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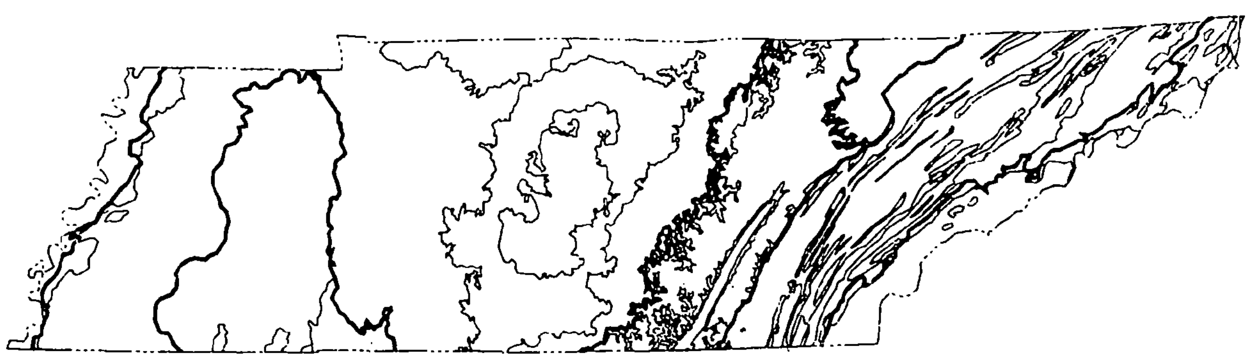

ECOREGIONS OF TENNESSEE

by

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ABSTRACT

Ecoregion frameworks are valuable tools for environmental resource inventory and assessment, for setting resource management goals, and for developing biological criteria and water quality standards. In a cooperative project with the Tennessee Department of Environment and Conservation, the U.S. Environmental Protection Agency, and other interested state and federal agencies, we have defined ecological regions of Tennessee at two hierarchical levels that are consistent and compatible with the U.S. EPA ecoregion framework. Eight level III ecoregions and twenty-five level IV ecoregions have been mapped for Tennessee. Ecoregions provide a spatial framework within which the quality and quantity of environmental resources, and ecosystems in general, can be expected to exhibit a particular pattern. A multi-agency cooperative effort also resulted in the identification of potential stream reference sites within the Tennessee ecoregions. Streams that are representative of the ecoregion and are minimally disturbed and least impacted from point and nonpoint source pollution can serve as suitable reference streams. The ecoregions and reference sites can be used to better understand regional variations in stream quality, assess attainable conditions, develop biological criteria, and augment the watershed management approach.

To obtain a larger, color map (16"x32", 1:1,000,000-scale) of the Level III and IV ecoregions of Tennessee or for an ARC/INFO export file of the ecoregion boundaries, contact the authors.

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INTRODUCTION

Spatial frameworks are necessary to structure the research, assessment, monitoring, and ultimately the management of environmental resources. Ecological region (ecoregion) frameworks are designed to meet these needs and have been developed in the United States (Bailey 1976, 1983, 1995; Bailey et al., 1994; Omernik 1987, 1995), Canada (Wiken 1986; Ecological Stratification Working Group 1995), New Zealand (Biggs et al., 1990), Australia (Thackway and Cresswell 1995), the Netherlands (Klijn 1994), and other countries. We define ecoregions as areas of relative homogeneity in ecological systems and their components. Factors associated with spatial differences in the quality and quantity of ecosystem components, including soils, vegetation, climate, geology, and physiography, are relatively homogeneous within an ecoregion. These regions separate different patterns in human stresses on the environment and different patterns in the existing and attainable quality of environmental resources. Ecoregion classifications are effective for inventorying and assessing national and regional environmental resources, for setting regional resource management goals, and for developing biological criteria and water quality standards (Gallant et al., 1989; Hughes et al., 1990, 1994; Hughes 1989; Environment Canada 1989; U.S. Environmental Protection Agency, Science Advisory Board 1991; Warry and Hanau 1993).

The development of ecoregion frameworks in North America has evolved considerably in recent years (Bailey et al., 1985; Omernik and Gallant 1990; Omernik 1995). The U.S. Environmental Protection Agency's (EPA) first compilation of ecoregions of the conterminous United States was performed at a relatively cursory scale, 1:3,168,000, and was published at a smaller scale, 1:7,500,000 (Omernik 1987). The approach recognized that the combination and relative importance of characteristics that explain ecosystem regionality vary from one place to another and from one hierarchical level to another. This is similar to the approach used by Environment Canada (Wiken 1986). In describing ecoregionalization in Canada, Wiken (1986) stated:

> "Ecological land classification is a process of delineating and classifying ecologically distinctive areas of the earth's surface. Each area can be viewed as a discrete system which has resulted from the mesh and interplay of the geologic, landform, soil, vegetative, climatic, wildlife, water and human factors which may be present. The dominance of any one or a number of these factors varies with the given ecological land unit. This holistic approach to land classification can be applied incrementally on a scale-related basis from very site specific ecosystems to very broad ecosystems."

The EPA's ecoregion framework has been revised and made hierarchical. It has been expanded to include Alaska (Gallant et al., 1995), as well as tie into a North American ecological region framework (CEC Ecosystem Working Group 1997). A Roman numeral classification scheme has been adopted for the hierarchical levels to avoid confusion over different usage of terms such as ecozones, ecodistricts, ecoprovinces, subregions, etc. Level I is the coarsest level, dividing North America into 15 ecological regions. At level II, the continent is subdivided into 52 ecoregions, and at level III the continental United States contains 98 ecoregions (U.S. EPA 1996).

The level III ecoregions defined initially by Omernik (1987) were shown to be useful for stratifying streams in Arkansas (Rohm et al., 1987), Nebraska (Bazata 1991), Ohio (Larsen et al., 1986), Oregon (Hughes et al., 1987; Whittier et al., 1988), Texas (Hornig et al., 1995), Washington (Plotnikoff 1992), and Wisconsin (Lyons 1989). The 1987 EPA ecoregion map was used to set water quality standards in Arkansas (Arkansas Department of Pollution Control and Ecology 1988), identify lake management goals in Minnesota (Heiskary and Wilson 1989), and develop biological criteria in Ohio (Ohio EPA 1988; Yoder and Rankin 1995). Many state agencies, however, have found that the resolution of the level III ecoregions does not provide enough detail to meet their needs. This has led to several collaborative projects, with states, EPA regional offices, and the EPA's National Health and Environmental Effects Research Laboratory in Corvallis, OR, to refine level III ecoregions and define level IV ecoregions at a larger (1:250,000) scale. These projects currently cover Oregon, Washington, North Dakota, South Dakota, Iowa, Indiana, Ohio, Pennsylvania, Massachusetts, Florida, and parts of Mississippi, Alabama, Virginia, Maryland, and West Virginia, and are largely in response to requests from EPA regional offices or state water resource management agencies.

Regional reference sites within an ecoregion can give managers and scientists a better understanding of attainable water body conditions. Water quality legislation and regulations, with a mandate to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters," depend on some model of attainable conditions, that is, on some measurable objectives towards which cleanup efforts are striving (Hughes et al., 1986). The biota and physical and chemical habitats characteristic of these regional reference sites serve as benchmarks for comparison to more disturbed streams, lakes, and wetlands in the same region (Hughes et al., 1986; Hughes 1995). These sites indicate the range of conditions that could reasonably be expected in an ecoregion, given natural limits and present or possible land use practices.

States are adopting biological criteria for surface waters to improve water quality standards. Biological criteria are defined as numeric values or narrative expressions that describe the reference biological integrity of aquatic communities inhabiting waters of a given designated aquatic life use (U.S. EPA 1990). To facilitate the development of biological criteria for streams and rivers of Tennessee, the Tennessee Department of Environment and Conservation (TDEC), U.S. EPA Region IV, U.S. EPA-Corvallis, and other agencies are collaborating to define level III and level IV ecoregions, and to select stream reference sites. Goals of the project for TDEC's Division of Water Pollution Control (DWPC) also include identifying high quality waters for application of the state's Antidegradation Statement in their water quality standards, documenting background levels of surface water chemical constituents on an ecoregion basis for setting future permit limits and 305(b) Report water quality assessments, and establishing ecoregion-specific chemical and biological water quality standards. In this paper, we discuss the method and materials used to refine level III ecoregions and define level IV ecoregions in Tennessee, and provide descriptions of the significant characteristics in these regions.

METHODS

Our regionalization process includes compiling and reviewing relevant materials, maps, and data; outlining the regional characteristics; drafting the ecoregion boundaries; creating digital coverages and cartographic products; and revising as needed after review by national, state, and local experts. In the regionalization process, we used primarily qualitative methods. That is, expert judgement was applied throughout the selection, analysis, and classification of data to form the regions, basing judgments on the quantity and quality of source data and on interpretation of the relationships between the data and other environmental factors. More detailed descriptions on the U.S. EPA's methods, materials, rationale, and philosophy for regionalization can be found in Omernik (1987;1995), Gallant et al., (1989), and Omernik and Gallant (1990). The regionalization process used for Tennessee was similar to that of other state-level EPA ecoregion projects (Griffith et al., 1994a,b,c; Woods et al., 1996).

Maps of environmental characteristics and other documents were collected from the state of Tennessee, U.S. EPA-Corvallis, and from other sources. The most important of these are listed in the References section. The most useful map types for our ecoregion delineation are usually physiography or land surface form, geology, soils, vegetation, climate, and land cover/land use. There are several different small-scale physiographic maps of Tennessee that can be found in a variety of publications. Statewide physiographic and land surface-form descriptions and maps were gathered primarily from Safford (1856), Glenn (1915), Fenneman (1938), Hardeman et al., (1966), Folmsbee et al., (1969), Hammond (1970), Fullerton et al., (1977), Miller (1979), and Bayer (1983), as well as the physiographic coverage from the Tennessee Wildlife Resources Agency's GIS. Landform subregions and landtype associations delineated by Smalley (1980, 1982, 1983, 1984, 1986) were useful for our regionalization. Topography and land-form features were also discerned from 1:100,000 scale topographic maps. Geologic information included maps such as the 1:250,000-scale state series (Hardeman et al., 1966), and the 1:1,000,000-scale Quaternary geology series (Colquhoun et al., 1987; Gray et al., 1991; Howard et al., 1991; Miller et al., 1988); state, regional, or local geology descriptions (Safford 1856; King et al., 1968; Luther 1977; Miller 1979) and national scale maps such as Hunt (1979) and King and Biekman (1974). Soils information was obtained from the U.S. Department of Agriculture's (USDA) county soil surveys, the 1:250,000-scale STATSGO soil maps, regional publications (Edwards et al., 1974), and the state-level 1:750,000-scale general soil map and descriptions (Springer and Elder 1980). Because soil taxonomy and interpretations are dynamic, and current soil series names may be different from those in earlier publications, soil information was also obtained from state soil experts (John Jenkins, Rick Livingston, USDA Natural Resources Conservation Service). For land use/land cover we used the 1:250,000 scale maps from the U.S. Geological Survey (USGS 1986) and the general classification of Anderson (1970). Also, for assessing variations in the mix of agriculture activities as an expression of land potential, many maps from the 1987 and 1992 Census of Agriculture were analyzed (U.S. Department of Commerce 1990, 1995). Vegetation and forest cover maps and information were obtained from Braun (1950), Kuchler (1964), the forest atlas of the South (USDA, Forest Service 1969), the national atlas (Kuchler 1970; U.S. Forest Service 1970), and from numerous journal manuscripts cited in the regional descriptions. In addition, a map produced from composited multi-temporal Advanced Very High Resolution Radiometer (AVHRR) satellite data was also used to assess boundaries and regional differences. This AVHRR NDVI (Normalized Difference Vegetation Index) data is currently being used by the USGS EROS Data Center to characterize land cover of the conterminous United States (Loveland et al., 1991, 1995).

We used USGS 1:250,000-scale topographic maps as the base for delineating the ecoregion and subregion boundaries. Although this map series is dated, it does provide quality in terms of the relative consistency and comparability of the series, in the accuracy of the topographic information portrayed, and in the locational control. It is also a very convenient scale. Eight of these quads cover more than 90% of the state and fourteen maps give complete coverage of Tennessee.

RESULTS AND REGIONAL DESCRIPTIONS

We have divided Tennessee into eight level III ecoregions (Figure 1) and 25 level IV ecoregions (Figure 2). Although these level IV ecoregions still retain some heterogeneity in factors that can affect water quality and biotic characteristics, they provide a more detailed framework and more precise ecoregion boundaries than the national-scale ecoregions (Omernik 1987). The ecoregion framework also provides more homogeneous units for inventorying, monitoring, and assessing surface waters than the commonly used hydrologic unit frameworks or political unit frameworks (Omernik and Griffith 1991). Most major river basins drain strikingly different ecological regions.

Ecoregion boundaries are often portrayed by a single line, but in reality they are transition zones of varying widths. In some areas the change is distinct and abrupt, for example where the Bluff Hills meet the Mississippi Alluvial Plain, or where the Cumberland Plateau Escarpment meets the limestone valleys of the Ridge and Valley ecoregion. In other areas, such as the division between the Mississippi Valley Loess Plains Ecoregion and the Southeastern Plains Ecoregion, the boundary is fuzzy and more difficult to determine. Fuzzy boundaries are areas of uncertainty or where there may be a heterogeneous mosaic of characteristics from each of the adjacent areas.

65. Southeastern Plains

Area within TN: 5099 sq. mi.
Percent of state: 12.1%

On Omernik's (1987) ecoregion map, this coastal plain ecoregion boundary ended near the Mississippi-Tennessee state line, with only a small arm extending north into McNairy and Hardin counties, TN. A large area of coastal plain west of the Tennessee River was included with the Interior Plateau ecoregion (71). This area of west Tennessee does have similar potential natural vegetation as the Interior Plateau, oak-hickory forests rather than oak-hickory-pine that characterizes the Southeastern Plains (Kuchler 1964). Several other characteristics, however, suggest that this area is more appropriately included with the Southeastern Plains. The landforms are irregular plains rather than open hills or plains with high hills (Hammond 1970); the geology consists of Cenozoic or Mesozoic-age sands, silts, and clays rather than Paleozoic limestone, chert, and shale (Hardeman et al., 1966); the surficial geology is generally sand and clay decomposition residuum rather than solution residuum (Miller et al., 1988; Gray et al., 1991); and the Tennessee state soils map shows a distinct coastal plain region (Springer and Elder 1980). According to TDEC biologists, streams in this area are relatively low-gradient, sandy-bottomed (with occasional gravel), and are similar to other coastal plain streams of west Tennessee. The Southern Coastal Plain MLRA also extends over this area to near the Kentucky state line (USDA, SCS 1981), and the area is within the Upper Gulf Coastal Section of the USFS (Bailey et al., 1994; Keys et al., 1995).

On our first draft map of Tennessee for this project, the western boundary of the ecoregion was similar to the coastal plain soil region shown by Springer and Elder (1980) and the geologic boundary between the Quaternary loess area and the Tertiary-age Claiborne and Wilcox Formations (Hardeman et al., 1966). During the multi-agency ecoregion meeting in Murfreesboro (May 9-11, 1995) to discuss the draft map, it was recommended that the boundary should be further west, as currently depicted, to include all of the more rolling and hilly areas of the Lexington, Smithdale, and Providence soil series.

The ecoregion as a whole was characterized by Omernik (1987) as containing smooth to irregular plains, oak-hickory-pine forests with southern mixed forest in the south, primarily Ultisol soils, and a mosaic of cropland, pasture, woodland, and forest. Elevations are generally between 50-900 feet (300-1000 feet in Tennessee), with local relief 100-300 feet. Elevations and relief are greater than the Mississippi Loess Plains (74) to the west, but generally less than the Interior Plateau (71) to the east. The ecoregion has been divided into five level IV ecoregions within Tennessee: Blackland Prairie (65a), Flatwoods/Alluvial Prairie Margins (65b), Southeastern Plains and Hills (65e), Fall Line Hills (65i), and Transition Hills (65j).

