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Environmental Setting and Water-Quality Issues of the Mobile River Basin, Alabama, Georgia, Mississippi, and Tennessee

Water-Resources Investigations Report 02-4162
National Water-Quality Assessment Program

U.S. Department of the Interior
U.S. Geological Survey

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By Gregory C. Johnson, Robert E. Kidd, Celeste A. Journey, Humbert Zappia, and J. Brian Atkins

U.S. GEOLOGICAL SURVEY
National Water-Quality Assessment Program

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FOREWORD

The U.S. Geological Survey (USGS) is committed to serve the Nation with accurate and timely scientific information that helps enhance and protect the overall quality of life, and facilitates effective management of water, biological, energy, and mineral resources. Information on the quality of the Nation's water resources is of critical interest to the USGS because it is so integrally linked to the long-term availability of water that is clean and safe for drinking and recreation and that is suitable for industry, irrigation, and habitat for fish and wildlife. Escalating population growth and increasing demands for the multiple water uses make water availability, now measured in terms of quantity and quality, even more critical to the long-term sustainability of our communities and ecosystems.

The USGS implemented the National Water-Quality Assessment (NAWQA) Program to support national, regional, and local information needs and decisions related to water-quality management and policy. Shaped by and coordinated with ongoing efforts of other Federal, State, and local agencies, the NAWQA Program is designed to answer: What is the condition of our Nation's streams and ground water? How are the conditions changing over time? How do natural features and human activities affect the quality of streams and ground water, and where are those effects most pronounced? By combining information on water chemistry, physical characteristics, stream habitat, and aquatic life, the NAWQA Program aims to provide science-based insights for current and emerging water issues. NAWQA results can contribute to informed decisions that result in practical and effective water-resource management and strategies that protect and restore water quality.

Since 1991, the NAWQA Program has implemented interdisciplinary assessments in more than 50 of the Nation's most important river basins and aquifers, referred to as Study Units. Collectively, these Study Units account for more than 60 percent of the overall water use and population served by public water supply, and are representative of the Nation's major hydrologic landscapes, priority ecological resources, and agricultural, urban, and natural sources of contamination.

Each assessment is guided by a nationally consistent study design and methods of sampling and analysis. The assessments thereby build local knowledge about water-quality issues and trends in a particular stream or aquifer while providing an understanding of how and why water quality varies regionally and nationally. The consistent, multi-scale approach helps to determine if certain types of water-quality issues are isolated or pervasive, and allows direct comparisons of how human activities and natural processes affect water quality and ecological health in the Nation's diverse geographic and environmental settings. Comprehensive assessments on pesticides, nutrients, volatile organic compounds, trace metals, and aquatic ecology are developed at the national scale through comparative analysis of the Study-Unit findings.

The USGS places high value on the communication and dissemination of credible, timely, and relevant science so that the most recent and available knowledge about water resources can be applied in management and policy decisions. We hope this NAWQA publication will provide you the needed insights and information to meet your needs, and thereby foster increased awareness and involvement in the protection and restoration of our Nation's waters.

The NAWQA Program recognizes that a national assessment by a single program cannot address all water-resource issues of interest. External coordination at all levels is critical for a fully integrated understanding of watersheds and for cost-effective management, regulation, and conservation of our Nation's water resources. The Program, therefore, depends extensively on the advice, cooperation, and information from other Federal, State, interstate, Tribal, and local agencies, non-government organizations, industry, academia, and other stakeholder groups. The assistance and suggestions of all are greatly appreciated.

Robert M. Hirsch
Associate Director for Water

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CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATIONS

Multiply	By	To obtain
inch per year (in/yr)	2.54	centimeters per year
foot	0.3048	meter
foot per mile (ft/mi)	0.1894	meter per kilometer
mile	1.609	kilometer
cubic foot per second (ft^3/s)	448.831	gallons per minute
cubic foot per second (ft^3/s)	28.32	liters per second
cubic foot per second (ft^3/s)	0.646317	million gallons per day
acre	0.4047	hectacre
acre-foot	43,560	cubic foot
pound, avoirdupois (lb)	0.4536	kilogram
billion tons	1.016×10^{12}	kilograms
pounds per year (lbs/yr)	0.4536	kilograms per year
cubic foot per second per square mile [$(ft^3/s)/mi^2$]	0.01363	liters per second per square kilometer
square mile (mi^2)	2.590	square kilometer

Temperature in degrees Fahrenheit (^oF) can be converted to degrees Celsius (^oC) by use of the following equation:
$^oC = (^oF - 32)/ 1.8$

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Abbreviations and Acronyms

303(d) reports	List of each State's surface waters which are classified as impaired by pollutants as required by section 303(d) of the Federal Clean Water Act of 1972
305(b) reports	State water-quality assessment documents required by section 305(b) of the Federal Clean Water Act of 1972
MLRA	Major land resource area
MSA	Metropolitan statistical area
NAWQA	National Water-Quality Assessment Program
PCB	Polychlorinated biphenyls
TRI	Toxic release inventory
U.S. EPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

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ABSTRACT

The Mobile River Basin is one of over 50 river basins and aquifer systems being investigated as part of the U.S. Geological Survey National Water-Quality Assessment (NAWQA) Program. This basin is the sixth largest river basin in the United States, and fourth largest in terms of streamflow, encompassing parts of Alabama, Georgia, Mississippi, and Tennessee. Almost two-thirds of the 44,000-square-mile basin is located in Alabama. Extensive water resources of the Mobile River Basin are influenced by an array of natural and cultural factors. These factors impart unique and variable qualities to the streams, rivers, and aquifers providing abundant habitat to sustain the diverse aquatic life in the basin.

