Stream Habitat and Riparian Land Cover

3.0

Question 2:

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

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

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

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

3.1 STREAM HABITAT CONDITION

Introduction

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

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

Key Findings

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

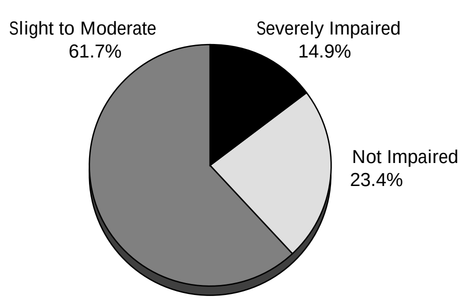

Figure 3.1.1 Distribution of habitat condition for 235 stream sites in the Holston and Hiwassee drainages. Based on qualitative visual assessments, 35 sites were severely impaired, 145 were slightly to moderately impaired, and 55 were not impaired.

Data Sources

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

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

Analysis, Spatial Patterns, and Trends

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

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

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

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

Trends cannot be addressed with currently available data.

Likely Future Trends and Implications

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

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

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

3.2 LAND COVER AND AQUATIC SYSTEMS

Introduction

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

Key Findings

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

Data Sources

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

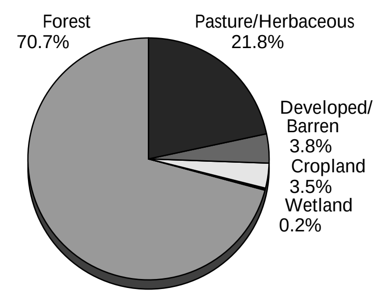

Figure 3.2.1 Distribution of aggregated land cover classes important for water resource integrity in the study area.