65a. Blackland Prairie

Area within TN: 50 sq. mi.
Percent of state: 0.1%

Extending north from Mississippi, this ecoregion covers only a small portion of McNairy County, Tennessee. The northern extent of the Blackland Prairie is debatable; even in the ecoregion in northern Mississippi, the soil mosaic appears to differ from the Blackbelt soils found in east-central Mississippi and central Alabama. There are, however, continuations of Blackland Prairie physical factors into Tennessee. The Cretaceous-age Demopolis Formation (Hardeman et al., 1966) in Tennessee is the geologic base of chalk, marl, and calcareous clay that characterizes the ecoregion in Mississippi and Alabama. The Quaternary geology map (Miller et al., 1988) also shows a dark gray clay solution residuum (rcg) of the Blackland Prairie extending into Tennessee. Although a soil survey for McNairy County is not yet published, Tennessee soil scientists do concur that there is Blackland Prairie in this part of the state (John Jenkins, USDA-NRCS, personal communication). Fenneman (1938, p.69) concludes that, "...the Black Belt gives out a little north of the Tennessee boundary." Heineke (1989) suggested a Northeastern Prairie Belt extended north into Henderson and Carroll counties of Tennessee.

The Blackland Prairie is a flat to undulating lowland, with elevations in Tennessee between 500-600 feet. The area is mostly in cropland and pasture, with small patches of mixed hardwoods, generally oaks and hickories. A local botanist suggests that there are more calciphilic trees, such as sugar maple, in this region than in the rest of ecoregion 65, as well as some native, calciphilic old-field herbs (Milo Pyne, The Nature Conservancy, personal communication). On Kuchler's (1964) natural vegetation map, the Blackbelt vegetation type (sweetgum-oak-cedar) did not extend into Tennessee. Patches of bluestem prairie are also associated with the ecoregion (DeSelm and Murdock 1993; Kuchler 1964), although there is evidence that historically these patches were no more extensive in this area than in the rest of the Southeast, and that the original application of the term "prairie" to the Black Belt referred to soils and not a unique grassland vegetation type (Rostlund 1957). Clayey soils from the marly coastal plain clay or silty soils from thin loess are the most typical soils, generally thermic Alfisols and Ultisols. The primary soil association for the Tennessee portion of the region is Oktibbeha-Silerton-Dulac (STATSGO) or Oktibbeha-Boswell-Dulac (Springer and Elder 1980). There are a few smaller occurrences of Blackland Prairie soils and geology to the north in McNairy and Henderson counties that were not mapped at this scale. Mean annual precipitation in the Tennessee portion is approximately 52 inches, with a frost-free period of 210 days.

65b. Flatwoods/Alluvial Prairie Margins

Area within TN: 36 sq. mi.
Percent of state: 0.08%

As with the Blackland Prairie, this narrow ecoregion belt extends north from Mississippi, but its distinctiveness fades quickly from Ripley, Mississippi north into Tennessee. The physiographic map by Cushing et al., (1964) extends the Flatwoods north to the Hardeman/Chester county line in Tennessee. The Tertiary-age Midway group (Porters Creek Clay and the Clayton Formation) underlie much of the ecoregion, with soils of montmorillonitic clays or silt loams. The soil associations shown in STATSGO within Tennessee are Tippah-Luverne-Smithdale and Wilcox-Falkner-Sweatman. In Mississippi and Alabama, we viewed this ecoregion as a transition region between the Blackland Prairie and the more forested plains and hills, but it was heterogeneous in terms of landuse/landcover. Some areas, as the Flatwoods name implies, are heavily forested (mostly white oak, pignut and mockernut hickories, shortleaf pine, sweetgum, tulip poplar, with some bottomland hardwoods), but there are prairie and alluvial areas with significant amounts of cropland and pasture. In Tennessee, the small region stands out as an area of agriculture between mostly forested land, with slightly lower elevations (400-500 feet) and less relief than the Southeastern Plains and Hills that surround it. Precipitation and temperatures are similar to the Blackland Praire (65a).

65e. Southeastern Plains and Hills

Area within TN: 4590 sq. mi.
Percent of state: 10.9%

This ecoregion contains several north-south trending bands of sand and clay formations. The Tertiary-age Claiborne and Wilcox Formations and Midway Group are to the west, and the Cretaceous-age McNairy Sand, the Coon Creek Formation of fossiliferous micaceous sand, and the Coffee Sand are to the east. With more rolling topography and more relief than the Loess Plains (74b) to the west (elevations range from 400 feet to over 650 feet), streams have increased gradient, generally sandy substrates, and distinctive faunal characteristics (Etnier and Starnes 1993). Potential natural vegetation is oak-hickory, grading into oak-hickory-pine toward the south into Mississippi (Kuchler 1964). Current land cover is mostly deciduous and mixed forest with areas of planted pine and pasture; cropland of soybeans, corn, sorghum, cotton and hay fields occupy the bottoms and terraces. Common trees of the upland forests include southern red oak, white oak, post oak, black oak, mockernut and pignut hickory, with some loblolly and shortleaf pine. More mesic slopes are dominated by white oak, sweetgum, and tulip poplar, with some sugar maple and American beech (Heineke 1989). Bottomland hardwoods are found in some of the larger river bottoms such as the Hatchie, and include overcup oak, swamp chestnut oak, willow oak, water hickory, sweetgum, river birch, tupelo, and bald cypress. Annual precipitation is 48-52 inches, with a freeze-free period of 200-210 days (Dickson 1974).

Although there are some differences within the ecoregion in the north-south trending bands of sand and clay formations, we have lumped these at this hierarchical level rather than split them, as there appears to be mosaics of loess, sand, and clay surficial materials, as well as varying patterns of silty, sandy, loamy, and clayey soils. The U.S. Forest Service (Keys et al., 1995) has split several of these bands out, including the Northern Pontotoc Ridge (222Cf), a term not often seen in the Tennessee literature. According to Fenneman (1938), the ridge loses its prominence in Tennessee, "...because the adjacent lowlands are poorly developed." Cushing et al., (1964), however, note that an extension of the Pontotoc Ridge may form the divide between the Mississippi and Tennessee Rivers in northern Tennessee and Kentucky.

In the north part of ecoregion 65e, the U.S. Forest Service (Keys et al., 1995) defines a Clay Hills subsection (222Cd), but the evidence for this boundary placement is not distinct. There are definite ridge-like, more forested extensions westward from Paris, north and south of the North Fork Obion River, of Claiborne and Wilcox Formation sand and clay geology, upland chert-pebble gravel and sand surficial deposits. The forested land cover rather than a mixed land cover may be due more to land ownership by clay mining companies than to distinctly different ecological characteristics (John Jenkins, USDA-NRCS, personal communication).

65i. Fall Line Hills

Area within TN: 9 sq. mi.
Percent of state: 0.02%

The Fall Line Hills level IV ecoregion of Mississippi and Alabama (Alabama DEM and Mississippi DEQ 1995) was earlier placed within ecoregion 68, the Southwestern Appalachians. We have revised these boundaries and placed the Fall Line Hills within ecoregion 65 for several reasons: 1) It is inappropriate to have the Southwestern Appalachians ecoregion (68) extend into west Tennessee, as shown by the earlier version of the EPA 1995 Level III Ecoregions of the continental U.S. map; 2) the area known as the Tennessee or Tombigbee Hills in Mississippi (and the Fall Line Hills in Alabama) is composed primarily of coastal plain sediments of the Mississippi Embayment; 3) The addition of the Transition Hills subregion (65j) within the Southeastern Plains ecoregion requires the inclusion of the Fall Line Hills in that coastal plain type level III ecoregion; and 4) the resultant framework would more closely resemble and follow the logic of the USFS and MLRA frameworks.

The ecoregion generally coincides with the Upper Loam Hills and Upper Clay Hills forest habitat regions (Hodgkins and Cannon 1976) and USFS subsections (Keys et al., 1995) in Mississippi and Alabama. This is mostly forested terrain of open hills with 200-400 feet of relief. Elevations in the small Tennessee portion, roughly between Chambers Creek and Pickwick Lake, are 450-685 feet. Medium to coarse sand decomposition residuum and chert gravel and sand decomposition residuum are the primary surficial materials in the ecoregion (Miller et al., 1988), covered by Ultisols of the Silerton, Smithdale, Waynesboro, and Pickwick soil series. The potential natural vegetation is oak-hickory-pine (Kuchler 1964). In Tennessee, the Fall Line Hills average 53 inches of annual precipitation with a frost-free period of 207 days.

65j. Transition Hills

Area within TN: 413 sq. mi.
Percent of state: 1.0%

The U.S. Forest Service names these the Transition Loam Hills (Keys et al., 1995; Hodgkins and Cannon 1976), but clay soils occur here as well as loam soils. The ecoregion includes the Paleozoic Bottom physiographic region in Mississippi (Pike et al., 1969) and part of the Fall Line Hills physiographic region in Alabama (Sapp and Emplaincourt 1975). As a transition area, arguments could be made that this ecoregion belongs with the Interior Plateau Ecoregion (Omernik 1987). The region includes much of the Southwestern Clastic Rock District defined by R. Paul Terrel (Fullerton et al., 1977) that was considered part of the Highland Rim. Many streams have cut down into the Mississippian and Silurian-age rocks and may look similar to those of the Interior Plateau. Cretaceous-age coastal plain sediments, however, overlie the older limestone, shale and chert (Fort Payne and Silurian Formations). The topography may be determined by the older underlying formations (Hodgkins and Cannon 1976), but the soils are mostly governed by the overlying coastal plain deposits. The Tuscaloosa Formation consists of gravel in a matrix of silt and sand, and the Eutaw Formation consists of fine-grained glauconitic, micaceous sand with interbedded clays (Hardeman 1966). Soils and MLRA maps generally include the southwest part of Wayne County, TN with the Coastal Plain (Springer and Elder 1980; USDA-SCS 1981). Soils are primarily thermic Paleudults, Hapludults, and Fragiudults, including the Silerton, Savannah, Dickson, Lax, Saffell, and Brandon series.

The Transition Hills ecoregion is a mostly forested region with oak-hickory-pine natural vegetation (Kuchler 1964). White oak, southern red oak, black oak and post oak are common, along with the hickories and shortleaf pine. Pine plantations associated with pulp and paper operations are a common land cover. Elevations in the Tennessee portion range from 400-1000 feet, the highest of ecoregion 65. Annual precipitation averages 50-56 inches, with a freeze-free period of 200-210 days.

66. Blue Ridge Mountains

Area within TN: 2510 sq. mi.
Percent of state: 6.0%

The Blue Ridge Mountains level III ecoregion extends from southern Pennsylvania to northern Georgia, varying from narrow ridges to hilly plateaus to more massive mountainous areas with high peaks. In Tennessee, the Blue Ridge region is often called the Unaka Mountains, and the term Great Smoky Mountains generally refers to those in the vicinity of the national park. The ecoregion within the state is characterized by forested slopes, high gradient, cool, clear streams, and rugged terrain on a mix of igneous, metamorphic, and sedimentary geology. Soils are mostly mesic, udic Dystrochrepts, Hapludults and Haplumbrepts. Elevations generally range from 1000-6000 feet, with Clingmans Dome, the highest point in Tennessee, reaching 6643 feet. Annual precipitation ranges from 45-60 inches, but can be 80 inches or more on the well-exposed high peaks of the Smoky Mountains (Dickson 1974). The freeze-free period within Tennessee is variable depending on elevation and latitude, ranging from less than 150 days to more than 200 days.

The Blue Ridge is the most floristically diverse region of the state (Wofford 1989). From a national scale, the potential natural vegetation consists of Appalachian oak forests, northern hardwoods, and Southeastern spruce-fir forests (Kuchler 1964), but shrub, grass and heath balds, hemlock, cove hardwoods, and oak-pine communities are also significant (Clebsch 1989). High elevation balds provide grassy habitat for birds and mammals that would not otherwise occupy these areas where spruce-fir forest dominate (DeSelm and Murdock 1993). A distinctive breeding bird community was detected in high elevation areas in the Blue Ridge (Nicholson 1991; Kendeigh and Fawver 1981). A distinct fish fauna, less diverse than the Ridge and Valley, is associated with streams and rivers of the region (Etnier and Starnes 1993; Bivens et al., 1985).

The ecoregion in Tennessee has been divided into four level IV ecoregions: Southern Igneous Ridges and Mountains (66d), Southern Sedimentary Ridges (66e), Limestone Valleys and Coves (66f), and Southern Metasedimentary Mountains (66g).

66d. Southern Igneous Ridges and Mountains

Area within TN: 235 sq. mi.
Percent of state: 0.6%

This ecoregion occurs in Tennessee's northeastern Blue Ridge near the North Carolina border, primarily on Precambrian-age igneous and some high-grade metamorphic rocks. Although igneous describes the initial origin of the rocks, some of them underwent various degreees of metamorphism, and the term crystalline might be a better general descriptor for these ridges and mountains. The typical rock types include Cranberry granite, Roan gneiss, Beech granite, and Mt. Rogers Group metavolcanics (Hardeman 1966). Elevations range from 2000-6000 feet, with Roan Mountain at 6286 feet. Unaka-Ashe soils are a typical association found on the steep slopes of the higher mountains, while Ashe-Evard soils are on side slopes and lower mountains. These tend to be loamy, well-drained, acid soils (Dystrochrepts and Haplumbrepts). Annual precipitation for the ecoregion is approximately 50-60 inches, and the freeze-free period is 150-170 days.

Although there are a few small areas of pasture and apple orchards, the region is mostly forested. Appalachian oak forest and northern hardwoods forest are Kuchler's (1964) general potential natural vegetation types. The mixed oaks and hickories (and the chestnut, before the blight) occupy the lower slopes, along with various pine and oak-pine communities on drier sites. Cove hardwoods, dominated by yellow poplar and yellow poplar-oak types, along with hemlock-white pine and hemlock-hardwood types are found on the more sheltered and moist northern slopes, coves, and ravines, up to about 4000-4500 feet. The northern hardwoods of the sugar maple-beech-yellow birch cover type occur above 3500 feet to about 5000 feet, and also include red maple, basswood, buckeye, hemlock, sweet birch, red oak, and black cherry. Above about 5400 feet, the red spruce and Fraser fir are found in small areas of the ecoregion, along with some yellow birch, mountain ash, and sugar maple. Rhododendron balds, grass balds, and alder balds can be found on Roan Mountain.

66e. Southern Sedimentary Ridges

Area within TN: 799 sq. mi.
Percent of state: 1.9%

This ecoregion in Tennessee includes some of the westernmost foothill areas of the Blue Ridge Mountains ecoregion, such as the Bean, Starr, Chilhowee, English, Stone, Bald and Iron Mountain areas. Elevations are in the 1000-4000 feet range. The geology is primarily Cambrian-age sedimentary rocks (shale, sandstone, siltstone, quartzite, conglomerate). Some streams in this ecoregion occur on limestone. In the north, there is a correlation of the ecoregion with the Ditney-Tate-Maymead soil association (STATSGO 208). These are found on the quartzites, shales, sandstones of the Erwin, Unicoi, and Hampton formations. To the south, the soil associations include Jefferson-Wallen-Gilpin (STATSGO 139) or Wallen-Jefferson-Ramsey (Springer and Elder 1980), predominantly friable loams and fine sandy loams (Dystrochrepts and Hapludults) with variable amounts of sandstone rock fragments. On Chilhowee Mountain, mixed oak forests on northern and eastern slopes and oak-pine forests on south and southwest slopes comprise about 60% of the forest cover, with second growth pine, yellow poplar, scrub oak, and oak-hickory cover types comprising approximately another 30% of the area (Thomas 1989). Virginia pine-pitch pine, along with some Table Mountain pine, occupies thin soil areas on exposed ridges, and hemlock-white pine, with abundant rhododendron, is found in the deeper ravines and moist coves. Annual precipitation for the Tennessee portion of the ecoregion is 44-48 inches in the north and 52-56 inches in the south. The frost-free period ranges from 150 to 200 days depending on latitude and elevation.

