Southern Appalachian Man and the Biosphere (SAMAB) Program:

Summary of Programs and Projects

SAMAB is a public/private partnership that focuses its attention on the Southern Appalachian Biosphere Reserve. The Southern Appalachian Biosphere Reserve covers parts of six states in the Southeastern region of the United States. The vision of the program is to:

promote the achievement of a sustainable balance between the conservation of biological diversity, compatible economic uses and cultural values across the Southern Appalachians. This balance will be achieved by collaborating with stakeholders through information gathering and sharing, integrated assessments, and demonstration projects directed toward the solution of critical regional issues.

The program encourages the utilization of ecosystem and adaptive management principles.

The SAMAB program presently consists of two organizational entities:

- the SAMAB Cooperative — twelve federal and three state agencies who have signed an “Interagency and Cooperative Agreement”;
- the SAMAB Foundation — a non-profit 501 (c) 3 Foundation consisting of representatives from private industry, NGO’s, universities/colleges, and local communities.

The SAMAB program has identified and addressed a number of issues affecting the Southern Appalachian region. Some of its programs and projects are listed below.

Environmental Monitoring and Assessment
- Forest Health Monitoring; Threats to forest health in the Southern Appalachians
  ⇒ Three workshops across region describing exotic insects and diseases affecting the forests
  ⇒ Approximately 100 plots already providing data. There are 100 additional plots expected in the next one to two years.
- Landscape Ecology/Landscape Monitoring
  ⇒ Held two workshops on Integrated/Ecological Assessments
  ⇒ In cooperation with EPA’s EMAP program, significant research is being funded on developing landscape scale modeling and analysis.

Sustainable Development/Sustainable Technologies
- Two regional workshops for better understanding and implementation strategies
- Community strategic planning/tourism
  ⇒ Assistance in developing a strategic plan for a community led to additional grants to that community for implementation
  ⇒ Outreach program to other communities underway.
- Geographic Information Systems
  ⇒ Regional geographic information system underway.
- Workshops on Forestry Best Management Practices

1 Prepared by Hubert Hinote, Executive Director, SAMAB Cooperative.
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Conservation Biology

- Wetlands
  - Regional conference led to publication of Book entitled “Wetlands of the Southeastern United States.”
- Economic Use(s)/Protection of Native Plants
  - First Regional workshop clarified local interest; data needs; and opportunities for achieving sustainable economic development of biological resources.
- Range of Native Brook Trout
  - Workshop led to additional funded research.
- Neo-tropical Migratory Birds
  - Cooperative support led to additional monitoring and education programs.

Ecosystem Management

- Testimony to the Senate subcommittee on Agricultural Research, Conservation, Forestry and General Legislation
  - Recognized by White House’s Interagency Task Force on Ecosystem Management as a demonstration area for ecological assessment and ecosystem management.
- Air Quality Management: Threats to Class I Airsheds
  - Brochure on “Understanding Air Pollution in the Southern Appalachians”
  - Workshop led to the Creation of the Southern Appalachians Mountain Initiative (SAM) — an eight state consortium of public and private groups to address air quality impacting Class I areas in the region;
  - Assisting in developing a framework for preparing air quality management plans on public lands in Southern Appalachian.
- Partner with U.S. Forest Service on the Chattooga Ecosystem Demonstration Project
- Regional Demonstration -- Southern Appalachian Assessment

Environmental Education and Training

- Directory of Environment Education and Training (member organizations)
- Videos, posters, and teacher guides
  - Reintroduction of the Red Wolf into the Great Smoky Mountains National Park, in Cooperation with WBIR-TV, (NBC affiliate) Knoxville, TN (video won an Emmy Award and the educational poster was selected by Urban America as one of top 20 posters in America in 1992).
  - “Water: From the Mountains to the Coast”, also in Cooperation with WBIR-TV, Knoxville.
  - Dogwood Anthracnose, in cooperation with several non-government organizations.

Cultural and Historical Resources

- Workshop(s) led to ongoing development of a cooperative program to preserve and promote regional cultural resources;
- Developing databases on regional cultural resources.

Public Information and Education

- Newsletter.
- An Annual Spring workshop/Planning meeting.
- Annual SAMAB (Fall) Conference -- brings scientists, managers, educators, and the public together.
- General Information about SAMAB and the Southern Appalachian Biosphere Reserve.
- SAMAB Home Page on the Internet.

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2 These were distributed to all schools and public libraries in the zone of cooperation.
In 1994, SAMAB initiated work on one of the most significant projects to date, the Southern Appalachian Assessment (SAA). This integrated assessment assembled existing data and evaluated past trends, current conditions, and future risks to the economic, ecological, and cultural resources of the region. The initial phase of the SAA was completed in July 1996 with publication of four resource-specific technical reports (atmospheric, aquatic, terrestrial, social/economic/cultural) and an integrated summary. Other products of the SAA include: 1) a comprehensive database made available to interested parties through a variety of media including a SAMAB Homepage on the Internet; and 2) identification of gaps in both available data and understanding of system function that should guide future research and monitoring activities. It is hoped that the results of the SAA will enable SAMAB partners to work together to protect the unique resources of Southern Appalachia while promoting economic development that is sustainable. However, the reports are not decision documents. This responsibility still rests with the individual managers. The SAA has been recognized as one of three prototypes by the National Assessment Program under the Office of Environmental Policy and is expected to set the standards for anticipated integrated assessments conducted across the country.
THE SOUTHERN APPALACHIAN ASSESSMENT

SUMMARY REPORT

Prepared by Federal and State Agencies

Coordinated through Southern Appalachian Man and the Biosphere Cooperative

July 1996
Our vision for the Southern Appalachian region is an environment for natural resources management that applies the best available knowledge about the land, air, water, and people of the region. Applied on public lands, this knowledge would provide a sustainable balance among biological diversity, economic uses, and cultural values. All would be achieved through information gathering and sharing, integrated assessments, and demonstration projects.

The Southern Appalachian Assessment takes a major step toward fulfillment of that vision. It is an ecological assessment – a description of conditions that goes beyond state, federal, or private boundaries. In using Southern Appalachian Assessment data, land managers can base their decisions on the natural boundaries of ecosystems rather than on the artificial boundaries of counties, states, or national forests and parks.

The assessment was accomplished through the cooperation of federal and state natural resource agencies within the Southern Appalachian region. It was coordinated through the auspices of the Southern Appalachian Man and Biosphere (SAMAB) cooperative. Members of the cooperative are: U.S. Department of Agriculture, Forest Service; Tennessee Valley Authority; U.S. Environmental Protection Agency; U.S. Department of the Interior, Geological Survey, National Park Service, National Biological Service, Fish and Wildlife Service; Appalachian Regional Commission; U.S. Army Corps of Engineers; Georgia Department of Natural Resources; North Carolina Department of Environment, Health, and Natural Resources; Tennessee Department of Environment and Conservation; U.S. Department of Commerce, Economic Development Administration; and the U.S. Department of Energy, Oak Ridge National Laboratory. This cooperation significantly expanded the scope and depth of analysis that might have been achieved by separate initiatives. It also avoided duplicating work that might have been necessary if each agency had acted independently. The findings in this assessment do not reflect unanimous (unqualified) views of all agencies involved on all points.

Although the Southern Appalachian Assessment is broad and comprehensive in subject matter and geographic scope, there are many opportunities to further expand the analyses based on this data.
Urgent demands for the assessment data restricted our timeframe. So identifying data gaps became as important a task as identifying and gathering existing data. The Southern Appalachian Assessment serves as both a useful reference and as a benchmark for future analyses.

There was no specific statutory requirement for the assessment. However, national forest land and resource management plans authorized under the 1976 National Forest Management Act have been in place for almost 10 years and are therefore subject to revision. Due to the relationship of the national forests and other federal lands to the biological, social, and economic conditions in the assessment area, more comprehensive and more scientifically credible data are needed to facilitate land management planning. This assessment supports individual forest plans by determining how the lands, resources, people, and management of the national forests interrelate within the larger context of the surrounding lands. The broadly identified pollutants and impacts of concern are not intended as a source of information upon which to base future regulatory or permitting action.

This report is one of five that document the results of the Southern Appalachian Assessment. The reports include a summary report, atmospheric, social/cultural/economic, terrestrial, and aquatic reports.

The five reports are available in printed form and via the Internet. By providing direct access to assessment materials via Internet, we hope that users can obtain information more quickly and at a lower cost than would have been possible otherwise. As with most reference documents, users will need only a small portion of the assessment for their specific projects at any given time. Moreover, an Internet document can be revised or updated when the occasion arises.

In-depth versions of data are available on the SAMAB, Forest Service, and Info South Home Pages on the World-Wide Web (WWW). These versions can be accessed at http://www.lib.utk.edu/samab for SAMAB’s Southern Appalachian Home Page, at http://wwwfs.fed.us/ for the Forest Service Home Page, and at http://wwwfs.libs.uga.edu for the Info South Home Page. Additional materials such as maps and data that support the assessment are described and referenced in each report.
An executive policy group provided guidance on the needs and concerns of the federal and state interests represented, served as a communications link with those interests, and made policy decisions which affected the assessment. The policy group included Co-Chair Forrest Carpenter (U.S. Department of Agriculture [USDA], Forest Service, Region 8); Co-Chair Cory Berish (U.S. Environmental Protection Agency); Co-Chair Charles Van Sickle (USDA Forest Service, Southern Research Station); Elizabeth Smith, Niki Nicholas (Tennessee Valley Authority [TVA]); Joe Clark (U.S. Department of the Interior, National Biological Service); Brian Cole (U.S. Department of the Interior, Fish and Wildlife Service); Virginia Dale (U.S. Department of Energy, Oak Ridge National Laboratory); Suzette Kimball (U.S. Department of the Interior, National Park Service); Boyd Rose (U.S. Department of Commerce, Economic Development Administration); Russ England (Georgia Department of Natural Resources); Karl Hermann (U.S. Department of the Interior, National Biological Service Cooperative/University of Tennessee); Angela Pitcock (Tennessee Department of Environment and Conservation); and Hubert Hinote (Southern Appalachian Man and the Biosphere).

