgrantees can include public agencies, universities, and private landowners. Practices must be oriented to nonpoint pollution prevention or abatement, and projects must include a technology transfer component. Contact: state water quality management agency.

P.L. 566 Small Watersheds Program

Authorizes the NRCS to initiate cooperative watershed studies in which both on-site and off-site soil and water resource impacts are analyzed and corrective actions recommended. Programs occur only in some watersheds having clearly identified needs and a local sponsoring organization. The FS provides technical assistance to NRCS for forestry analysis.

The lands involved are typically private, but public lands may be either treated or utilized to solve problems originating on private land. Flood control structures are an example of a measure taken, often on public land and for the public's benefit, to solve problems generated by upstream activities on private land. If recommended improvement measures are determined by NRCS to be cost-effective and if funding is secured, cost-sharing becomes available. Contact: local NRCS district conservationist.

Emergency Watershed Protection Program (EWP)

The EWP program is managed by NRCS in conjunction with other agencies to restore stream channels, remove blockages, stabilize landslides, and solve flooding problems caused by catastrophic natural events. Restoration of watershed conditions following hurricanes, tornadoes, fires, and other storm events is provided for both private and public lands, depending on the source of problems. These improvements can be cost-shared or fully funded, depending on the immediacy of the need for treatment. Contact: state conservationist.

River Basin Planning

This USDA program, coordinated by NRCS, is similar to the P.L. 566 Small Watersheds program in that it provides a mechanism for evaluating the overall watershed condition of an approved study area, but it is strictly a planning program. It can and often does precede a Small Watersheds study and in fact can identify the need for a P.L. 566 study. As in the latter, the FS provides forest resource input for river basin plans. Contact: state conservationist.

Clean Water Initiative

This TVA effort includes partnership agreements with public and private cooperators to solve aquatic resource problems. Cost-share agreements have been used in the past for implementation.

Effectiveness of Programs

Environmental effects of most of the above programs are not readily quantifiable and have not been evaluated over the SAA area. Some programs are preventative (BMPs), others are restorative (EWP), and still others combine restoration with long-term protection (WRP). This mix of purposes leads to different results and precludes definition declaration of their overall effectiveness in the SAA area. The responsible agencies track program implementation, but no overall conclusions can be drawn at this time.

Impacts of Human Activities

5.0

Question 4:

What are the current and potential effects on Aquatic Resources from various activities?

In this chapter, the effects of various land management or human activities on Southern Appalachian aquatic resources will be assessed. Effects refer to the quality or condition of the water, the stream or river channel, the lake bed or its margins, aquatic organisms, and the riparian area that is adjacent to the water. Effects can be either positive or negative changes in quality or condition.

These activities can increase or decrease erosion into the aquatic system and deposit sediment in streams, rivers, and lakes; alter the physical shape of stream channels; change the chemistry of waters; and change aquatic organisms.

Activities include the development of human habitation and service facilities at urban, suburban, and rural sites; agricultural facilities and operations; construction, maintenance, and use of roads and highways; mining and petroleum extraction and processing sites; industrial facilities; water resources development; and forestry operations including silviculture, recreation, and wilderness or preservation actions.

As the assessment progressed, the aquatics team recognized that portions of chapters 2, 3, and 5 raise similar and overlapping concerns. Thus, the reporting of the assessments of aquatic species at risk is included with chapter 2, while the assessment of aquatic habitat condition is included in chapter 3.

Question 4 was answered by searching various databases from the U.S. Environmental Protection Agency (EPA), National Resource Conservation Service (NRCS), and U.S. Geological Survey (USGS), for information on human activities and their effects on water resources in the Southern Appalachian Assessment (SAA) area. Using Geographical Information System (GIS) technology, these data were combined with maps of the waterbodies and watersheds (section 2.1) or counties of the area to determine the extent of the impact of these activities. Where regionwide databases were not available, results from surveys of literature and research reports were relied upon to define principles that are likely to apply throughout the SAA region.

5.1 HYDROLOGIC, NONPOINT, AND POINT SOURCE EFFECTS

Key Findings

- Two-thirds of the reported water quality impacts are due to nonpoint sources, such as agricultural runoff, stormwater discharges, and landfill and mining leachate.
- Soil disturbance, due to agriculture and its potential for generating soil erosion that might reach the aquatic system, declined from 1982 to 1992. Potential soil erosion was reduced by more than 50 percent in 23 counties during that 10 years, while 8 counties showed an increase of more than 50 percent.
- The impacts on hydrology are greatest for land uses and activities near streams. Away from the riparian zone, hydrologic impacts increase with the proportion of watershed that is disturbed.
- In the majority of counties in the SAA area, less than 30 percent of the land base is devoted to agriculture. Those counties with more land in agriculture do not necessarily have greater estimated erosion potential, but often do have greater estimated nitrogen loading from fertilizer and animal manure.
- In counties with high pesticide sales, 25 percent or more of the land base is more likely to be devoted to agricultural uses.
- Population in the SAA area increased 19

percent from 1970 to 1980. The growth rate totaled 7 percent over the next 10 years. Development of housing, service facilities, and roads to serve the growing population has provided increasing impacts on water quality.

- In nearly 40 percent of the watersheds in the SAA area, at least 6 percent of their stream length is near to and potentially impacted by graveled or paved lower class roads. In a few counties, as much as 20 percent of their stream length is near roads.
- A total of 890 potential pollution-source sites are listed under the Comprehensive Environmental Resource Compensation Liability Act (CERCLA) within the SAA. Of these, 22 superfund sites are on the National Priorities List (NPL), and 84 are either abandoned or closed landfills.
- At the time of this assessment, 170 sanitary landfills were active in the SAA area that were not on the CERCLA list.
- In the 305(b) Water Quality Reports to Congress, SAA states indicate that the mining impacts on water quality occur predominantly in the Tennessee River basin and southwestern Virginia. Mining and urban or suburban developments have made the largest alterations in hydrology of the SAA region, principally by changing the timing of flows and increasing stormflows.
- Forest comprises the primary land cover of the region. Unlike agriculture, forestry activities that disturb soil are dispersed in both space and time. Thus, forestry has a low potential for impacting aquatic resources.
- Both agriculture and forest harvest will increase streamflow by reducing vegetation, and thus evapotranspiration, in proportion to the watershed area that has been cleared.
- About 3,000 point sources currently discharge treated wastewater into surface waters within the Southern Appalachian region. Seven percent of these National Pollutant Discharge Elimination System (NPDES) permit sources are considered major facilities, based on volume of discharge and pollutant loading.
- The majority of the permit sources with discharges greater than 1 million gallons per day, (132 out of 222) are municipal treatment facilities. Municipal sources constitute 40 percent of all permitted discharges.
- Urban areas are a large source of biological oxygen demand (BOD). Waters with estimated high BOD loading are often in watersheds that have more miles of stream that do not support designated uses.
- The three industries with the largest number of point discharges are mining, textile, and chemical. Of those industries, 4 mining, 19 textile, and 21 chemical sites are rated as major facilities.
- Some 30 NPDES permit facilities have discharged significant levels of toxic chemicals into SAA waters. These discharges do not meet water quality standards for those waters and require individual control strategies.
- A total of 17 fish consumption advisories have been issued in the SAA area, and each state has at least one of these advisories. Eleven of the warnings are for polychlorinated biphenyl (PCB) contamination, one is due to PCB and chlordane contamination, three are due to mercury contamination, and two are due to dioxin contamination. Of the 17 advisories, 10 are located on 4 rivers and a lake that cross state lines.

Data Sources, Data Quality, and Pre-analysis Treatment

The base GIS data layers for these analyses were the waterbodies (streams, rivers, and lakes) and watershed boundaries, both previously described in section 2.1. Information from other chapters used to interpret Question 4 are the land cover satellite data described under section 3.2, land ownership boundaries and data, such as critical species information, described in chapter 2. The results are categorized by state and county boundaries and by hydrological unit code (HUC) watersheds. Activities are assessed in terms of their ability to change the hydrology or the water quality of the aquatic system. Water quality effects are separated into those that are caused by nonpoint sources and by point sources.

Hydrologic Impacts

Hydrologic changes may be significant on a small watershed or at a stream site, but rarely are noticeable at the scale of a large watershed or river basin. The stream channel size and shape are the result of the historic flow pattern, from droughts to floods, and of the sediment input from the uplands. When a hydrologic regime of the stream changes, the channel characteristics will adjust to the new regime. Publications that describe hydrologic processes in detail include Hewlett (1982), Anderson and others (1976), Ward (1975), and Brooks and others (1991). Leopold (1994) offers a lengthy discussion of stream adjustments that are due to changes in the hydrologic conditions of watersheds.

Nonpoint Sources

For the purposes of this report, any source of contamination that does not require an NPDES permit is considered a nonpoint source of pollution. Some source categories, such as acid mine drainage, include both point and nonpoint discharges and are also discussed in this section.

Industrial sites, landfills, and other locations that are potential origins of nonpoint source pollution are identified pursuant to CERCLA. The Comprehensive Environmental Response Compensation and Liability Information System (CERCLIS) database, maintained by EPA, is the source for this inventory of CERCLA sites and for related information on the extent of site contamination and status of remedial action. From the CERCLIS database, the NPL further identifies high-risk Superfund sites, which by definition have or can adversely impact human health or the environment and have been targeted for cleanup.

Landfills are included in the CERCLA list only if they are abandoned or closed and have not met federal and state sanitary landfill regulations. Rules require that existing landfills be properly closed and capped, with provision for long-term monitoring of groundwater for seepage. Location data provided by states and compiled by EPA is available for 90 percent of the sanitary landfill sites.

Mining activities that have adversely affected water quality are documented in the 305(b) Reports to Congress from SAA states and are identified according to river or watershed. Impacts are reported as miles of stream either partially supporting or not supporting designated uses. (see section 2.2).

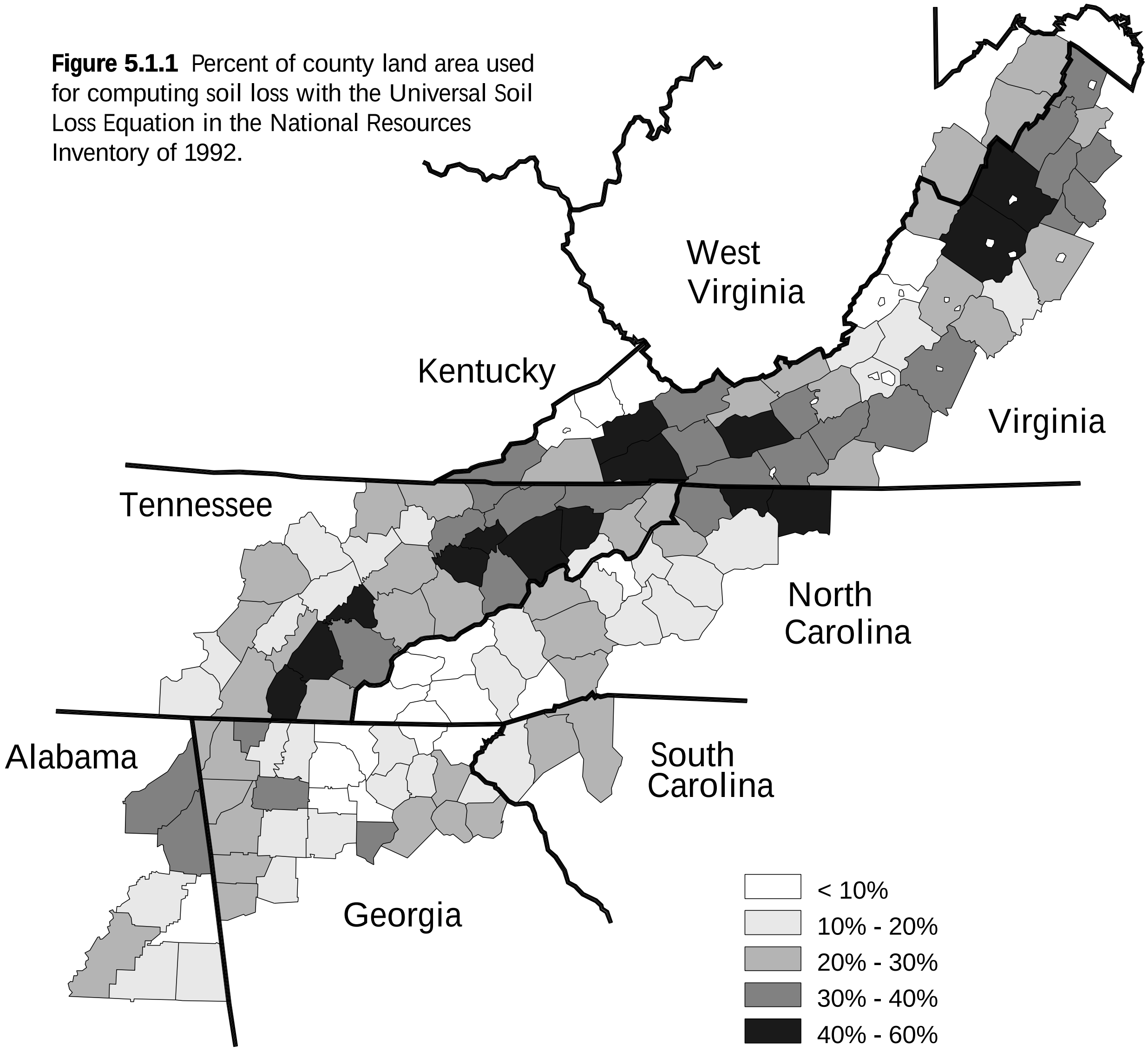
The Natural Resource Inventory (NRI) database, built by the NRCS (formerly the Soil Conservation Service), sampled each county in the SAA region for land use. For each sample point where agriculture was the land use, estimates of soil erosion potential were calculated (Soil Conservation Service 1994). These inventories were made at 5-year intervals in 1982, 1987, and 1992. The erosion potential from the NRI cannot be taken as a total measure of sediment that reaches waterbodies from agricultural practices. These are estimates of erosion potential on the cropland site and cannot be used to estimate the proportion of eroded soil that is carried to waterbodies or drainage channels. As such, these erosion potentials are a relative estimate of the sediment-producing opportunity and of the quality of agricultural land management practices in a county. A large portion of the SAA region is forested; thus, in two-thirds of the SAA counties, less than 30 percent of the land base is included in this analysis (fig. 5.1.1).

The Universal Soil Loss estimate, in tons/acre/year, and an area weighting factor for each sample point were extracted from the NRI database for the 3 inventory years. The erosion rates, weighted by their representative areas, were summed for each of the SAA counties and divided by the county area in agricultural use to determine an average erosion rate for each county.