66f. Limestone Valleys and Coves

Area within TN: 139 sq. mi.
Percent of state: 0.3%

The Blue Ridge overthrust belt forced rocks to the east up and over younger rocks to the west. In places, the Precambrian rocks have eroded through to Ordovician limestones, as seen especially in deep cove areas that are surrounded by steep mountains. We have mapped eleven of the main limestone valley and cove areas in the Blue Ridge of

Tennessee; other limestone stream and river valleys occur in the ecoregion, but could not be delineated at this scale and level of resolution. The small but distinct limestone areas include the Mountain City lowland area and Shady Valley in the north, to Wear Cove, Tuckaleechee Cove, and Cades Cove in the south. The geology in the northern areas is primarily the Cambrian-age Shady dolomite, while the coves in Great Smoky Mountains National Park are on the Cambrian and Ordovician Knox Group limestones and dolomites with some areas of Blockhouse shale (Hardeman 1966; King et al., 1968). Quaternary geology is mostly cherty clay solution residuum. Typical Ultisol and Alfisol series found in the valleys and coves include Keener, Lonon, Northcove, Statler, and Bledsoe (Richard Livingstone, NRCS, personal communication). Elevations are generally 1500-2500 feet. The frost-free period is 160-190 days, and precipitation ranges from 45-55 inches.

Most of these limestone valleys and coves were originally forested, but have been cleared for agriculture. Hay and pasture, with some tobacco patches on small farms, are typical land uses. Knolls and slopes are dominated by oaks, with some white pine, hemlock, tulip poplar, sourwood, and dogwood. Virginia pine and pitch pine are found on drier sites and old field successional areas. The resource management of Cades Cove as a historic district has had multiple ecological effects and tradeoffs regarding changes to terrestrial flora and fauna, as well as the aquatic ecosystem (Bratton et al., 1980). The open fields of Cades Cove tend to be dominated by exotic plant species and grasses such as fescue and witch grass. In northeast Tennessee, Shady Valley historically had extensive wetlands, and its soils still have a residual histic component (Milo Pyne, The Nature Conservancy, personal communication). Vegetation changes for Shady Valley and Johnson County have been described by Barclay (1957).

66g. Southern Metasedimentary Mountains

Area within TN: 1338 sq. mi.
Percent of state: 3.2%

The name of this ecoregion follows that of the U.S. Forest Service subsection (Keys et al., 1995). It is a region of low mountains, elevations 1000-6000 feet, with local relief 1000-3000 feet. The geologic materials are generally older and more metamorphosed than the Southern Sedimentary Ridges (66e) found at the western margins and northern part of the Blue Ridge ecoregion in Tennessee. The geology consists of metamorphic and sedimentary rocks of the Pre-Cambrian age Ocoee Supergroup: mostly siltstone, sandstone, shale, conglomerate, graywacke, arkose, phyllite, slate, schist, and quartzite of the Walden Creek, Great Smoky, and Snowbird Groups (Hardeman 1966; King et al., 1968). The slate and phyllite of the Anakeesta Formation in the Great Smoky Group contain iron sulfides that can locally acidify small streams, especially when slumps or road cuts expose the sulfide materials to air and water (Huckabee et al., 1975). Surficial geology in the ecoregion consists of bouldery colluvium (Miller et al., 1988; Howard et al., 1991). Soils are generally Dystrochrepts and Hapludults, with Haplumbrepts and Spodosols at the highest elevations (Springer and Elder 1980). Soil associations are shown as Sylco-Ranger-Citico and Ditney-Jeffrey-Brookshire on the state map; Ramsey-rock outcrop-Barbourville and Junaluska-Spivey-Tsali in the STATSGO database. Other common soil series include

Cataska, Keener, Lostcove, and Unicoi.) Average annual precipitation in the ecoregion is 55-75 inches, with a freeze-free period 170-200 days (Dickson 1974; Mundy and Gray 1986).

These mountains support extremely complex and numerous plant communities and a great diversity of plant species. The potential natural vegetation of the ecoregion had three general classes defined by Kuchler (1964), Appalachian oak forest, northern hardwoods, and Southeastern spruce-fir forest. The low to intermediate elevation areas are dominated by mixtures of oaks, pines, and various combinations. Pines such as Virginia pine, pitch pine, shortleaf pine, white pine, and Table Mountain pine can occur in pure stands or mixed with oaks on a variety of drier, exposed, or shallow-soil sites. Oaks in the drier areas include post oak, blackjack oak, southern red oak, scarlet oak, and black oak. White oak and chestnut oak are widespread at intermediate elevations, and the more mesic northern red oak extends to higher elevations, and is also found in the cove hardwoods (Clebsch 1989). The mixed mesophytic or cove hardwoods forest is rich in tree species, occurring in the more moist and sheltered coves, ravines, and northerly slopes, up to about 4000-4500 feet in elevation (Whittaker 1956). Yellow poplar, hemlock, oaks, basswood, sugar maple, ash, beech, basswood and other hardwoods are typical. Hemlock forests occur in slightly more-exposed sites than the cove hardwoods, up to similar elevations. The northern hardwoods forests are found from about 3500 feet in elevation to over 5000 feet, and are dominated by sugar maple, beech, yellow birch, hemlock, red oak, buckeye, basswood, and wild black cherry. Spruce-fir forests, found generally above 5500 feet, have been affected greatly over the past twenty-five years by the balsam wooly aphid, as well as by a growth decline in red spruce (Ramseur 1989; Clebsch 1989). Shrub and grass balds at the highest elevations are dynamic, ecologically significant, oft-debated, and celebrated areas (Mark 1958; Gersmehl 1970; Lindsay and Bratton 1979).

A special area of management concern in this ecoregion is the Copper Basin or Ducktown District. Located in the southeast corner of Tennessee and extending into North Carolina and Georgia, the bowl-like basin was the site of copper mining and smelting from the 1850's to 1987. By the early 1900's, sulfur dioxide fumes and intensive lumbering left a severely eroded expanse of bare earth devoid of plant life. Surrounding zones included areas of grasses, stunted shrubs, and dead-topped trees with gullied subsoils. Erosion has contributed large loads of sediment and metals to the Ocoee River, and has caused the loss of approximately 98% of the storage capacity of Ocoee No. 3 Reservoir (Denton et al., 1994). Revegetation efforts in the Copper Basin have occurred on and off since the 1930's (Quinn 1988). A map of the extent of three forest injury zones (Quinn 1993), based on a 1906 U.S. Forest Service map, covers an area about 540 square miles in the three states. The extent of the underlying Copperhill Formation of the Great Smoky Group is not shown on the state geology map (Hardeman 1966), and it is difficult to determine if pre-mining ecological conditions were different from other areas of ecoregion 66g. Natural vegetation was thought to be similar to the mixed forest of surrounding areas (Quinn 1991).

The Conasauga watershed area also exhibits some ecological differences from the rest of ecoregion 66g, primarily in its different fish species and benthic macroinvertebrates. This is most likely due to its drainage connection with the Gulf of Mexico.

67. Ridge and Valley

Area within TN: 7668 sq. mi.
Percent of state: 18.2%

"If anything is evident from this discussion of the geology of the Great Valley, it should be the fact that it is complicated," (Luther 1977).

In Tennessee, this northeast to southwest trending ecoregion is also known as the Great Valley of East Tennessee. It is a relatively low-lying region between the Blue Ridge Mountains to the east and the Cumberland Plateau on the west, but elevations range from a low of about 700 feet in Hamilton County to over 3000 feet on Chimneytop Mountain in northern Greene County. The roughly parallel northeast-to-southwest trending ridges and valleys come in a variety of widths, heights, and geologic materials, a result of extreme folding, thrusting, and faulting events. Silurian, Ordovician, and Cambrian-age limestone, dolomite, shale, siltstone, sandstone, chert, mudstone, and marble are found in the ecoregion in Tennessee. Springs and caves are relatively numerous.

The land-surface form has been classed as open hills with 300-500 feet of local relief, and more than 75% of the gentle slope in the lowland (Hammond 1970). Case (1925) found four types of topography in the region and noted that they were so intermingled that it was difficult to classify them regionally. The types he noted were: 1) short broken ridges or rounded hills, locally known as knobs, 2) long, straight, narrow, sharp-crested ridges with narrow intervening valleys, 3) uniformly fluted ridge and valley land, with long, narrow, rounded ridges separated by narrow, flattish valleys, and 4) broad, rolling uplands separated by canyon-like valleys or in places by broader valleys. Much of the drainage is in a trellised pattern, with small streams draining the ridge slopes, joining at right angles with larger, lower-gradient stream courses that meander along the parallel valley floors. The larger rivers that come out of the Blue Ridge Mountains often transect the ridges and valleys. The ecoregion has great aquatic habitat diversity in Tennessee and supports a diverse fish fauna rivaled only by that of the Highland Rim (Etnier and Starnes 1993).

The frost-free period in the Tennessee portion is 190-220 days. Annual precipitation ranges from the state low of near 40 inches in the north, where moisture-laden clouds are intercepted by the Cumberland Plateau/Mountains and the Blue Ridge Mountains, to 54 inches in the south (Dickson 1974). Potential natural vegetation was mapped as Appalachian oak forest (Kuchler 1964), and this grades into Oak-Pine towards the Georgia border (Shanks 1958). Present-day forests cover about 50% of the region, and vary in composition and structure due to the diversity of physical environments and human uses (Martin 1989).

To be consistent with the Ridge and Valley ecoregion classification in states to the north (Woods et al., 1996), the ecoregion in Tennessee has been subdivided into the following regions: Southern Limestone/Dolomite Valleys and Low Rolling Hills (67f), Southern Shale Valleys (67g), Southern Sandstone Ridges (67h), and Southern Dissected Ridges and Knobs (67I).

67f. Southern Limestone/Dolomite Valleys and Low Rolling Hills

Area within TN: 5324 sq. mi.
Percent of state: 12.6%

This is a heterogeneous ecoregion composed predominantly of limestone and dolomite, but there are other rock formations and strata with varying characteristics. Landforms include undulating valleys as well as low rolling hills and ridges, with elevations ranging from 700 feet in the south to 2000 feet on the highest hills in the north. The soils are primarily Paleudults (Fullerton, Dewey, Decatur, Bodine, Waynesboro series) that are variable in their productivity, and landcover ranges from areas of intensive agriculture to other areas of thick forest. Most of the Ridge and Valley's urban areas are located in 67f.

White oak forests, bottomland oak forests, and sycamore-ash-elm riparian forests are the most common forest types (Martin 1989). Loblolly pine plantations occur in several areas in the southern part of the ecoregion. Grassland barrens, dominated by little bluestem, are one type of non-forest vegetation that occurs in the Ridge and Valley. These often occur on shallow, clayey soils usually over the Chickamauga group limestone, and may have cedar-pine glades intermixed. (DeSelm et al., 1969; De Selm and Murdock 1993). The climate is slightly more mild compared to the higher elevation ridges and mountains of East Tennessee. The frost-free period ranges from 190-220 days, and average annual precipitation is 40 inches in the north to 54 inches in the south.

67g. Southern Shale Valleys

Area within TN: 1433 sq. mi.
Percent of state: 3.4%

The Southern Shale Valleys consist of lowlands, rolling valleys, and some slopes and hilly areas, that are dominated by fine-grained rock, primarily shale. Local relief is generally 100-400 feet. In the north, two areas of the ecoregion are associated with the Ordovician-age Sevier shale, which tends to be calcareous. The largest area extends from northern Blount County, past Douglas Lake, parts of the Lick Creek and Holston River valleys, the Kingsport area, and into Virginia. The second area is more dissected, hilly and steep, extending from near Johnson City, around South Holston Lake and into Virginia, at the foot of the Blue Ridge Mountains ecoregion. Soil associations in these areas are mostly Bays-Dandridge-Montevallo (STATSGO) or Dandridge-Needmore-Whitesburg soil associations (Springer and Elder 1980). These are slightly acid or neutral, well drained or excessively drained soils, primarily Eutrochrepts and Hapludalfs.

The shale valleys to the south are associated with Cambrian-age shale, limestone, and siltstone, and what was previously called the Litz-Sequoia-Talbott soil association. As Springer and Elder (1980, p.52) noted for these mostly acid soils, "Except for a few narrow bands of limestone, shale underlies the unit. Nearly all of the soils formed in residuum from this tilted shale." Townley and Montevallo soils are now used in place of the Litz and Sequoia series in the southern Ridge and Valley (Rick Livingston, NRCS, personal communication).

The steeper slopes in the ecoregion are used for pasture or have reverted to brush and forested land, while hay, corn, tobacco, and garden crops are grown on the foot slopes and bottom land (Springer and Elder 1980). The forested sections are mostly white oak communities and some white oak-hickory, along with successional cedar and pine types

(Martin 1989). Virginia pine and shortleaf pine forests occur here, and plantations of loblolly and white pine are extensive in some areas, especially toward the south. Annual precipitation is 40-48 inches in the north, with a freeze-free period of 180-200 days, while the southern areas near the Georgia border receive 50-54 inches of precipitation and 220 frost-free days.

67h. Southern Sandstone Ridges

Area within TN: 326 sq. mi.
Percent of state: 0.8%

The Southern Sandstone Ridges are high, steep, forested ridges with narrow crests, and have typically stony, sandy soils of low fertility. Elevations can reach over 3000 feet, and precipitation averages 44-54 inches. Although most all of the ridges were once logged, a variety of forest types of different ages and composition occurs here. The natural vegetation consists primarily of Appalachian oak forest (Kuchler 1964). White oak communities are common, some mixed mesophytic and tulip poplar forests are found in depressions and on lower slopes, and chestnut oak forests occupy some of the drier upland sites (Martin 1989). Pitch pine can be found on the higher, exposed ridges.

This ecoregion encompasses the major sandstone ridges, but the map delineations often enclose some associated areas of shale and siltstone. Some of these areas are not separated because of the map scale and the generalized geologic information. Wallen Ridge and Powell Mountain in Hancock and Claiborne counties are composed primarily of the Silurian-age Clinch Sandstone and Rockwood Formation (shale, siltstone, sandstone). The soil associations are shown as Wallen-Jefferson in the county soil survey and Armuchee-Collegedale-Montevallo by STATSGO. East of Powell Mountain, parts of Newman Ridge (Chattanooga Shale, Newman Limestone, and the Pennington Formation shales, siltstones and sandstones) could be similar to ridges of ecoregion 67i. Soils, however, are shown as Jefferson-Wallen-Gilpin, similar to other sandstone ridge areas.

The polygon enclosing the Clinch Mountain sandstone ridge area in the northern part of the ecoregion has areas of shale as well. It appears that the west side has more sandstone (Silurian-age Clinch Sandstone) as does Short Mountain and Pine Mountain on the east, while the central and southeast areas have more shale (Mississippian and Devonian-age Chattanooga Shale and the Grainger Formation of shale, siltstone, sandstone and conglomerate). Armuchee-Collegedale-Montevallo soils are on the west, and Jefferson-Wallen-Gilpin soils are to the east.

White Oak Mountain, in Hamilton County in the southern part of the ecoregion, has some sandstone on the west side, but abundant shale and limestone as well (shale, siltstone and sandstone of the Rockwood Formation, Ft. Payne chert and shale, and Newman Limestone). The delineated ridge polygon also encompasses Grindstone Mountain, capped by the Gizzard Group sandstone, the only preservation of Pennsylvanian-age strata in the Valley and Ridge of Tennessee (Tennessee Division of Geology 1979).