The assessment is divided into four major resource groups: terrestrial, atmospheric, aquatic, and social/cultural/economic. Teams were organized to address each group and to develop data and technical reports. Two of the teams were subdivided due to the diversity of the material they were developing: the Terrestrial Team was comprised of the Forest Health Subteam and the Plant and Animal Subteam; and, the Social/Cultural/Economic Team was comprised of the Human Dimensions Subteam, the Recreation Subteam, the Timber Supply and Demand Subteam, and the Roadless and Wilderness Subteam. Three operational groups were important to the development of the assessment reports: the Public Involvement Team, the Write/Edit/Design Team, and the Geographic Information Systems (GIS) Team.

Assessment team leaders were: Aquatic Team, Jack Holcomb (USDA Forest Service) and Jim Harrison (EPA); Atmospheric Team, William Jackson (USDA Forest Service), Van Shrieves (EPA), James M. Kelly (TVA), and Jim Renfro (NPS); Social/Cultural/Economic
Figure 2
Early in the 20th Century, people were leaving the mountains to find better opportunities elsewhere.
The living systems of the Southern Appalachians Assessment Area (fig. 1)—the animals, the plants, and the land, air, and water that support them—have experienced enormous changes in the 20th century. At the start of the century, land management practices exploited natural resources. The results were rapidly eroding cropland and pasture and heavily logged forests in which little of value remained. People were leaving the area to find better opportunities in more hospitable surroundings (fig. 2).

A concerned nation supported restoration and conservation efforts. National forests were created to protect the headwaters of major rivers in the Southeast. The Great Smoky Mountains and Shenandoah National Parks were established to preserve some of the special places in the Southern Appalachians. Together, those national forests and national parks now make up the largest concentration of federal land in the eastern United States. A special authority was established to oversee the protection and development of the Tennessee Valley. Organized efforts were supported to control wildland fires, and research was financed to find ways to restore and protect the land.

The results are most gratifying. With the assistance of many people and organizations, the area’s ecosystems recovered or made improvements. Despite setbacks, such as the destruction of the American chestnut by chestnut blight, much has been achieved. Forests were restored, key areas were preserved in a natural state, soils were protected from erosion, and the power of the Tennessee River system to create human disasters was largely controlled.

As the 21st century approaches, the Southern Appalachians are thought of as desirable places to live (fig. 3).
The area has become a vital refuge from urban America for plants, animals, and people. Millions of tourists come each year to enjoy the scenery and the area’s special places.

**Time for a Checkup**

According to their biological clocks, the forests established in the Southern Appalachians between 1900 and 1940 are no longer young. They are what people would consider to be middle-aged. They are old enough to suffer from serious problems but young enough for their passing to seem premature.

The Southern Appalachian Assessment (SAA) is the ecological equivalent of a thorough medical checkup. It was designed to take a careful look at what we know about the region’s ecosystems and its air, water, and land resources. The hope is that potentially serious problems can be identified before they threaten the well-being of the natural resources.

Using the best available technology, the scientists who conducted the SAA gathered and interpreted large quantities of data about the region. The results provide estimates of what is happening in the region and what the consequences of those trends may be.

The assessment revealed no major crises, but some of its findings are worrisome. Forest pests are causing some serious problems, particularly in northern Virginia. Ecological changes are occurring in the region’s forests. Pollution makes some streams unsuitable for human use. Acidity has significantly affected water quality and fish species in certain streams. The pressures of human development are having serious effects on natural resources around the region’s cities, and conflicts over uses of the area’s natural resources are brewing.

The authors of the SAA do not attempt to provide solutions for the problems that have been identified. They avoid prescriptions, because prescribing is a political process in which all Americans must have a part. Instead, the assessment tries to give the information people need for a productive discussion of the problems.
The Southern Appalachian Assessment (SAA) is the ecological equivalent of a thorough medical checkup. It was designed to take a careful look at what we know about the region's ecosystems and its air, water, and land resources. The hope is that potentially serious problems can be identified before they threaten the well being of the natural resources.

The Southern Appalachians

The area chosen for the assessment covers some 37.4 million acres of mountains, foothills, and valleys stretching from northern Virginia and eastern West Virginia to northwestern South Carolina, northern Georgia, and northern Alabama (fig. 1). When the first Native Americans came to the region, forests dominated the landscape, and they still do. Forests cover 70 percent of the region. Pastures cover 17.4 percent, croplands cover 3.4 percent, and areas developed for roads, dwellings, and other human structures cover 3.1 percent (fig. 4).

Figure 4
Current land cover in the study area.
decreased slightly, reversing an increasing trend that occurred since the 1920s. Forest acreage grew for many years as croplands and pastures were abandoned and returned to natural vegetation. In the future, however, additional losses of forest are expected as population in the region expands.

More than 4 million acres in the Southern Appalachians are managed by the USDA Forest Service. The area’s national forests include the George Washington and Jefferson in Virginia, a portion of the Monongahela in West Virginia, the Pisgah and Nantahala in North Carolina, a portion of the Sumter in South Carolina, the Cherokee in Tennessee, the Chattahoochee in Georgia, and a portion of the Talladega in Alabama. The area also contains the Great Smoky Mountains National Park, Shenandoah National Park, Little River Canyon, and the Blue Ridge Parkway (figs. 7, 8, and 9). Other federal lands are managed by the Tennessee Valley Authority, Oak

Figure 7
Figure 8
The region contains the largest concentration of federal lands in the eastern U.S. This is the Pisgah National Forest in North Carolina.

Figure 9
Privately owned pasture land in Virginia — the vast majority of the region is privately owned.
The Social, Cultural, and Economic Status of the Southern Appalachians

Ecosystems are important because they are the places where people live, work, and play. This portion of the SAA focuses on the human dimensions and human activities in the ecosystems of the study area. The history of human influences is outlined, and recent changes in human communities and human influences are described in some detail. Recent changes in the timber economy of the region are analyzed. Since the Southern Appalachians are a tourism and recreation destination for people throughout the eastern United States, supplies of and demands for recreation are analyzed. Finally, the areas of public land where human influences are severely limited — the roadless areas and officially designated wilderness — are described.

Recent changes in the Southern Appalachians are making the area’s people less unique than they once were.

History

The steep slopes and rocky soils of the Southern Appalachians make the region less hospitable to large-scale farming than the regions to the south and east. But that same topography produced a pleasant climate and provided places for people seeking a lifestyle of hunting and subsistence farming. That was the lifestyle of the Native Americans prior to European-led settlement, and it was the dominant lifestyle of settlers and their descendants until the 20th century.

Communities formed around creek and river drainages, and people concentrated their agriculture on the flatter spots near water. Until the supply of relatively flat land ran low, the steeper slopes remained in forest or pasture. Community boundaries normally ran to the tops of ridges, and forested slopes were open to hunting by anyone in the community.
The individual family farm and the immediate community were the centers of cultural and economic activity (fig. 12). Food and clothing were made inside the family grouping, and there was relatively little commerce with the world outside the community. Communities often were dominated by a single family or a few families. Children were often educated in their own home or in the home of a nearby relative. Kinship groups dominated all aspects of life, including religion and politics. Concepts of right and wrong were both taught and enforced by kinship groups.

After the Civil War, industry grew rapidly in most of the eastern United States. That process was much less evident in the Southern Appalachians. As a result, even before the end of the 19th century, this region came to be thought of as different from the rest of the country.

Differences may have been exaggerated by writers who sought to entertain as well as inform, but there is no doubt that Southern Appalachian residents had far less income, poorer medical care, and less formal education than the residents of surrounding areas. To correct these problems, special efforts have been made by private and public organizations to improve human conditions in the area. The Appalachian Regional Commission, Economic Development Administration, and TVA continue such efforts to this day.

Recent changes in the Southern Appalachians, however, are making the area’s people less unique than they once were. In the last 50 years, many people have left the area to seek better opportunities elsewhere. At the same time, the area’s climate and scenery have attracted permanent residents from outside. The result is a mixed culture that is no longer dominated by the descendants of early settlers. New residents and people in families that have lived in the area for generations often disagree about appropriate uses of both public and private land.
The greatest increase in population density has been near metropolitan areas. The greatest increase in population density in the Southern Appalachians has been near metropolitan areas in northern Georgia, northwestern South Carolina, and portions of Tennessee, North Carolina, and Virginia (fig. 14).

Population in the Southern Appalachians is expected to increase by 12.3 percent between 1990 and 2010. Fastest growth is expected in northern Georgia, eastern Tennessee, and northern and southern Virginia.

Over the past 20 years, as the economy grew, poverty declined significantly. The proportion of families below the poverty level decreased from 20 percent in 1970 to 11 percent in 1990. The poverty level in the study area is now just slightly below that in the seven-state region. Unemployment was low in 1970, but turned upward in 1980 and 1990 in response to overall national recessions.

Farming, once a dominant force in the region's economy,
decreased by 31 percent between 1969 and 1987. The proportion of the region's area in farms decreased from 34 percent in 1969 to 25 percent in 1987 (fig. 15).

Over the past 20 years, as the economy grew, poverty declined significantly.
Southern Appalachian Attitudes Toward Resource Management

Although they may differ somewhat in intensity and balance, the attitudes of Southern Appalachian residents about natural resources and ecosystem management are quite similar to attitudes across the nation. Throughout the United States, environmental concerns remain high. Most Americans feel, however, that environmental protection and economic growth are compatible. When
The Timber Economy

Forests and their use have strongly shaped the landscape of the Southern Appalachians. Wood has been vital for subsistence and commerce there for many years. Practically all of the region's forests have been harvested at least once since the mid-1800s, and an industry based on sustained timber growth and production in second-growth forests thrives there today.

Increasingly, however, forest values other than timber are controlling the ways in which forests are utilized. Often the values of watershed protection, scenery for tourists, wildlife habitats, and suitable sites for recreation and development control when and where timber is harvested. Ongoing changes in the demographics and landscape of the Southern Appalachians could reshape its timber economy.