Puckett (1995) found that commercial fertilizer and animal manure are the largest sources of nitrogen loading on southeastern United States watersheds. These nitrogen inputs are significantly greater in watersheds where agriculture is the dominant land use. However, he concluded that only a small part of the total nitrogen applied to the land reaches the aquatic system. Following the technique of Puckett, commercial fertilizer application rates found in the 1985 EPA National Database of Fertilizer Sales and 1987 animal population figures from the Census of Agriculture were used as estimators of potential nitrogen loading of the aquatic system.

Pesticides are routinely applied to agricultural lands, residences, lawns, and golf courses. This analysis estimates pesticide loading found only on agricultural land. Pesticide-use data were obtained from the same NRI database as used for erosion estimates and are based on pesticide sales by county. Agricultural pesticides include herbicides, insecticides, and

Figure 5.1.1 Percent of county land area used for computing soil loss with the Universal Soil Loss Equation in the National Resources Inventory of 1992.



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fungicides. Pesticides can reach surface waters from aerial drift, stormwater runoff, and careless handling. Pesticides that are present in surface waters can contaminate public drinking water supplies and sediments in aquatic habitats. Bioaccumulation of pesticides may appear at several levels in the food chain.

In Chapter 3, the distribution of land covers that are important to aquatic resources reflects differences in ecological regions. Agricultural land uses are more predominant in the Ridge and Valley, while forests are more dominant in the Blue Ridge. Federal and state agencies have monitoring and research programs that focus on the impacts that forests and forest uses have on aquatic resources in the SAA region. Information on these impacts is available in research reports from Coweeta Hydrologic Laboratory in Macon County, North Carolina (Stickney and others 1994); Fernow Experimental Forest in Tucker County, West Virginia (Godwin and others 1993); Tennessee Valley Authority (TVA), Oak Ridge National Laboratory, National Park Service, and National Biological Service at Gatlinburg, TN, as well as numerous universities with forestry, fisheries, hydrology, and forest ecology programs in and near the SAA region. Other sources include reviews such as Waters (1995), Hackney and others (1992), and Swank and Crossley (1988).

Roads can be a major source of lowered water quality in the SAA region. During road construction, soil is exposed to erosion processes. Graveled and ungraveled roads provide a continuing potential for soil erosion. Periodic maintenance of road ditchlines and graveled roadbeds reexposes soil to erosion. Where these roads are near streams, lakes, and rivers, this eroded soil easily can be washed into the aquatic habitat. In addition to sediment reducing water quality, petroleum products and chemicals washed by storms from road surfaces can also pollute streams. For the purposes of this assessment, the amount of road length near to waterbodies is used as measure of a major potential for water quality degradation.

The road data were obtained from the USGS 1:100,000 Digital Line Graph (DLG) files. These were assembled for the SAA region into four files, based on road size and use. Class 1 includes all primary highways, both federal and state numbered routes. Class 2 is secondary paved routes, such as major county roads. Class 3 is the minor paved county roads and major gravel-surfaced roads. Class 4 includes paved streets in both cities and towns and lesser rural gravel roads. The DLG files also included a class for trails, which was retrieved for the SAA but not used in the road analysis (USGS DLG database).

The road classes would be most useful for this analysis if gravel or soil-surfaced roads were in classes that are distinctly separate from paved roads. The newest roads, built or reconstructed after the DLG file was created, are not in this database. Small rural and most forest access roads are also omitted. The newer DLG files that are being created by USGS from 1:24,000 scale maps will show more complete road detail. When road positions were drawn on the maps that were the source of this digital data, true positions may have been shifted to allow for space to print the adjacent road and stream symbols. This position error is not considered significant for the purposes of this analysis.

A drinking water source is one of the highest uses of the SAA aquatic resource. Thus the location of water intakes are focal points for assessing impacts on water quantity and quality. Drinking water intake data were obtained from EPA Drinking Water Supplies file. Stream information was obtained from EPA River Reach 1 (RF1) database.

Point Sources

Point sources are both municipal and industrial in origin. Every point source discharge to surface waters of the United States is required to obtain a permit to discharge under the NPDES. (See section 4.1 for further background on water quality laws and regulations.) These permits specify limits for mass or concentration of specific pollutants, monitoring requirements, and other provisions such as spill prevention plans, which can all be used to assess pollution loading and risks. The database that stores the information on wastewater dischargers is the EPA Permits Compliance System (PCS). The PCS maintains data about individual dischargers, including location, allowed flows, limits for each pollutant allowed to be discharged, monitoring requirements, and information concerning permit violations. The PCS database contains location data for more than 85 percent of the individual point sources in the SAA region, however, precise locations are not available for the other, usually small, sources. For major dischargers and most minor dischargers, PCS has a record of the Discharge Monitoring Reports (DMR) of each source. The DMRs are required reports, usually monthly, that document the self-monitoring of permit limits by the discharger.

Facilities covered by Section 304(l) of the Clean Water Act (CWA) regulations are a subset of all PCS-listed facilities. The priority or "short" list of 304(l) facilities is the list of sites where discharges of toxic pollution are known to cause water quality problems. These facilities are proposed to EPA for Section 304(l) listing by state environmental programs.

Additional information on toxic discharges was obtained from the EPA Toxics Release Inventory (TRI). The TRI contains the annual records of releases of toxic or hazardous substances to air, water, and land. Reports of quantities released to water are based on a variety of techniques, including direct measurements or estimates that are provided by the individual facilities. The latest available data for 1993 were the basis for this analysis.

The protection of human health through the regulation of toxic pollutants in fish is a joint federal and state responsibility. The Food and Drug Administration (FDA) has direct enforcement responsibility over all contaminated food, including fish and shellfish, that is shipped in interstate commerce. The EPA is responsible for establishing tolerances (maximum permissible levels) for residues of pesticide chemicals that may appear in fish. Environmental agencies and health departments at the state and local levels are responsible for issuing public health advisories and regulations for local fisheries. States may determine a more appropriate level of concern or "trigger point" for a chemical based on site-specific monitoring data or surveys. This analysis presents all the fish consumption advisories in the SAA area. These advisories are due to the presence of chlordane (a pesticide used for termite control until recently banned), dioxins (byproducts of the kraft mill paper bleaching process), mercury (used by chemical and munitions facilities), and PCBs (widely used in industrial and commercial equipment for power generation and distribution until banned in 1976). Generally, when a state issues an advisory on a stream or lake, a press release is issued that describes the associated health risks in detail. In most states, these advisories are published in the annual sport fishing regulations or biennial water quality reports of fish and wildlife or health agencies. This analysis consulted state 305(b) reports, a recently released national database entitled National Listing of Fish Consumption Advisories (NLFCA), and EPA's Fish Contamination Database (managed by the Environmental Services Division in Athens, GA) and (Alabama Department of Environmental Management 1994; Denton and others 1994; Georgia Department of Natural Resources 1994, 1995; Murphy and Stiber 1994; North Carolina Department of Environment, Health, and Natural Resources 1994; South Carolina Department of Health and Environment 1994; TVA 1995a; EPA 1992, 1995a, 1995b).

In addition, the EPA 1992 Needs Assessment for sewer and sewage treatment systems was used to provide estimates of the resources needed for upgrading municipal and community sewage collection and treatment over the next decade. This assessment includes both the estimated need to upgrade or replace existing facilities and the need for expansion to accommodate anticipated future demand.

Analyses, Spatial Patterns, and Trends

Hydrologic Impacts

Natural events will have the same hydrologic effects as human activities that create similar conditions. Floods may cause major changes in the stream channel system through the scouring action of peak flows and the transfer of sediment. The channel may be either eroded or filled, both of which would create long-term effects on water quality by causing channel adjustments. Future runoff timing, peak and low flows, and flow volumes should not be changed.

Droughts minimize stream flows; thus, bedload movement will be reduced and channels filled with deposits. Sediment loading can increase if surface runoff occurs where groundcover is killed by drought.

Landslides often deposit a large volume of soil, rock, and organic debris in stream channels. Some material is immediately transported downstream; more will gradually move during successive storms, while the remainder stabilizes where the slide stops. Locally, the site of the slide will have increased runoff peaks and sediment loading.

The effects of wildfire, insects, disease, and wind and ice storms are dependent on the severity and extent of changes in evapotranspiration, infiltration, and vegetation growth. Immediate effects of wildfire include an increase in total runoff and storm flows if extensive areas of vegetation are killed and soil is exposed. Nutrient loading may be temporarily increased. Recovery from fires is typically rapid in the East within a few years (Anderson and others 1976).

Insects and disease will change the total volume of runoff only if extensive areas of vegetation are killed. Normally only a few species are attacked and the remaining vegetation quickly utilizes the extra soil moisture and nutrients that become available. Where riparian trees are killed, woody debris loading may be increased and stream temperature raised slightly. Insect droppings may significantly change the water quality. Wind and ice storms typically disturb patches of land of limited area and have little influence on streams except for possible increases in woody debris. Runoff characteristics should not change where the vegetation is not killed, large areas of soil are not exposed, and infiltration rates are not changed.

Urban and suburban development of forested watersheds creates a major impact on the hydrologic regime. Development can increase the percentage of impervious surfaces on a watershed from nearly zero in a rural setting to almost 100 percent in commercial or industrial areas. Lull and Sopper (1969) conclude that urbanization in forested watersheds tends to "…reduce interception, infiltration, soil-moisture storage and evapotranspiration, and to increase overland flow and runoff. Several studies of peak flows have shown that they may be increased by 1.2 to 5 times over peaks from rural conditions…. During development and construction of suburban areas, sedimentation may be increased greatly; even after construction, sedimentation in these areas may be 5 to 10 times that from protected watersheds.” They also find that annual maximum peak flows increase, although maximum daily flows decrease. Total flow volume increases because a greater percentage of summer precipitation appears as runoff.

Surface and underground mining cause similar effects on the hydrologic regime, although to differing degrees. Surface mining includes all forms of open mines, while underground mines utilize tunnels and shafts. Mining effects on the hydrology of an area depend directly on the areal extent of the operation and the implementation and effectiveness of runoff and pollution control practices. Mining typically alters the timing and volume of runoff and the chemical and physical quality of the runoff. In general, surface mining results in higher stream flow and storm flow volumes than underground mining (Nelson and others 1991). This is due to the greater areal removal of vegetation and soil, the volume of spoils created, and general compaction of the area. Channels will adjust to increased peak flows and higher loading of fine and coarse sediments. Channel adjustments may include enlargement, filling with sediment, or overflow and braiding (multiple channels).

The hydrologic effects of agriculture are directly dependent on the amount of soil exposed, season of exposure, level of soil compaction, the location of the disturbance relative to stream channels, and the proportion of watershed disturbed. Annual row crops expose large areas of soil. If a compacted soil layer develops below the plow zone, water infiltration is restricted and surface runoff increases. Peak flow rates from watersheds with extensive row cropping will be greater than from forested watersheds. The lower evapotranspiration of row crops will result in a total water yield that is somewhat higher than with forest cover. If fields are cropped to the edge of stream channels, stream temperature will be increased (Swift and Messer 1971) and woody debris loading of the streams will be greatly decreased.

Pasture effects on hydrology depend directly on management. Pasture management for good ground cover, high infiltration rates, and protected stream banks will yield minimum impacts. Typically, however, pastures are overgrazed, have compacted soils, and allow animals free access to riparian areas and streams. Riparian areas are often more heavily grazed than upland areas because they consist of flatter terrain, water, shade, and more succulent vegetation (Platts 1991). There, surface runoff occurs during most storms, resulting in increased peak flows and associated water quality problems. Animal feedlots concentrate impacts and accentuate the hydrologic and water quality problems.

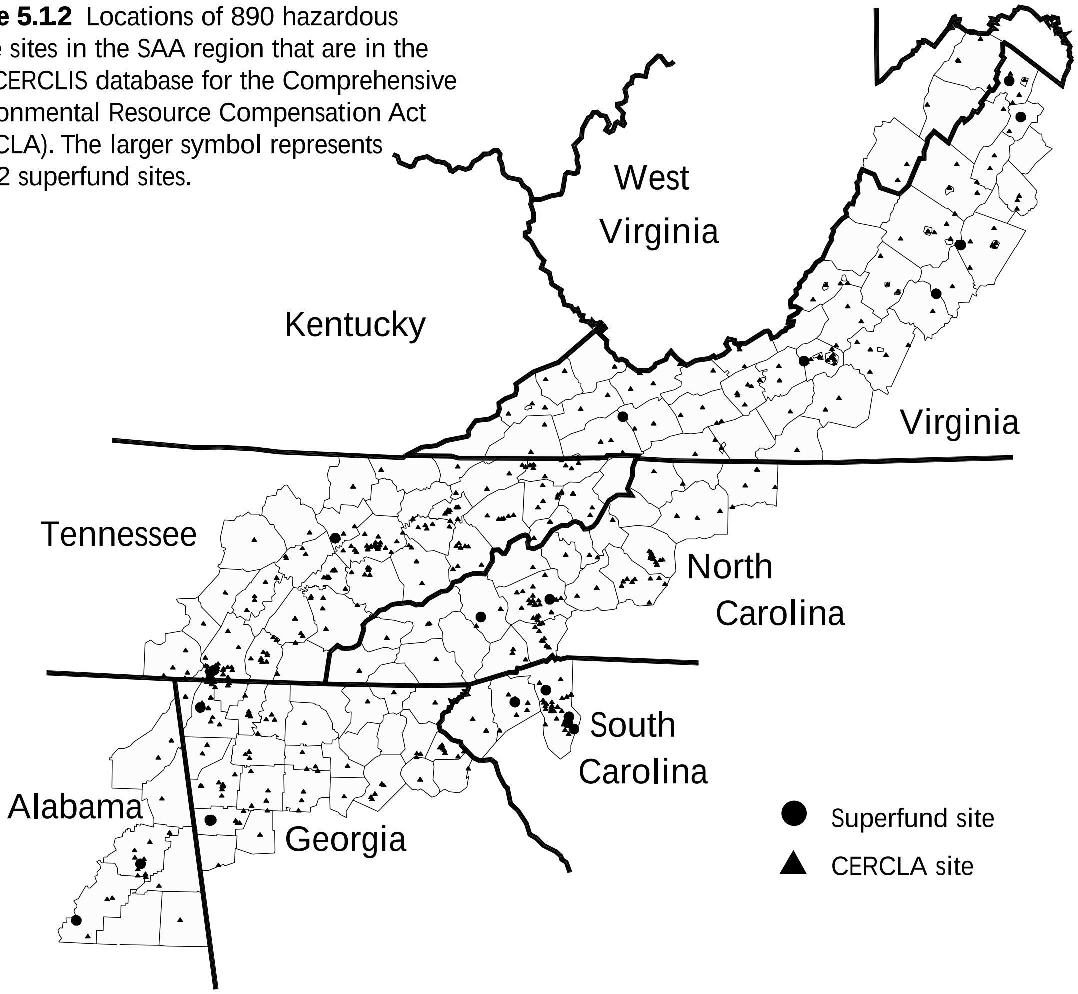
Orchard effects will vary greatly, depending primarily on the amount of bare soil and roading. Soils within well-established orchards should have high infiltration rates. However, the road system may produce rapid surface runoff.