67i. Southern Dissected Ridges and Knobs

Area within TN: 585 sq. mi.
Percent of state: 1.4%

The ridges delineated for this ecoregion are primarily those with abundant shale that have a prominant topographic expression. They are lower and more dissected than ridges of ecoregion 67h. On topographic maps, one can often see the distinctly different contour patterns of these dissected ridges compared to the sandstone ridges of 67h. The shale ridge contour lines show a more crenulated pattern reflecting the more broken, almost hummocky ridges, compared to the smoother, more parallel contour patterns of the more sharply pointed sandstone ridges. In states to the north of Tennessee, streams of this ecoregion tend to be less acidic than on the sandstone ridges (67h), and have storm hydrographs with higher peaks (Woods et al., 1996).

In Tennessee, the ridges on the east side of the ecoregion tend to be associated with the Ordovician-age Sevier shale, Athens shale, and Holston and Lenoir limestones. These formations can include calcareous shale, limestone, siltstone, sandstone, and conglomerate (Hardeman 1966). In the central and western part of the ecoregion, the dissected ridges are associated with the Cambrian-age Rome Formation: shale and siltstone with beds of sandstone. Again, this mixture of geologic materials illustrates the difficulty of separating shale ridges from sandstone ridges, and it is the resistant sandstone beds that most often form the ridge.

An effort was made to obtain supporting information for the geological distinctions from soils classifications, either from the county soil surveys, the state soil map (Springer and Elder 1980), or from soils and geology explanations from Tennessee Division of Geology (1973; 1979) publications and Martin (1989). Dystrochrepts and Eutrochrepts are the primary soil great groups of the ecoregion. Soils that appeared to be associated with the Rome Formation shale ridges included the Lehew, Litz, Muskingum, and Montevallo series. Soils over the Sevier and Athens shale and the Holston and Lenoir formations include the Dandridge, Whitesburg, Wallen, Calvin, Montevallo, Tellico, and Alcoa series.

Chestnut oak forests and pine forests are typical for the higher elevations of the ridges, with areas of white oak, mixed mesophytic, and tulip poplar on the middle and lower slopes, knobs, and in draws (Martin 1989). Some pasture and cropland is found on the less sloping land. The frost-free period is generally 180-210 days. Precipitation increases from 44 inches in the north to 54 inches in the south or at higher elevations.

68. Southwestern Appalachians

Area within TN: 4813 sq. mi.
Percent of state: 11.4%

The ecoregion defined by Omernik (1987) contained two separate areas of the Southwestern Appalachians: the Cumberland Plateau area of Tennessee, southern Kentucky, northwest Georgia, and northeast Alabama; and the forested area of the southern Plateau plus the Fall Line Hills in north-central Alabama. We have recently modified the ecoregion boundary in the Sand Mountain area of northern Alabama to join these two areas (U.S. EPA 1996). The ecoregion's land-surface form was characterized as open low to high hills and open mountains, with natural vegetation of oak-hickory-pine and mixed mesophytic forests, and Hapludults as the dominant soil great group. Land use was characterized as a mosaic of cropland, pasture, woodland, and forest (Omernik 1987). In Tennessee, the eastern boundary of the ecoregion, along the more abrupt escarpment of the Cumberland Front where it meets the Ridge and Valley (67), is relatively smooth and only slightly notched by small eastward flowing stream drainages. The western boundary, where it meets the Interior Plateau's Eastern Highland Rim (71g), is more crenulated with a rougher escarpment that is more deeply incised. The deeper gorges provide wet and cool environments that can harbor distinct plant communities (Caplenor 1979). Hinkle (1989) concluded that the mixed mesophytic forest was mostly restricted to these deeper ravines and escarpment slopes, and the upland forests were better characterized as mixed oak forests. Streams have cut down into the limestone but the gorge taluses are composed of sandstone boulders. Many waterfalls occur where the sandstone is undercut.

We have divided the Southwestern Appalachians of Tennessee into three level IV ecoregions: the Cumberland Plateau (68a), the Sequatchie Valley (68b), and the Plateau Escarpment (68c).

68a. Cumberland Plateau

Area within TN: 3184 sq. mi.
Percent of state: 7.6%

This area is generally considered the Mid-Cumberland Plateau (e.g., Smalley 1982) consisting of open low mountains and tablelands of considerable relief. The ecoregion is about 1000 feet higher than the Eastern Highland Rim (71g) to the west, and receives slightly more precipitation with cooler annual temperatures than the surrounding lower-elevation ecoregions. The plateau surface is less dissected with lower relief compared to the Cumberland Mountains (69d) or the Plateau Escarpment (68c). The plateau surface is generally 1200-2000 feet in elevation, with the Crab Orchard Mountains reaching over 3000 feet. Annual precipitation averages 48-60 inches from north to south, and the freeze-free period is 180-200 days.

The geology of the Cumberland Plateau is Pennsylvanian-age conglomerate, sandstone, siltstone, and shale: the Crab Orchard Mountains Group in the south, and Rockcastle Conglomerate and Crooked Fork Group in the north (Hardeman et al., 1966). In two small areas north of the Sequatchie Valley, the Pennsylvanian-age sandstone has eroded down to the Mississippian carbonate rocks to form the uvalas or sinks of Grassy Cove and Crab Orchard Cove. The most common soil series on the Cumberland Plateau are Lily (formerly Hartsells), Ramsey, Lonewood, and Gilpin; generally loamy, silicious, mesic Hapludults and Dystrochrepts. The region is mostly forested, with minor areas of agriculture, pine plantations, and coal mining activities.

Kuchler (1964, 1970) suggests a small area of northern hardwoods vegetation on the higher peaks of the Crab Orchard Mountains, but the majority of the plateau surface is dominated by mixed oak and oak-hickory communities (Hinkle 1989). White oak is generally the most frequent species, but scarlet oak and black oak are also common. Some red maple dominated stands are found in poorly drained lowland sites, and shortleaf pine and Virginia pine are associated with oak species on upper slopes, old fields, and cliff edges.

Many mesophytic tree species found in the ravines and gorges of the Plateau Escarpment (68c), such as sugar maple, sweet birch, cucumber tree, and white basswood, are mostly absent from the Cumberland Plateau upland (Hinkle 1989).

The western boundary of the ecoregion is distinct in the southern and central part of the state, with general accordance of soil, geology, and physiography. North of the Caney Fork and Sparta, however, there is less distinction, and more outliers of the Plateau characteristics occur on the Eastern Highland Rim. R. Paul Terrel mapped that area of the Highland Rim as the "Cumberland Plateau Transition and Outlyers" (sic) (Fullerton et al., 1977).

68b. Sequatchie Valley

Area within TN: 250 sq. mi.
Percent of state: 0.6%

Structurally associated with an anticline, of which the Crab Orchard Mountains are the topographic high, erosion of broken rock to the south scooped out the linear Sequatchie Valley. The Sequatchie River rises from springs associated with interior drainage of coves or sinkholes (Grassy, Swaggerty, and Crab Orchard Coves) further north in 68a and 68c (Milici 1967). The open, rolling, predominantly limestone valley floor, generally 600-1000 feet in elevation, is usually at least 1000 feet below the top of the Cumberland Plateau (68a). Cherty clay solution residuum overlies the Knox Group limestone and dolomite, with a low central ridge separating west and east valleys of Mississippian and Ordovician limestone and shales. Pailo-Fullerton-Barger soils are typical of the low hills and ridges of the valley (Paleudults and Hapludults), with Waynesboro-Etowah-Sullivan soils on the stream terraces and floodplains (primarily Eutrochrepts). The freeze-free period is approximately 190-210 days, with annual precipitation of 52-60 inches. The potential natural vegetation is Appalachian oak forest and mixed mesophytic forest (Kuchler 1964), but the valley is an agriculturally productive region, with most land in pasture, hay, soybeans, small grain, corn, and tobacco. Southern red oak, white oak, post oak, and hickories are common in the wooded areas. The region is sometimes considered as a part of the Ridge and Valley (67).

68c. Plateau Escarpment

Area within TN: 1379 sq. mi.
Percent of state: 3.3%

The delineation of this ecoregion at this hierarchical level was debated by those attending the multi-agency ecoregion meeting in Murfreesboro, but there are distinct differences in geology, land form, soils, and vegetation from the Cumberland Plateau (68a). TDEC Chattanooga Field Office personnel also recommended that the Plateau Escarpment was an important region to distinguish for this framework. It is a transition area between the plateau (68a) and the valley areas (68b, 67f) or the Eastern Highland Rim (71g), characterized by steep slopes and high velocity, high gradient streams. Elevations are generally between 800-2100 feet and local relief is often 1000 feet or more. General climate characteristics are similar to the Cumberland Plateau (68a), although the cliffs, ravines, and gorges can have a variety of micro-climates. More eroded outliers and remnants of the Plateau Escarpment can be found on the Eastern Highland Rim (71g).

From low to high elevation, the geology includes Mississippian-age Monteagle and Bangor Limestone, the Hartselle Formation sandstone, shale, and limestone, the Pennington Formation shale, siltstone, and dolomite, and the Pennsylvanian-age Gizzard Group of shale, siltstone, sandstone, and conglomerate (Hardeman 1966). Many waterfalls occur near the boundary of 68c and 68a where the sandstone cap is undercut by the erosion of softer underlying rocks. Surficial geology is classified as colluvium with huge angular, slabby blocks of sandstone. Common soil series include Bouldin, Ramsey, Gilpin, Allen, Jefferson, and Varilla.

The rugged topography inspired Braun (1950) to designate much of this portion of the Cumberland Plateau as the "Cliff Section." The wet and cool environments in the gorges have provided a refugia for forest communities that are generally better known to the north or at higher elevations in the Blue Ridge Mountains (Caplenor 1979). Twelve vegetation community types in the Plateau ravines and gorges were identified by Hinkle (1989), ranging from mixed oak and chestnut oak on the upper slopes, mixed mesophytic forests on the middle and lower slopes (beech-tulip tree, sugar maple-basswood-ash-buckeye), with hemlock along rocky streamsides and river birch along floodplain terraces. In the gorges of Fall Creek Falls State Park, the forest communities were classified as mixed mesophytic, hemlock, hemlock-basswood, hemlock-yellow birch, oak-hickory, and chestnut oak (Caplenor 1965).

69. Central Appalachians

Area within TN: 896 sq. mi.
Percent of state: 2.1%

The Central Appalachians ecoregion stretches from northern Tennessee to central Pennsylvania, consisting of high hills and low mountains, with mixed mesophytic forests, Appalachian oak forests, and small areas of northern hardwoods forests (Omernik 1987). The dissected, rugged terrain is composed of sandstone, shale, conglomerate and coal. Soils developed from the interbedded rock are primarily Dystrochrepts and Hapludults. Bituminous coal mines are common, and have caused the siltation and acidification of streams. In Tennessee, we have defined one level IV ecoregion, the Cumberland Mountains (69d).

69d. Cumberland Mountains

Area within TN: 896 sq. mi.
Percent of state: 2.1%

In contrast to the more plateau-like area dominated by sandstone geology to the west and southwest in ecoregion 68, this is a highly dissected mountainous ecoregion of high relief with more shale. From low to high elevations, the geology includes the Slatestone, Indian Bluff, Graves Gap, Red Oak Mountain, Vowell Mountain, and Cross Mountain Formations (Wilson and Stearns 1958; Hardeman 1966). These are some of the younger Pennsylvanian-age shales, sandstones, siltstones, and coal. There are also sandstone-dominated ridges, such as Pine Mountain and Cumberland Mountain in Campbell County (associated with the Cumberland Block or Pine Mountain Thrust Plate), and Walden Ridge in Anderson County. These are the Strike Ridges defined by Smalley (1984). The mountainous area to the west and southwest of the Cumberland Block is referred to as the Wartburg Basin (Smalley 1984; Hinkle 1989). The ecoregion contains steep mountain slopes with narrow crests, with elevations generally 1200-3000 feet. Cross Mountain west of Lake City reaches 3534 feet in elevation. Narrow winding valleys separate the mountain ridges, and relief can range from 1800-2000 feet. Annual precipitation is approximately 50-55 inches and the frost-free period is 180 days.

Soils of the Cumberland Mountains are generally well-drained, loamy, acidic, with low fertility and mesic soil temeratures (Dystrochrepts and Hapludults). The primary soil association is Muskingum-Gilpin-Jefferson, shown on the state general soil map (Springer and Elder 1980), or the Kimper-Shelocta-Hazleton association shown by the STATSGO database. Other common soil series include Ramsey, Lily, and Alticrest. Most of the land cover is deciduous and mixed forest. Large tracts of land are owned by lumber and coal companies, and there are many areas of stripmining.

The potential natural vegetation is a mixed mesophytic forest (Kuchler 1964), although composition and abundance would vary greatly from place to place depending on aspect, slope position, and degree of shading from adjacent land masses. Braun (1950) thought that the mixed mesophytic forest reached its best development in this area, and her Cumberland Mountain section of the Mixed Mesophytic Forest region generally coincides with Fenneman's (1938) Cumberland Mountain physiographic section. The current forests have been altered by logging, coal mining, chestnut blight, and fire since Braun's descriptions were made. White oak, chestnut oak, and black oak forests are common, with northern red oak forests on north slopes. Sugar maple-yellow poplar-basswood-buckeye forests, or some combination, occur in coves and north-facing drainages. Other important tree species in the mixed mesophytic forest include red maple, yellow birch, black walnut, cucumber tree, eastern hemlock, black cherry, sweetgum, and bitternut hickory. American beech is found on middle to lower slopes, generally below 2000 feet, and shortleaf, pitch, and Virginia pines occur on some shallow-soil ridges and exposed slopes.

71. Interior Plateau

Area within TN: 15,735 sq. mi.
Percent of state: 37.4%

The Interior Plateau is a diverse ecoregion extending from southern Indiana and Ohio to northern Alabama. The geology is a mix of Paleozoic limestone, chert, sandstone, siltstone and shale, distinctly different from the coastal plain sands of western Tennessee ecoregions 65 and 74. The landforms include open hills, plains with hills, irregular plains, and tablelands of moderate relief (Hammond 1970). Elevations are lower than the "Appalachian" ecoregions (66, 67, 68, 69) to the east. Oak-hickory forest, with some areas of bluestem prairie and cedar glades are Kuchler's (1964) natural vegetation type. The ecoregion has the most diverse fish fauna in Tennessee (Etnier and Starnes 1993).

In Tennessee, we have divided the Interior Plateau into five level IV ecoregions: Western Pennyroyal Karst (71e), Western Highland Rim (71f), Eastern Highland Rim (71g), Outer Nashville Basin (71h), and Inner Nashville Basin (71i).

71e. Western Pennyroyal Karst

Area within TN: 857 sq. mi.
Percent of state: 2.0%

There are many sources of evidence supporting the delineation of this ecoregion as distinct from the Western Highland Rim (71f). In comparison to other regional frameworks of Tennessee, our boundaries of the region are most similar to those of the Southern Pennyroyal region defined by R. Paul Terrell in Fullerton et al., (1977). The ecoregion is also similar to Smalley's (1980) Weakly Dissected Karst Plain region, and extends slightly further south than Shanks' (1958) Kentucky Prairie Barrens floristic region. As seen on topographic maps and Hammond's (1970) land form map, it is a flatter area of irregular plains rather than the open hills of the Western Highland Rim, with elevations in the Tennessee portion generally ranging from 500-750 feet. Underground drainage and small sinkholes are common in some areas.

Soils are mostly of the Pembroke, Crider, and Baxter series that formed from a thin loess mantle over residuum of Mississippian-age St. Genevieve and St. Louis limestones. The productive soils have made this a notable agricultural area, and most of the ecoregion is cultivated or in pasture. Annual precipitation averages 49 inches and the freeze-free period in the Tennessee area is about 200 days. Many areas have soils with fragipans (Dickson, Taft, and Guthrie series) creating imperfectly drained soils, and the wetter areas have usually been drained for agriculture. Cedar Hill Swamp in Robertson County was at one time one of the best remaining examples of an oak swamp in the ecoregion (Ellis and Chester 1989).