This analysis of the Southern Appalachian timber economy was structured around four questions:

- What are the supplies of and demands for wood products in the Southern Appalachians?
- Where and how does the wood-products industry depend on National Forest System timber in the Southern Appalachians?
- What are the relationships among timber production, employment, and income in the Southern Appalachians?
- What national forest land is tentatively suitable for timber production in the region and how can assessment findings be incorporated in further analysis of timber suitability?

The Setting

Forests cover more than 24 million acres of the assessment area. The forests of the study area are extremely diverse. More species of trees are native to the Southern Appalachians than to any other northern temperate region of the globe. In addition, the nature of
Supplies of readily accessible high quality hardwood trees are diminishing and prices for these trees are rising.

High quality hardwood logs are used in furniture manufacturing.

Markets are expanding for the lowest quality timber as well. Pulpwood production has recently expanded in the southern quarter of the Southern Appalachians (fig. 20) and timber production for use in composite boards is the most significant new wood products industry in the region.

Employment and Income

The wood products industry has provided stable employment and income in the region over the last 20 years (fig. 21). Wood products employment and income grew over this period, but at a slower rate than for the economy as a whole. As a result,
Markets are expanding for the lowest quality timber as well.

Figure 21  Employment in lumber and wood products, furniture and fixtures, paper and allied products in the Southern Appalachians, 1975-1993. (Self-employed workers are not included.) (Source: Department of Labor, unemployment insurance database, ES-202)

its share of the total economy declined from 6 percent to 4 percent in 20 years.

Differences in employment in the solid wood and pulpwood industries have implications about future employment in the industry. Per unit of material harvested, solid wood manufacturing employs nearly twice as many people as pulpwood manufacturing and more of the solid wood jobs are located in rural areas. If timber use continues to shift towards pulpwood and chip products, then employment in wood manufacturing could be expected to fall. Employment would shift toward higher paying jobs in a few places, but fewer jobs would be provided.

The wood products industry has provided stable employment. Wood products employment and income grew over this period, but at a slower rate than for the economy as a whole.
On average, USDA Forest Service timber is larger and older than privately held timber and the national forests hold a larger share of high-grade oak sawtimber.

The Role of National Forests

About 17 percent of the region's timberland is in national forests. In individual counties, however, the USDA Forest Service manages up to 69 percent of timberland. In these areas, USDA Forest Service decisions strongly influence the local wood processing industry.

On average, USDA Forest Service timber is larger and older than privately held timber and the national forests hold a larger share of high grade oak sawtimber (fig. 22). Since this is the kind of timber that is in shortest supply and greatest demand, national forest timber sales can affect the markets for high quality oak.

National forest management differs from private land management and results in different forests and patterns of timber production. The terrain is usually more rugged and there are fewer roads, making these lands more expensive to harvest. National forests have more timber, less harvesting, less growth, and slightly higher mortality than private forests in the area.

Figure 22  Red oak sawtimber inventory by grade and owner. (Grade 1 is the highest grade in timber.) (Source: USDA Forest Service, Eastwide Database, Hansen and others, 1992)
Since 1980, national forests have provided 10 to 12 percent of Southern Appalachian timber production. National forest harvests increased from the late 1970s through the mid-1980s. Production peaked in 1985 and fell rapidly after 1991 (fig. 23). Current sale levels are comparable with those of the late 1970s and current policies could decrease harvest levels further.

In some locations within the Southern Appalachians, national forest timber harvests have a significant impact on timber markets. One area is centered in the southwestern corner of North Carolina and includes parts of southeastern Tennessee and northern Georgia. The other extends from the northeastern corner of Tennessee north to the West Virginia border. In these locations the national forest share of timber production has been between 35 and 52 percent.

**Implications for Future Planning**

Planning for the management of national forest lands is complex and requires accurate information about the various values that specific tracts can yield. The determination of what land is and is not suitable for timber production is an especially important step in the planning process. Once a tract is classed as unsuitable for timber production, it is removed from further consideration for this use. This analysis therefore can strongly influence the supply of timber from a national forest.

Findings from the SAA analysis of timber supply and demand could be helpful in further analysis of suitability for timber production in forest planning. The SAA analysis shows a great deal of price variation with species and grades of material harvested. The
financial analysis for suitability therefore should account for the species and grades of material that each silvicultural prescription would yield. The location of the tract under consideration with respect to specific markets also needs to be considered. Finally, price forecasts need to be carefully constructed for individual products rather than for groups of wood products.

Outdoor Recreation

Throughout the United States, the Southern Appalachians are well known for their scenery and the recreation opportunities they provide. These qualities fuel an economy that provides meaningful experiences to visitors and employment for residents. They also give residents positive feelings about the places where they live.

In the assessment, analyses developed from a base of five questions. Three of the questions address the economic aspects of recreation:

- What opportunities are there for public land in the Southern Appalachians to provide unique or unsatisfied forest-related recreation demands?

- How has the recreating public within traveling distance of public land changed in the past 10 years and what are predicted future changes?

- What are the supplies of and demands for major types of recreation settings and activities within the area?

Two questions related to providing a positive sense of place were addressed:

- How is the changing social context of the Southern Appalachians likely to affect future recreation demands on public lands?

- How do recreation opportunities affect the lifestyle and local culture of the area?
Throughout the United States, the Southern Appalachians are well known for their scenery and the recreation opportunities they provide.

Figure 24
This map shows the distribution of settings across the Southern Appalachians. About 45 percent of the region is rural, 24 percent is naturally appearing forests, and about 8 percent is remote. The only primitive setting occurs in the Great Smoky Mountains National Park.

Settings – The Context for Recreation Experiences

If a person chooses to spend leisure time outdoors pursuing nature-based activities, then the type of recreation setting is important. Outdoor recreation supply is defined as the opportunity to participate in a desired recreation activity in a preferred setting. The setting creates the context for the experience a person can expect. For example, hiking along a trail in a setting far from the sights or sounds of humans creates a different experience than hiking in a farm pasture. In both cases, hiking is the activity, but the difference in settings creates a different experience. Thus, determining the type, amount, distribution, and ownership of settings across the landscape is central to understanding recreation supply (fig. 24).
or remained stable (fig. 27). Since the population has increased, demands for specific recreation opportunities have risen.

The most active one-fourth of recreation participants account for about two-thirds of recreation activity (fig. 28). These people are predominately white, male, and under the age of 60. In the last 10 years, increasing numbers of females have become avid recreators, however.

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Figure 27: The percentage of people participating in nature-based recreation has grown or remained stable. Due to population increases, demands for specific recreation opportunities have risen swiftly.
density use of the public forests and parks. As these population
around the edges of the Appalachian Mountains. One result is high
Cochrane, NC; Altona, NY; Chatham County and Knoxville, TN, and
region's mountain sections. Many users of recreation facilities live in
Appalachian chain, particularly in the southern portion of the Blue
edges of the Appalachian chain. A high proportion of the
A high proportion of recreation use on federally owned land occurs at the outer edges of the Appalachian chain.

For recreation activities, likely to be easier than demands for nature and primitive settings.

Developed camping, recreation, camping for developed settings are
driving, skiing, and hunting. The expected to enjoy excellent health, they are likely
to the recreational

Figure 28. This figure shows the estimated number of outdoor recreation

For two-thirds of the activity.
Participating in the southern Appalachian, about one-fourth of these accounted

Day-use
Cultural Study
River Use
Hiking
Camping
Swimming
Fishing
Figure 29
These high use areas are popular recreation places where congestion occurs on weekends in the spring, summer, and fall seasons.

centers grow, use patterns will creep toward the center of the mountain ranges (fig. 29).

Congestion tends to also occur on the shores of lakes and streams, because the settings are in high demand for fishing and camping. High use occurs where trails are well developed and interconnected to allow travel in loops. Due to limited sources of supply, settings and facilities for mountain biking, horseback riding, off-highway vehicle driving, and whitewater rafting often are congested.

Maintaining a “Sense of Place.” People often develop strong positive feelings about specific places in and around their communities. Social scientists call these feelings a sense of place (fig. 30). Nature-based settings are key ingredients for enhancing a sense of place in the Southern Appalachian communities. Recreation and scenic opportunities facilitate social interaction, provide a strong
Rapid development in some Southern Appalachian communities appears to be taking away the sense of place of long-term residents. Southern Appalachian people have traditionally been independent and family-oriented, with a strong attachment to the land. The high country was often thought of as community property for uses such as hunting, fishing, and gathering forest products. Many of these uses have continued on national forests, but increased tourism and in-migration have led to conflicts between developers and long-term residents.

Figure 30
The scenic mountainous backdrop surrounding this community is one attribute that leads people to form a bond of attachment to the land, thus creating a “sense of place.”
Conflicts related to sustained development can probably be
minimized by understanding the special character and attributes of
communities. Preserving key attributes during development is
e xtremely important to long-term residents. In addition, open
spaces and distinctive landscapes for nature-based activities con-
tribute to the lifestyles of residents and visitors.

Over 30,000 jobs are directly related to recreation facilities on
federal land. The counties with the greatest number of these jobs
are located near the area's two national parks and the large con-
centration of national forests in western North Carolina. A high net
economic value is placed on whitewater rafting ($126 per day). The
value placed on camping is relatively low ($6 per day). Therefore,
counties with whitewater rivers, such as the Chattooga, Nantahala,
and Ocoee, have seen increases in recreation-related employment.
(Recreation values are from USDA Forest Service Public Areas
Recreation Visitor Survey, 1985-1987.)

Roadless Areas and Designated Wilderness

Distribution and Location

People are interested in the number, size, location, and status of
roadless areas in the Southern Appalachians. These areas are an
inventory of undeveloped land that satisfies the definition of
wilderness found in section 2(c) of the 1964 Wilderness Act (FSH
1909.12). An inventory of roadless areas conducted for the SAA
reflects past management and land use. Some people want to know
where roadless areas occur because of their interest in protecting
natural areas from development. Others are interested in knowing
where these areas occur and when they may be available for other
future uses.

The assessment addressed four groups of questions about
wildernesses and roadless areas:

- Where are roadless areas on national forests in the SAA
  area? What are the spatial relationships of these roadless
areas to units of the National Wilderness Preservation System and to areas with general roadless character on state and other federal land?

- What is the Forest Service doing to maintain or enhance natural processes in national forest wildernesses? What is the Forest Service doing that affects the integrity of roadless areas on national forests?