Forest management Best Management Practices (BMP) are practices that are applied to the land for the production of trees while protecting aquatic, vegetation, wildlife, and recreation resources within a forested area. Each practice may have significant or insignificant effects on hydrologic processes, depending on the intensity and areal extent of the activity.

Timber harvesting reduces evapotranspiration in the short term, thereby increasing soil moisture and the potential for increased stream flow. Flow increases occur when soil moisture normally would be depleted by growing trees. Stream flow increases are greatest during the first year after harvesting and decline quickly with tree regrowth. Research studies in or near the SAA area indicate that first year stream flow increases up to 16 area-inches for clearcuts (100 percent of trees) and up to 4 inches for selection cuts that remove 30 percent or less of the trees (Swank and others 1988). Typically, cutting less than 20 percent of a well-stocked timber stand will not increase stream flow (Douglass 1967). Peak flow rates from clearcut watersheds are rarely increased for small storms unless the soils have been greatly compacted and infiltration is severely reduced. Large storms are more likely to result in higher peak flows, not due to the timber harvest, but due to the large excess of precipitation relative to available soil moisture storage.

Site preparation is a group of forestry practices used to regenerate a new forest stand. Techniques range from simply cutting the residual woody vegetation to mechanical clearing and cultivation. Herbicides and fire are

Figure 5.1.2 Locations of 890 hazardous waste sites in the SAA region that are in the EPA CERCLIS database for the Comprehensive Environmental Resource Compensation Act (CERCLA). The larger symbol represents the 22 superfund sites.



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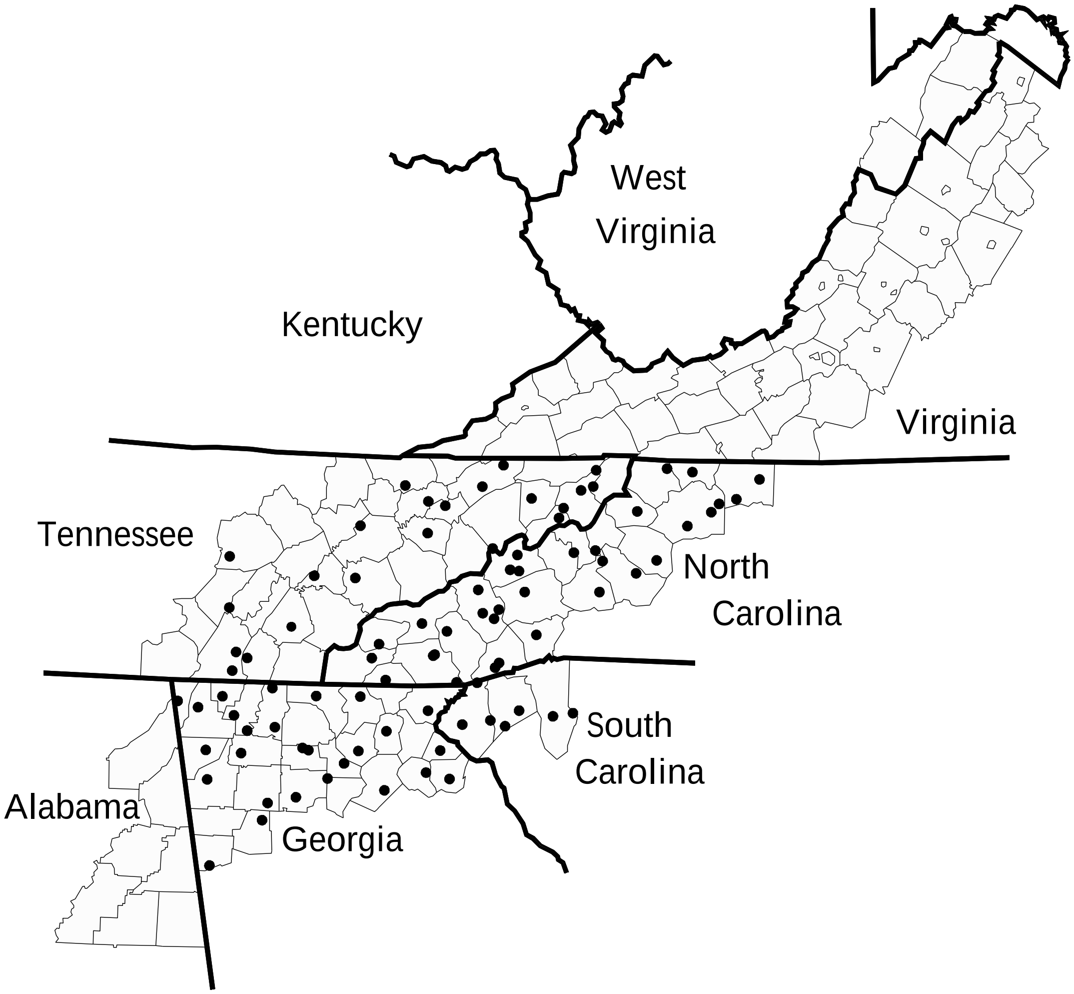
sometimes used. Site preparation effects on hydrology are directly related to the amount of soil that is compacted and the amount of organic surface layers that are removed from the disturbed soil. Prescribed fire is the controlled burning of unwanted material within the forest. The effects of fire on hydrology depend on how much vegetation is killed, the amounts of organic soil layers that are consumed, and whether soil is exposed. Intense fires may lead to increased peak flows due to surface runoff and increased total water yield due to evapotranspiration reduction. The duration of any effects from fires is strongly influenced by the rate of revegetation (Anderson and others 1976).

Roads that cross or lie near natural drainage channels affect the path and time in which storm water takes to reach the aquatic system. This extra water will accelerate erosion, increase sediment loading, and change runoff characteristics. Compared with vegetated land, precipitation runs off roads quickly instead of infiltrating, which will increase peak flow rates and shorten storm flow duration. However, unless roads occupy a significant proportion of the watershed, total water yield and flow timing will not be observably affected.

Dams and their reservoirs can change the regime and water quality of astream. The magnitude of the changes will depend in part on the size of the stream, the volume and depth of the reservoir, and the location of the outlet. Reservoirs may stop virtually all downstream movement of sediment and may initiate downstream channel erosion by releasing clean outflow with sediment carrying capacity. Downstream productivity can be reduced when drifting organic material and food organisms are trapped. Downstream water temperature is influenced by the location of the outlet of a reservoir. Water released from the top of a reservoir is warmest and water released from the bottom is coldest. Dissolved oxygen content of the released water may also be affected. Unless bypasses are provided, fish movement is stopped totally, preventing upstream or downstream migration for spawning and growth. Flooding of streams by impoundments has destroyed shallow-water habitats for fish and molluscs, resulting in loss or imperilment of



species (section 2.4). Where the volume of water in a reservoir is allowed to fluctuate, it will absorb and reduce high or peak flows and supplement low flows. These flow changes may have secondary effects downstream, such as changes in aquatic plant species, increased plant growth, and changes in channel size and shape. A somewhat more detailed discussion is presented by Hynes (1970).

Nonpoint Sources

Based on the 305(b) Water Quality Reports to Congress from SAA states, two-thirds of the reported water quality impacts in the SAA area are due to nonpoint sources.

The CERCLA program began in 1980 and is continuing to identify sites nationally that require further evaluation as Superfund sites. Inventory of the pollution sources in the SAA area found 890 CERCLA sites, and evaluated environmental impacts, from 22 Superfund sites. Currently, the rate of identification of new CERCLA sites is low. Furthermore, CERCLA sites are not usually significant sources of the types of pollution that are causing widespread impacts in the SAA area. Many sites in the CERCLIS database will not require immediate action and most are low priority for future remedial action. However, the 890 CERCLA sites (fig. 5.1.2) do show the potential to cause locally significant impacts and are more prevalent in urban areas. Abandoned or closed landfill sites account for 84 of these CERCLA sites.

Of the 22 Superfund sites, Records of Decision are in place at 19 sites to direct remedial actions. Impacts on surface or groundwater bodies have been documented for eight of these sites. The Superfund sites are found in developed areas, such as Greenville County, South Carolina, which has 5 of the 22 Superfund sites. The Superfund sites are plotted with larger symbols in figure 5.1.2.

Sanitary landfills are located in most counties in the SAA area and are found in both urban and rural settings. Figure 5.1.3 shows locations of most of the 170 active sanitary landfills in the SAA area. Landfills historically have been a significant source of CERCLA sites. Therefore, to avoid future environmental

Water Usage and Rights

6.0

Question 5:

What is the status and apparent trends in water usage and supplies in the Southern Appalachians, including water rights and uses on national forest system land?

Water is often referred to as our most precious natural resource. Every aspect of our lives and all other living organisms depend on water for sustenance and growth. Food, shelter, the production of goods, and all other human activities depend on water. Seldom do we stop to think about the importance of water as our faucets are turned on in anticipation of a hot shower or to prepare our food. We swim, drink from fountains, and water our lawns, rarely thinking about the source of our water. In the United States we are blessed with an abundant supply of clean water. Where supplies may be scarce, technology through the construction of dams and elaborate conveyance systems has permitted development of thriving communities in previously arid areas. As populations increase and place concomitant pressures on our water supplies, the awareness and importance of water will emerge as one of the most significant environmental issues well into the next century.

Water supplies in the South and particularly in the Southern Appalachian Assessment (SAA) area are abundant in the form of year-round rainfall, surface water flowing through streams, and groundwater. Average rainfall within the SAA averages 40 to 60 inches annually, with over 60 inches in the north Georgia mountains and the southwestern tip of North Carolina (Council on Environmental Quality 1989). Groundwater usage in states within the SAA ranges from a low of 394 million gallons per day (Mgal/d) in Alabama to 996 Mgal/d in Georgia (Solley and others 1993). These figures represent entire state averages and are not specific to the SAA study area. However, the combined effects of high runoff, shallow water tables, and abundant streamflows provide substantial water storage in the South. Recharge of shallow aquifers is accomplished in most years by high infiltration rates of southern soils and the annual occurrence of prolonged wet weather in winter. (Healy 1985)

With expanding development and urbanization, there will be an increasing demand on water supplies. Although water supplies have historically been abundant in the Southern Appalachians, there is a need for the compilation and study of water usage patterns in this unique ecosystem.

The categories of water usage include commercial, domestic, hydroelectric, industrial, irrigation, livestock, and mining. Sections 6.1 and 6.2 summarize the more salient water uses and, where possible, discuss some of the apparent trends in usage in the SAA area. Projections for water use, well into the next century, are based on a study by the USDA Forest Service with assumptions of continued uses and patterns of development. Water uses and rights on National Forest System land are discussed to provide background information on how that water use is monitored.

6.1 WATER USAGE AND SUPPLIES

Introduction

The Southern Appalachians are headwaters for nine major rivers. These rivers provide drinking water for much of the southeastern United States. Recent short-term droughts and reports of water pollution have further heightened concern over water quality and quantity issues that could take on increasing significance as we approach the end of the 20th century. The management of our water resources is transitioning from one of water-supply development to that of water-demand management and conservation (Solley 1993).

The expanding land uses in the South

Table 6.1.1 Total water use in the Southern Appalachian Assessment area in million gallons per day (mgd) from 1985–1990. From county water use data.

	Use Category								
	Commercial		Domestic		Industrial		Agriculture		Total
Year	(mgd)	(%)	(mgd)	(%)	(mgd)	(%)	(mgd)	(%)	
1985	124.4	5.0	462.9	18.4	1804.8	71.8	121.3	4.8	2513.6
1990	156.1	7.7	453.3	22.4	1324.5	65.5	87.4	4.3	2021.2

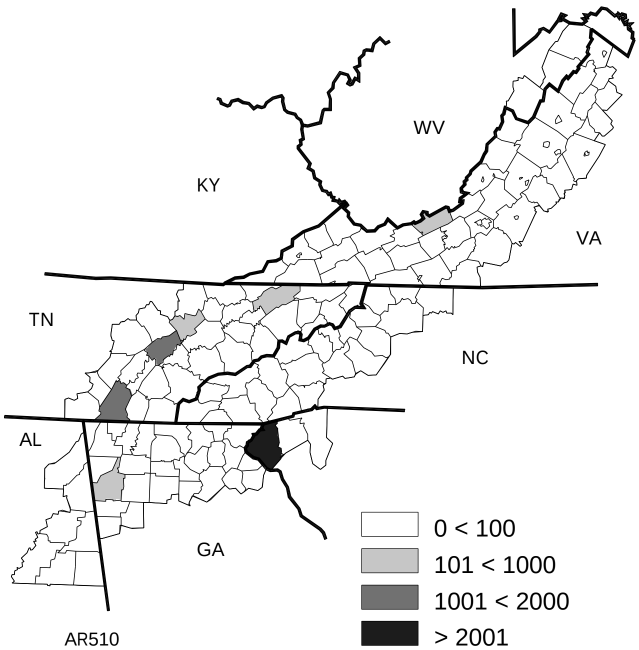


Figure 6.1.1 Range of thermoelectric water use (million gallons per day) by county in the SAA area for 1990. Actual use shown in table 6.1.2.

Table 6.1.2 Total water use in million gallons per day (mgd) in the Southern Appalachian Assessment area for thermoelectric cooling during 1985 and 1990.

Year	Total Use	Percent Increase
1985	5201	
1990	6766.1	30.1

require an abundance of water – water needed for homes, businesses, industry, and irrigation. Although the total consumptive use of water in the South as a whole is only a fraction of what is available, there are some localities which suffer shortages (Healy 1985). Local water shortages may result from inadequate conveyance systems, the lack of adequate infrastructure to supply water, or localized drought. The importance of high-quality water is becoming increasingly critical, and some users are taking steps to establish legal rights in anticipation of future competition. Furthermore, in many places surface water or groundwater has become severely polluted from unwise land-use practices, further increasing the demand and strain on water resources. Water use patterns in the South have also changed over the last 40 years. Water use has increased more than 70 percent since 1960. The rate of irrigation use has leveled off, while industrial use has increased more than tenfold.

The purpose of this report is to document known information regarding water supplies and usage within the Southern Appalachians and to look at apparent trends established over the past 40 years to provide some basis for future water demand.

Historically, the Southern Appalachian region has enjoyed an abundant supply of water. The Southern Appalachians receive an average of 50 to 60 inches of precipitation annually. Average annual runoff is 10 to 20 inches with higher amounts in the southern high-mountainous areas (Council on Environmental Quality 1989). For this report, water usage data for industrial, commercial, domestic, agricultural, and thermoelectric uses were compiled by county within the study area for the period 1985 to 1990. The following key findings and apparent trends are based on an assumption of reliable data with projections dependent on assumed population growth and future development within the South.