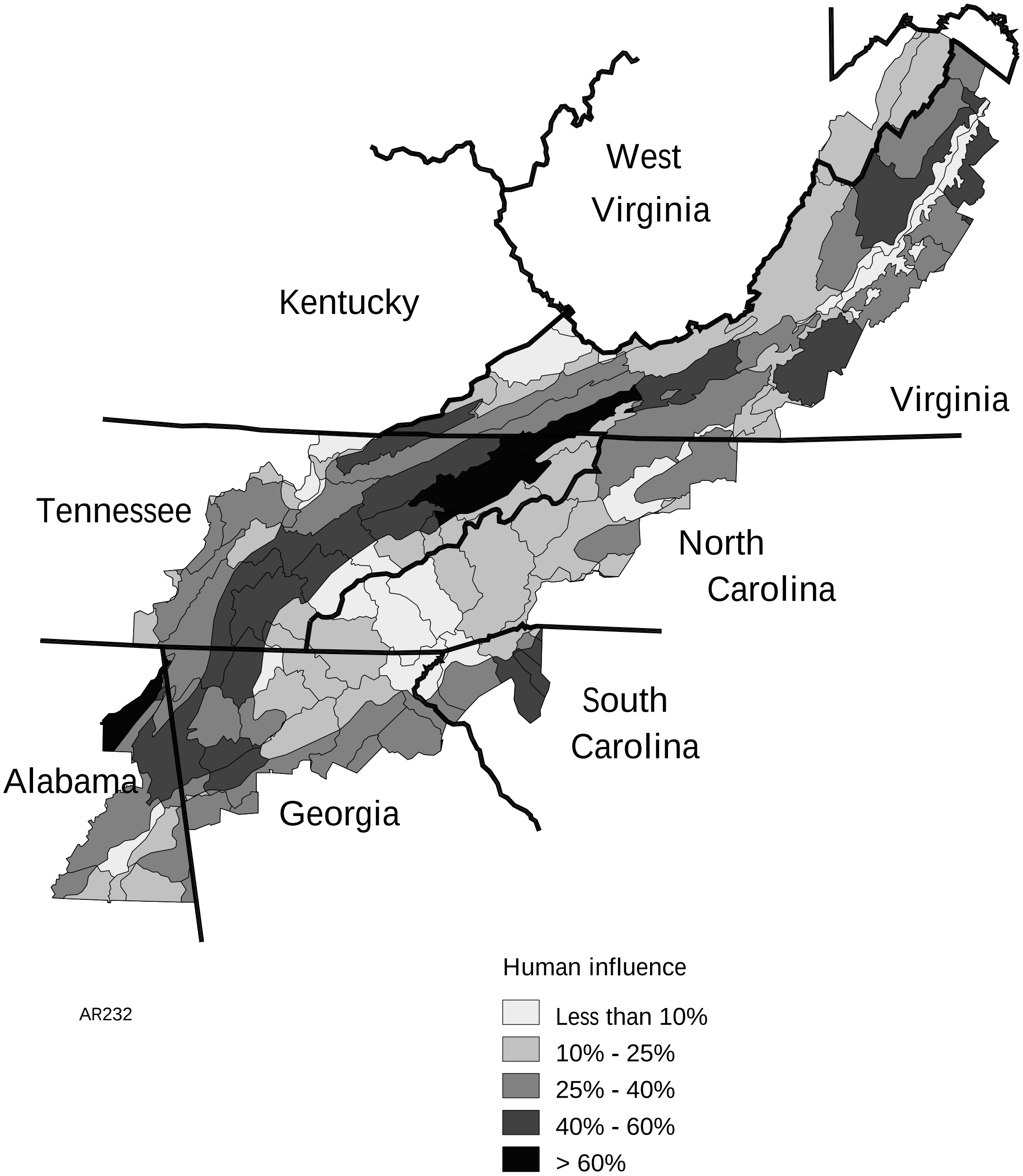

Figure 3.2.2 Intensive human influence on landscapes in the study area. Intensive human uses include the developed/barren, cropland, and pasture/herbaceous classes. Subdivisions of the SAA area defined by portions of hydrologic units within ecoregions are ranked according to potential for aquatic resource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

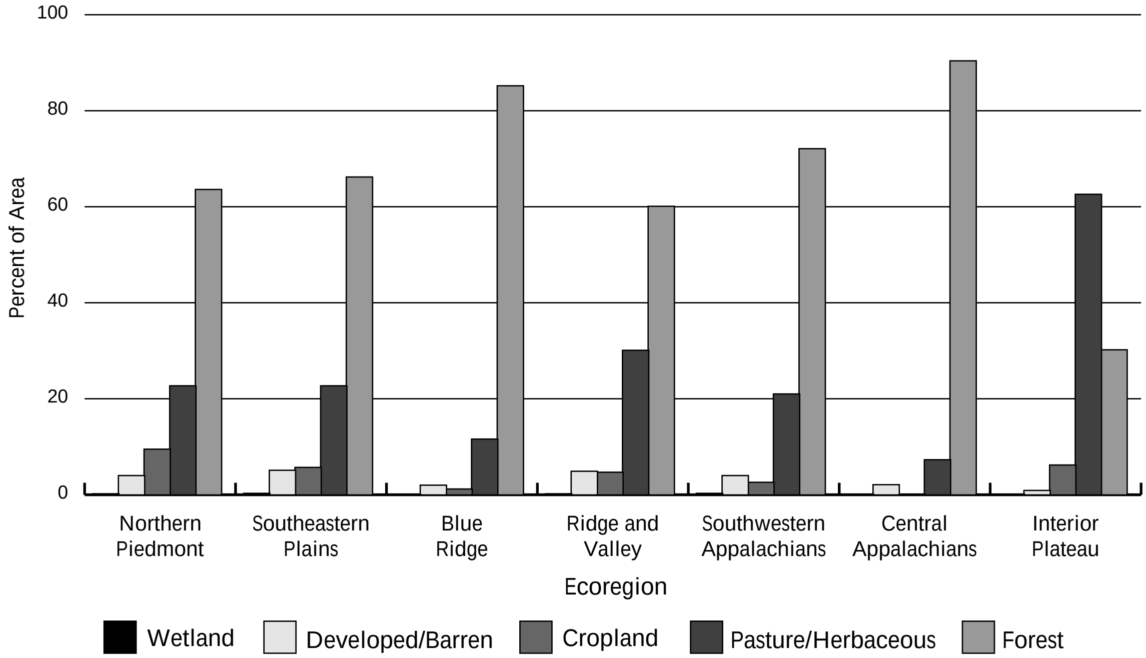

Figure 3.2.3 Distribution of land use/land cover classes by ecological region. Agricultural land uses are more predominant in the Ridge and Valley, while forests dominate the Blue Ridge. Ecoregions are as follows with the number in parentheses indicating the percent of Southern Appalachian Assessment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