- Is there a relationship between the amount of use wildernesses are receiving and their proximity to major population centers?

- What are the spatial relationships of wilderness and roadless areas to other assessment resources, including, but not limited to, old growth, critical habitat, tentatively suitable acres for timber management, recreation settings and use patterns, special classification areas, and land-type associations on national forests?

Roadless areas and wilderness are a limited resource in the Southern Appalachians (fig. 31). One hundred forty-four roadless areas and 39 designated units of the National Wilderness Preservation System occur in national forests, national parks, and
• What habitat types, habitat parameters, and management activities are important in providing the distribution and types of habitats to sustain viable populations and/or desired habitat capability for the “short list” of wildlife and plants?

• Based on current knowledge of ecological unit land capabilities for the Southern Appalachians, what are the general habitat mixes and conditions needed to:
  - Recover federally listed threatened and endangered species?
  - Conserve populations of species with viability concern?
  - Maintain the existing species and community diversity that will not result in the loss of viability of any plant or animal species (in the context of the entire Southern Appalachian region)?
  - Provide sustainable levels of species populations at desired levels on national forests?

The forest health assessment also addressed four questions:

• What changes and/or trends in forest vegetation or soil productivity are occurring in the Southern Appalachians in response to human-caused disturbances or natural processes?

• What are the potential effects of the presence and absence of fire on forest health?

• How is the health of the forest ecosystem being affected by native and exotic pests?

• How is current and past management affecting the health and integrity of forest vegetation in the Southern Appalachians?

Currently around 70 percent of the SAA area is forested.
Wildlife and Plant Species and Important Habitats

Broad Vegetation Classes

To help describe the structure of the SAA ecosystems, sixteen broad landcover classes were identified to characterize habitats across the SAA area. These broad landcover classes included: northern hardwood forests, mixed mesophytic hardwood forests, oak forests, bottomland hardwood forests, montane spruce-fir forests, white pine-hemlock forests, southern yellow pine forests, white pine-hemlock-hardwood forests, mixed pine-hardwood forests, grass-shrub habitats, barren land, agricultural cropland, agricultural pasture, wetlands, developed land, and water. Classes of old-growth forest types were identified for an analysis for possible old growth on National Forest System lands. The forest classes were further characterized according to successional classes to better describe forest landscape conditions. These successional classes have different plant and animal species associated with them. Forest early-successional stages (0 to 10 years old) provide for habitat for species such as bobwhite quail, ruffed grouse, Bachman’s sparrow, and prairie warbler, while forest late-successional habitats (beginning at ages 60 to 90 depending on forest type) provide important habitat components such as large cavity trees, large snags, and denning trees for species such as pileated woodpecker, black bear, and gray squirrel.

Currently around 70 percent of the SAA area is forested, with the remaining 30 percent in nonforest land cover. Deciduous forests dominate the forest landscape, with oak forest being the major type. Evergreen and mixed evergreen-deciduous forest share the remaining proportion of forested land. Pasture land comprises...
Table 3  The acreage summary of the current Southern Appalachian Assessment area vegetation and landcover types as determined by FIA and LANDSAT remote sensing imagery.

<table>
<thead>
<tr>
<th>Landcover Classes</th>
<th>Total Acres</th>
<th>% of Total SAA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest Cover Types</td>
<td>26,172,425</td>
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<tr>
<td>Deciduous Types</td>
<td>17,621,894</td>
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<td>Northern Hardwood</td>
<td>615,004</td>
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</tr>
<tr>
<td>Mixed Mesophytic Hardwood</td>
<td>3,126,124</td>
<td>8.4</td>
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<tr>
<td>Oak Forests</td>
<td>13,427,883</td>
<td>35.9</td>
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<tr>
<td>Bottomland Hardwood</td>
<td>452,883</td>
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</tr>
<tr>
<td>Evergreen Types</td>
<td>4,514,743</td>
<td>12.1</td>
</tr>
<tr>
<td>White Pine-Hemlock</td>
<td>665,925</td>
<td>1.8</td>
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<tr>
<td>Montane Spruce-Fir</td>
<td>90,101</td>
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</tr>
<tr>
<td>Southern Yellow Pine</td>
<td>3,758,717</td>
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</tr>
<tr>
<td>Forest Types</td>
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</tr>
<tr>
<td>White Pine-Hemlock-Hardwood</td>
<td>830,565</td>
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<tr>
<td>Mixed Pine-Hardwood</td>
<td>3,205,223</td>
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<tr>
<td>Nonforest Cover Types</td>
<td>11,233,231</td>
<td>30</td>
</tr>
<tr>
<td>Grass/Shrub, Old Fields</td>
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<tr>
<td>Agricultural Cropland</td>
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<tr>
<td>Agricultural Pasture</td>
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<tr>
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<td>Barren</td>
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<tr>
<td>Water</td>
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<tr>
<td>Wetlands</td>
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</tr>
<tr>
<td>Totals</td>
<td>37,419,400</td>
<td>100</td>
</tr>
</tbody>
</table>

¹Forest acreage is estimated using FIA data in combination with LANDSAT data. Nonforest acreage is estimated using LANDSAT data.

Figure 32  A summary of forest and non-forest land by ecological sections in the Southern Appalachian Assessment area (fig. 5).
Seventy percent of the total forest area is in mid- to late-successional stages.

Figure 33  Nearly 70 percent of the forest is in mid- to late-successional vegetation stages.

the largest proportion of nonforested categories (table 3). The largest proportion of the SAA area's forested ecosystems are in the Blue Ridge Mountain section, followed by the combined Northern Ridge and Valley-Allegheny Mountains-Northern Cumberland Mountains (fig. 32). The remaining ecological units were considered agriculturally dominated.

Around 84 percent of the land in the SAA area is in private ownership, with the remaining in public ownership. A little over three-fourths of the forested land and around 98 percent of the nonforested land are located on private ownership.

Since the mid-1970s, acreage of forest land has decreased by around 2 percent. Acreage of forest early-successional and late-successional classes has increased over the same time period, while sapling-pole classes decreased and mid-successional classes held steady. Seventy percent of the total forest area is in mid- to late-successional stages, with the remaining 30 percent in early- and sapling-pole successional stages (fig. 33). Acres of urban developed land have increased in size since around 1980, while all other nonforested lands have decreased in acres. Private lands contain the highest proportion of forest early-successional, sapling-pole, and mid-successional classes. National Forest System lands

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National Forest System lands contain the highest proportion of forest late-successional classes.
well as increased acorn production resulting from the increase in mid- to late-successional oak forests (fig. 43). Outlook for these species is for current population trends to level off within the next 15 years.

Black bear have made moderate range expansions since 1970 (fig. 44), particularly in southern Virginia and northern Tennessee and North Carolina, resulting in linking of the northern and southern population centers. There also has been a moderate increase in population densities. This increase likely is related to both non-habitat factors such as protection and conservative harvest as well as the increased acorn capability resulting from the increase.
in the southern Appalachians are potentially suitable habitat. Black bears are associated with a broad range of forest types in successional stages. However, removal of human activity is a key characteristic for their habitat. Approximately 7.1 million acres are generally associated with higher bear populations. (Figure 45).

Lesser extant national forest land, than on the remaining densest generally are associated with national park land and to a lesser extent, oak forests. Figure 45.
Bobwhite quail population densities have declined during the last 25 years (fig. 49). Quail population decline is likely a result of the loss of agricultural land in the region as well as changes in agricultural practices. It is expected that habitat for quail will continue to decrease due to shifts of agricultural lands to improved pasture and a continuing isolation of suitable early-successional grass-shrub and cropland habitats. Quail populations are low on national forests, national parks, and the Cherokee Indian Reservation compared to most other ownerships.

It is expected that Bobwhite and other early-successional species dependent on grass-shrub and cropland will decrease due to shifts in land uses.

Landscape-level Habitat Suitability Analysis for Selected Species Groups – Habitat suitability spatial analysis was conducted for selected species groups. These species groups lend themselves to broad, landscape-level analysis using remote sensing data. Seven habitat suitability models were developed and analyzed. The results for black bear are included within game species. The results are provided for (1) area-sensitive mid- to late-successional deciduous forest species, (2) general high-elevation forest species, (3) seeps, springs, and streamside species, (4) high-elevation bald early-successional species – early-successional
grasseshrub species, (5) closed canopy deciduous forest species, and (6) high-elevation spruce-fir-northern hardwood forest species. It should be noted that these landscape-level models represent only gross habitat suitability based on general habitat requirements. Many species included have very specific, micro-habitat requirements not discernible in a broad scale analysis. Therefore, results of the suitability models should be viewed as providing a regional scale picture of habitat potential among ownerships and ecological units rather than an indication of site-specific presence or absence of a particular species or group.

**Area-Sensitive Mid- to Late-Successional Deciduous Forest Species** - This species group is made up of 16 birds, associated with mid- to late-successional deciduous forests, including neotropical migrant species, such as cerulean warbler, hooded warbler (fig. 50), and wood thrush. All the species included in this group are considered to be area-sensitive, requiring continuous forested tracts. Many also avoid forest edges during nesting and therefore are considered forest interior species.

*Figure 50*  
Hooded warbler is one of 16 birds that require mid-to late-successional deciduous forest.
The outlook for these forest communities and the seven species associated with these general high-elevation habitats is uncertain due to the negative effects caused by air pollution and exotic pests. A downward trend for these habitats is probable over the next 15 years.

Seeps, Springs, and Streamside Species – This group includes 31 species associated with forested riparian areas as well as those found in springheads, seeps, and river gravel bars (fig. 53). Some species included in this habitat association are Acadian flycatcher, Junaluska salamander, harperella, and Ruth’s golden aster. There are approximately 2.3 million acres of riparian habitat in the assessment area, 1.5 million acres (65 percent) of which is in forest cover. Due to limitations of the remote sensing data, habitat suitability modeling was attempted only for forested riparian habitat. Species associated with forested riparian habitat included a number of salamanders and fewer numbers of plants, birds, and mammals. A large majority of the forested riparian habitat is on private land. The future quality of these habitats is uncertain and may decline due to threats from hemlock woolly adelgid, an exotic insect.