Key Findings

- Approximately two-thirds of the water use within the study area is industrial, and the remainder is divided between commercial, domestic, and agricultural (table 6.1.1).
- Overall, water usage in the domestic, industrial, and agricultural categories decreased 19.6 percent between 1985 and 1990,

Table 6.1.3 Water use by county for hydroelectric power in million gallons per day (mgd) in 1990. Counties are identified with a range of use in figure 6.1.1.

		Water Use	
FIPS[1] Code	County	(mgd)	(%)
51167	Russel	12.5	0.2
51071	Giles	345.8	5.1
47145	Roane	1170.3	17.3
47073	Hawkins	602.7	8.9
47065	Hamilton	1295.5	18.2
47001	Anderson	511.4	7.6
45073	Oconee	2352.7	34.8
37021	Buncombe	1.7	0
13115	Floyd	416.5	6.2
13015	Bartow	57	0.8

[1]FIPS = Federal Information Processing System

primarily due to a decrease of 26.6 percent in industrial use. Agricultural and domestic use also declined, whereas commercial use increased.

- Thermoelectric water usage increased 30 percent from 1985 to 1990 (fig. 6.1.1, table 6.1.2). Over 70 percent of the thermoelectric usage is by the three nuclear generating facilities: Oconee Plant, operated by Duke Power, 34.8 percent; Sequoyah Plant, 19.2 percent, and Watts Bar Plant, 17.3 percent, both operated by Tennessee Valley Authority (TVA) (table 6.1.3).
- Over 22 percent of water use in the study area occurs in Sullivan County, Tennessee, where industrial use exceeds 450 million gallons per day. Other industrial usage by county ranges from 0.5 to 82 million gallons per day (table 6.1.4).
- Of the total off-stream water withdrawals in the Southern Appalachian states, approximately 76 percent is surface water and the remaining 24 percent groundwater (fig. 6.1.2).

Data Sources

Water data were compiled by the U.S. Geological Survey (USGS). The water use program in the USGS, Water Resources Division, collects and publishes water use information at 5-year intervals. The categories of data are industrial, mining, public supplies, thermoelectric, livestock, and irrigation. The water use data are collected in cooperation with individual states and other federal agencies. Data may be gathered from existing manual and electronic files, collected in the field, or alternatively modeled using climatic or econometric models (Hutson 1995).

Under federal guidance, the standardized collection and analysis methods allow evaluations based on similar assumptions and comparable data. The data are used to provide historic water-use information to enable scientists to project the hydrologic effects of future water demands, such as reduced reservoir levels and lower groundwater levels (Hutson 1995; Solley 1993).

Analysis, Spatial Patterns, and Trends

The trend in decreasing water usage within the study area from 1985 to 1990 is consistent with water usage patterns nationally, where the rate of water usage increased steadily between 1950 and 1980 (figs. 6.1.3, 6.1.4) and then began an overall decline (Solley 1993). Two exceptions to this decreasing trend were the public supply and thermoelectric power categories. Withdrawals for both of these categories were about 5 percent and 30 percent more, respectively, during 1990 than during 1985. The Southern Appalachian area water usage increase of 30 percent in thermoelectric is a striking exception to the national rate.

Even though population increased nationally 4 percent between 1985 and 1990, withdrawal and consumptive use estimates increased by only 2 percent. Consumptive use within the Southern Appalachians, however, showed a decrease of 2 percent. This can be attributed to

Table 6.1.4 Water use in million gallons per day for each county in the Southern Appalachian Assessment (SAA) area.

County	State	Commercial	Domestic	Industrial	Agriculture	Total[1]	Thermoelectric
Calhoun	AL	2.3	11.39	4.94	2.04	20.67	0
Cherokee	AL	0.4	3.55	0.15	1.56	5.66	0
Clay	AL	0.09	1.53	0.11	0.89	2.62	0
Cleburne	AL	0.49	1.03	0.93	0.86	3.31	0
De Kalb	AL	0.26	4.54	2.45	4.87	12.12	0
Randolph	AL	0.03	1.72	0.34	1.25	3.34	0
Talladega	AL	0.81	4.19	75.62	1.4	82.02	0
Banks	GA	0.25	0.78	0.07	0.71	1.81	0
Bartow	GA	0.85	6.05	9.14	0.69	16.73	57
Catoosa	GA	0.16	3.69	0.01	0.76	4.62	0
Chattooga	GA	1.08	2.88	7.64	0.12	11.72	0
Cherokee	GA	0.54	6.31	0.56	1.17	8.58	0
Dade	GA	0.13	1.14	0	0.1	1.37	0
Dawson	GA	0.03	0.69	0	0.22	0.94	0
Fannin	GA	0.09	1.15	0	0.1	1.34	0
Floyd	GA	2.62	6.39	30.32	3.87	43.2	416.5
Forsyth	GA	0.72	3.71	1.08	0.82	6.33	0
Franklin	GA	0.26	1.93	0.02	1.03	3.24	0
Gilmer	GA	0.22	1.97	1.51	0.51	4.21	0
Gordon	GA	1.31	3.12	8.59	0.61	13.63	0
Habersham	GA	0.41	3.01	1.85	1.06	6.33	0
Hall	GA	3.15	6.33	3.87	2.53	15.88	0
Haralson	GA	0.06	2.51	0	0.29	2.86	0
Lumpkin	GA	0.16	1.47	0	0.91	2.54	0
Murray	GA	0.23	2.39	0.88	0.47	3.97	0
Paulding	GA	0.02	3.65	0	0.51	4.18	0
Pickens	GA	0.22	1.5	0	0.36	2.08	0
Polk	GA	0.08	1.9	1.95	0.13	4.06	0
Rabun	GA	0.28	1.17	1.87	0.13	3.45	0
Stephens	GA	0.26	1.98	2.3	0.32	4.86	0
Towns	GA	0.08	0.55	0	0.06	0.69	0
Union	GA	0.08	0.85	0	0.14	1.07	0
Walker	GA	0.58	5.64	5.8	0.41	12.43	0
White	GA	0.1	1.41	0	0.48	1.99	0
Whitfield	GA	7.39	6.17	22.16	0.81	36.53	0
Alleghany	NC	0.04	0.55	0	0.82	1.41	0
Ashe	NC	0.05	1.36	0.44	0.77	2.62	0
Avery	NC	0.21	0.82	0.01	1.45	2.49	0
Buncombe	NC	12.47	11.59	9.78	0.92	34.76	1.7
Burke	NC	1.27	3.93	11.29	0.95	17.44	0
Caldwell	NC	0.65	3.94	1.94	0.64	7.17	0
Cherokee	NC	0.35	1.5	0.27	0.23	2.35	0
Clay	NC	0.02	0.41	0	0.13	0.56	0
Graham	NC	0.09	0.41	0.03	0.02	0.55	0
Haywood	NC	1.15	2.58	52.23	0.51	56.47	0
Henderson	NC	1.27	3.87	2.83	0.77	8.74	0
Jackson	NC	0.53	0.9	0.01	1.64	3.08	0
McDowell	NC	0.29	1.77	4.35	0.23	6.64	0
Macon	NC	0.61	1.31	0.04	0.23	2.19	0
Madison	NC	0.36	1.5	0.01	0.43	2.3	0
Mitchell	NC	0.26	1.01	0.46	0.13	1.86	0
Surry	NC	1.26	3.49	6.88	2.02	13.65	0
Swain	NC	0.13	0.66	0.01	0.07	0.87	0
Transylvania	NC	0.2	1.47	31.11	0.19	32.97	0
Watauga	NC	1.57	2	0.03	0.4	4	0
Wilkes	NC	1.22	3.78	4.7	2.56	12.26	0
Yancey	NC	0.08	0.92	1.2	0.26	2.46	0

Table 6.1.4 (cont.) Water use in million gallons per day for each county in the Southern Appalachian Assessment (SAA) area.

County	State	Commercial	Domestic	Industrial	Agriculture	Total[1]	Thermoelectric
Greenville	SC	19.03	24.01	6.56	0.49	50.09	0
Oconee	SC	1.97	4.31	3.38	0.25	9.91	2352.7
Pickens	SC	4.47	7.04	3.34	0.16	15.01	0
Anderson	TN	2.92	10.17	6.03	0.38	19.5	511.4
Bledsoe	TN	0.38	0.75	0.05	0.42	1.6	0
Blount	TN	1.77	5.78	4.7	0.42	12.67	0
Bradley	TN	2.1	4.95	9.08	0.63	16.76	0
Campbell	TN	0.35	2.21	0.1	0.06	2.72	0
Carter	TN	0.81	5.53	20.73	0.11	27.18	0
Claiborne	TN	0.33	1.83	0.06	0.23	2.45	0
Cocke	TN	0.91	2.18	0.74	0.35	4.18	0
Cumberland	TN	0.5	2.93	0.44	0.57	4.44	0
Grainger	TN	0.11	1.08	0.05	0.36	1.6	0
Greene	TN	3.31	3.18	0.82	1.11	8.42	0
Hamblen	TN	0.79	2.72	25.05	0.18	28.74	0
Hamilton	TN	14.43	18.6	26.94	0.72	60.69	1295.5
Hancock	TN	0.07	0.42	0.06	0.1	0.65	0
Hawkins	TN	0.38	3.24	73.46	0.37	77.45	602.7
Jefferson	TN	1.14	2.55	0.24	0.62	4.55	0
Johnson	TN	0.17	1	0.47	0.13	1.77	0
Knox	TN	5.01	35.47	8.15	0.59	49.22	0
Loudon	TN	0.52	2.14	7.24	0.31	10.21	0
McMinn	TN	0.63	2.13	73.47	0.86	77.09	0
Marion	TN	0.45	2.03	0.11	0.14	2.73	0
Meigs	TN	0.08	0.68	0.04	0.56	1.36	0
Monroe	TN	0.57	2.29	0.32	0.36	3.54	0
Morgan	TN	0.03	1.07	0.03	0.07	1.2	0
Polk	TN	0.15	1.59	29.04	0.15	30.93	0
Rhea	TN	0.54	1.76	0.54	0.45	3.29	0
Roane	TN	1.22	3.29	3.02	0.3	7.83	1170.3
Sequatchie	TN	0.09	0.66	0.05	0.07	0.87	0
Sevier	TN	2.93	3.01	0.7	0.22	6.86	0
Sullivan	TN	1.47	4.52	450.72	0.44	457.15	0
Unicoi	TN	0.23	1.55	0.35	0.14	2.27	0
Union	TN	0.15	0.86	0.06	0.06	1.13	0
Washington	TN	3.16	10.48	3.86	1.35	18.85	0
Albemarle	VA	0.26	8.13	0.07	0.65	9.11	0
Alleghany	VA	0.69	1.86	59.56	0.06	62.17	0
Amherst	VA	2.46	7.1	14.4	0.26	24.22	0
Augusta	VA	3.51	7.32	14.98	3.08	28.89	0
Bath	VA	1.62	0.36	0.01	0.12	2.11	0
Bedford	VA	0.55	3.88	28	0.81	33.24	0
Bland	VA	0.34	0.48	0	0.2	1.02	0
Botetourt	VA	0.89	1.87	0.21	0.36	3.33	0
Buchanan	VA	0.11	2.35	0.31	0.01	2.78	0
Carroll	VA	0.68	2.24	0.69	0.64	4.25	0
Craig	VA	0.05	0.33	0	0.11	0.49	0
Dickenson	VA	0.2	1.32	0	0.04	1.56	0
Floyd	VA	0.07	0.9	0	0.46	1.43	0
Franklin	VA	0.43	2.97	0.29	1.46	5.15	0
Frederick	VA	0.2	5.07	0.3	0.35	5.92	0
Giles	VA	0.44	1.23	66.68	0.17	68.52	345.8
Grayson	VA	0.13	1.24	0.02	0.36	1.75	0
Greene	VA	0.11	0.77	0	0.16	1.04	0
Highland	VA	0.01	0.2	1.42	0.19	1.82	0
Lee	VA	0.13	1.84	0.01	0.37	2.35	0
Madison	VA	0.21	0.9	0	0.52	1.63	0
Montgomery	VA	1.72	7.52	27.53	0.51	38.48	0

Table 6.1.4 (cont.) Water use in million gallons per day for each county in the Southern Appalachian Assessment (SAA) area.

County	State	Commercial	Domestic	Industrial	Agriculture	Total[1]	Thermoelectric
Nelson	VA	0.17	0.95	0	0.75	1.87	0
Page	VA	0.42	1.63	0.35	0.81	3.21	0
Patrick	VA	0.18	1.31	0.37	0.29	2.15	0
Pulaski	VA	1.55	2.59	1.87	0.38	6.39	0
Rappahannock	VA	0.04	0.49	0	0.19	0.72	0
Roanoke	VA	7.28	14.96	4.92	0.27	27.43	0
Rockbridge	VA	0.5	1.38	2.96	0.6	5.44	0
Rockingham	VA	0.83	7.62	15.38	6.08	29.91	0
Russell	VA	0.17	2.15	0.03	0.53	2.88	12.5
Scott	VA	0.22	1.74	0.57	0.33	2.86	0
Shenandoah	VA	0.73	2.37	2.5	1.03	6.63	0
Smyth	VA	0.77	2.42	0.61	0.48	4.28	0
Tazewell	VA	0.92	3.45	0.56	0.39	5.32	0
Warren	VA	1.57	1.96	1.22	0.16	4.91	0
Washington	VA	0.96	4.82	0.78	0.95	7.51	0
Wise	VA	0.59	3.29	0.53	0.04	4.45	0
Wythe	VA	0.9	1.91	0.36	0.72	3.89	0
Hampshire	WV	0.11	1.11	0.46	0.14	1.82	0
Hardy	WV	0.09	0.8	1.41	0.47	2.77	0
Pendleton	WV	0.05	0.54	0.62	0.37	1.58	0
Totals		155.87	453.85	1321.76	87.29	2019.97	6766.1