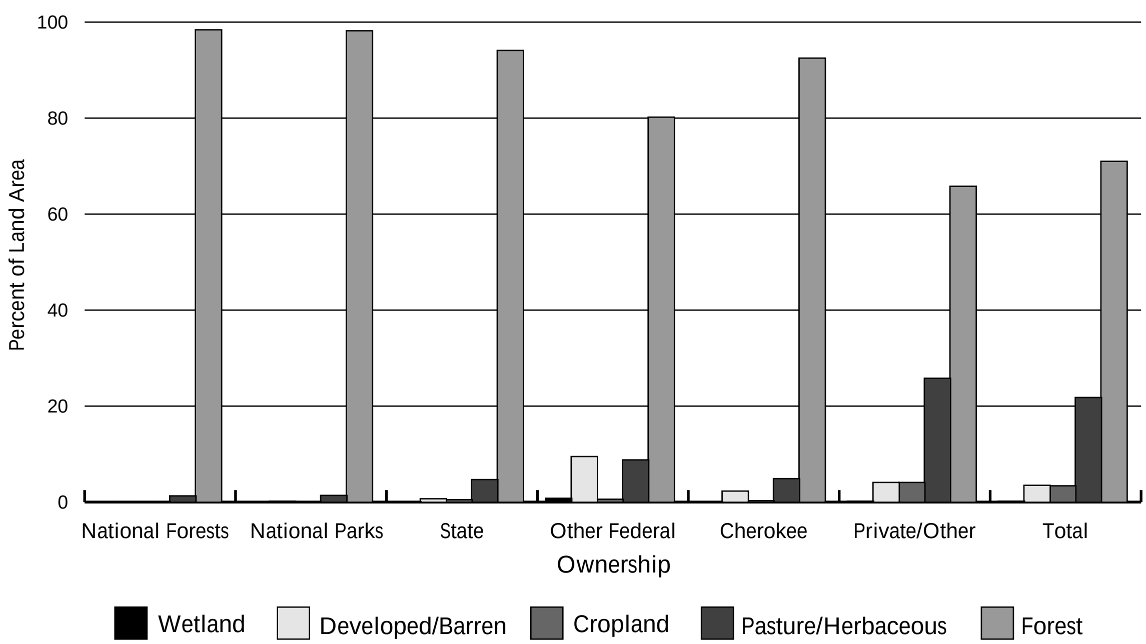

Figure 3.2.4 Land cover by ownership. Federal holdings, including national forests and national parks, have a higher percentage of classes evidencing less human influence than the rest of the study area.

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

Analysis, Spatial Patterns, and Trends

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

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

Likely Future Trends and Implications

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

3.3 RIPARIAN INVENTORY

Introduction

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

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

Key Findings

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

Data Sources

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

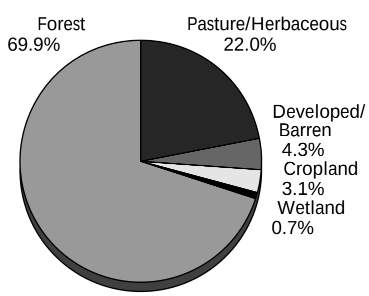

Figure 3.3.1 Riparian zone land cover. Aggregated land cover classes for the riparian zone of the entire study area. The riparian zone is defined as land areas within 100 feet of watercourses.