Figure 53
Species such as the spotted salamander can be found in seeps, springs, or streamside habitat.
High-Elevation Bald and Early-Successional Grass-Shrub Species –
These two groups include species associated with open conditions including early-successional forests (i.e., 10 species that include bobwhite quail, eastern cottontail (fig. 54), prairie warbler, and Bachman’s sparrow) and, grassy and heath balds and old fields (i.e., 18 species that include Blue Ridge goldenrod (fig. 55), Roan Mountain bluet, and chestnut-sided warbler). There are approximately 1.5 million acres of early-successional habitat at lower elevations and 27,000 acres above 3,500 feet. The majority of this habitat is found on private lands (97 percent and 71 percent for low and high elevation). National forests provide 2 percent of the low elevation early-successional habitat, but 25 percent of the high-elevation early-successional habitat. The Southern Cumberland Plateau and Southern Ridge and Valley and Southern Appalachian Piedmont contain much of the low elevation grass-shrub habitat. Eighty-six percent of the high-elevation early-successional habitat is in the Blue Ridge Mountains.

The outlook overall is for the high-elevation bald habitats to remain near or slightly above the current levels over the next 15 years. However, the effects from air pollution on these communities could adversely affect quality of the remaining habitat. Populations of the rare species associated with this habitat will continue at low levels.

Figure 54
The eastern cottontail is an early successional species.

Figure 55
Blue Ridge goldenrod. National forests provide 2 percent of the low elevation early successional habitat and 25 percent of the high-elevation early successional habitat.
Figure 56
The purple turtlehead is associated with high-elevation spruce-fir and northern hardwood forests. Almost 80 percent of the high-elevation spruce-fir and northern hardwood forests is on national forests and parks.

It is expected that the acreage in early-successional habitat at lower elevations will probably remain at near current levels.

High-Elevation Spruce-Fir-Northern Hardwood Forest Species – This group includes species associated with higher elevation mid- to late-successional spruce-fir and northern hardwood forests that includes the spruce-fir moss spider, purple turtlehead (fig. 56), Carolina and Virginia northern flying squirrel, and Cheat Mountain salamander. There are approximately 184,000 acres of high-elevation spruce-fir-northern hardwood forest in the assessment area. Almost 80 percent of this habitat is located on national park and national forest lands. The majority of the high-elevation spruce-fir-northern hardwood habitat is in the Blue Ridge Mountains. The outlook for this community and the 23 species associated with these high-elevation habitats is uncertain due to the negative effects caused by air pollution and exotic pests. A downward trend for these habitats is expected over the next 15 years.

Maintaining Habitats – The mid- and late-successional deciduous forests in the Southern Appalachians are an important habitat for 80 of the 472 species on the SAA special species list. Less than 50 percent of this habitat is in tract sizes greater than 5,000 acres, with most of these tracts occurring on national forests and national parks. Maintaining the larger tracts will support all species associated with mid- and late-successional forests. Late-successional deciduous forests provide special habitat features required by some species, such as large cavity trees, large standing snags, and den trees. Spatial arrangement of these features will enhance the habitat.

Maintaining federally listed and viability concern species associated with these habitats may require protecting species occurrence locations from road construction, preventing loss of forests to development, and providing mitigating measures for some silviculture practices.

Early-successional habitats (0 to 10-year-old forest communities and abandoned/idle land) are required by 10 out of the 472 special species and are important for several of the game species and habitat generalist species. These habitats can result from even-aged regeneration harvests, group selection harvests, disturbance (i.e., insect, disease, fire), and from once cultivated, now untreated
lands. These habitats succeed rapidly into sapling forests and so are not very abundant. The landscape principles of isolation, patch size, and source/sink communities are ways of maintaining these habitats.

**Rare Communities**

Analyses revealed 31 rare community classes in the Southern Appalachians: beaver pond and wetland complexes, beech gap forests, boulder fields (forested), calcareous cliffs, calcareous woodlands and glades, Carolina hemlock forest, caves, granitic domes, granitic flatrocks, grassy balds (fig. 57), heath balds, high-elevation rocky summits, mafic and calcareous fens, mafic cliffs, mafic woodlands and glades, mountain lakes, mountain longleaf pine woodlands, mountain ponds, river gravel cobble bars, sandstone cliffs, seasonally dry sinkhole ponds, serpentine woodlands and glades, shale barrens, sinkholes and karstlands, sphagnum and shrub bogs, spray cliffs, spruce-fir forests, swamp forest-bog complexes, Table Mountain pine–pitch pine woodlands, talus slopes (nonforested), and wet prairies.

**Figure 57**
High elevation grassy balds are one of 31 rare communities and streamside habitats that provide habitat for 84 percent of the federally listed plants and animal species.
Rare communities are important for the region’s biological diversity.

The Blue Ridge Mountain section and the combined Northern Ridge and Valley-Allegheny Mountains—Northern Cumberland Mountains, which account for around 50 percent of the SAA land area, contain over 80 percent of the occurrences of rare communities. The majority of rare communities occur on private lands, followed by national forests and national parks (fig. 58).

Figure 58  About two-thirds of the rare communities occur on private lands.

These rare communities are important for the region’s biological diversity. While these communities occupy a very small percentage of the region’s land area, around 84 percent of the federally listed terrestrial plant and animal species and 74 percent of the viability concern species are associated with rare communities and streamside habitats. The maintenance of these habitats requires a range of activities from prescribed burning and vegetation manipulation, to protection from human use and development.
Forest Health

Natural Processes and Human-Caused Disturbances to Ecosystems

Human-caused disturbances, such as introduction of exotic plants and diseases, extirpation of species, or utilization of natural resources, raise special concerns because their long-term consequences often are unknown. Natural disturbances that currently affect ecosystems are probably similar to past disturbances, whereas human disturbances may be very different than those in the past.

The use of fire by Native Americans and later settlers significantly altered Southern Appalachian forests for hundreds of years. Fire prevention and suppression in the 20th century, therefore, has changed a long-term pattern, and there are ecological consequences.

Fire is probably the most common form of natural disturbance in most of the ecosystems of the Southern Appalachians. It is particularly important in systems dominated by southern yellow pines, and its ecological effects in those systems are well understood. Effects in dry deciduous forests also are important but are less understood. Fire probably was a major factor in the development of oak forests on upland sites.

In the absence of fire, two rare forest communities in the Southern Appalachians – mountain longleaf pine woodlands and Table Mountain pine-pitch pine woodlands – are being replaced by hardwoods and loblolly pine. The endangered red-cockaded woodpecker is associated with longleaf pine woodlands in northeastern Alabama and northwestern Georgia. Table Mountain pine has cones that open only when exposed to high temperatures from fires. Fire exclusion, therefore, will cause continued decline of this community.

Other forest types and plant communities where fire plays a role in community dynamics include: yellow birch boulder fields, high-elevation red oak, montane oak-hickory, white pine, chestnut oak, dry to mesic oak-hickory, xeric shortleaf pine, xeric Virginia pine, heath balds, grassy balds, ultramafic barrens, and bogs.
Many important tree species in the Southern Appalachians are being severely affected by exotic pests.

Figures 60 & 61
Hemlock woolly adelgid threatens to spread throughout the range of eastern and Carolina hemlock.
The current declines are probably more pronounced than in the past because a higher percentage of the landscape contains oak. While oaks will not be eliminated by the decline, their numbers and diversity are being reduced. The vulnerability of a stand to oak decline appears to increase with tree size, tree age, and oak abundance in the stand. Incidence of oak decline is only about half as frequent on private as on public land. The states of North Carolina and Virginia have highest incidence (fig. 62).

Introduced into North America around 1869, the European gypsy moth has moved steadily southward through the Appalachians (fig. 63). It is now common in northern Virginia. Oak
• Validate habitat relationships for federally listed species and globally imperiled species.

• Develop management guidance for the 31 rare community groupings in the SAA – a priority because of their importance to most of the rare species. Concurrently, continued efforts to develop conservation strategies for the viability concern species should be pursued.

• Fill knowledge gaps that exist in the role of fire management in the Southern Appalachians. Some specific items include developing a better understanding of the overall history and role of fire in the Southern Appalachian forests, including its role in rare communities, the maintenance of deciduous forests, and the regeneration of oak. Methods for using fire to enhance biological diversity, rare communities, vegetation composition, and stand structure as related to maintenance of ecosystem components should be established for the Southern Appalachians.

• Make developing gene conservation strategies a priority for important forest trees to protect declining tree species. Emphasis should also be given to improving the resistance of Eastern and Carolina hemlock, American chestnut, and butternut to insects and diseases. Genetic engineering efforts to improve resistance should be pursued.
Atmospheric Resources

For many years, Americans have been concerned about air pollution because of its effects on human health and the natural environment. Air pollution is a by-product in the combustion of fossil fuels for energy. People need the energy for transportation, industry, and comfortable homes and businesses. Air pollution is not confined to city boundaries but can be transported hundreds of miles from sources to impact resources in the Southern Appalachians.

A team of specialists was assembled to gather information currently known about the effects of air pollution to forest and aquatic resources in the Southern Appalachians. Public concerns in recent years led to extensive research on the impacts of acidic deposition (acid rain) and impacts of ground-level ozone on forests. Previously reported pollution trends and studies on air pollution effects on visibility, aquatic resources, and terrestrial resources were important sources of information for the team. Air quality monitoring data were also used either as the measured values, or as input into mathematical models to predict pollution concentrations across the landscape.
With the assistance of the public, five questions were formulated to guide the air quality assessment:

- What are the major air pollutants that could impact the Southern Appalachians, and what areas receive the greatest exposure?
- What is the current concentration of particulate matter in the air of the Southern Appalachians?
- How good is visibility in the Southern Appalachians, and how does air pollution affect visibility?
- To what extent are aquatic resources in the SAA area being affected by acid deposition?
- What impact does ground-level ozone have on forests in the SAA region?

Not all of the questions could be answered with complete certainty from available information. In its work, therefore, the team identified new information that would have been helpful in answering the questions. Filling these information gaps will be useful if another assessment is conducted in the future.