[1]Total does not include thermoelectric use

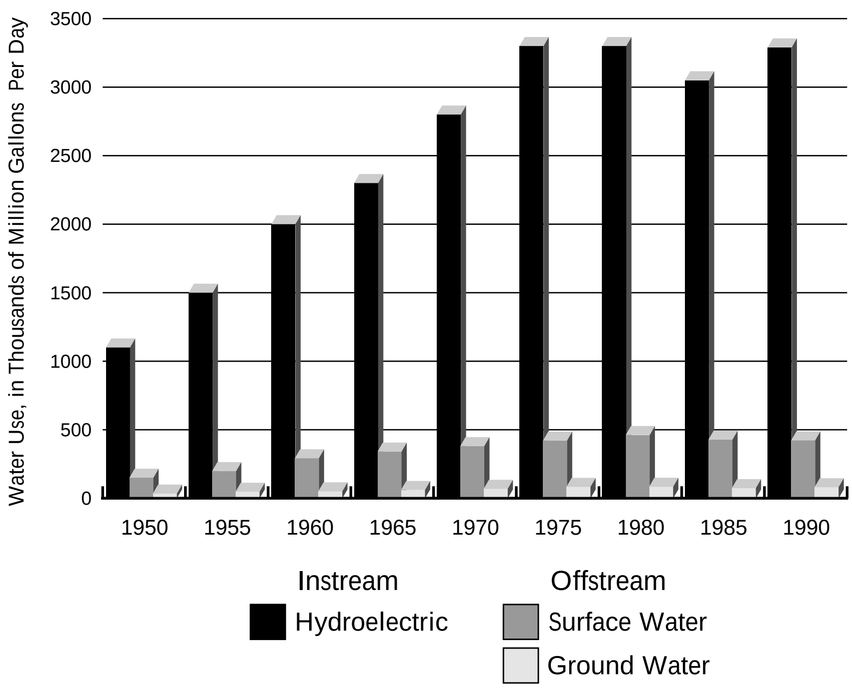


Figure 6.1.2 Trends in offstream and instream water uses, 1950-1990. Offstream use includes public supply, rural and domestic livestock, irrigation, and industrial (thermoelectric and other industrial). (Source: US Geological Survey Circular #1081)

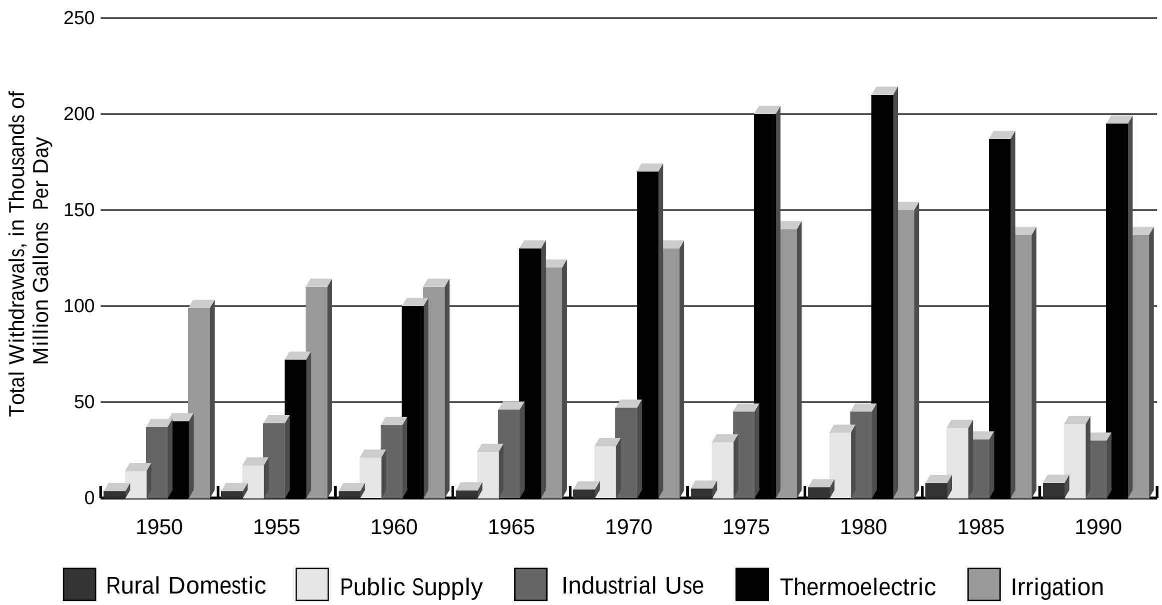


Figure 6.1.3 Trends in freshwater withdrawals by water use category for rural, public supply, industry, thermoelectric, and irrigation from 1950-1990. (Source: US Geological Survey circular #1081)

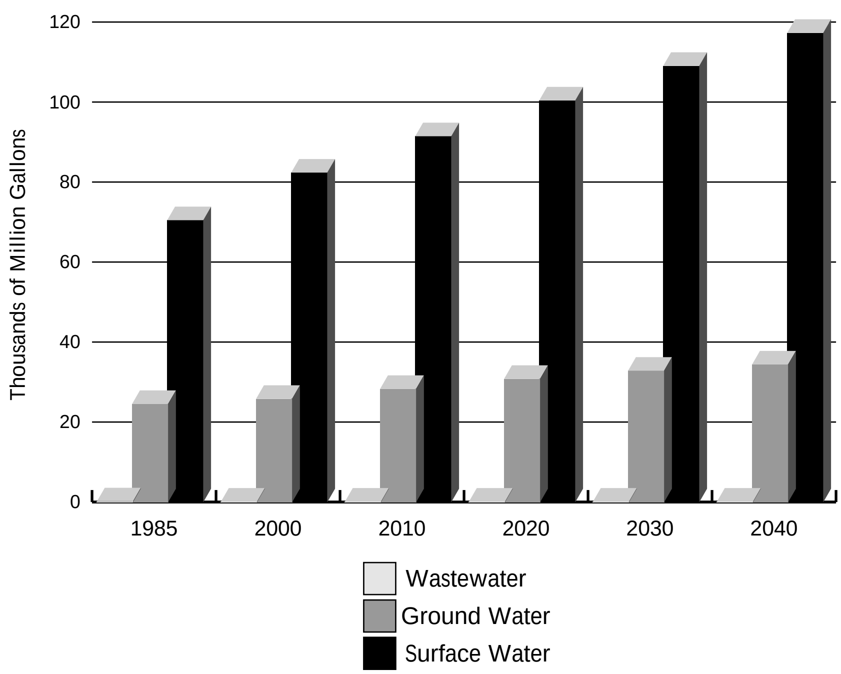


Figure 6.1.4 Total freshwater withdrawals in million gallons per day in the South from 1960-1985 with projections to the year 2040. (Source: An Analysis of the Water Situation in the United States: 1989–2040, USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Gen. Tech. Report #RM–177–178 pp.)

a number of factors, from water availability to implementation of conservation measures.

National trends in water use from 1950 to 1990 can be attributed in part to the factors listed below (Solley 1993). These trends can be inferred for the Southern region, as well.

- Availability of water is a primary determinant in the quantity of water used for irrigation and hydroelectric power generation.
- Higher energy prices, improved application techniques, increased competition for water, declines in farm commodity prices, and a downturn in the farm economy in the 1980s reduced the demand for irrigation water.
- New technologies requiring less water, improved plant efficiencies, increased water recycling, higher energy prices, the economic slowdown, and changes in laws and regulations to reduce the discharge of pollutants resulted in decreased requirements for industrial water and less water being returned to the natural system after use.
- The public in general has become more aware of the strain on water resources and the need to conserve. Additionally, many states have reduced water demand.

Likely Future Trends

A study by the USDA Forest Service (1989) projects water withdrawals and consumptive use to the year 2040 (figs. 6.1.4, 6.1.5). The projections, which show a gradual increase in use, are based on the availability of reliable data and assumptions for future population growth, economic conditions, energy-resource development, and environmental regulations.

It seems likely that water withdrawals will continue to increase as populations increase. However, based on trends established over the past 40 years, it is probable that the per-capita use rate will actually decline. This is based on an assumption of increasing water delivery costs, active conservation measures, and competition for multiple uses of water ranging from recreation and esthetic enjoyment to greater emphasis on fish and wildlife habitat needs (Hutson 1995).

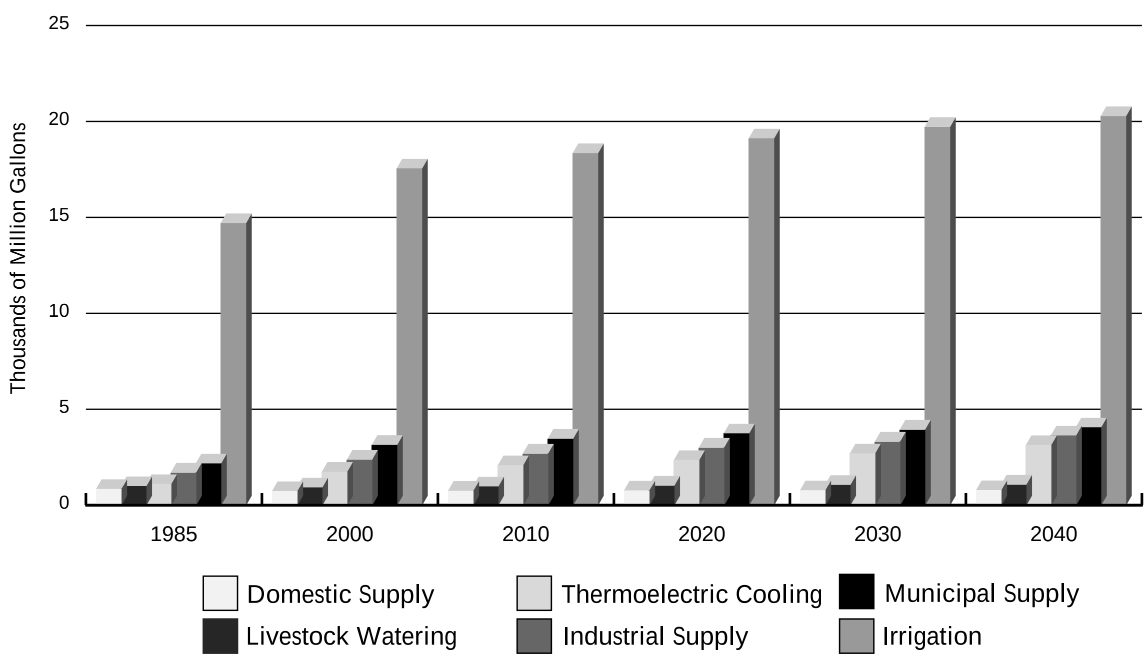


Figure 6.1.5 Total freshwater consumption (millions of gallons per day) in the South as projected from 1985-2040. Projected use categories are domestic, livestock, thermoelectric, industrial, municipal, and irrigation. See table 6.1.6. (Source: An Analysis of the Water Situation in the United States: 1989–2040, USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Gen. Tech. Report #RM–177–178 pp.)

Table 6.1.5 Total freshwater withdrawals in million gallons per day in the South, 1960–1985, with projections of demand to 2040.

	1960	1965	1970	1975	1980	1985
Groundwater	15570	21820	19165	23650	24040	24520
Surface Water	34635	42765	57415	68265	83295	70460
Wastewater	30	5	20	65	70	175
		Projected				
		2000	2010	2020	2030	2040
Groundwater		25795	28280	30790	32830	34390
Surface Water		82360	91450	100400	109050	117300
Wastewater		100	110	100	105	105

(Source: USDA Forest Service, 1989. An analysis of the water situation in the United States: 1989–2040, Rocky Mountain Forest and Range Experiment Station, Gen. Tech. Report #RM–177–178 pp.)

Table 6.1.6 Total freshwater consumption in million gallons per day in the South, 1960–1985, with projections of demand to 2040.

	1960	1965	1970	1975	1980	1985
Domestic self–supplies	519	798	721	661	842	843
Industrial self–supplies	1524	1581	2220	2075	2781	1702
Irrigation	9143	14913	12646	17564	16356	14701
Livestock watering	416	472	540	680	769	992
Municipal central supplies	1139	1301	1612	2323	2172	2176
Thermoelectric steam cooling	96	228	568	1061	1536	1089
		Projected				
		2000	2010	2020	2030	2040
Domestic self–supplies		732	750	766	777	783
Industrial self–supplies		2378	2690	3003	3317	3633
Irrigation		17550	18349	19116	19717	20278
Livestock watering		925	977	1022	1054	1073
Municipal central supplies		3140	3464	3742	3942	4056
Thermoelectric steam cooling		1739	2083	2351	2703	3132

(Source: USDA Forest Service, 1989. An analysis of the water situation in the United States: 1989–2040, Rocky Mountain Forest and Range Experiment Station, Gen. Tech. Report #RM–177–178 pp.)

Conclusion

Despite major droughts and chronic water shortages in some localities, the nation as a whole and particularly the South is not "running out" of water. Concerns about water shortages arise because of uneven distribution of water in relation to regional and seasonal distribution of water demands (Council on Environmental Quality 1989). The more serious problem facing the Southern Appalachians is the adverse impact on water quality impacts from man as development continues to accelerate. Impacts on water quality are addressed in chapter 5 of this report.

6.2 WATER RIGHTS AND USES ON NATIONAL FOREST LANDS

Introduction

A number of federal laws and judicial doctrines are in place to protect rights to water for mining, agriculture, manufacturing, and other purposes. The Organic Act of 1897 is the authority for watershed management and explicitly states that one purpose for establishing the national forests is securing favorable water flows. The act allows waters within the national forest boundaries to be used for domestic, mining, or irrigation purposes under the laws of the states wherein the national forest boundaries are situated, or under U.S. law. Subsequent laws and legal decisions that affect National Forest System water rights and uses include judicial doctrine (Winters v. United States, 207 U.S. 568 – also known as the Winters Doctrine), the General Exchange Act, the Organic Act of 1944, and the McCarran Amendment.

The Winters Doctrine established federal reserved water rights in 1908. The rulings implicitly reserve water needed for reservation purposes and include groundwater as well as surface water. Federal reserved water rights, unlike state water rights, are not lost by nonuse and may provide for future needs. The priority date is the date of withdrawal of the reservation. The General Exchange Act (March 20, 1992-42 Stat. 465 as amended 16 U.S.C. 485, 486) "provides authority for accepting title to lands within National Forests in exchange for National Forest lands reserved from the public domain." Lands so acquired do not have reserved status for purposes of claiming water under the reservation principle. However, such acquired lands may carry with them water rights established under state laws. A provision of the Organic Act of 1944 authorizes appropriations for Forest Service investigation, establishment, and purchase and protection of water rights needed for Forest Service administration use. The McCarran Amendment of 1952 allows the United States to be joined as a defendant in lawsuits related to water rights adjudication and the administration of such rights if the United States is the owner or in the processing of acquiring such rights.

All of the states in the Southern Appalachians have water rights governed by the "riparian right" doctrine. Riparian owners are entitled to make reasonable use of water where water flows through their land. There is a general stipulation that the water use cannot unreasonably interfere with downstream uses. This liberalized use of water in most states is being modified by state agencies with the development of comprehensive controls of water use to deal with common water quality and quantity problems (Dewsnut and others 1973).

The Forest Service water use, rights, and requirements (WURR) program is national in scope with specific guidance on data collection, storage, and retrieval of water rights files. The purpose of the program is to provide a uniform data file for recording and storing information on water uses, requirements, and water rights. The information is needed in the planning and implementation of programs on National Forest System land and provides ready access at all organizational levels to water rights information. The system also allows administration of special uses for permittees where water is used off National Forest System land. The primary users of the WURR system are land managers, water resource specialists, hydrologists, planners, and water-rights specialists who may be involved in legal proceedings or administrative determinations.