Analysis, Spatial Patterns, and Trends

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

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

Likely Future and Implications

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

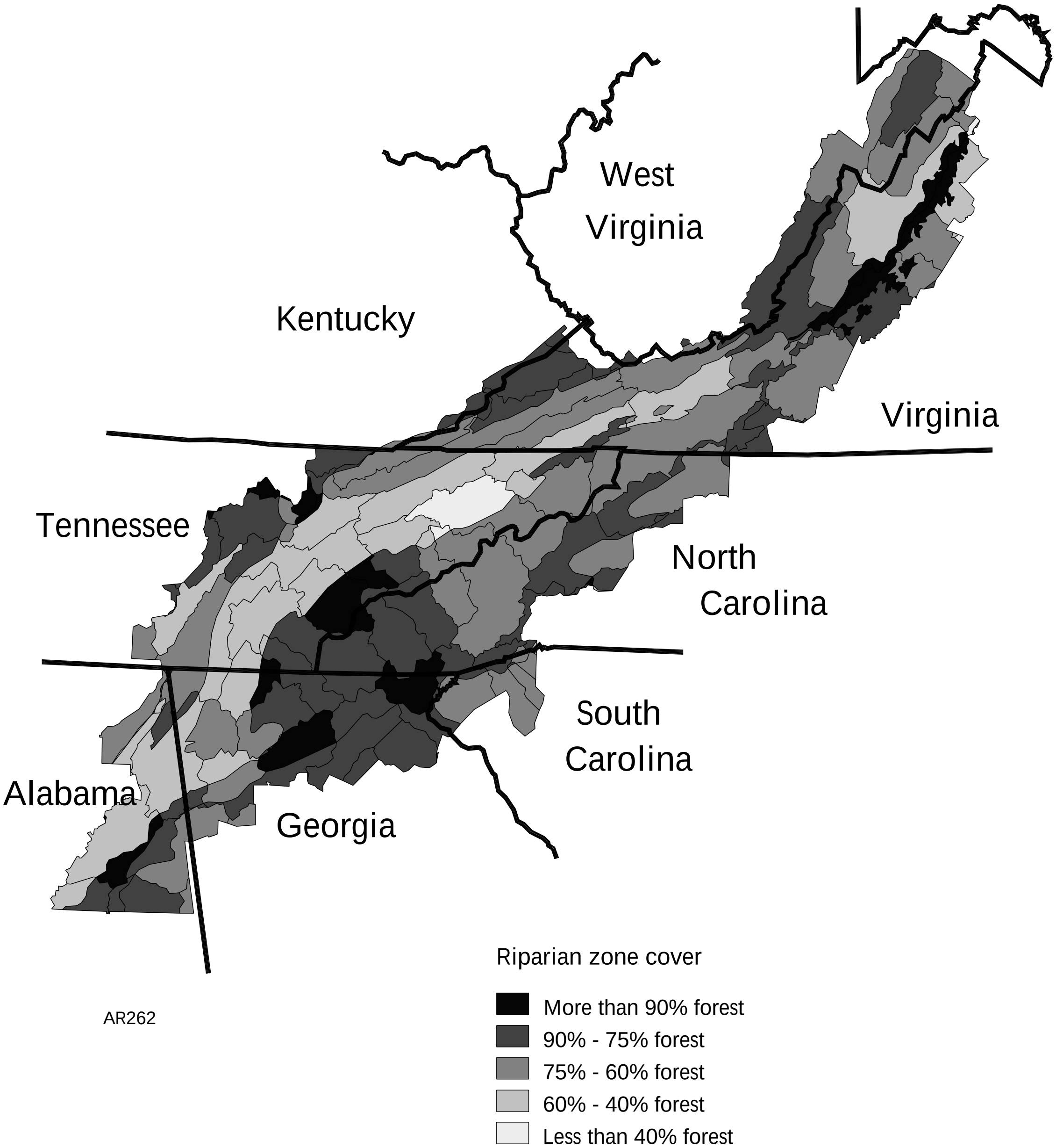

Figure 3.3.2 Riparian zone forest cover by ecoregion and hydrologic unit/watershed combined. Forest cover in the riparian zones of the study area ranges from less than 25 percent to 100 percent. This map shows subdivisions of the SAA area defined by portions of hydrologic units within ecological regions.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

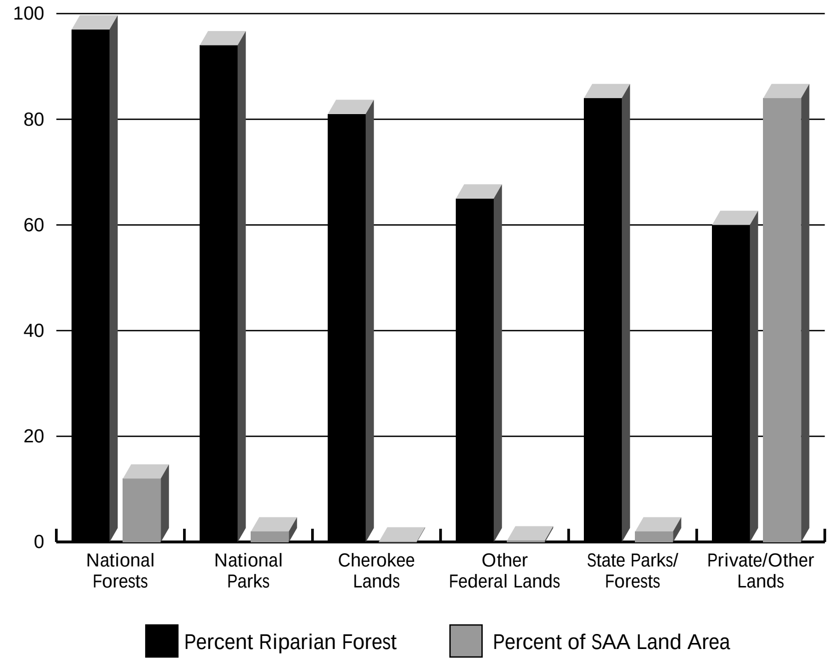

Figure 3.3.3 Riparian zone land cover by ownership. Land cover in the riparian zone differs by ownership in the study area. Federal holdings, including national forests and national parks, have over 90 percent forest cover in the riparian zone.

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