**Major Air Pollutants Become Secondary Pollutants**

Many pollutants are released into the atmosphere from both natural sources and human activities. The chemicals that are released are called “primary pollutants.” The primary pollutants discussed in the report are the major ones that could impact natural resources of the Southern Appalachians. There are others not reported that affect human health. Many of these primary pollutants impacting natural resources go through chemical reactions in the atmosphere and form “secondary pollutants.” The primary pollutants of greatest concern in the Southern Appalachians are sulfur dioxide, nitrogen oxides, volatile organic compounds, and particulate matter. Secondary pollutants formed from these reduce visibility, acidify soils and streams, and injure vegetation.
Visibility has deteriorated considerably since the 1940s with the poorest visibility in the summer, which is the major tourist season. Studies have shown there is a strong correlation between the emission of sulfur dioxide and haziness.

Sulfur Dioxide and Visibility Impairment

Sulfur dioxide is a gas released into the atmosphere during the combustion of fossil fuels that contain sulfur. In the atmosphere, sulfur dioxide is transformed into sulfate particles that reduce visibility and acidify soils and streams in the study area. For visitors and residents, spectacular views are major attractions in the Southern Appalachians, and many people are concerned because they think visibility in the region is declining. Long-term measurements show that they are correct. Visibility has deteriorated considerably since the 1940s with the poorest visibility in the summer, which is the major tourist season (fig. 64). Studies have shown there is a strong correlation between the emission of sulfur dioxide and haziness (fig. 65).

Figure 64
Haze in the James River Face Wilderness, and throughout the Southern Appalachians, is worse in summer (top) than in winter (bottom). Haze reduces the distance a person can see and the clarity of an object being viewed.
Despite this national decrease, the U.S. Environmental Protection Agency (EPA) has reported that sulfur dioxide emissions in EPA Regions 3 and 4, which include the SAA, have increased slightly between 1985 and 1994.

Figure 65 Studies have shown a strong correlation between the emission of sulfur dioxide and haziness. (Source: Trijonis and others 1991)

Nationally, coal-fired electricity generating plants are the major sources of sulfur dioxide emissions (fig. 66). Many of these are located inside the study area in northern Alabama, northern Georgia, and eastern Tennessee. Other large sources near the study area are on the Piedmont Plateau in North Carolina, in the Ohio Valley, and on the Allegheny Plateau in West Virginia and Pennsylvania. In the nation as a whole, sulfur dioxide emissions increased between 1940 and 1970 and since then have steadily decreased to approximately 1940 levels (fig. 67). Despite this national decrease, the U.S. Environmental Protection Agency (EPA) has reported that sulfur dioxide emissions in EPA Regions 3 and 4, which include the SAA, have increased slightly between 1985 and 1994.
Figure 66 In 1994, electric utilities were the largest emitters of sulfur dioxide in the United States. (Source: EPA 1995a)

Figure 67 National trends in emissions of nitrogen oxides, volatile organic compounds, sulfur dioxide, and particulate matter. Implementation of the Clean Air Act of 1970 reduced human-caused emissions of sulfur dioxide, volatile organic compounds, and particulate matter. Emissions of nitrogen oxides have remained level or increased slightly since 1970. (Source: EPA 1995a)
Acid Deposition and Aquatic Effects

In addition to improving visibility, reductions in sulfur dioxide emissions are predicted to reduce the amount of acid deposition in the Southern Appalachians. Acid rain became a prominent news story in the 1980s. Forests at high elevations in the Southern Appalachians were among those thought to be at risk, and considerable research was done there in the National Acid Precipitation Assessment Program. That program’s National Stream Survey was a primary source of information about effects of acid deposition on aquatic systems. Another was the National Atmospheric Deposition Program’s National Trends Network. Six of its deposition measuring sites are in the assessment area.

The primary acidifying chemicals in rainfall are sulfates and nitrates. Technical problems make measurement of cloudwater and dry deposition difficult. As a result, estimates of the amounts of acid-forming chemicals entering high-elevation ecosystems that receive significant cloudwater deposition are consistently low.

Sulfate deposition is highest at the highest elevations and in the northern portion of the Southern Appalachians (fig. 69). Unfortunately, portions of streams at high elevations are probably least able to neutralize or “buffer” incoming acidity. Sulfate concentrations in precipitation seem to be decreasing in the Southern

Figure 69
Modeled distribution of wet sulfate deposition in the Southern Appalachians, 1983-1990. Deposition of sulfate in rainfall is greatest at high elevations and in the northern part of the Southern Appalachians.
that can offset the acid effects of sulfates and nitrates. Consequently, acidity of rainfall has not improved.

Fixed nitrogen is an important nutrient for plant growth, but as forests mature, a balance is reached between plant use and recycling back into the system by decaying plant materials. Insect defoliation causes rapid recycling of nitrogen, so gypsy moth defoliation could add to the problem as this insect moves southward through the study area. Nitrate loadings (concentrations of chemicals) from rainfall are highest in the northern portion of the SAA and at some high elevation sites (fig. 70). Nitrogen saturation

Sulfate concentrations in precipitation seem to be decreasing in the Southern Appalachians, but so are the concentrations of buffering chemicals that can offset the acid effects of sulfates and nitrates.

is expected to play an increasing role in stream acidification in the future. The current extent of nitrogen saturation is not known, but it does appear to be occurring at one high elevation site, the Great Smoky Mountains National Park.

Occasional or chronic acidification of streams by sulfates and nitrates can lead to elevated levels of dissolved aluminum, which

Figure 70
Modeled distribution of wet nitrate deposition in the Southern Appalachians, 1983-1990. As with sulfate, deposition in rainfall is greatest at high elevations and in the northern part of the Southern Appalachians.
Throughout the SAA area, ozone exposures and soil moisture availability in most years are sufficient to cause growth losses in highly sensitive species, such as black cherry.

the total (fig. 72). Trees are the largest source of volatile organic compounds with vehicle emissions ranking second. Nationally, emission of volatile organic compounds from human activities increased between 1940 and the 1970s, but has decreased since the 1970s. Overall, future emission levels in the Southern Appalachians are projected to increase by 2010 as vehicle miles traveled increase with an increasing population.

![Pie chart showing solvent utilization and non-industrial sources (data from EPA 1995a)](image)

**Figure 72** Many types of volatile organic compounds are emitted into the atmosphere. (Source: EPA 1995a)

Ozone is highly damaging to tissues inside of plant leaves, which it enters through small pores called stomates. Symptoms of ozone injury in leaves are well known, and these symptoms have been observed on the leaves of sensitive species throughout the Southern Appalachians. Species and individual plants of a given species vary widely in their sensitivity.

No published reports or data document the amount of growth loss (damage) caused by exposure of trees to ambient ozone in the Southern Appalachians. The Atmospheric Team identified areas where ozone damage has the greatest potential to occur by examining data on ozone exposures and soil moisture. Throughout the SAA area, ozone exposures and soil moisture availability in most years are sufficient to cause growth losses in highly sensitive...
species, such as black cherry. Little to no growth losses are likely in moderately sensitive species, such as yellow-poplar; or in resistant species, such as red oak. Low moisture in the mid-1980s reduced tree growth considerably. Ozone is believed to have had only a minimal role in these growth losses. Damages from drought and ozone exposure are believed to be inversely related. Drought is thought to minimize ozone effects because it causes stomates to close, preventing ozone from entering the leaves. Between 1983 and 1990, highly sensitive vegetation in the northern and southern portions of the SAA area may have experienced the greatest frequency of ozone damage (fig. 73).

Ozone-sensitive species growing at high elevations may be more sensitive to ozone exposure than those growing at lower elevations.
Figure 74  Nationally, the major source of particulate matter 10 microns or smaller are fugitive dust from roads, construction, and agriculture. (Source: EPA 1995a)

1Construction emissions represent the majority of the miscellaneous-fugitive dust-other category.
2Natural sources/wind erosion emissions are discussed as fugitive dust sources throughout this report.
3Point and fugitive process sources are all sources except the fugitive dust sources.
4Includes miscellaneous-agriculture and forestry-agricultural livestock and miscellaneous-fugitive dust-other excluding construction.

Particulate Matter and Prescribed Burning

Particles in the atmosphere include wind-blown soil, soot, smoke, and liquid droplets. Nationally, the major source of particulate matter 10 microns or smaller are fugitive dust sources from roads, construction, and agriculture (fig. 74). Nationally, between 1940 and 1994, particulate matter emissions from stationary sources have decreased significantly, but point sources only comprise 8 percent of the total emission. Overall, particulate matter emissions are expected to remain constant to the year 2010.

Violations of the National Ambient Air Quality Standard (NAAQS) for particulate matter have not occurred at any monitoring site in the Southern Appalachians. The standard sets upper limits for the annual average (50 microns per cubic meter of air) and for the average for any 24-hour period (150 microns per cubic
meter). In both cases, only airborne particles and aerosols 10 microns or less in size are measured.

Between 1985 and 1994, average annual particulate matter concentrations appear to have declined in the SAA area. For particles of 10 microns or less, the annual mean for the region declined from 44 to 24 microns per cubic meter. It should be noted, however, that during the period the focus of measurement shifted from total suspended particulates to particles of 10 microns or less. This shift led to the replacement of sampling equipment. As a result, measurements of long-term change may not be completely reliable.

A small or moderate increase in prescribed fires should not cause a problem with the annual NAAQS for particulate matter.

At most monitoring stations, particulate matter concentrations are currently well below NAAQS values. New sources that emit modest amounts of particulate matter, therefore, will not cause violations of the annual standard. Annual average concentrations of particulate matter do not differ substantially by state, and urban monitored values do not differ greatly from those for rural sites. In the area as a whole, averages for spring and summer are about 12 percent higher than the annual mean.

Like annual averages, maximum 24-hour concentrations appear to be declining. Between 1985 and 1994, 24-hour concentrations at specific locations seldom exceeded 90 percent of the NAAQS maximum. Land managers must be concerned about exceeding 24-hour particulate standards in the vicinity of prescribed forest burns. Stationary air sampling equipment is seldom close enough to a prescribed forest burn to be helpful. Some special sampling has been done near such fires in Florida and Texas. In nine-tenths of the cases, particulate matter concentration was below 150 microns per cubic meter 1 mile away from the outer edge of the fire. In two-thirds of the cases, the standard was maintained as close as 0.5 mile from the outer edge.
• Develop public participation process that assists with the definition of acceptable and unacceptable visibility conditions.