Currently, the WURR database is being maintained at the regional office level. For the Southern Region, (Atlanta, GA, USDA Forest Service, Regional Office) WURR files are maintained in an Oracle database that provides detailed information on water uses, location, purpose of use, amount of use, and the source type of water. The water source categories include streams, springs, impoundments, lakes, ponds, and groundwater. Water from national forest land is used for many purposes. In the Southern Region, predominant uses are for domestic household, irrigation, recreation, municipalities, and to maintain fish and wildlife habitat. Currently the WURR system is undergoing a significant change. The Region is working to update the storage and retrieval system to improve record keeping and accessibility by adopting an improved system.

The Forest Service Regional Office in Atlanta, currently maintains water rights files for all states within the study area. Water rights and usages are catalogued by the National Hydrologic Unit Coding (HUC) system. This system is based on major watersheds that often cross county and state boundaries. The WURR database does not lend itself to integration with water uses identified by state or county boundaries. Consequently, a direct comparison of water usage on National Forest System land with those portrayed within the SAA boundary is not possible and only general qualitative comparisons can be made.

This report summarizes the predominant uses on National Forest System land by state. This information can be used to identify watersheds that supply water and identify specific types of uses. Future trends in water usage on National Forest System land are also discussed.

Key Findings

- Water usage on National Forest System lands ranges from 1,700 gallons per day in Alabama to 1,315,000 gallons per day in Virginia. The Chattahoochee National Forest uses approximately 81,000 gallons per day, and the National Forests in North Carolina

Table 6.2.1 Water use estimates in thousands of gallons of water per day (tgd) on national forest land based on Water Use Rights Records (WURR).

Forest	Total Use	Domestic (tgd)	Domestic (%)	Municipal (tgd)	Municipal (%)	Industrial (tgd)	Industrial (%)	Fish/Wildlife (tgd)	Fish/Wildlife (%)	Recreation (tgd)	Recreation (%)
Alabama	1.7	1.7	100								
Georgia	81.4	21.1	26	60.3	74						
North Carolina	172.2	97.6	57	38	22	500	19	36.1	20		
South Carolina	No use information reported for the three counties within the SAA										
Tennessee	359.7	194.5	54	165.2	45						
Virginia	1314	350.5	27	190	14			614	47	160.6	12

% = percentage of total use

uses 172,000 gallons per day. The Cherokee National Forest in Tennessee uses 360,000 gallons per day. Only three counties in South Carolina are included in the assessment and no water rights were recorded for this area. The forests in South Carolina do maintain rights for 39 sites within 4 watersheds in the SAA area.

- Of the 1,315,000 gallons per day of usage in Virginia, 1,126,000 are drawn from the Holston River. Industrial withdrawals from the Holston River for Sullivan County, Tennessee, and Scott and Washington, VA, are the highest within the SAA study area.
- Water impoundments from the Holston River in Virginia for fish and wildlife (614,000 gallons per day) represents the largest use on National Forest System land within the SAA boundary.

Water usage on national forest land is minuscule in comparison to county usage.

Data Sources

Information presented is from known water use levels from available forest data. The information is not intended to reflect the complete list of water uses or water rights needed to protect and support beneficial water uses on national forest land.

Water rights and use data were compiled from the Forest Service Regional Office Oracle database. Water rights entries vary considerably by forest. South Carolina had no water rights entries within the SAA study area. Only three counties from South Carolina are included in the study area. South Carolina has 39 water use sites identified within 4 watersheds. Water rights uses are approximate and used on a very broad scale for comparative purposes. There is a need to update the water rights files once a new database system is in place. This is anticipated to be completed in 1996.

Analysis, Spatial Patterns, and Trends

A general comparison was made between two counties in Tennessee and the Nolichucky watershed on the Cherokee National Forest. Johnson and Carter Counties used approximately 30 million gallons per day in 1990. Comparatively, national forest water rights estimates for this watershed are approximately 51,594 gallons per day or less than 0.2 percent of the two-county usage rate. Another comparison was made for the total water used in Swain and Macon Counties, North Carolina, with national forest usage within the Upper Little Tennessee watershed. Combined water usage within the two counties was approximately 3 million gallons per day, whereas national forest usage was 6,030 gallons per day, which is approximately 0.2 percent on a comparative basis. It is probable that this ratio would hold true for most county/watershed comparisons, since usage on national forest land pales in comparison to county usage.

Table 6.2.1 compares the usage categories and rates for each forest. Virginia uses the greatest amount of water and Alabama uses the least – 1,315,000 and 1,700 gallons per day, respectively. North Carolina draws water from 20 watersheds, whereas Tennessee draws from 11. Georgia uses water from five watersheds and Virginia only three. This variability is due to the size of streams, available water, types of uses that demand water, and population density.

Likely Future Trends

Water usage on national forest land within the Southern Region has not been a significant issue for forest managers. Water supplies have historically been abundant and demands on water supplies have been easily managed. As populations continue to increase in the Southern Region, there will be greater demand and competition for water resources. Water usage increases on national forest will more than likely mirror trends projected in the South. However, usage rates on national forest land should be minimal due to the nature of management activities and limited future development. There may, however, be an increasing trend in the number of requests for special use permits off national forest land, especially in rural and suburban areas that abut national forests.

Evaluation of the Assessment, Integration of Findings, Data Gaps, and Future Work

Specific objectives of the aquatic resource assessment were to collect, assimilate, and analyze existing data with the purpose of identifying past, current, and future trends within the Southern Appalachian Assessment (SAA) area. The role of this assessment was to catalog and report information rather than form management decisions or recommendations based on that information. From the inception of this assessment, the aquatic resources team was directed to provide an analysis with a broad view of the aquatic resources across the entire region without limitation by national forest, national park, other federal ownership, state, or private land boundaries. This ambitious goal was begun with the realization of a need to balance the amount of information gathered against restricted financial resources and a short time frame. No such assessment has ever been completed by an interagency team working part-time with such limited resources.

Aquatic resource data collection sites were scattered, sometimes sparsely, across the SAA area. Where data did exist, they were often of questionable quality or derived from inconsistent sources. Definitive conclusions based on such limited data would be risky. Consequently, for many aquatic resources, the team could not determine with confidence the current status or likely future trends across the SAA as a whole. Where information was available and there was reasonable confidence in the data, aquatic resource status was discussed and future trends were projected. Specific findings from all chapters are summarized in the executive summary and chapter 1 of this document. The reader should recognize this assessment as an initial step toward gathering the detailed information required to document the current condition of aquatic resources over the SAA region.

The aquatic resource team faced other challenges throughout the development of the project. Each federal agency has its own mission and culture, and these differences are reflected in the various viewpoints presented in this report. The land cover TM satellite data – necessary for the completion of the aquatic technical report – were delayed, almost too late to be included in this report. Despite setbacks, delays, and limitations, the aquatic resource team worked diligently to meet the objectives of the assessment within the allotted time frame. This often required long hours and a great deal of dedication from the team members and people from the various agencies supporting the effort.

The assessment was a success and has yielded some valuable lessons and insights not only in terms of aquatic resources, but also in demonstrating that cooperative relationships between various agencies, through a shared common vision, can accomplish a formidable task. Each agency brought specific regional data to the process: water quality data from The U.S. Environmental Protection Agency (EPA); maps, streamflow, and water use data from the U.S. Geological Survey (USGS) and Tennessee Valley Authority (TVA); and land cover data from the USDA Forest Service, to name a few examples. The assessment would not have been successful without this sharing of data and resources.

In this final chapter, three major topics that span the questions in chapters 2 through 6 will be addressed: integration of findings; data gaps; and future work, including monitoring needs, research opportunities, and some ideas for future assessments.

Integration of Findings

Where possible, aquatic resource assessment findings were integrated with findings from the atmospheric, terrestrial, and social/cultural/economic assessments (SAMAB 1996a; SAMAB 1996b; SAMAB 1996c). Some integrated findings were reported in chapters 2 through 6 of this report. There are many more opportunities for integration of data and our findings with those from the three other technical teams. Further integrated analyses will be simplified because data will be accessible through the Internet. This section contains brief discussions of several additional findings that integrate data from two or more of the technical reports.

Recent Human Population Trends and Projected Wastewater Infrastructure Needs (1995-2005)

An analysis of human population trends and the anticipated wastewater infrastructure needs over the next 10 years indicates that areas with high population density (more than 168 persons per square mile) are generally also counties with projected wastewater infrastructure needs greater than $100 million (fig. 5.1.23). Moderately high-need counties ($10 million to $100 million) are also counties with relatively high population density or counties expected to experience a significant increase in population.

A notable exception to this relation concerns several counties in the southwestern portion of Virginia that have a relatively low population density and stable or declining growth, but which anticipate treatment and collection construction costs between $10 million and $100 million per county (fig. 5.1.23). This region of Virginia will likely have some of the highest per-capita costs for wastewater treatment in the SAA area because both human population densities and anticipated growth are low.

Interaction of Mining Impacts with Atmospheric Sulfate Deposition

Southwestern Virginia, specifically Wise, Dickenson, and Buchanan Counties, have the largest number of active mines per county (fig. 5.1.5). These counties are also in a region that has a high potential for adverse impacts due to atmospheric sulfate deposition (see Atmospheric Technical Report [SAMAB 1996a]). Because the historic and current mining activities in these counties have already impacted the water quality of several streams (fig. 5.1.4), it is not likely that the sulfate due to air deposition will result in further significant degradation. Other watersheds in the SAA area also have documented impacts due to past mining practices (fig. 5.1.4) that would probably mask some of the potential impacts due to deposition of atmospheric sulfate.

Several areas of moderate to high potential for sulfate deposition do not contain large numbers of mining operations. Here, observable impacts, such as decreased pH and acid neutralizing capacity or loss of acid-intolerant aquatic species due to atmospheric sulfate deposition are most likely. These areas are candidates for trend monitoring to better characterize the long-term impacts of atmospheric sulfate deposition on aquatic resources in the SAA area.

Roadless Areas and Wildernesses as Refuges for Terrestrial and Aquatic Plant and Animal Resources

Roadless areas and wildernesses potentially provide increased protection for the plants and animals that live in these areas. Nine federally listed T&E species in the heritage program EOR database occur in wildernesses in the SAA area – one amphibian, one bird, one mammal, and six plant species. Likewise, 19 federally listed T&E species occur in roadless areas 2 bird, 2 fish, 5 mammal, 1 mollusc, 1 other invertebrate, and 8 plant species.

Terrestrial viability concern and aquatic special concern species in the heritage program EOR database were also found in roadless areas and wildernesses. In roadless areas, 4 amphibian, 1 bird, 2 fish, 5 mammal, 1 reptile, 6 invertebrate, and 65 plant species were found. In wildernesses, 4 amphibian, 1 bird, 3 mammal, 2 mollusc, 9 other invertebrate, and 47 plant species were found.

Ten rare communities are represented in wildernesses, and 11 rare communities are represented in roadless areas.

Roadless areas and wildernesses do not appear to provide refuge for large numbers of federally listed T&E species, terrestrial viability concern species, or aquatic special concern species. However, these areas may protect more species than were represented in the heritage program database. Some species may be difficult to find in these areas. Other species may have been found but not reported to the heritage programs.

Roadless areas and wildernesses can provide protection for trout and a special kind of backcountry trout fishing experience. Roadless areas in the SAA area include 2,431 miles of potential wild trout streams. Wildernesses include an additional 846 miles of potential wild trout streams. Together, wildernesses and roadless areas include about 10 percent of the streams that potentially support wild trout.

Population Pressure on Aquatic Systems Due to Land Uses

Increasing human population density and the resulting intensive human uses of the landscape place high stresses on aquatic systems in many areas and have the potential for increasing pressure on aquatic systems due to nonpoint source pollution and habitat degradation. Population density in the study area has increased from 79.7 per square mile in 1970 to 101.8 per square mile in 1990; the area's population is projected to grow an additional 12.3 percent by the year 2010.

Land covers that may represent human activity (e.g., developed or barren, cropland, and pasture or herbaceous) already exceed 50 percent of the land area for many large watersheds (fig. 3.2.2). Very few large watersheds have less than 10 percent of these land covers. Although most of these areas are used intensively by humans, some barren lands such as rock outcrops and some herbaceous lands such as balds and rhododendron beds are areas of limited human use. Unfortunately, we could not resolve developed from barren and pasture from herbaceous land covers in the data set.

Intensive human activities occur both across the entire landscape (fig. 3.2.2) and in the riparian zone (fig. 3.3.2). Historically, riparian zones were largely forested, and human activities have reduced forest land cover in areas close to watercourses to less than 60 percent in many large watersheds (fig. 3.3.2), with smaller reductions in the rest of the study area. Areas with less than 60 percent forest cover in riparian zones (fig. 3.3.2) are concentrated in the great valley that runs through the Ridge and Valley province from the Shenandoah Valley to northwestern Georgia and into Alabama. The great valley may have been relatively unforested prior to European settlement. But the great valley is also a corridor of much human development and transportation, which can be expected to expand with human population.

Riparian Areas as Habitats for Plants and Animals

Riparian habitat constitutes an estimated 2.3 million acres of the study area. For analysis, a riparian zone was assumed to be 100 feet on each side of streams and rivers. Of these acres, 69.8 percent are forested riparian habitats. Riparian areas are important habitat for wildlife and plants because these areas provide conditions and resources that are lacking in drier surrounding uplands, which may also be more subject to human activities such as logging, agriculture, or development. A total of 49 terrestrial plant and animal species from the SAA short list (see Terrestrial Technical Report SAMAB 1996b]) are associated with riparian habitats. Of these species, 10 species are federally listed threatened and endangered, with 81 percent of these EORs occurring on private lands. There are 24 viability concern species (equivalent to aquatic special concern species in section 2.4 of this report) associated with these habitats, with private lands containing 42 percent of the EOR occurrences, national forests 37 percent of the occurrences, and national parks 16 percent of the occurrences. Habitat needs of wildlife in riparian areas are carefully considered by many managers and landowners while planning their activities, but other owners and managers continue to adversely impact wildlife and plants dependent on riparian habitat. Several programs to assist agencies and landowners in management of riparian areas were described in section 4.2.

Data Gaps

In this report, "data gaps" refers to missing or incomplete data. Data gaps include aquatic resources for which little or no data exist. They also include gaps in the spatial distribution, timing, or quality of data collection or lack of certain critical information in data sets. Some data limitations have been discussed in the foregoing chapters. But others are universal to the sections and chapters of this report and will be discussed here.