The vegetation of this part of Tennessee has been characterized as transitional between Braun's (1950) mixed mesophytic forest region and the more xeric oak-hickory region (Chester and Ellis 1989; Duncan and Ellis 1969). From a national scale, oak-hickory dominates the potential natural forest matrix, but the region was once also characterized by mosaics of bluestem prairie (Kuchler 1970). The barrens of Kentucky that extended south into Stewart, Montgomery, and Robertson counties, were once some of the largest natural grasslands in Tennessee (Chester and Ellis 1989). These prairies were earlier considered floristically similar to the prairies of the Middle West (Transeau 1935; Shanks 1958), but there is abundant evidence to suggest that the barrens are not an outlier of the Midwestern tallgrass prairie (Baskin et al., 1994). Barrens flora included big bluestem, little bluestem, Indian grass, switch grass, and herbs and forbs such as blue sage, milkweed, and white prairie clover (Baskin et al., 1994; Chester 1993). Where not cleared for agriculture, forests on the broad uplands and slopes contain various combinations white oak, black oak, southern red oak, scarlet oak, eastern red cedar, hickories, red maple, northern red oak, and elms depending on slope aspect (Smalley 1980). Present-day forests on upland flats and depressions of the Pennyroyal plain are dominated by blackgum, sweetgum, red maple, slippery elm, black oak, willow oak, and pignut hickory (Chester et al., 1995). Similar species can be found in the lower terraces and streambottoms (Smalley 1980).

The eastern boundary of the region is not distinct, although there is a definite change in the land cover mosaic east of Portland in Sumner County, with more patches of forest. Our boundary between this ecoregion and the Eastern Highland Rim (71g) did not follow exactly a soil association line, but generally placed it where the Baxter-Mountview-Pembroke (Dickson) soils of the Western Pennyroyal Karst met the Sugargrove-Sulphura-Dickson soils (STATSGO #55) and the more forested patches of the Eastern Highland Rim. Our placement was also influenced by information on Kentucky soils, physiography, and geology (Bailey and Winsor 1964; Agricultural and Industrial Development Board of Kentucky 1953; USDA-SCS 1975; Noger 1988). This break is also near the USFS division between the Eastern and Western Higland Rim (Smalley 1983; 1980; Keys et al., 1995).

The southern boundary of the ecoregion differs from the USFS Penneroyal (sic) Karst Plain subsection 222Eh that extends further south (Keys et al., 1995). Their boundary follows the cherty clay solution residuum (rcc) Quaternary geology class (Gray et al., 1991; Miller et al., 1988), and the hilly and rolling (D2) vs. hilly and steep (D1) areas from the state soil map (Springer and Elder 1980). We believe the boundary is more distinct further north, and thus avoid lumping flat, karst, "barrens" and agricultural terrain of 71e, with hilly, forested, well dissected terrain that is more typical of 71f.

71f. Western Highland Rim

Area within TN: 5871 sq. mi.
Percent of state: 13.9%

This ecoregion is part of a broad, tilted plateau, with landforms characterized as open hills with 50-75% of the gentle slope in the lowlands (Hammond 1970). Elevations are 400-1000 feet, with local relief 300-500 feet. The geologic base is limestone, chert, and shale of Mississippian age. Surficial geology is chert-fragment solution residuum; cherty silty clay, locally phosphatic, solution residuum; and cherty clay solution residuum. In the western portion of the region near the Tennessee River, older Silurian-age limestone and shale is exposed, and barrens occur here on shallow, clayey soils (Milo Pyne, The Nature Conservancy, personal communication). Soils of the Western Highland Rim tend to be cherty, acid, and low in fertility, mostly Paleudults and Fragiudults. Common soils series include Mountview, Dickson, Baxter, Brandon, Bodine, Hawthorne, Sulphura, Lax, and Saffell. Streams of the Western Highland Rim are characterized by coarse chert gravel and sand substrates with areas of bedrock, moderate gradients, and relatively clear water (Etnier and Starnes 1993). The freeze-free period in the Tennessee portion of the region is 185-205 days, and annual precipitation is approximately 50-56 inches.

The oak-hickory natural vegetation was mostly deforested in the mid to late 1800's, in conjunction with the iron-ore related mining and smelting of the mineral limonite, but now the region is again heavily forested. Drier ridges and slopes are dominated by scarlet oak, chestnut oak, black oak, and post oak, with abundant white oak on the broader uplands. The more moist north slopes have beech-maple or beech-tulip poplar-white oak communites (Duncan and Ellis 1969; Chester et al., 1995). Ravines and streambanks may contain red elm, silver maple, red maple, boxelder, sweetgum, black willow, and sycamore. In addition to the limestone barrens near the Tennessee River, barrens are also found on some upland loess soils of the Western Highland Rim, and these can have different vasuclar taxa from the limestone barrens (DeSelm 1988).

Some agriculture occurs on the flatter interfluves and in the stream and river valleys: mostly hay, pasture, and cattle, with some cultivation of corn and tobacco. The flatter area around Lawrenceburg contains more extensive cropland and pasture, and some geographers suggest this district resembles the southern part of the Eastern Highland Rim (R.Paul Terrel in Fullerton et al., 1977). There is some merit to the idea of a Southern Highland Rim to cover these areas of less relief and more agriculture, especially as it extends south into Alabama. As Smalley (1980) noted, in Alabama it is an "arbitrary division between the Eastern and Western Highland Rims."

71g. Eastern Highland Rim

Area within TN: 2923 sq. mi.
Percent of state: 6.9%

In many places, the Eastern Highland Rim of Tennessee has more level terrain than the Western Highland Rim (71f), with landforms generally characterized as tablelands of moderate relief, irregular plains, and some open high hills (Hammond 1970). Elevations are 800-1300 feet with local relief 100-500 feet, therefore lower and flatter than ecoregion 68 to the east. In Kentucky, the ecoregion is often called the Eastern Pennyroyal. The boundary between the Eastern Highland Rim and the Western Pennyroyal Karst ecoregion (71e) was discussed in the section on 71e. The western boundary of the ecoregion in Tennessee, where it meets the Outer Nashville Basin (71h), tends to remain on the rim or plateau area, putting the dissected escarpment within the Nashville Basin. In northern Tennessee, the ecoregion includes more strongly dissected areas near the Cumberland River and Dale Hollow Lake. There is a hilly, knobby transition to the Nashville Basin around the Cumberland River area (Smalley 1983; Fullerton et al., 1977), and the division between 71g and 71h in this area is not easily made.

Geologic materials in the region consist of Mississippian-age limestone, chert, shale, and dolomite. The surficial geology is mostly cherty clay or chert-fragment solution residuum. Soils are mostly Paleudults and Fragiudults, with common soil series on the smoother areas including Dickson, Mountview, Baxter, Waynesboro and Decatur. The ecoregion contains some hilly outliers from the Cumberland Plateau, and there is also karst terrain sinkholes and depressions, especially noticeable between Sparta and McMinnville in Warren and White Counties. Numerous springs and spring-associated fish fauna are also found in the region (Etnier and Starnes 1993).

Kuchler's (1964) natural vegetation for the region is primarily oak-hickory forest, but the region is transitional between the oak-hickory type to the west and the mixed mesophytic forests of the Cumberland Plateau and Cumberland Mountains to the east. McKinney (1989) summarized the forest communities of the Eastern Highland Rim as xeric and sub-xeric oak-hickory forests; mesic upland forests of sugar maple, beech, tulip poplar and white oak; mixed mesophytic forests of sugar maple, beech, tulip poplar, white oak, black walnut, yellow buckeye, and white basswood; swamp forests of overcup oak, sweetgum, willow oak, river birch, and red maple; bottomland forests of silver maple, box elder, red maple, sycamore, and slippery elm; and rare hemlock forests that have a mixed mesophytic or a mixed oak component. Shanks (1958) showed a strong representation of bottomland hardwoods in Lincoln and Coffee counties, reflecting a floristic peninsula extending northward into his barrens region of the southeastern Highland Rim, and known for its plants of coastal plain affinities. Extensive areas of the original bottomland forest in the ecoregion have been inundated by the large impoundments. The barrens areas formed over chert rock and soils that often limited tree life but supported grasses such as switchgrass, Indiangrass, and little bluestem. These former prairie areas are now mostly oak thickets or pasture and cropland. Cropland, pasture, and an extensive ornamental nursery industry occupy much of the more level land throughout the ecoregion. In Tennessee, the freeze-free period for the ecoregion is 190-210 days, and annual precipitation is 52-56 inches.

71h. Outer Nashville Basin

Area within TN: 4414 sq. mi.
Percent of state: 10.5%

This is a more heterogeneous ecoregion than the Inner Nashville Basin (71i), with more rolling and hilly topography. As DeSelm (1959) wrote, "It is into this region that remnants of the dissected rim extend...". Some regional frameworks of Tennessee separate the Outer Nashville Basin from the strongly dissected escarpment, but these hills and knobs are usually labeled as transition areas (Smalley 1980, 1983; Fullerton 1977). Our Outer Nashville Basin ecoregion encompasses more of the topographic basin and attempts to include most all of the areas of Ordovician limestone bedrock. It thus includes some of the Mississippian-age Fort Payne Formation (characteristic of the Highland Rim) among the higher hills and knobs. This formation, however, is characteristic of this ecoregion as well, occurring throughout the Outer Nashville Basin on the higher hills. From a stream ecosystem perspective, this more encompassing regional delineation includes most of those systems that have substrates on the Ordovician geology.

The limestone geology is generally non-cherty, except on hills in the south, and the rocks and soils are high in phosphorus. The Quaternary geology consists of phosphatic sandy solution residuum and cherty silty clay, locally phosphatic, solution residuum. In places such as the Columbia/Mt. Pleasant area, the limestone yields commercial phosphate.

On the west side of the ecoregion, the boundary tends to follow the line dividing the Dellrose-Mimosa-Bodine soil association (STATSGO #66) and the Bodine-Sulfura-Dellrose association (STATSGO #54) of the Western Highland Rim (71f). On the east side, however, the ecoregion boundary keeps to the top of the plateau or rim, and some of the Bodine-Sulfura-Dellrose soils of the escarpment are included within the Outer Nashville Basin. In the south, the boundary follows the Ordovician-age limestone into Limestone County, Alabama in the area around the lower Elk River to Wheeler Lake. In addition to Dellrose, Mimosa, and Bodine, other soils series common to the outer basin include Stiversville, Hampshire, Armour, Maury, Barfield, Hawthorne and Sulphura.

Elevations are generally 500-1200 feet, although the unique Short Mountain is over 2000 feet. The freeze-free period is 190-210 days, and annual precipitation is 48-54 inches. Deciduous forest with pasture and cropland are the dominant land covers. Oak-hickory is the dominant forest type, but some transitional mixed mesophytic also occurs. White oak, southern red oak, northern red oak, black oak, scarlet oak, shagbark hickory and pignut hickory are common. On more northerly and mesic slopes, oaks and hickories with yellow poplar, elms, red maple, American beech, sugar maple, black walnut, white ash, or black cherry can be found. Poorly drained terraces and stream bottoms contain willow oak, sweetgum, red maple, blackgum, green ash, and American sycamore.

Streams are low to moderate gradient, with productive, nutrient-rich waters, resulting in algae, rooted vegetation, and occasionally high densities of fish. The Nashville Basin as a whole has a distinctive fish fauna, notable for fish that avoid the region, as well as those that are present (Etnier and Starnes 1993).

71i. Inner Nashville Basin

Area within TN: 1670 sq. mi.
Percent of state: 4.0%

This ecoregion is generally less hilly and lower in elevation than the Outer Nashville Basin (71h). Outcrops of limestone are common, and soils are generally shallow (a few inches deep in the once large tracts of cedar glades) and are redder and lower in phosphorus than those in the outer basin (Springer and Elder 1980). Talbott, Bradyville, and Mimosa (Hapludalfs) are typical soil series, along with Gladeville (Rendolls) and Barfield (Hapludolls) soils. Elevations are mostly 500-900 feet, with some higher hills. The geology consists of the Ordovician-age Ridley, Lebanon, and Carters limestone formations (Hardeman et al., 1966), with a surficial layer of thin clayey solution residuum (Gray et al., 1991; Miller et al., 1988). Streams are lower gradient than surrounding regions, often flowing over large expanses of limestone bedrock.

The major plant communities of the Inner Nashville Basin include cedar glades, cedar thickets, cedar-hardwood forests, and deciduous forests. This unique mixed grassland/forest cedar glades vegetation type is apparent at a national scale (Kuchler 1964; 1970), and has been described by Harper (1926), Freeman (1933), and Quarterman (1950a,b; 1989) among others. Cedar glades have Eastern red-cedar associated with the ecological complex, but are defined as the open areas of rock, gravel, or shallow soil that remain bare or are occupied by low-growing herbaceous plant communities (Quarterman 1989). Glades have been distinguished from the more prairie-like barrens as having less than 50% cover of perennial grasses (Quarterman 1989). Glades in the Southeast are customarily identified by their substrate (Quarterman et al., 1993), and the limestone glades of Tennessee, with their many endemic species, are primarily located on the Lebanon and Ridley limestones of the Inner Nashville Basin. The most characteristic hardwoods within the Inner Nashville Basin are a maple-oak-hickory-ash association (McKinney and Hemmerly 1984).

The more xeric, open characteristics and shallow soils of the cedar glades affect the distribution of amphibians and reptiles (Jordan et al., 1968). Species associated with the deciduous forests of middle Tennessee, such as aquatic turtles, salamanders, and certain snakes, are mostly absent from cedar glade habitats. Zigzag salamanders are common in the cedar glades because the larval stages and hatchlings are terrestrial. Lizards such as the northern fence lizard, the six-lined racerunner, the five-lined skink and the southeastern five-lined skink, are generally more abundant than in surrounding habitats, and are prey for cedar glade snakes such as the midwest worm snake, black king snake, eastern milk snake, and southeastern crowned snake (Jordan et al., 1968).

Urban, suburban, and industrial land use in the Inner Nashville Basin has increased rapidly in recent years. Due to the generally shallow soils, productive cropland is generally in small tracts on terraces or narrow bottoms. Pasture and hay are common, with small areas of row crops. The freeze-free period is 190-210 days, and annual precipitation ranges from 48 to 53 inches. Similar to most of Tennessee, the precipitation is well-distributed throughout the year, although slightly higher amounts fall December through March.

73. Mississippi Alluvial Plain

Area within TN: 854 sq. mi.
Percent of state: 2.0%

This riverine ecoregion extends from southern Illinois, at the confluence of the Ohio and Mississippi Rivers, south to the Gulf of Mexico. It is mostly a flat, broad floodplain with river terraces and levees providing the main elements of relief. Regionally, the soils tend to be poorly drained, although locally some sandy soils are well-drained. Winters are mild and summers are hot, with temperatures and precipitation increasing from north to south. Bottomland deciduous forest vegetation covered the region before clearance for cultivation. The Tennessee portion of this ecoregion is within one level IV ecoregion, the Northern Mississippi Alluvial Plain (73a).

73a. Northern Mississippi Alluvial Plain

Area within TN: 854 sq. mi.
Percent of state: 2.0%

Within the state, this is a relatively homogenous region of Quaternary alluvial deposits of sand, silt, clay, and gravel. It is bounded distinctly on the east by the Jackson Formation bluffs of Tertiary age, and on the west by the Mississippi River. Average elevations are around 250 feet, ranging from near 300 feet in the north near Reelfoot Lake to 215 feet near Memphis in the south. The two main distinctions in the Tennessee portion of the ecoregion are between areas of loamy, silty, and sandy soils with better drainage, and areas of more clayey soils of poor drainage that may contain wooded swamp land and oxbow lakes. Robinsonville (Udifluvents) and Commerce (Fluvaquents) are well-drained to somewhat poorly drained Entisols of the region, Sharkey and Tunica soils are poorly-drained Haplaquepts, and Reelfoot (Argiudolls) and Bowdre (Hapludolls) soils are somewhat poorly-drained Mollisols. Annual precipitation is 48-50 inches, with a freeze-free period around 220-230 days.