• Relate episodic acidification in streams with changes in biological populations using in situ observations and experiments. Models are needed to determine dose-response relationships for aquatic biota.

• Evaluate the impact of continued sulfate deposition on the "delayed" acidification of streams as sulfate is released from soils once they become saturated.
Aquatic Resources

Introduction

Water is the largest constituent of living organisms and a prerequisite for life. Concerns about water and aquatic resources in the Southern Appalachians began long before this assessment. The national forests in the region were established early in the 20th century primarily to protect the headwaters of major rivers from land uses that encouraged flooding, erosion, and stream sedimentation. Similarly, the Tennessee Valley Authority (TVA) was established to control disastrous flooding of the Tennessee River system and to improve navigation to enhance economic development.

In the years since national forests were established, the value of the region's water has increased many fold. Some would argue that clean water for the surrounding cities is the region's most important product (fig. 75). But the area's streams are much more than water sources for people. They support the region's ecosystems and are dominant features of its landscapes. More recently, concern for the region's streams surfaced during meetings in 1994 when the SAA interagency team sought public opinion on important resource issues. Based on issues raised by the public at hearings, as well as state and federal agency concerns, five questions were formulated to focus the aquatic resource assessment:

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

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

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

• 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?

This report provides an overview of the physical setting, a summary of effects of human activities on aquatic resources, an assessment of water quality, an assessment of aquatic species, a brief summary of laws and regulations, and a brief discussion of water uses within the SAA. Three integration findings are discussed, and research needs identified during the assessment are listed.

Physical Setting

High rainfall maintains year-long flows in an unusually dense network of streams. Stream density in the SAA region averages 12 feet of channel length (fig. 76) per acre of land. Natural lakes and impoundments cover nearly 870 square miles (fig. 77) of surface area.

The SAA area contains parts of 73 major watersheds; 29 are wholly within the SAA region, 18 have more than one-half of their area within the region, and 29 have less than one-half within the region. Nine major rivers that rise in the Southern Appalachians provide drinking water to the major cities in the Southeast. These drainages ultimately flow to the Chesapeake Bay, the Ohio River, the Tennessee River, the Gulf of Mexico, and the Atlantic Ocean (fig. 78).
Figure 76
Mean stream density is 12 channel feet per acre and very high in some portions of the study area if all small mountain streams were measured.

Figure 77
Many counties in the Southern Appalachians have high acres of lake and reservoir surface representing around 1.5 percent of the total area.
Figure 78  Major drainages in the Southern Appalachians flow into the Chesapeake Bay, the Ohio River, the Atlantic Ocean, the Gulf of Mexico (via the Alabama River), and the Mississippi River (via the Tennessee River).

Effects of Human Activities on Aquatic Resources

Human activities affect aquatic resources by altering the quality or condition of the water, altering stream channels, and altering adjacent riparian areas. Aquatic resources can be influenced by erosion, deposition of sediment, alteration of stream channels, and changes to the chemistry of water.

Examples of human activities that affect aquatic resources include: land development, road construction, mining, agricultural activities, and forestry operations.

People often alter the vegetative cover on the land to suit their needs. The distribution of land cover classes that are important to aquatic resource is highly uneven across ecological regions. Agricultural land dominates in the Ridge and Valley region, while forest dominates the Blue Ridge region. The distribution of land
About 70 percent of the area in riparian zones in the Southern Appalachians is forested.

Uses is an indicator (fig. 79) of the potential impacts on aquatic resources. Impacts from developed land and plowed fields are likely to be higher than those from forestry activities. Federal holdings, including national forests and national parks, are largely forested and, therefore, have fewer human influences than much of the rest of the study area.

Riparian zones serve vital ecological functions for aquatic life. Vegetation stabilizes stream banks and provides food material for aquatic species. Stream bank vegetation also moderates water temperature and provides large woody material for stream structure and fish habitat.

Figure 79  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).
The types of land cover in riparian zones give some indication of how these zones are being managed. About 70 percent of the area in riparian zones in the Southern Appalachians is forested, 22 percent is pasture, 3 percent is cropland, 4 percent is developed, and less than 1 percent is wetland. On national parks and national forests, more than 90 percent of riparian zones have forest cover. On private land, the percentage of forest cover in riparian zones is much lower, amounting to about 60 percent.

People often alter the land in ways that affect the flow of water. These hydrologic changes may be significant on a small watershed or at a stream site but rarely noticeable at the scale of a large watershed or river basin. When the hydrologic regime of a stream changes, the channel is altered to the new regime. Natural events, such as floods, droughts, and landslides can have similar or even greater hydrologic effects than human activities. Major changes in a stream channel system can include scouring during peak flows and transfers of sediment. Dams and their reservoirs change the hydrologic regime by replacing turbulent channel flows with slow movement of water through deep flooded lakes. The natural movement of sediment through the system is halted, and downstream channel erosion may be initiated.

Approximately two-thirds of the water pollution in the Southern Appalachians is attributable to nonpoint sources.

Nonpoint Source Pollution

Water quality can be affected by nonpoint and point source pollution. Nonpoint sources have diffuse places of origin such as agricultural fields, logging sites, roads, and abandoned landfills. Point sources are associated with identifiable conveyance systems such as pipes and industrial drainage channels.

Approximately two-thirds of the water pollution in the Southern Appalachians is attributable to nonpoint sources. In a majority of the counties in the study area, less than 30 percent of the land is devoted to agriculture, and the amount of land that is in crops and pasture has been declining. Unlike agriculture, forestry
disturbances to soil and vegetation are dispersed in both space and
time. Thus, forestry has a lower potential for chronically impacting
aquatic resources. Roads are major contributors of nonpoint-
source pollution. Nearly 40 percent of the watersheds in the study
area have at least 6 percent of their stream length close to gravel or
low-quality paved roads. In a few counties, as much as 20 percent
of stream length is near roads.

Between 1982 and 1992, 23 counties in the region reduced
potential soil erosion due to agricultural activities by more than 50
percent, while 8 counties had an increase of more than 50 percent.
Human development can also increase soil erosion rates. The
population of the Southern Appalachians grew by 19 percent
between 1970 and 1980 and by 7 percent between 1980 and
1990. Construction of houses, service facilities, and roads for
this growing population undoubtedly had adverse effects on
aquatic resources.

Point Source Pollution

About 3,000 point sources discharge treated wastewater into
water bodies in the Southern Appalachians. The majority of sources
with discharges greater than 1 million gallons per day (132 of 222)
are municipal treatment facilities. The three industries with the
largest number of point discharge sites are mining, textiles, and
chemicals. These industries have 44 discharge facilities that are
rated as major.

According to lists submitted by the states to EPA, 30 facilities
with National Pollutant Discharge Elimination (NPDES) permits
have discharged significant amounts of toxic chemicals into
Southern Appalachian waters and are subject to cleanup plans for
toxic chemical releases under Section 304(L) of the Clean
Water Act.
A total of 890 potential pollution sources in the Southern Appalachians are listed under the Comprehensive Environmental Resource Conservation Liability Act (CERCLA). Twenty-two sites are on the National Priorities List as Superfund sites, and 84 are either abandoned or closed landfills. At the time of this assessment, 170 active sanitary landfills, managed under current rules, were not on the CERCLA list. Mining, human development, and dams cause the largest hydrologic alterations in the region. Mining impacts on water quality are primarily in the Tennessee River basin and in southwestern Virginia.

Assessment of Water Quality

The assessment of water quality in rivers and their tributaries is based on ability to support designated uses, such as fishing, aquatic life, swimming, and drinking water. The states are responsible for adopting water quality criteria to maintain the designated uses of streams and reporting biannually on the condition of streams and waterbodies.

In watersheds representing 75 percent of the river miles in the study area, over 80 percent of the river miles have water quality that partially or fully supports designated uses (fig. 80). The remaining miles of stream in these watersheds do not have suitable quality for current uses. Water quality is impaired on more than 20 percent of the stream miles in 15 watersheds. The Tennessee and Alabama river systems include most of the significantly impacted watersheds. In the study area, Virginia watersheds in the Chesapeake Bay drainage have the highest percentage of waterbodies meeting water quality standards for designated uses.

Among lakes larger than 500 acres in the Southern Appalachians, 38 percent are eutrophic. That is, they contain high

Figure 80
Over 80 percent of the streams have water quality that supports designated uses such as fishing, swimming, and drinking water.
Figure 81 Eutrophic lakes contain high concentrations of nutrients, which promote growth of algae and deplete oxygen supplies. (Mesotrophic indicates moderate amounts of dissolved nutrients; oligotrophic indicates small amounts of dissolved nutrients.)

Concentrations of nutrients, which promote growth of algae and deplete oxygen supplies (fig. 81).

When a state issues an advisory about eating the fish caught in a stream or lake, a press release is issued describing the associated health risk in detail. In most states, these advisories are published in annual sport fishing regulations and posted near the waterbodies. A total of 17 fish consumption advisories are currently in force in the SAA area. Eleven are for polychlorinated biphenyl (PCB) contamination, one is for chlordane, three are for mercury, and two are for dioxin contamination (fig. 82).
The native and introduced species of trout in the Southern Appalachians are of special interest to anglers (fig. 84). These fish require cold mountain streams and are seldom found in the streams of surrounding flatlands (fig. 85). About 39 percent of the SAA region is within the range of wild trout. About 70 percent of streams that are in the range for wild trout are on private land. For various reasons, wild trout species may not actually occur in all the streams within their range. Like most fish, trout are
sensitive to acidic conditions. Almost 60 percent of potential wild trout streams in the SAA region are in areas that are highly sensitive to acidification. Another 27 percent are in areas that are moderately sensitive. Most of the highly sensitive streams are in the northern part of the study area. Hemlock woolly adelgids threaten streamside hemlocks, which are important components of the riparian ecosystems that support trout streams. Gypsy moths also may impact trout habitat by defoliating large areas of mountain watersheds.