A large-scale regional assessment requires data collection efforts involving all lands. Many data sets were available to the SAA for only small portions of the area (e.g., the benthic macroinvertebrate data of section 2.8). In several cases, several similar data sets could be combined to provide regional coverage, but such combinations must be done with great care (see discussion of meta-analysis in the section on future work below). Some data sets focused on public lands, such as those of the national parks and forests. Similar information about aquatic resources on privately owned lands is often lacking.

To produce trend information about aquatic resources also requires long-term data collection efforts with sampling occurring rather frequently over time. Statistical time-series analyses, impossible for the SAA, require more intensive sampling times than were available. However, the SAA should prove to be a useful benchmark for future analysis. Although long-term and large-scale monitoring efforts are massive and expensive, they are critical to addressing regional questions about trends in aquatic resources.

In many cases, data were available only as county summaries. For example, the amount of pesticide applied per year (fig. 5.1.19) was summarized for counties, precluding a more meaningful presentation as amounts applied in watersheds. Some data are collected only by counties, at times to protect privacy of individuals (e.g., fig. 5.1.6), and cannot be easily converted to watersheds. However, if data can be collected at finer spatial scales (e.g., points or farm fields), they can be aggregated to more meaningful land units like watersheds, and more accurate assessments would be possible.

For nearly all the data analyses, statistically valid regional sampling designs were lacking. Data sets must be statistically unbiased samples that is, randomly selected and independent observations from a population, which produce accurate estimates of parameters describing the entire population. For some data sets, for example, the EOR data set from the heritage program used to describe threatened, endangered, and special concern (TE&SC) species (section 2.4), samples were not random and probably not independent. Although the original studies were all appropriately designed, when aggregated into the regional data set, statistical validity was lost.

The second concern associated with statistical validity is that the population from which a sample is selected must be appropriate for the question at hand. All statistically valid samples consist of data collected to meet a specific objective or hypothesis. Although a sample may have been properly selected from a population that was correct for a particular question, that population and sample may be inappropriate for a different assessment question. Many data sets we encountered were of limited use because smaller, headwater streams were either not represented at all or were seriously undersampled compared to larger streams and rivers. In remote, rugged mountain areas, sampling of headwater streams is physically and logistically difficult, but is necessary for a statistically valid assessment of all aquatic resources.

Roughly half of the fish and mussel species known to occur in the SAA area were described in the chapter on status and trends of aquatic resources. The hundreds of fish and mussel species that are neither threatened or endangered nor important game fish exceeded our capabilities to summarize for this report. Greater knowledge of these species is critical to an assessment of biological diversity in the SAA area.

For many fish species, especially the other species discussed in section 2.6 and the species not treated in this report, the amount of information available varied from state to state. Recent books on "...Fishes of..." for North Carolina, Tennessee, and Virginia (Menhinick 1991; Etnier and Starnes 1993; Jenkins and Burkhead 1994) were invaluable to this effort. Similar volumes on the fishes of other states or mussels of the Southeast would have greatly assisted this effort. Late in the assessment processes, it was discovered that the fish distribution data in the Jenkins and Burkhead (1994) volume are now available in a computerized database maintained by the Virginia Department of Game and Inland Fisheries. Similar databases for the other states would be a valuable resource for agencies, private concerns, and individuals.

For amphibians, turtles, and the remaining invertebrate groups, information about distribution of all species, including those at risk, is especially sparse because there are few biologists who are experts about these species.

Some otherwise good data sets, particularly those that contain information about biological organisms collected at various sites across the region, were not usable because the sample sites have never been adequately geo-referenced. That is, although the location information would allow one to return to the site with the help of a good map (usually a 1:24,000 USGS quadrangle sheet), this information has not been converted to the format that a GIS would require.

Although the location of reservoirs and many of their water quality properties are well known, knowledge about the organisms in reservoirs is often poor. In many cases, the species that are present are not even known. Quantitative estimates of reservoir fish populations are notoriously difficult to obtain. Frequently, an estimate from a single cove expanded to the entire reservoir or a qualitative estimate must suffice. For other aquatic species groups, even less information is available.

The sedimentation impact of soil-disturbing agriculture was estimated for this report by two analyses methods: a statistical sample of points that are under agricultural use in counties, and satellite land cover data. But other land uses and active mines contribute sediment to streams, and models or data to estimate sediments produced from noncultivated land and mines are lacking. Data on location of roads and headwater streams are also inadequate or a valid assessment of impacts of roads and land uses on streams and waterbodies.

Most of these data gaps present opportunities for future work, particularly further research and monitoring, which will be discussed in the next section.

Future Work

From the perspective of the assessment process, research and monitoring needs stand out as ideas for future work. Research and monitoring will be discussed together in this section because these two topics are intertwined. But monitoring and research have different meanings to the various agencies involved in the SAA. One agency's monitoring need is another agency's research opportunity. For some agencies, monitoring and research are essentially the same thing, and for others, such as the Forest Service, these are two distinct activities carried out by different branches of the agency. The research activity of designing, testing, and analyzing monitoring programs further ties research to monitoring. This section will also address some future needs for GIS analysis and future uses of this assessment and assessments that may follow.

Need for GIS Analysis

Development of GIS data and tools for aquatic resource analysis has lagged development for terrestrial and human resource analysis, perhaps because aquatic applications appear less obvious and more difficult. Base GIS data on topography, streams, waterbody boundaries, and roads are needed at the 1:24,000 scale for all lands. Headwater streams that are not represented as blue lines on the 1:24,000 USGS quadrangle sheets must be delineated in the GIS. The USGS, National Park Service, Forest Service, and TVA are in the process of constructing these data layers for the SAA area.

Refinements, corrections, and additions to exiting databases would expedite use of these essential data. Upstream and downstream linkages, stream orders, and stream names are incomplete for the GIS data set of the RF3 file. Additional information on the type of surface (paved, gravel, soil) for all roads is critical to assessment of the sediment load entering streams from this major sediment source. Many existing data sets (e.g., biological and habitat data, point source discharges, and water supply points) should be amended with accurate geo-referencing (i.e., latitude and longitude) to link sample points to the RF3 database in a GIS.

Solving the problem of properly delineating watersheds and aggregating nested watersheds in the GIS is an active area of current work that will be of benefit to future analysis of aquatic GIS resource information. Accurately delineating watersheds requires highly detailed digital elevation models and has been done for small watersheds in limited areas. But to do so for an area the size of the SAA area is computationally formidable. With accurately defined watershed boundaries, data from several data layers that fall within watershed boundaries can be selected and models that link aquatic resources, land base characteristics, and stressors can be developed.

Monitoring Needs and Design

Monitoring is defined simply as the repeated measurement of characteristics at one or more sites for comparison over time to detect change or comparison with established references to detect differences. Monitoring can be conducted at spatial scales that range from very specific sites to the globe. In this discussion, we are primarily concerned with monitoring studies of aquatic resources conducted at regional scales. Many fine monitoring studies do not have formal statistical designs, but other monitoring studies are designed to be statistically valid so that powerful conclusions can be drawn.

Regional scale monitoring efforts are potentially massive undertakings. Three such efforts, EMAP and R-EMAP, NAWQA, and RAT, were mentioned in the introduction to chapter 2. These programs are largely efforts of single agencies (EPA, USGS, and TVA, respectively), although one R-EMAP effort, the Mid-Atlantic Highlands Assessment (MAHA), is an interagency effort. Effective regional monitoring efforts will increasingly depend on interagency cooperation. The differing missions of cooperating agencies will require some compromise and make monitoring design a challenge. Nevertheless, when agencies pool their monitoring needs and resources and agree on study design, efficiencies can be realized.

Ecological classifications that stratify or partition large regions into relatively homogeneous landscape units are useful for design of monitoring programs because stratifications are statistical tools for reducing variability in data. Different ecological classification systems are in use by different agencies, largely because the systems were devised by respective agency scientists to meet agency objectives (Bailey 1995; Maxwell and others 1995; Omernik 1995). Each classification system can be useful for reducing variability in particular monitoring studies, depending on objectives, variables measured, and sampling design. If federal and state resource agencies can agree on common definitions and boundaries for ecological classification at scales important for aquatic resources, coordination of monitoring studies and their results will be easier.

Although tight coordination of monitoring efforts among agencies is certainly of benefit to all, there are tradeoffs. If all monitoring efforts of agencies were pooled into a single region-wide monitoring effort, the risk is quite high that critical information would be missed by the resulting design. The value of a diversity of efforts and multiple sample designs is that more problems and successes can be detected. That is why the combination of monitoring efforts represented by the suite of NAWQA, RAT, and R-EMAP is potentially powerful.

New tools and improved monitoring methods and sampling designs are continuing needs. In some cases, methods are needed that more accurately and precisely measure the variable of interest because increased precision increases statistical power (i.e., the ability to statistically detect a difference) of any monitoring design. Modifications of sampling design can also increase statistical power, and each completed study provides information that can be used to design the next monitoring effort.

For many monitoring studies, an array of reference streams that represent different ecological regions, stream sizes, elevations, and aquatic habitat types in the SAA area would be valuable for monitoring efforts. These sites could document the natural range of chemical, physical habitat, and biological community condition (fish, benthic macroinvertebrates, and other organism groups) for healthy and relatively unimpacted areas. Such a set of reference streams provides a baseline against which other sites can be compared.

Some specific monitoring needs follow directly from the data gaps identified above. Integrated physical habitat, biological, and chemical monitoring is needed at more sites to fully answer questions such as those posed by the SAA. Lower-order streams, from first – (ephemeral) and second – (intermittent) to third – (small perennial) and fourth-order streams, which dominate many watersheds, are under-represented in many monitoring studies. Finally, quality control and full documentation are needed to maximize the utility of aquatic resource data for further analysis.

Research Opportunities

Researchers will find many opportunities for further research in the pages of this report and in the data sets available on the Internet and CD-ROM. The following paragraphs outline a few of the opportunities identified by the aquatic resources team.

Expanded research is needed that links multiple aquatic resources to their watershed and regional environments. This research would include development of predictive models that relate landscape factors such as watershed and riparian land cover, land use, human population patterns, topography, and geology to direct instream measures of instream aquatic habitat and biological integrity (fish, benthos, and other organisms). In the past, few models that relate watershed habitat to aquatic organisms have been attempted because the linkages seem conceptually too distant and data and analysis capabilities were lacking (see Flebbe and others [1988] for an exception). Related research is needed to devise ways to link aquatic resources across disparate spatial and temporal scales.

Basic research is needed to establish physical, chemical, and biological responses to multifarious stressors. For example, invasion by gypsy moth presents a complex set of consequences that are difficult to track in chemical and biological responses. Defoliation by gypsy moth can paradoxically both increase and decrease food sources for aquatic organisms. Likewise, control of gypsy moth has paradoxical consequences for stream insects and fish. Acidification, hemlock wooly adelgid, land use, riparian management, recreational use of riparian areas, and other human activities may simultaneously produce several different, and perhaps conflicting, responses by aquatic resources.

Sediment is produced from all lands and the amount varies depending on land cover, land use, road density, and other factors. A fundamental need is for research to produce models that can predict amounts of sediment produced from the land, based on remotely sensed land cover information. The Universal Soil Loss Equation (USLE) model used in this report was designed for plot studies in agricultural land and is not adequate for all land cover types. Research currently underway to develop new models is critical to consideration of sediment sources in future assessments and planning.

Cumulative effects of multiple land management activities in watersheds are of concern to many in the Southern Appalachians and elsewhere. Research progress on this subject is slow and difficult. A dependable database of turbidity or total suspended solids determinations, collected with consistent methods from a large number of streams of different sizes, would provide the basis for some of this needed research. Several data sources identified in this assessment–headwater stream monitoring on national forest and other public lands; turbidity analyses of the raw water intake stream, required for every public drinking water system; and sediment deposition rates for reservoirs–could contribute to research on cumulative effects.

Relatively new basic research to link aquatic resources with the social, cultural, and economic domain of human activity should be expanded. Historically, aquatic ecology has been conducted as if humans were not part of the aquatic system. At best, creel surveys were conducted to determine how many game fish were removed. But humans are part of the aquatic system, whether by introducing bait fish, removing game fish, stocking, hiking, horseback riding, mountain biking, waterskiing, and any number of other activities. Whether we like it or not, aquatic systems exist within a social, cultural, and economic context, and management of aquatic systems does and should consider the human context. New and exciting research is underway in these areas, including ecological economics, recreation research, and human dimensions research.

Meta-analysis is a rather new field of research that "uses formal statistical procedures to retrieve, select, and combine results from previous separate studies" (Wachter 1988). Many of the analyses presented in this report would properly be considered meta-analyses. But the tools for meta-analysis are not fully developed. Further research into methods by which results from different studies can be combined is critical because future regional assessments are likely to rely on data sets collected from different sources.

Regional Assessments

Identification of additional analysis, monitoring, and research needs is one of the most important outcomes of the aquatic resource assessment. Meeting these needs will ensure that similar questions can be answered more fully in future assessments. Although the SAA aquatic resources team was tasked to answer five specific questions, outlined in the executive summary at the beginning of this report, most of the questions could be recast into the first: What are the status and trends of aquatic resources? Four key questions that concern status and trends might be addressed in future assessments of aquatic resources in the region:

- What is the full range of condition for all aquatic resources of the region? More information is needed to know more about tiny pristine streams and polluted large rivers, game fish, and threatened and endangered species and everything in between.

- What is the reference condition? If problem areas are to be identified or an aquatic resource is to be restored, clear, measurable, and attainable standards are needed.
- Where do the aquatic resource problems or concerns exist? There is a need to develop and apply screening techniques that are sensitive to the wide array of stressors and effects to ensure that all problem areas are identified.
- Where is the condition of aquatic resources improving over time? There is a critical need to evaluate the effectiveness of aquatic resource management efforts and to measure, with known confidence, changes in aquatic systems over time for large areas.

Those involved in the SAA wish to see the effort begun in the summer of 1994 continue in some way. No doubt, individual agencies will build on the aquatic resource information collected for the SAA. The Forest Service, for one, has already begun the forest planning process, prescribed by the National Forest Management Act, for five national forests with land in the SAA area. The SAA will be part of the planning process, providing the context and an important information base for individual forest plans. Those involved in the assessment have proposed that the multiple agency collaboration initiated with the SAA be continued and perhaps expanded to include other state, federal, and local agencies, which may have been less involved than the agencies represented by the authors of this report. Repeating this assessment, with improvements, at intervals in the future will be invaluable to future planning and management.

Information gathered for the SAA will be used by many groups for many purposes. Government agency planners at all levels – federal, state, regional, and local – should find information they can put to use. Agencies like the Forest Service can determine the array of TE&SC and other species at risk that should be considered in planning for a national forest, ranger district, or management area activity. Private citizens, companies, citizen groups, and special interest groups will all find information of value to their own planning and stewardship of aquatic resources. Agencies and private concerns can more easily determine the array of possible stressors for a particular project area than was possible before the assessment. Schools and young students will probably be leaders in use of the vast data sets available to them on the Internet or on CD-ROM. And researchers will find plenty to improve and expand on in future publications and reports.