Most of the region is in cropland, with some areas of deciduous forest. Soybeans, cotton, corn, sorghum, and vegetables are the main crops. The potential natural vegetation (Kuchler 1964) consists of Southern floodplain forest (oak-tupelo-baldcypress). The oaks are mostly southern red oak, overcup oak, swamp chestnut oak, Nuttall oak, water oak, and black oak. In addition to tupelo and bald cypress, other common trees include red maple, sugarberry, pecan, elm, eastern cottonwood, and sweetgum. The bottomland hardwood communities around Reelfoot Lake include a bald cypress community with black willow; a swamp red maple-green ash-black willow community; a sugarberry-soft maple-green ash community; a water oak-sweetgum-bitternut hickory community; and an upland forest community containing tulip poplar, black walnut, black cherry, and sassafras (Guthrie 1989).

Reelfoot Lake, in Lake and Obion counties, was created by a series of strong earthquakes in 1811 and 1812 and provides important habitat for fish, birds, and other wildlife. Although the size of the lake has been reduced greatly due to soil erosion from surrounding land, more than 56 species of fish inhabit its waters, the richest assemblage of swamp-dwelling fishes in Tennessee (Etnier and Starnes 1993). Waterfowl, raptors, and migratory songbirds are also often seen in the region. Open Lake in Lauderdale County is another tectonic lake in this ecoregion (Rick Livingston, NRCS, personal communication).

74. Mississippi Valley Loess Plains

Area within TN: 4509 sq. mi.
Percent of state: 10.7%

This ecoregion stretches from near the Ohio River in western Kentucky to Louisiana. It consists primarily of irregular plains, with oak-hickory and oak-hickory-pine natural vegetation. Thick loess tends to be the distinguishing characteristic. With flatter topography than the Southeastern Plains ecoregion (65) to the east, streams tend to have less gradient and more silty substrates. Agriculture is the dominant land use in the Tennessee portion of the ecoregion.

We have divided the ecoregion into two level IV ecoregions: the Bluff Hills (74a) and the Loess Plains (74b). The possibility of including a third region, Alluvial Floodplains, was debated by the authors and collaborators at several of the ecoregion meetings in Tennessee, but the consensus was not to delineate these river bottoms at this hierarchical level.

74a. Bluff Hills

Area within TN: 486 sq. mi.
Percent of state: 1.1%

Along the western edge of the ecoregion, bordering the Mississippi Alluvial Plain, are deep loess hilly areas, often called bluff hills (Cross et al., 1974). In Tennessee, the steep parts of these bluffs nearest the river occur on geology that Hardeman (1966) calls the Jackson Formation. Mississippi River boatmen called the high bluffs that edged the river at four points in Tennessee the Chickasaw Bluffs (Safford 1856). Consisting of sand, clay, silt, and lignite (Hardeman 1966), the bluffs are capped by loess greater than 60 feet deep (Miller et al., 1988; Gray et al., 1991). The disjunct ecoregion in Tennessee encompasses those thick loess areas that are generally the steepest, most dissected, and forested.

The soils of the region are generally deep, steep, silty, and erosive. Upland soils, mostly Hapludalfs, Fragiudalfs, or Eutrochrepts, include the Memphis, Loring, and Natchez series. Adler soils (Udifluvents) are common in the floodplains. Gravels are sometimes exposed at the base of the bluffs. Several locations have deep excavations through the loess cap to quarry sand and gravel. The landcover of the ecoregion is primarily forest and pasture, with small fields of crops on the more level rolling hilltops or in the narrow valley bottoms. Annual precipitation averages 50 to 52 inches, with a frost-free period of 200-230 days.

As the ecoregion extends south through Mississippi, oak-hickory forests characterize this hilly portion of the ecoregion, rather than the oak-pine mix on the plains to the east (USDA, Forest Service 1969; Kuchler 1970; U.S. Forest Service 1970). A mosaic of microenvironments is found in the carved loess due to variations in slope aspect and different exposures to sun, moisture, and wind. On the ridges and dry slopes of the Third Chickasaw Bluff in Shelby County, sweetgum, white oak, tulip poplar, sugar maple, hophornbeam, and black oak were dominant (Miller and Neiswender 1989). The moist slopes were dominated by American beech, sweetgum, tulip poplar, sugar maple, and northern red oak. Streambeds, ravines, and bottomland forests contained sycamore, eastern cottonwood, American beech, sweetgum, tulip poplar, sugarberry, northern red oak, green ash, and hackberry. Small cypress swamps had, in addition to the cypress, minor components of sugarberry, boxelder, green ash, and water hickory. Vegetation on some of these Chickasaw bluffs in Tennessee appear to be more similar to forests of the cove hardwoods communities of the Blue Ridge and Cumberland Plateau areas than to other forests of the Mississippi Embayment (Miller and Nieswender 1989). Shanks (1958) defined a relatively narrow Mississippi River Bluffs subregion that is rich in mesophytes, noting that some woody species had Appalachian and Central Basin affinities. The abundance of mesophytes such as beech and sugar maple in the Bluff Hills forests may rest as importantly on lack of human disturbance of the stand being studied as on particularly mesic habitat conditions (Mark Cowell, Indiana State University, personal communication).

Smaller streams of the Bluff Hills have localized reaches of increased gradient and small areas of gravel substrate that create aquatic habitats that are distinct from those of ecoregion 74 as a whole. Unique, isolated fish assemblages more typical of upland habitats can be found in these stream reaches (Etnier and Starnes 1993).

74b. Loess Plains

Area within TN: 4023 sq. mi.
Percent of state: 9.6%

The Loess Plains ecoregion within Tennessee consists of gently rolling, irregular plains, 250-500 feet in elevation, with 100-200 feet of local relief. The loess can be over 50 feet thick, and soils are primarily Fragiudalfs and Hapludalfs, with Fluvaquents and Udifluvents in the bottoms. Common soil series are Grenada, Loring, Memphis, Collins, Waverly, Falaya, and Routon. Oak-hickory and southern flooplain forests are Kuchler's (1964) potential natural vegetation types. Habitats in the Haywood County portion of 74b were classified as upland forest, bottomland forest, cypress-gum swamp, beaver marsh, old field, wet field, and disturbed (Lewis and Browne 1991). Most of the forest cover has been removed for cropland. The remaining upland forest is characterized by canopy species such as white oak, southern red oak, blackjack oak, black oak, post oak, mockernut hickory, and pignut hickory (Lewis and Browne 1991; Heineke 1989). The ecoregion in Tennessee is a productive agricultural area of soybeans, cotton, corn, milo, and sorghum crops, along with livestock and, historically, some poultry. The freeze-free period is 200-230 days north to south, and annual precipitation is 50-52 inches.

Several large river systems and their tributaries, the Obion, Forked Deer, Hatchie, Loosahatchie, and Wolf, cross the ecoregion with wide flood plains that are distinct from the adjacent uplands. The Hatchie River mainstem is one of the least disturbed and supports populations of deer, wild turkeys, beavers, otters, waterfowl, and migratory birds. The bottomland forests contain overcup oak, water oak, willow oak, swamp chestnut oak, water hickory, silver maple, sweetgum, sycamore, river birch, green ash, tupelo, and cypress. Streams of the ecoregion are low-gradient and murky, with silt and sand bottoms. Many of the streams have been deforested and channelized, and much of the once-abundant forested wetland habitat has been lost. Valley plugs or channel blockages, where channel aggradation and driftwood accumulation combine to change flow patterns, are common along the low-gradient alluvial streams in this region (Diehl 1994).

STREAM REFERENCE SITE SELECTION

To develop biological criteria and evaluate impaired water bodies, it is important to establish reference conditions that are suitable for comparison. A key function of an ecoregion framework is its use in selecting regional reference sites and facilitating the assessment of regionally attainable conditions. Ideally, control sites for estimating attainable conditions should be as minimally disturbed as possible yet representative of the streams for which they are to be controls (Hughes et al., 1986). Although no two streams are alike, we hypothesize that streams within an ecoregion will have generally similar characteristics as compared to all streams within a state, major basin, or larger area. If an ecoregion has a variety of stream types, it might also be important to classify these types and to consider groundwater influences, as these may tend to mask regional differences. Additional classifications or hierarchical levels may be needed to sort out differing stream segments and habitat types.

General guidelines for selecting reference sites have been given in Hughes et al., (1986) Gallant et al., (1989), and by Hughes (1995). The process continues to be refined, however, as experience is gained in current and ongoing ecoregion/reference site projects. For any given project it may be necessary to modify or expand general procedures; due to varying characteristics or objectives in different areas, it is difficult to follow strictly a detailed rule-based approach that will be applicable to all regions. Our process of selecting candidate reference sites in Tennessee is outlined below:

1). We defined level III and level IV ecoregions within which there is apparent homogeneity in a combination of geographic characteristics that are likely to be associated with resource quality, quantity, and types of stresses and biological responses.

2). We characterized disturbance generally (such as areal or nonpoint source pollution, and local or point sources of pollution) in each ecoregion and analyzed geographic characteristics to better understand representative or typical conditions. What comprises disturbance may vary considerably from one region to another. In regions with nutrient-rich soils, poor drainage, but great agricultural potential, all streams may have been channelized at one time or another, and all watersheds may have a high percentage of agricultural land use. Reference streams in such a region comprise those with few if any point sources, lack of recent channelization activity, and riparian zones with a relatively large percentage of woody vegetation. Regions with nutrient-poor soils, lacking agricultural potential, and containing a different set of identifying landscape characteristics such as steep forested mountains and cool, clear, high-gradient streams, are likely to be affected by different types of stressors. Relative lack of silvicultural activities, mining, or heavy recreational usage may be important criteria in selecting minimally-impacted, representative reference streams in these regions.

3). We chose a set of stream sites that appeared relatively undisturbed and completely within the ecoregion, and approximated the area of the surface watersheds. The list of candidate reference sites was compiled from suggestions made by personnel from the TDEC Division of Water Pollution Control, USFS, Tennessee Valley Authority, and Tennessee Department of Health, from previous surveys of "pristine" streams (Etnier et al., 1983), as well as from examination of maps to find streams that appeared to be relatively undisturbed yet representative of the ecoregion. The actual number of sites/watersheds selected was a function of the apparent homogeneity or heterogeneity of the region, the size of the region, hydrologic characteristics, and simply how many stream sites/watersheds were available for selection. The point of diminishing returns, regarding the number of streams necessary to address regional attainable quality and within-region variability, may be reached with only a few sites in ecoregions that are relatively homogeneous and/or small. Complex regions, on the other hand, are likely to require a large number of sites. Another consideration was access, that is, did roads or trails allow the biologists to get near the stream section for sampling? Although sampling locations should be as far from bridges as possible, access across private property or other cultural and natural hazards can reduce the number of candidate sites for consideration as final reference sites to be sampled.

Disturbance and typicalness were interpreted from information shown on 1:250,000-scale and 1:100,000-scale USGS topographic maps, land use and land cover maps, county soil surveys, and local expert judgement. The existence of populated areas, industry, agricultural land use, forestry, mining, fish hatcheries, transportation routes, etc., were interpreted from mapped information and other sources. The 1993 Tennessee Water Quality Assessment 305(b) report (Denton et al., 1994) was also consulted for each potential site to assess water chemistry/quality, and point- or non-point source pollution impacts. The number of preliminary candidate sites per ecoregion varied, ranging from none in some of the smallest ecoregions (65a,b), to more than twenty sites in ecoregions 68a and 71f. We developed a list of the candidate sites that included the ecoregion, site number, stream name and location, estimated watershed area, major basin, county, 1:100,000-scale and 1:250,000-scale map names, TDEC Field Office, and additional comments. This was given to the state biologists along with maps of the site locations.

4). Each set of sites was reviewed by state biologists, and sites were visited during ground reconnaissance to evaluate the usefulness of the ecoregions, the characteristics that comprise reference sites in each ecoregion, the range of characteristics and types of disturbances in each region, and the way in which site characteristics and stream types vary between regions. In this process, sites found to be unsuitable were dropped (because of disturbances not apparent on the maps or due to anomalous situations) and other sites were added. TDEC biologists assessed nearly 300 streams statewide in the initial screening of candidate reference sites (Linda Cartwright, TDEC-DWPC, personal communication).

5) Some aerial reconnaissance was conducted to identify disturbances not observable from the ground, to get a better sense for the spatial patterns of disturbances and geographic characteristics in each region, and to photograph typical characteristics, site locations, or disturbances for use in briefings and publications.

It should be remembered that all reference sites have some level of disturbance. There are no pristine, unimpacted watersheds in Tennessee, or, considering atmospheric deposition of contaminants, anywhere else in the U.S. We searched for the least or minimally impacted sites, but levels of impact are relative on a regional basis. The characteristics of appropriate reference sites will be different in different ecoregions and for different waterbody and habitat types. It is desirable, therefore, to have a large number of candidate reference sites for each region to help define the different types of streams, to illustrate the natural variability within similar stream types, and to clarify the factors that characterize the best sites from factors present in the lower quality sites.

A set of current reference stream sites should be just one part in determining reference stream condition. Other aids such as historical data, laboratory data, quantitative models, and best professional judgement can also be helpful (Hughes 1995).

CONCLUSIONS AND RECOMMENDATIONS

This general ecoregion framework developed for Tennessee appears to be a useful framework for environmental resource assessment and management. It is a formalization of some commonly recognized regions in Tennessee and has similarities to other frameworks of the area. The interest in such a multi-purpose regional framework should be in its potential usefulness, rather than the absolute truth of boundary line placement on the ground, or the correspondence of any one ecological component. Modifications of the framework might be warranted, however, as more information and understanding is gained. Our intent was to make the ecoregion framework compatible and consistent with the EPA ecoregion framework in surrounding states. This consistency allows biologists, ecologists, and resource managers to share and compare environmental data across political boundaries. We encourage TDEC and other Tennessee agencies and organizations to consider the analysis of compatible data from these neighboring states that share ecological regions to help clarify regional conditions and characteristics.

The hypothesis that a regional framework and sets of regional reference sites can give managers and scientists a better understanding of the spatial variations in the chemical, physical, and biological components of water bodies in Tennessee is intuitive but must be tested. We believe that these tools can help build a foundation for assessing attainable conditions. A preliminary assessment of stream chemistry values from the sampled reference sites in Tennessee does indicate some distinct regional differences. Significant time and effort will be required for the collection and creative analysis of data to develop biological criteria and regional water quality standards, and to more fully understand attainable water conditions. The process of selecting regional reference sites requires considerable time, conscientious map analysis, and thorough field reconnaissance. Enough reference sites must be selected to account for the natural variability within the ecoregions. If the selected reference sites show a high range of variability, additional stratification may be necessary. Developing or modifying multimetric indices for fish, macroinvertebrate, and habitat evaluations at reference sites also requires significant time and experimentation. Part of the challenge will be to analyze and integrate environmental data in meaningful ways, with the desirable longer-term goal of developing potential indexes of ecological integrity to assess more holistically the health of Tennessee's ecosystems.

The goal of TDEC's Division of Water Pollution Control is to reclaim polluted waters, to prevent future pollution, and to plan for the future use of the waters of the state (Denton et al. 1994). The ecoregion framework is one tool to help implement the requirements of the Tennessee Water Quality Control Act and develop water quality criteria that will protect designated uses of water bodies. It is a tool that allows for the recognition of natural differences in different areas of the state, and, together with the reference sites, clarifies the regional definition of high quality waters. Avenues for maintaining or even improving the quality of identified reference streams should be explored, since these are some of the best quality streams remaining. The Antidegradation Statement in Tennessee's water quality standards appears to offer one way of protecting these high quality waters.