The integrity of fish communities was estimated from community composition, fish abundance, and fish condition. Fish communities were sampled at 300 subjectively selected sites in the Ridge and Valley and Blue Ridge provinces. On 69 percent of the sampled streams, moderate to severe fish community degradation was observed. However, only 19.5 percent of the 46 North Carolina mountain streams had moderately or severely degraded fish communities. A larger and more widely distributed sample would be needed to estimate the condition of fish communities in the Southern Appalachians as a whole.

**Laws, Regulations, and Programs Affecting Aquatic Resources**

The Clean Water Act of 1972 and subsequent amendments provide the legal framework for the protection of aquatic resources. The Act's objective is to “restore and maintain the chemical, physical, and biological integrity of the nation's waters.” In 1987, the Act reaffirmed the national goals for elimination of discharges of pollutants into navigable waters of the United States and, where attainable, water quality that provides for the protection and propagation of fish, shellfish, and wildlife. A further requirement of the Clean Water Act is the development of programs for control of pollution (non point source) that originates from diffuse sources such as agricultural fields and construction sites.

Under the Clean Water Act, the discharge of pollutants into waterbodies is regulated and limited through the National Pollutant...
A number of federally funded programs have been established to protect, restore, or improve aquatic resources in the United States.

Discharge Elimination System (NPDES). Water quality standards are implemented and enforced by the states and the EPA through the NPDES permit system. Water quality standards are implemented through discharge permits issued by EPA or delegated states. Currently, all states in the SAA area have NPDES permitting authority.

A nationwide permit program that regulates dredge and fill operations is administered by the U.S. Army Corps of Engineers. It is extensively used for regulation of activities in wetlands and navigable streams.

Nonpoint source pollution is controlled through the development and implementation of Best Management Practices (BMPs) for forest, agricultural, and developed land. An example of a BMP is seeding and mulching to stabilize newly constructed forest roads (fig. 86).

A number of federally funded programs have been established to protect, restore, or improve aquatic resources in the United States. These programs are sponsored by various agencies, including the USDA Forest Service, the Natural Resource Conservation Service, the National Park Service, EPA, TVA, and the U.S. Army Corps of Engineers. These programs provide technical assistance to and share costs with private landowners. Sponsored activities include erosion control, purchase of easements on private wetlands with follow-up restoration, and assistance in management of riparian zones.

Figure 86
Best Management Practices are essential for controlling nonpoint source pollution.
The last 8 years have been a turning point in water resource legislation and pollution control. Programs have been specifically designed to deal with nonpoint source pollution and toxics as well as point sources. Programs also have emphasized protection of national treasures such as the Great Lakes and Chesapeake Bay. The water pollution control program administered by EPA has been largely successful in reducing point source pollution. Many streams and lakes have gradually recovered from years of abuse and now support abundant aquatic life as well as swimming and other recreation activities. The design and use of BMPs have demonstrated that technology also can reduce nonpoint source pollution.

Between 1985 and 1990, water use for domestic, industrial, and agricultural purposes decreased by 19.6 percent in the Southern Appalachians.

**Water Usage in the SAA and Withdrawals on Federal Land**

In 1990, about two-thirds of the water use in the study area was industrial. The remainder was divided among commercial, domestic, and agricultural uses. Between 1985 and 1990, water use for domestic, industrial, and agricultural purposes decreased by 19.6 percent in the Southern Appalachians. This decline in use is consistent with a national trend. Across the nation, water use increased steadily between 1950 and 1980, and then began an overall decline (fig. 87).

In the southern region, water from national forest land is predominantly used for domestic, household, irrigation, recreation, municipalities, and to maintain fish and wildlife habitat. Water use on the national forests ranges from 1,700 gallons per day in Alabama to 1,315,000 gallons per day in Virginia. The vast majority of water use in Virginia's national forests is from the Holston River. Industrial withdrawals from that river in Sullivan County, TN,
Figure 87 Water use increased steadily between 1950 and 1980, then began to decline. (Source: US Geological Survey circular #1081)

are the highest in the study area. Water impoundments (dam and accumulated water) from the Holston River in Virginia for fish and wildlife (614,000 gallons per day) represent the largest use on National Forest System land within the SAA boundary.

In comparison with water use in developed areas, water use on national forests is generally insignificant. The high-quality water that comes from national forest watersheds is of enormous value to cities downstream, however.

Integration of Findings

Where possible, aquatic resource assessment findings were integrated with findings from the atmospheric, terrestrial, and social/cultural/economic assessments. Some integrated findings were reported in chapters 2 through 6 of the Aquatics Technical Report. Although beyond the scope of the SAA, there are many more opportunities for integration of data and findings with those from the three other technical teams. Further integrated analyses will be simplified by data accessible through the Internet. This section briefly discusses several findings that are based on integrated data from two or more of the technical reports.
Interaction of Mining Impacts with Atmospheric Sulfate Deposition

Wise, Dickenson, and Buchanan Counties in southeastern Virginia have large numbers of active mines (fig. 88). These counties are also in a region that has a high potential for adverse impacts due to atmospheric sulfate deposition (Atmospheric Technical Report). Because the historic and current mining activities in these counties have resulted in significant atmospheric sulfate deposition, the interaction of mining and atmospheric sulfate deposition is a critical issue.

Figure 88
Many active mines are located in the study area.
counties have already impacted the water quality of several streams, it is not likely that the sulfate from continuing air deposition will result in further significant degradation (fig. 89). Past mining practices on other watersheds in the SAA area also have caused documented impacts that may mask some of the future impacts of atmospheric sulfate deposition.

Several areas with moderate to high potential for sulfate deposition do not contain large numbers of mining operations. Here, observable impacts of sulfate deposition, such as decreased pH and acid neutralizing capacity and loss of acid-intolerant aquatic species, 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.
Population Pressure on Aquatic Systems Due to Land Uses

Increasing human population density and the resulting intensive human uses of the landscape put high stresses on aquatic systems in many areas through nonpoint source pollution and habitat degradation. Population density in the study area increased from 80 people per square mile in 1970 to 102 people per square mile in 1990, and the area's population is projected to grow an additional 12.3 percent by the year 2010.

In this assessment, it was not possible to adequately estimate the impacts of increasing population on aquatic resources. We know that land covers which represent human activity (e.g., developed or barren, cropland, and pasture or herbaceous) already occupy more than 50 percent of the land area on many large watersheds (fig. 90). Very few large watersheds have less than 10 percent of their area in these land covers. Most of these areas are intensively used by humans, but some land is barren because of rock outcrops and some land with a herbaceous cover is in high-elevation balds and rhododendron beds where little human activity is occurring. Unfortunately, we could not separate some kinds of developed and undeveloped ecosystems in the data set.

Intensive human activities are occurring in many riparian zones. Historically, riparian zones were largely forested, but human activities have reduced forest land cover to less than 60 percent in riparian areas in many large watersheds (fig. 91). Areas with less than 60 percent forest cover in riparian zones are concentrated in the so-called “great valley” that runs through the Ridge and Valley Province from northern Virginia to northwestern Georgia and northeastern Alabama. The great valley now contains a high concentration of heavily developed areas. This development can be expected to increase as the human population expands.

Increasing human population density and the resulting intensive human uses of the landscape puts increased stresses on aquatic systems.
Human activity occupies more than 50 percent of the land area on many watersheds.

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 (Terrestrial Technical Report) are associated with seeps, springs, and streamside habitats. Of these species, 10 species are federally listed threatened and endangered, with 81 percent of these Element Occurrence Records (EOR) occurring on private lands. There are 24 viability concern species (equivalent to aquatic special concern species) 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.
Research and Monitoring Needs

Many data gaps were identified during the aquatic resource assessment. Little or no data exist to address some important resource questions. In addition, the spatial distribution, timing, or quality of data collection severely limits the usefulness of data. These problems were translated into the monitoring needs and research opportunities listed below:

- Develop more consistent data for all lands within the region. Long-term monitoring, with frequent sampling based on an appropriate statistical design, is necessary to accurately portray current conditions and future trends.

- Gather data on the hundreds of fish and mussel species that are neither threatened or endangered nor important game species in the SAA area. Greater knowledge of the distribution of these species is critical to an assessment of biological integrity. Additionally, better knowledge about organisms in reservoirs is needed.

- Establish baseline aquatic conditions for healthy and relatively unimpacted streams as reference sites to compare to other streams and evaluate the biological, physical, and chemical integrity of water resources within the SAA.

- Gather information on the physical, chemical, and biological responses to diverse stressors such as acidification, gypsy moth, and hemlock woolly adelgid. Further research is needed on cumulative effects of multiple land management activities (on a watershed basis).

- Develop Geographical Information Systems (GIS) data for topography, streams, waterbody boundaries, and roads at the 1:24,000 scale. Furthermore, methods for properly delineating watersheds and aggregating subwatersheds in GIS are needed.
• Improve methods to predict sediment produced from multiple land management activities. Effects of sedimentation on resident aquatic organisms and their habitat must be determined through research. This information is critical in meeting the analysis and disclosure requirements of NEPA.

• Expand the basic research that links aquatic resources to the social, cultural, and economic domain of human activity. Further research into methods of combining information or data sets from various studies is needed.
The Southern Appalachian Assessment is not the first major assessment of the region’s environmental health. And we hope it will not be the last. As in 1901 when the first assessment was completed, this report shows where improvements can be made. But unlike the situation at the turn of the century, conditions are much better today. Now, the Southern Appalachian region is regarded as a valuable asset that can supply the people of the United States with high quality places to live, to play, and to produce essential commodities.

Maintaining these qualities will require good management and careful stewardship combining the efforts of both public and private landowners. The Southern Appalachian Assessment can facilitate planning, good management and serve as a basis for continuing study. The assessment presented in this set of documents is a beginning, not the end, of a process. A significant archive of data has been assembled that we hope will form the basis for additional study, for research, for environmental education, and for local planning.

While completing the assessment, many limitations in the existing data were identified. We hope these limitations will be given serious consideration as programs of research and monitoring are planned. But above all, the assessment is intended as the basis for dialogue among those interested in the welfare of the Southern Appalachian region.