This assessment is the first of several regional assessments of aquatic resources either underway or planned for the eastern United States. Several agencies cooperating in the SAA will participate in other assessments and have indicated their willingness to support and expand future cooperative assessments. These new assessments will build on and benefit from information shared on sources of data and the lessons learned. Some assessments, such as the MAHA, already underway, overlap geographically with the SAA area and will more directly benefit from shared data and analyses. Eventually, as these overlapping regional assessments are completed, opportunities for integrating the results across assessments expand dramatically. And eventually, a new SAA will build on the combined experiences and successes.

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Glossary

acid neutralizing capacity (ANC):
The total acid-combining capacity of a water sample as determined by titration with a strong acid. Acid neutralizing capacity includes alkalinity (carbonate) as well as other basic chemicals.

acid deposition:
Rain, snow, or particulate matter containing high concentrations of sulfuric acid, nitric acid, or hydrochloric acid, usually produced by atmospheric transformation of the byproducts of fossil fuel combustion. Precipitation with a pH lower than 5.0 is generally considered to be acidic.

acidification:
To convert into an acid or become acid.

ACP:
Agriculture Conservation Program – USDA cost-share program for streambank improvement

AGNPS:
Agricultural Nonpoint Source Model (NRCS) A single-event computer model developed by The NRCS to simulate sediment and nutrient support from agricultural watersheds

ALDGF:
Alabama Division of Game and Fish

allopatric:
Condition where one species lives in a section of stream without other closely related species; the species have disjunct distributions; opposite of sympatric.

base cation:
A positively charged ion; usually includes calcium, magnesium, sodium, and potassium.

BASINS:
EPA's Better Assessment Science Integrating Point and Nonpoint Sources Model

BMPs:
Best Management Practices – Methods used by an agency or landowner to meet nonpoint source pollution control needs.

BOD:
Biological oxygen demand – Dissolved oxygen required by organisms for the aerobic biochemical decomposition of organic matter present in water.

buffering capacity:
The ability of a solution to accept additions of acid or alkali and not significantly change pH.

catchment:
Watershed. All the land and stream systems above and draining to a given point in a river or stream.

category 1:
Taxa for which USFWS has sufficient information to support proposals to list them as endangered or threatened species, but for which proposed rules have not been issued.

category 2:
Formerly taxa for which USFWS has information to indicate that proposing to list them as endangered or threatened is possibly appropriate, but for which persuasive data are not currently available. The category 2 designation was eliminated by USFWS Director Mollie Beattie in 1995 (FWS/TE/95-01837).

CEQ:
Council on Environmental Quality

CERCLA:
Comprehensive Environmental Response. Compensation and Liability Act of 1980 P.L. 96-510 STAT 2767; 42 U.S.C. 9601-9675

CERCLIS:
Comprehensive Environmental Response, Compensation and Liability Information System – data base maintained by EPA.

channelization:
Artificial change of a stream channel profile.

COE:
U.S. Army Corps of Engineers

commercial water use:
Water for motels, hotels, restaurants, office buildings, other commercial facilities, and institutions. The water may be obtained from a public supply or may be self-supplied. See also public supply and self-supplied water.

consumptive use:
That part of water withdrawn that is evaporated, transpired, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate water environment. (Also referred to as water consumed.)

conveyance loss:
Water that is lost in transit from a pipe, canal, conduit, or ditch by leakage or evaporation. Generally, the water is not available for further use; however, leakage from an irrigation ditch, for example, may percolate to a groundwater source and be available for further use.

creel survey:
A survey of anglers.

CWA:
Clean Water Act

DLG:
Digital Line Graph

DMR:
Discharge Monitoring Reports

domestic water use:
Water for household purposes, such as drinking, food preparation, bathing, washing clothes and dishes, flushing toilets, and watering lawns and gardens. Also called residential water use. The water may be obtained from a public supply or may be self-supplied. See also public supply and self-supplied water.

EMAP:
U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program

endangered species:
A species or subspecies in danger of extinction throughout all or a significant portion of its range.

endemic (endemism):
Species restricted to a particular geographic area; for aquatic species, usually limited to one or a few small streams or a single drainage.

EOR:
Element Occurrence Record in the state heritage programs' databases

EPA:
U.S. Environmental Protection Agency

EPT index:
Index of the number of families (or genera) in a sample that belong to the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Tricoptera (caddisflies).

ESA:
Endangered Species Act of 1973

eutrophication:
Condition of a lake where deleterious effects are caused by increased nutrients (nitrogen and phosphorous) and a decrease in oxygen.

evapotranspiration:
The rate of liquid water transformation to vapor from open water, bare soil, or vegetation with soil beneath.

EWPP:
Emergency Watershed Protection Program – NRCS program for emergency stream repair due to natural disorders.

extirpation:
Extinction of a species from all or part of its range.

freshwater:
Water that contains less than 1,000 milligrams per liter (mg/L) of dissolved solids; generally, more than 500 mg/L of dissolved solids is undesirable for drinking and many industrial uses.

FSA:
Farm Services Agency – USDA

FWPCA:
Federal Water Pollution Control Act P.L. 80-845 (Clean Water Act)

FWS:
Fish and Wildlife Service

GADNR:
Georgia Department of Natural Resources

GIS:
Geographic Information System

global ranks:
Ranks assigned by The Nature Conservancy and state heritage programs based on number of occurrences.

G1: Extremely rare and critically imperiled species, as determined by the network of state natural heritage programs, experts, and The Nature Conservancy, with five or fewer occurrences or very few remaining individuals or especially vulnerable to extinction.

G2: Very rare and imperiled, with 6 to 20 occurrences or few remaining individuals or vulnerable to extinction.

G3: Either very rare and local throughout its range or found locally (sometimes abundantly) in a restricted range or vulnerable to extinction; usually fewer than 100 occurrences are documented.

G4: Apparently secure globally, though possibly quite rare in parts of its range, especially at the periphery; usually 100 to 1,000 occurrences.

G5: Demonstrably secure globally, though possibly quite rare in parts of its range, especially at the periphery; usually at least 1,000 occurrences.

G?: Unranked, or rank uncertain.

G_Q_: Questionable taxonomic assignment.

G_T_: Rank of a subspecies or variety (e.g., G5T1 denotes a critically imperiled subspecies of a globally secure species).

groundwater:
Generally all subsurface water as distinct from surface water; specifically, that part of the subsurface water in the saturated zone (a zone in which all voids are filled with water) where the water is under pressure greater than atmospheric.

herptiles:
Amphibians and reptiles.

HUC:
Hydrologic units. Code cataloguing the watersheds, developed by USGS.

hydroelectric power water use:
The use of water in the generation of electricity at plants where the turbine generators are driven by falling water. Hydroelectric water use is classified as an instream use in this report.

IBI:
Index of Biotic Integrity – A measure of fish community condition or habitat quality.

instream use:
Water that is used, but not withdrawn, from a ground- or surface-water source for such purposes as hydroelectric power generation, navigation water quality improvement, fish propagation, and recreation. Sometimes called nonwithdrawal use or in-channel use.

irrigation water use:
Artificial application of water on lands to assist in the growing of crops and pastures or to maintain vegetative growth in recreational lands such as parks and golf courses.

lithology:
Description or study of the outermost solid layers of the earth.

livestock water use:
Water for livestock watering, feed lots, dairy operations, fish farming, and other on-farm needs. Livestock as used here includes cattle, sheep, goats, hogs, and poultry. Also included are animal specialties. See also rural water use and animal specialties water use.

MAGIC:
Model for Acidification of Groundwater in Catchments. It is currently the model of choice for assessing many watershed processes associated with acid deposition. MAGIC has been tested more than any other acidic deposition effects model. Results from these tests indicate that MAGIC correctly projects the direction of change of watershed responses and accurately projects the magnitudes of rates of change for surface water ANC and pH. MAGIC reasonably represents sulfur retention within watersheds and the generation and leaching of cations from watersheds, two functions generally acknowledged to be the most important of the modeled processes.

MAHA:
Mid-Atlantic Highlands Assessment – EPA

million gallons per day (Mgal/d):
A rate of flow of water.

mining water use:
Water use for the extraction of minerals occurring naturally including solids, such as coal and ores; liquids, such as crude petroleum; and gases, such as natural gas. Also includes uses associated with quarrying, well operations (dewatering), milling (crushing, screening, washing, flotation, and so forth), and other preparations customarily done at the mine site or as part of a mining activity. Does not include water used in processing, such as smelting, refining petroleum, or slurry pipeline operations. These uses are included in industrial water use.

mussel:
An aquatic marine bivalve mollusc having a dark elongated shell; a clam.

NAPAP:
National Acid Precipitation Assessment Program

NAWQA:
U.S. Geological Survey's National Water Quality Assessment program

NCDEHNR:
North Carolina Department of Environment, Health, and Natural Resources

NCWRC:
North Carolina Wildlife Resources Commission

NLFCA:
National Listing of Fish Consumption Advisories

NPL:
National Priorities List, EPA's CERCLA sites, superfund sites

NPS:
USDI National Park Service

NRCS:
Natural Resource Conservation Service, formerly USDA, soil conservation service

NRI:
Natural Resource Inventory – a multi-resource inventory based on soils and related resource data. NRCS.

nonpoint source pollution:
A diffuse source of pollution not regulated as a point source. May include atmospheric deposition, agricultural runoff, and sediment from land-disturbing activities.

offstream use:
Water withdrawn or diverted from a ground or surface-water source for public water supply, industry, irrigation, livestock, thermoelectric power generation, and other uses. Sometimes called off-channel use or withdrawal.

order (stream):

PCB:
Polychlorinated biphenyl

PCS:
Permits Compliance System – database containing NPDES permit-holding facilities. (EPA)

per-capita use:
The average amount of water used per person during a standard time period, generally per day.

perennial stream:
Stream that flows throughout the year.

petrographic:
The description and systematic classification of rocks.

pH:
The negative logarithm of hydrogen ion activity. The pH scale goes from 1 (most acidic) to 14 (most alkaline). The difference of 1 pH unit indicates a tenfold change in hydrogen ion activity.

point source pollution:
Sources of pollution with a known specific point of origination, i.e., a sewer outfall or pipe from a facility.

public water use:
Water supplied from a public water supply and used for such purposes as firefighting, street washing, and municipal parks and swimming pools. See also public supply.

public supply:
Water withdrawn by public and private water suppliers and delivered to users. Public suppliers provide water for a variety of uses, such as domestic, commercial, thermoelectric power, industrial, and public water use. See also commercial water use, domestic water use, thermoelectric power water use, industrial water use, and public water use.

R-EMAP:
Regional EMAP – See EMAP

rare species:
Any native or once-native species of wild animal which exists in the state in small numbers and has been determined to need monitoring; these may include peripheral species.

RAT: River Action Teams of TVA

RBP:
EPA's Rapid Bioassessment Protocol used for monitoring benthic macroinvertebrates.

RF3:
EPA Reach File Version 3.0

riparian zone:
The land bordering a lake, stream, or tidewater.

rural water use:
Term used in previous water-use circulars to describe water used in suburban or farm areas for domestic and livestock needs. The water generally is self-supplied and includes domestic use, drinking water for livestock, and other uses, such as dairy sanitation, evaporation from stockwatering ponds, and cleaning and waste disposal. See also domestic water use, livestock water use, and self-supplied water.

salmonids:
Fish of the family Salmonidae, the chars, trouts, salmons, and whitefishes.

SCWMRD:
South Carolina Wildlife and Marine Resources Department

sediment:
Inorganic material deposited in the stream system.

sensitive species:
A term used for special concern species by some states.

siliciclastic:
Pertaining to clastic noncarbonate rocks which are almost exclusively silicon-bearing, either as forms of quartz or as silicates.

SOS:
Save our Streams, a program of the Isaak Walton League.

special concern species:
In this report, a species that is federally listed as Category 2 or ranked as globally rare (G1, G2 or G3) by state heritage programs and The Nature Conservancy. A term also used by some states for any species of wild animal native or once-native to the state which is determined by the state to require monitoring.

splash dams:
Dams, usually temporary, built of wood across mountain streams to pond up large amounts of water. Logs were floated on the ponded water and the dam was blown up to create a sudden rush of water that carried the logs downstream. The stream below the dam was cleared of all obstructions (e.g., rocks, logs) prior to dam blow-up to facilitate transport.

STORET:
EPA's storage and retrieval computer database for water quality.

stratigraphic:
Pertaining to strata, or layers, as in a description of layers of rock types.

stressors:
Pressure or change brought upon an ecosystem by pollution sources such as sediment, contaminants, and toxins.

superfund:
High risk CERCLA sites on the National Priorities List.

surface water:
An open body of water, such as a stream or lake.

sympatric:
Condition where two or more closely related species live together in the same section of stream; the species have overlapping distributions; opposite of allopatric.

taxon (taxa):
A taxonomic group of any rank (e.g. species, germs, family, etc.).

taxonomic:
Classification of organisms into categories according to their natural relationships.

thermoelectric power water use:
Water used in the process of the generation of thermoelectric power. The water may be obtained from a public supply or may be self-supplied. See also public supply and self-supplied water.

threatened species:
A species or subspecies that is likely to become endangered throughout all or a significant portion of its range.

TIP:
Toxicity Index Profile – Estimate of cumulative potential for toxic impacts in water – EPA

TRI:
Toxics Release Inventory – EPA inventory of toxic releases.

TVA:
Tennessee Valley Authority

TWRA:
Tennessee Wildlife Resources Agency

USFWS:
U.S. Department of the Interior, Fish and Wildlife Service

USGS:
U.S. Geological Survey

USLE:
Universal Soil Loss Equation

VDGIF:
Virginia Department of Game and Inland Fisheries

VTSSS:
Virginia Trout Stream Sensitivity Study conducted by researchers at the University of Virginia.

water use:
(1) In a restrictive sense, the term refers to water that is actually used for a specific purpose, such as for domestic use, irrigation, or industrial processing. In this report, the quantity of water use for a specific category is the combination of self-supplied withdrawals and public supply deliveries. (2) More broadly, water use pertains to human's interaction with and influence on the hydrologic cycle, and includes elements such as water withdrawal, delivery, consumptive use, wastewater release, reclaimed wastewater, return flow, and instream use. See also offstream use and instream use.

watershed:
(drainage basin, catchment basin, river basin) The total area above a given point on a stream that contributes water to the flow at that point.

withdrawal:
Water removed from the ground or diverted from a surface water source for use. See also offstream use and self-supplied water.

WRP:
Wetlands Reserve Program – USDA Natural Resources Conservation Service cost-share program for wetland restoration.

WURR:
The Forest Service Water Use, Rights, and Requirements

WVDNR:
West Virginia Division of Natural Resources