Water cannot be viewed in isolation from its watershed and that is why holistic perspectives are important. Although watersheds are useful study units for understanding the quantity and quality of water at any given point on a stream, it must be recognized that the spatial distribution of factors that affect water quantity and quality (such as vegetation, land cover, soils, geology, etc.), does not coincide with topographic watershed boundaries (Omernik and Griffith 1991). Because there are an infinite number of points on a stream from which watersheds can be defined, watershed management or ecosystem management requires a spatial framework that considers the regional tolerances and capacities of landscapes. That is why the ecoregion framework can complement TDEC's watershed management approach. When ecoregions and watersheds are used together correctly, they provide a powerful mechanism for developing resource management strategies.

While the ecoregion framework may be useful for developing regionalized chemical and biological criteria for streams, other uses of such a framework in different parts of the country have included: lake classification and development of eutrophication criteria; development of nonpoint-source pollution management goals; reporting on the status or attainment of water quality; assisting programs addressing wetland classification and management; analyzing types and distributions of protected areas or ecological reserves; and developing regional indicators of forest disturbance and biodiversity. Scott et al., (1993) suggested that identifying management areas for biological diversity requires an analysis of the distribution of biodiversity from the perspective of ecoregions rather than political units.

Improving the quality of aquatic and terrestrial ecosystems in Tennessee will require the cooperation and coordination of federal, state, and local interests. It is our hope that a consistent hierarchical ecoregion framework will help improve communication and assessment within and among different agencies. Although pollution of water bodies, fragmentation or loss of habitat, and alteration of landscapes have many causes, regional assessment tools can be valuable to both resource managers and researchers for stratifying natural variability and addressing the nature of these issues.

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Appendix1
Summary Table of Ecoregion Characteristics

Appendix 1.
Summary Table of Ecoregion Characteristics

65 SOUTHEASTERN PLAINS

Level IV Ecoregion		Physiography		Geology	Soil			Climate			Potential Natural Vegetation	Land Use and Land Cover
	Area (square miles)		Elevation / Local Relief (feet)	Surficial and bedrock	Order (Great Groups)	Common Soil Series	Temperature / Moisture Regimes	Precipitation Mean annual (inches)	Frost Free Mean annual (days)	Mean Temperature January min/max; July min/max, (F)		
65a. Blackland Prairie	50	Irregular plains and undulating lowland; low gradient streams with clay, sand, and silt substrates	500-600 / 50-100	Quaternary dark gray clay or clay loam over Cretaceous-age chalk, marl, and calcareous clay	Ultisols (Hapludults); Alfisols (Hapludalfs, Paleudalfs). Bottomland Entisols (Fluvaquents, Udifluvents)	Oktibbeha, Silerton, Dulac, Sumter	Thermic / Udic	52	210	29/50 68/91	Oak-hickory forest; Blackbelt forest of sweetgum, oak, cedar; patches of bluestem prairie	Cropland and pasture, with small patches of mixed hardwoods and pine
65b. Flatwoods/Alluvial Prairie Margins	36	Undulating plains and lowland; sluggish, low gradient, sand bottomed streams	400-500 / 25-50	Quaternary massive clay decomposition residuum and alluvial silt, sand, and gravel; Tertiary massive, blocky clay and glauconitic sand	Alfisols (Hapludalfs, Paleudalfs); Ultisols (Hapludults)	Tippah, Luverne, Smithdale, Wilcox, Falkner	Thermic / Udic, Aquic	52	210	29/50 68/91	Oak-hickory, oak-hickory-pine forest, bottomland hardwoods	Pasture, hay, and cropland, with areas of mixed hardwoods and pine
65e. Southeastern Plains and Hills	4,590	Dissected irregular plains, some low hills with broad tops; fairly wide stream bottoms with broad, level to undulating terraces; low to moderate gradient mostly sandy bottomed streams	400-650 / 100-300	Quaternary ferruginous sand, clayey fine sand, and massive clay decomposition residuum; chert-pebble gravel and sand; some colluvial and alluvial loess; Tertiary sand, clay, silty clay, and lignite; Cretaceous sand	Alfisols (Paleudalfs, Fragiudalfs); Ultisols (Hapludults, Paleudults); some bottomland Entisols (Fluvaquents)	Lexington, Smithdale, Providence, Dulac, Waverly, Bibb, Iuka, Freeland	Thermic / Udic, some Aquic	48-52	200-210	24-29/44-50 66-68/89-91	Oak-hickory, oak-hickory-pine forest; some bottomland hardwoods (sycamore, sweetgum, tupelo, oaks, cypress)	Mostly deciduous forest and mixed forest intermixed with areas of pasture and fields of hay, soybeans, corn, sorghum, wheat, and cotton
65i. Fall Line Hills	9	Dissected open hills with rounded tops; low to moderate gradient streams with sandy substrates	450-680 / 100-300	Quaternary medium to coarse sand decomposition residuum; Cretaceous fine-grained sand	Ultisols (Paleudults, Hapludults)	Silerton, Smithdale, Waynesboro, Pickwick	Thermic / Udic	53	207	29/50 67/90	oak-hickory-pine forest	Deciduous forest and mixed forest
65j Transition Hills	413	Dissected open hills, broad to rounded tops and steep side slopes; low to moderate gradient streams with sand and some gravel	400-1000 / 200-400	Quaternary chert gravel and sand, medium to coarse sand deccomposition residuum, minor chert-fragment solution residuum; Cretaceous fine grained sand, and chert gravel in silt and sand	Ultisols (Paleudults, Hapludults, Fragiudults)	Silerton, Savannah, Dickson, Lax, Saffell, Brandon	Thermic / Udic	53	205	28/48 66/90	oak-hickory-pine forest	Mixed forest, deciduous forest, pine plantations; some cropland and pasture in narrow valley bottoms and on gently sloping hilltops

66 BLUE RIDGE MOUNTAINS

Level IV Ecoregion		Physiography		Geology	Soil			Climate			Potential Natural Vegetation	Land Use and Land Cover
	Area (square miles)		Elevation / Local Relief (feet)	Surficial and bedrock	Order (Great Groups)	Common Soil Series	Temperature / Moisture Regimes	Precipitation Mean annual (inches)	Frost Free Mean annual (days)	Mean Temperature January min/max; July min/max, (F)		
66d. Southern Igneous Ridges & Mountains	235	Low to high mountains with rounded domes or long linear ridges and steep, long sideslopes. High gradient, bedrock and boulder-bottomed cool, clear streams	2000-6200 / 2000-3000	Quaternary granitic boulder colluvium; Precambrian granite, gneiss, and metavolcanics	Inceptisols (Dystrochrepts); Ultisols (Hapludults)	Unaka, Ashe, Edneyville, Evard	Mesic / Udic	48-60	150-170	20/45 57/82	Appalachian oak forest (mixed oaks, hickory, pine, poplar, birch, maple); mixed mesophytic (beech, buckeye, basswood, tulip poplar); Northern hardwoods (maple, birch, beech, hemlock)	Mostly forested and public land (Cherokee National Forest); some private land, with small clearings for pasture or orchards on less steep land
66e. Southern Sedimentary Ridges	799	Low rounded mountains, some with long linear ridges and steep slopes. High gradient, bedrock and boulder-bottomed cool, clear streams	1000-4500 / 2000-3000	Quaternary sandy shaly colluvium; Cambrian shale, sandstone, siltstone, quartzite, conglomerate	Inceptisols (Dystrochrepts); Ultisols (Hapludults)	Wallen, Jefferson, Ditney, Unicoi, Cataska	Mesic / Udic	44-48 in north; 52-56 in south	150-200	21-24/46-48 58-62/83-86	Appalachian oak forest (mixed oaks, hickory, pine, poplar, birch, maple); mixed mesophytic (beech, buckeye, basswood, tulip poplar); Northern hardwoods (maple, birch, beech, hemlock)	Forested with large areas of public land (Cherokee National Forest); recreation, hunting, and forestry
66f. Limestone Valleys and Coves	139	Relatively flat to rolling valleys and coves with broad, long foot slopes, benches, and alluvial fans at base of surrounding high mountains. Moderate gradient streams with cobble and boulders	1500-2500 / 100-300	Quaternary cherty clay solution residuum; Cambrian and Ordovician limestone and dolomite	Ultisols (Paleudults, Hapludults); Alfisols (Hapludalfs)	Keener, Lonon, Northcove, Statler, Bledsoe	Thermic / Udic	45-55	160-190	23/46 60/85	Appalachian oak forest (mixed oaks, hickory, pine, poplar, birch, maple)	Small farms and rural residential; hay and pasture, with some tobacco patches; small wooded areas on fringes
66g. Southern Metasedimentary Mountains	1,338	Low to high mountains, gently rounded to steep slopes. High gradient, bedrock and boulder-bottomed cool, clear streams	1000-6600 / 2000-4000	Quaternary bouldery colluvium; Pre-Cambrian sandstone, siltstone, shale, conglomerate, quartzite, graywacke, arkose, phyllite, slate, and schist	Inceptisols (Dystrochrepts, Haplumbrepts); Ultisols (Hapludults)	Sylco, Ditney, Jeffrey, Brookshire, Junaluska, Spivey, Cataska, Keener, Lostcove, Unicoi	Mesic / Udic	55-75	170-200	24/47 61/86	Appalachian oak forest (mixed oaks, hickory, pine, poplar, birch, maple); northern hardwoods (maple, birch, beech, hemlock); Southeastern spruce-fir forests (Fraser fir, red spruce, rhododendron)	Forested; large areas of public land (Cherokee National Forest, Great Smoky Mountains National Park); tourism, recreation, hunting, some forestry

67 RIDGE AND VALLEY

Level IV Ecoregion		Physiography		Geology	Soil			Climate			Potential Natural Vegetation	Land Use and Land Cover
	Area (square miles)		Elevation / Local Relief (feet)	Surficial and bedrock	Order (Great Groups)	Common Soil Series	Temperature / Moisture Regimes	Precipitation Mean annual (inches)	Frost Free Mean annual (days)	Mean Temperature January min/max; July min/max (F)		
67f. Southern Limestone / Dolomite Valleys and Low Rolling Hills	5324	Undulating to rolling valleys with rounded hills, some steep ridges in the north; caves and springs; moderate to low gradient streams with bedrock, cobble, gravel, and sandy substrates	700-2000 / 100-700	Quaternary cherty clay solution residuum; Ordovician dolomite and limestone, cherty in places	Ultisols (Paleudults)	Fullerton, Dewey, Decatur, Bodine, Waynesboro	Thermic / Udic	40-54	190-220	24-28/43-47 64-68/85-89	Appalachian oak forest (mixed oaks, hickory, pine, poplar, birch, maple); bottomland oak and mesophytic forests; cedar barrens	Cropland and pasture, mixed forest, some pine plantations, rural residential, urban and industrial
67g Southern Shale Valleys	1433	Undulating to rolling valleys, some low, rounded hills and knobs; moderate to low gradient streams with bedrock, cobble, gravel, and sandy substrates	800-1500 / 100-400	Quaternary sandy shaly decomposition residuum; Ordovician and Cambrian shale, limestone, siltstone	Inceptisols (Eutrochrepts, Dystrochrepts); Ultisols (Hapludults); Alfisols (Hapludalfs)	Dandridge, Bays, Needmore, Montevallo, Townley	Thermic, mesic / Udic	40-54	190-220	25-28/45-47 64-68/87-89	Appalachian oak forest (mixed oaks, hickory, pine, poplar, birch, maple)	Pasture with small fields of hay, corn, tobacco; small farms and rural residential; minor patches of mixed forest, some pine plantations
67h. Southern Sandstone Ridges	326	Tall, steep ridges, some narrow intervening valleys; high to moderate gradient streams with mostly rocky substrates	900-3000 / 800-1200	Quaternary quartzite-block loamy colluvium; Ordovician, Silurian, Devonian and Mississippian sandstone, shale, siltstone, conglomerate	Inceptisols (Dystrochrepts); Ultisols (Hapludults)	Wallen, Jefferson, Gilpin	Mesic / Udic	44-54	180-200	22-26/41-45 62-66/83-87	Appalachian oak forest (mixed oaks, hickory, pine, poplar, birch, maple); some mixed mesophytic forest (beech, tulip poplar, oaks, buckeye, basswood)	Deciduous and some mixed forest; minor pasture and cropland in narrow valley bottoms
67i. Southern Dissected Ridges and Knobs	585	Ridges, hills, and knobs, lower and more dissected than 67h; small, moderate to high gradient streams with rock, cobble, and gravel substrates	800-2000 / 300-600	Quaternary sandy shaly decomposition residuum; Cambrian and Ordovician shale, siltstone, sandstone, quartzose limestone	Inceptisols (Dystrochrepts, Eutrochrepts); Ultisols (Hapludults)	Lehew, Litz, Muskingum, Montevallo, Wallen, Dandridge, Tellico, Steekee,	Mesic / Udic	44-54	180-210	23-27/42-46 63-67/84-88	Appalachian oak forest (mixed oaks, hickory, pine, poplar, birch, maple); some mixed mesophytic forest (beech, tulip poplar, oaks, buckeye, basswood)	Mostly mixed forest, some pasture and cropland on less sloping land

68 SOUTHWESTERN APPALACHIANS

Level IV Ecoregion		Physiography		Geology	Soil			Climate			Potential Natural Vegetation	Land Use and Land Cover
	Area (square miles)		Elevation / Local Relief (feet)	Surficial and bedrock	Order (Great Groups)	Common Soil Series	Temperature / Moisture Regimes	Precipitation Mean annual (inches)	Frost Free Mean annual (days)	Mean Temperature January min/max; July min/max, (F)		
68a. Cumberland Plateau	3,184	Undulating and rolling tableland and some open low mountains; somewhat weakly dissected	1200-2000 / 300-800	Quaternary sandy decomposition residuum; Pennsylvanian conglomerate, sandstone, siltstone, shale	Ultisols (Hapludults); Inceptisols (Dystrochrepts)	Lily, Ramsey, Lonewood, Gilpin	Mesic / Udic	48-60	180-200	21-27/42-47 61-66/83-88	Mixed oak forest on uplands; mixed mesophytic forest (maple, buckeye, beech, tulip poplar, oak) in ravines and gorges	Mostly forested; timber and coal mining activities; some cropland and pasture; tourism; public recreation and wildlife areas
68b. Sequatchie Valley	250	Undulating to hilly 4 mile wide linear valley, some level bottomland and low terraces; small alluvial fans; moderate to low gradient streams and several springs	600-1000 / 100-300	Quaternary cherty clay solution residuum; Ordovician limestone and dolomite, Mississippian and Ordovician cherty limestone and shale	Ultisols (Paleudults, Hapludults)	Waynesboro, Etowah, Sequatchie, Pailo, Fullerton	Thermic / Udic	52-60	190-210	25/45 65/88	Appalachian oak forest (mixed oaks, hickory, pine, poplar, birch, maple)	Cropland and pasture, with hay, soybeans, small grain, corn, and tobacco; mostly mixed forest on central ridge
68c. Plateau Escarpment	1,379	Long, steep mountainsides, some nearly vertical cliffs near top of escarpment; ravines and gorges; high velocity, high gradient streams and many waterfalls	800-2100 / 900-1500	Quaternary colluvium with huge blocks; Pennsylvanian sandstone, siltstone, shale, conglomerate; Mississippian limestone, sandstone, shale	Ultisols (Paleudults, Hapludults); Inceptisols (Dystrochrepts)	Bouldin, Ramsey, Gilpin, Allen, Jefferson, Varilla	Mesic / Udic	52-60	180-200	21-27/42-47 61-66/83-88	Mixed oak and chestnut oak on upper slopes; mixed mesophytic forest (beech, tulip poplar, maple, basswood, buckeye, hemlock) on lower slopes	Forested; steep slopes limit road building and forestry; minor cropland and pasture in lower stream bottoms

69 CENTRAL APPALACHIANS

Level IV Ecoregion	Area (square miles)	Physiography	Elevation / Local Relief (feet)	Geology: Surficial and bedrock	Soil: Order (Great Groups)	Soil: Common Soil Series	Soil: Temperature / Moisture Regimes	Climate: Precipitation Mean annual (inches)	Climate: Frost Free Mean annual (days)	Climate: Mean Temperature January min/max; July min/max (F)	Potential Natural Vegetation	Land Use and Land Cover
69d. Cumberland Mountains	896	Low mountains with long, steep slopes, narrow to rounded uneven crests, and narrow, winding valleys; highly dissected by moderate to high gradient, bedrock- dominated, clear-water streams	1200-3500 / 1500-2000	Quaternary sandstone- and shale-clast loamy colluvium; Pennsylvanian shale, sandstone, siltstone, and coal	Inceptisols (Dystrochrepts); Ultisols (Hapludults)	Jefferson, Shelocta, Gilpin, Petros, Ramsey, Lily, Alticrest, Muskingum	Mesic / Udic	50-55	180	21/43 / 61/85	Mixed mesophytic forest (maple, buckeye, beech, tulip poplar, oak)	Deciduous and mixed forest; extensive coal mining; forestry

71 INTERIOR PLATEAU

Level IV Ecoregion	Area (square miles)	Physiography	Elevation / Local Relief (feet)	Geology: Surficial and bedrock	Soil: Order (Great Groups)	Soil: Common Soil Series	Soil: Temperature / Moisture Regimes	Climate: Precipitation Mean annual (inches)	Climate: Frost Free Mean annual (days)	Climate: Mean Temperature January min/max; July min/max (F)	Potential Natural Vegetation	Land Use and Land Cover
71e. Western Pennyroyal Karst	857	Irregular plains, mostly gently rolling and weakly dissected; karst sinkholes and depressions; few permanent streams, mostly gravel and bedrock substrates	500-750 / 60-200	Quaternary cherty clay solution residuum; Mississippian limestone	Alfisols (Paleudalfs); Ultisols (Paleudults, Fragiudults)	Pembroke, Crider, Baxter, Mountview, Dickson	Thermic / Udic	48-51	190-200	23/43 / 66/88	Oak-hickory forest and bluestem prairie	Mostly cropland and pasture: tobacco, livestock, with some corn, soybeans, and small grains; small patches of mixed and deciduous forest; large military reservation
71f. Western Highland Rim	5,871	Highly dissected open hills, rolling to steep; narrow winding to moderately broad ridges; some level bottom land along major streams and rivers; moderate gradient streams with gravel, sand, and bedrock substrates	400-1000 / 300-500	Quaternary cherty clay and chert fragment solution residuum; Mississippian chert and cherty limestone, calcareous silicastone, some shale	Ultisols (Paleudults, Fragiudults, Hapludults); Alfisols (Paleudalfs); Inceptisols (Dystrochrepts, Eutrochrepts)	Mountview, Dickson, Baxter, Brandon, Hawthorne, Sulphura, Lax, Saffell	Thermic / Udic	50-56	185-205	23-26/45-48 / 63-67/88-90	Oak-hickory forest; somewhat transitional between the more xeric oak-hickory forest to the west and the more mesic mixed mesophytic forest to the east	Mostly deciduous forest; some pasture and cropland on flatter stream and river valley terraces, primarily hay, cattle, and some corn and tobacco
71g/ Eastern Highland Rim	2,923	Weakly dissected plateau or tablelands; moderately dissected open hills and knobs to the north; some sinkholes and depressions; low to moderate gradient gravel- and bedrock-bottomed streams; springs	800-1300 / 100-500	Quaternary cherty clay and chert fragment solution residuum; Mississippian chert and cherty limestone, calcareous silicastone, minor shale, some sandstone on knobs in north	Ultisols (Fragiudults, Paleudults); Alfisols (Paleudalfs)	Dickson, Mountview, Baxter, Waynesboro, Cumberland, Decatur	Thermic / Udic	52-56	190-210	24-27/44-47 / 63-68/87-89	Mostly oak-hickory, but transitional between the more xeric oak-hickory forest to the west and the more mesic mixed mesophytic forest to the east; several areas of bottomland hardwoods	Cropland and pasture, with nurseries, hay, and small acreages of corn, cotton, soybeans, small grains, and tobacco; farm woodlots and deciduous forest; urban
71h. Outer Nashville Basin	4,414	Open hills, gently rolling to steep; some plains with hills; highly dissected escarpments; moderate gradient bedrock- and gravel-bottomed streams	500-1200 / 300-500	Quaternary phosphatic sand solution residuum and cherty silty clay, locally phosphatic, solution residuum; Ordovician limestone and shaly limestone; Mississippian chert and cherty limestone on higher hills and knobs; some Devonian (Chattanooga) shale	Ultisols (Paleudults, Hapludults); Alfisols (Hapludalfs); Inceptisols (Dystrochrepts, Eutrochrepts)	Dellrose, Mimosa, Stiversville, Hampshire, Armour, Maury, Barfield, Hawthorne, Sulphura	Thermic / Udic	48-54	190-210	25/47 / 66/89	Mostly oak-hickory, but transitional between the more xeric oak-hickory forest to the west and the more mesic mixed mesophytic forest to the east	Mosaic of urban, pasture, mixed forest, and cropland; generally deciduous forest on ridge caps, pasture and red cedar stands on hillsides, small fields of corn, tobacco, hay, and garden crops on foot slopes and bottom land
71i. Inner Nashville Basin	1,670	Smooth to rolling plain, with some small knobs and hills; low gradient clear water streams on bedrock substrate	500-900 / 60-400	Quaternary thin clayey solution residuum; Ordovician limestone, low in phosphates	Alfisols (Hapludalfs); Mollisols (Rendolls); Inceptisols (Eutrochrepts)	Talbott, Bradyville, Gladeville, Inman, Mimosa	Thermic / Udic	48-53	190-210	25/46 / 66/90	Oak-hickory forest; cedar glades (poverty grass, red cedar, winged elm, hackberry, oaks)	Urban and residential; pasture and cropland of hay, with some corn and small grains; beef cattle and dairying; patches of mixed woodland and stands of red cedar

73 MISSISSIPPI ALLUVIAL PLAIN													
Level IV Ecoregion		Physiography		Geology	Soil			Climate			Potential Natural Vegetation	Land Use and Land Cover
	Area (square miles)		Elevation / Local Relief (feet)	Surficial and bedrock	Order (Great Groups)	Common Soil Series	Temperature / Moisture Regimes	Precipitation Mean annual (inches)	Frost Free Mean annual (days)	Mean Temperature January min/max; July min/max, (F)		
73a Northern Mississippi Alluvial Plain	854	Flat plains and levees of the Mississippi River floodplain. A few low-gradient streams, mostly channelized; oxbow lakes, ponds, swamps, tectonic lakes (Reelfoot, Open)	215-300 / 25-50	Quaternary alluvial sand, silt, clay, gravel	Entisols (Fluvaquents, Udifluvents); Inceptisols (Haplaquepts); Mollisols (Argiudolls, Hapludolls); Alfisols (Endoaqualfs)	Commerce, Robinsonville, Sharkey, Tunica, Reelfoot, Bowdre, Forestdale	Thermic / Udic, Aquic	49-52	200-230	25-30/43-48 68-73/89-91	Southern floodplain / bottomland hardwood forests (oak-tupelo-bald cypress)	Extensive cropland of soybeans, cotton, corn, sorghum, vegetables, hay; some deciduous forest and forested wetlands

74 MISSISSIPPI VALLEY LOESS PLAINS												
Level IV Ecoregion		Physiography		Geology	Soil			Climate			Potential Natural Vegetation	Land Use and Land Cover
	Area (square miles)		Elevation / Local Relief (feet)	Surficial and bedrock	Order (Great Groups)	Common Soil Series	Temperature / Moisture Regimes	Precipitation Mean annual (inches)	Frost Free Mean annual (days)	Mean Temperature January min/max; July min/max, (F)		
74a. Bluff Hills	486	Irregular plains with dissected hills and ridges; steeper hillsides and narrow hollows to the west, smoother terrain to the east. Moderate to low gradient silt and sand bottomed streams, some with occassional gravel	250-500 / 100-200	Quaternary loess more than 60 ft. deep; Tertiary sand, silt, clay and lignite of the Jackson Formation along western bluffs; Coastal plain gravel exposed at base of bluffs	Alfisols (Hapludalfs, Fragiudalfs); Entisols (Udifluvents, Fluvaquents); Inceptisols (Eutrochrepts)	Memphis, Loring, Adler, Natchez	Thermic / Udic	50-52	200-230	25-30/43-48 68-73/89-91	Oak-hickory forests, with some areas richer in mesophytes such as beech and sugar maple	Deciduous forest; pasture and cropland (hay, soybeans, cotton, corn, wheat) on small farms on gentler slopes
74b. Loess Plains	4,023	Irregular plains, level to gently rolling, with wide, flat bottomlands and floodplains; low gradient silt and sand bottomed streams, most have been channelized	250-500 / 50-100	Quaternary loess with alluvial silt and sand in bottomlands	Alfisols (Fragiudalfs, Hapludalfs, Epiaqualfs); Entisols (Fluvaquents, Udifluvents)	Grenada, Loring, Memphis, Collins, Waverly, Falaya, Routon	Thermic / Udic and Aquic	50-52	200-230	25-30/43-48 68-73/89-91	Oak-hickory forests, southern floodplain / bottomland hardwood forests (oak-tupelo-bald cypress)	Cropland of soybeans, cotton, corn, grain sorghum, and some pasture; deciduous forest and forested wetlands on larger bottomlands

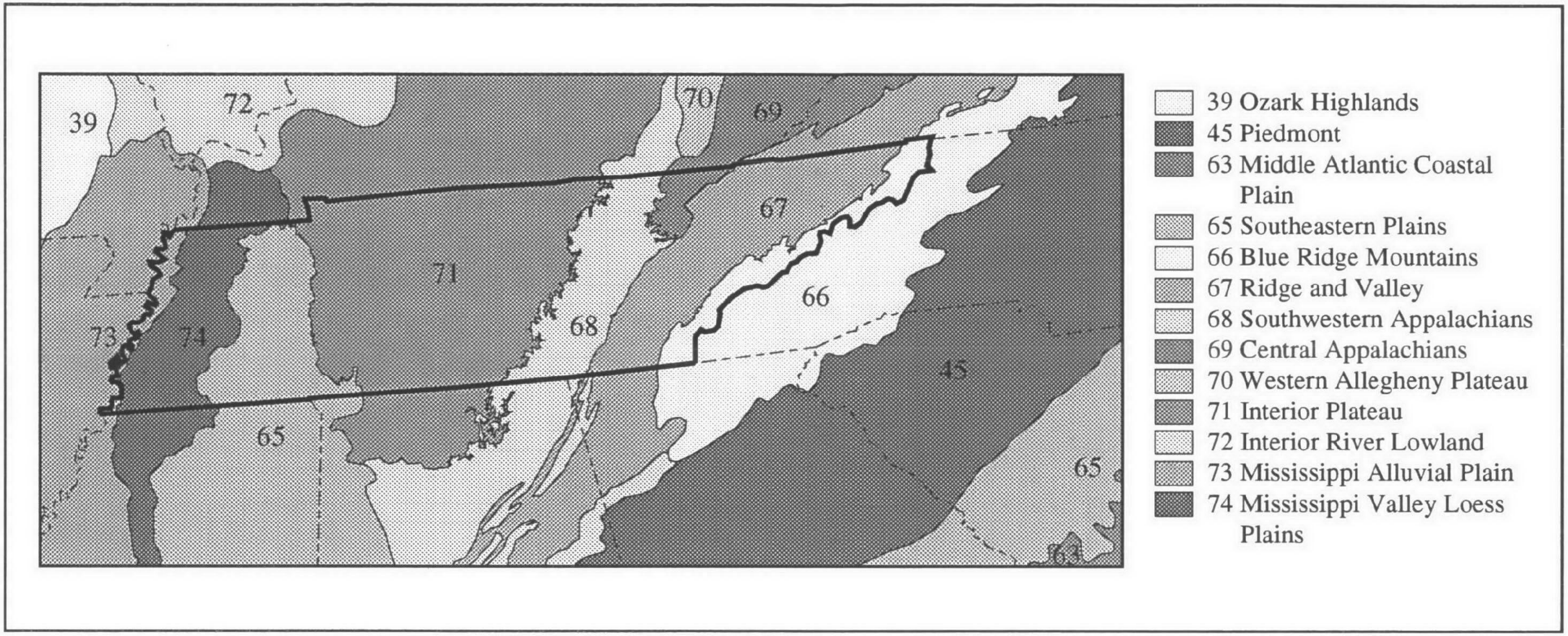
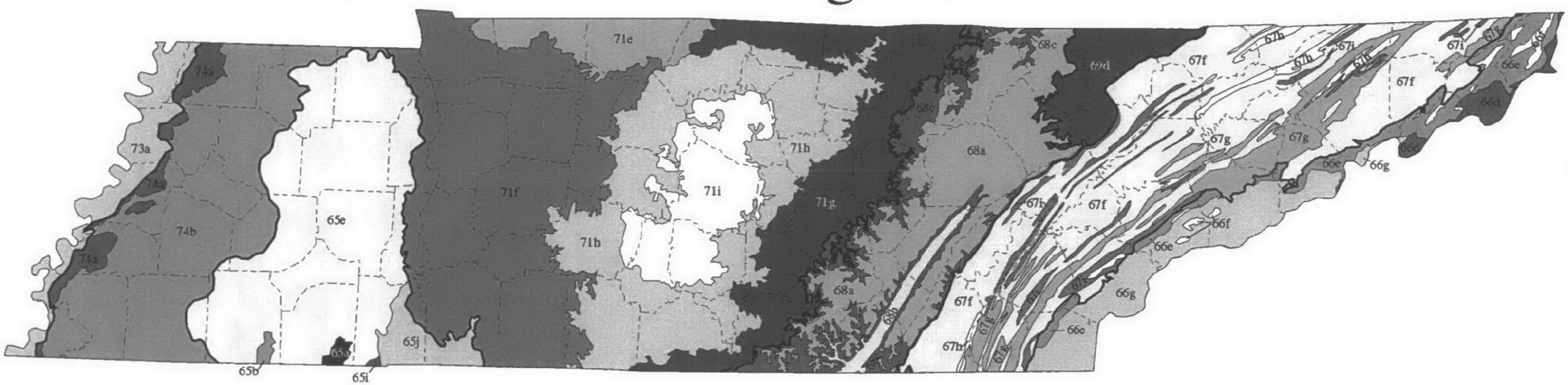


Figure 1. Level III Ecoregions of Tennessee and Neighboring States.

Level III and IV Ecoregions of Tennessee



65 Southeastern Plains
- 65a Blackland Prairie
- 65b Flatwoods/Alluvial Prairie Margins
- 65e Southeastern Plains and Hills
- 65i Fall Line Hills
- 65j Transition Hills

66 Blue Ridge Mountains
- 66d Southern Igneous Ridges and Mountains
- 66e Southern Sedimentary Ridges
- 66f Limestone Valleys and Coves
- 66g Southern Metasedimentary Mountains

67 Ridge and Valley
- 67f Southern Limestone/Dolomite Valleys and Low Rolling Hills
- 67g Southern Shale Valleys
- 67h Southern Sandstone Ridges
- 67i Southern Dissected Ridges and Knobs

68 Southwestern Appalachians
- 68a Cumberland Plateau
- 68b Sequatchie Valley
- 68c Plateau Escarpment

69 Central Appalachians
- 69d Cumberland Mountains

71 Interior Plateau
- 71e Western Pennyroyal Karst
- 71f Western Highland Rim
- 71g Eastern Highland Rim
- 71h Outer Nashville Basin
- 71i Inner Nashville Basin

73 Mississippi Alluvial Plain
- 73a Northern Mississippi Alluvial Plain

74 Mississippi Valley Loess Plains
- 74a Bluff Hills
- 74b Loess Plains

Level III ecoregions

Level IV ecoregions