Data from Federal, State, and local agencies provide a description of the environmental setting of the Mobile River Basin. Environmental data include natural factors such as physiography, geology, soils, climate, hydrology, ecoregions, and aquatic ecology, and human factors such as reservoirs, land use and population change, water use, and water-quality issues. Characterization of the environmental setting is useful for understanding the physical, chemical, and biological characteristics of surface and ground water in the Mobile River Basin and the possible implications of that environmental setting for water quality.

The Mobile River Basin encompasses parts of five physiographic provinces. Fifty-six percent of the basin lies within the East Gulf section of the Coastal Plain Physiographic Province. The remaining northeastern part of the basin lies, from west to east, within the Cumberland Plateau section of the Appalachian Plateaus Physiographic Province, the Valley and Ridge Physiographic Province, the Piedmont Physiographic Province, and the Blue Ridge Physiographic Province.

Based on the 1991 land-use data, about 70 percent of the basin is forested, while agriculture, including livestock (poultry, cattle, and swine), row crops (cotton, corn, soybeans, sorghum, and wheat), and pasture land accounts for about 26 percent of the study unit. Agricultural land use is concentrated along the Black Prairie Belt district of the Coastal Plain. Urban areas account for only 3 percent of the total land use; however, the areal extent of the metropolitan statistical areas (MSA) may indicate more urban influences. The MSAs include urban areas outside of the city boundaries and can include adjacent counties. Seven MSAs are delineated in the Mobile River Basin, including Montgomery, Mobile, Tuscaloosa, Birmingham, Gadsden, Anniston, and Atlanta. The total population for the Mobile River Basin was about 3,673,100 in 1990.

State water-quality agencies have identified numerous causes and sources of water-body impairment in the Mobile River Basin. In 1996, organic enrichment, dissolved oxygen depletion, elevated nutrient concentrations, and siltation were the most frequently cited causes of impairment, affecting the greatest number of river miles. Bacteria, acidic pH, and elevated metal concentrations also were identified as causes of impairment. The sources for impairment varied among river basins, were largely a function of land use, and were attributed primarily to municipal and industrial sources, mining, and agricultural activities.

INTRODUCTION

The Mobile River Basin is the sixth largest river basin in the United States, encompassing parts of Alabama, Georgia, Mississippi, and Tennessee (fig. 1) (Lamb, 1979), and the fourth largest river basin in streamflow. Almost two-thirds of the 44,000-square-mile basin is located in Alabama. Extensive water resources of the Mobile River Basin are influenced by an array of natural and cultural factors. These factors impart unique and variable qualities to the water in streams, rivers, and aquifers, which provide abundant habitats that sustain the diverse aquatic life in the basin.

The Mobile River is formed by the confluence of two large rivers, the Tombigbee and Alabama Rivers, near Mount Vernon, Alabama. Downstream from the confluence, the Mobile River flows about 30 miles to the south before splitting into several distributaries. After flowing across a deltaic plain, these distributaries discharge to Mobile Bay (fig. 2), contributing approximately 95 percent of the freshwater inflow to the bay (Loyacano and Smith, 1979). Streamflows in these distributaries are affected cyclically by tidal processes, creating a unique and complex fluvial-estuarine system.

The Mobile River Basin is one of over 50 river basins and aquifer systems (Study Units) being studied as part of the U.S. Geological Survey National Water-Quality Assessment (NAWQA) Program. Full-scale implementation of the NAWQA Program was initiated in 1991. Information from the different study units will help Federal, State, and local agencies to make management, regulatory, and monitoring decisions to better protect, enhance, and use water resources (Hirsch and others, 1988). The NAWQA Program is designed so that the study units constitute the principal building blocks of the Program. Equivalent information from individual study units can be aggregated to assess water-quality issues on both a regional and national scale.

The long-term goals of the NAWQA Program are to (1) describe the water-quality conditions of a large representative part of the Nation's freshwater streams, rivers, and aquifers; (2) describe how the water-quality conditions are changing over time; and (3) provide a sound, scientific understanding of the major natural and human factors that affect these water-quality conditions (Leahy and others, 1990; Leahy and Wilbur, 1991). The NAWQA Program uses an integrated approach to assess water quality. Multiple lines of evidence, including physical, chemical, and biological information, are collected to determine water-quality conditions.

Design of a water-quality assessment generally considers the environmental setting of the hydrologic system because interactions between the different components of the system determine the degree of difference in water-quality conditions throughout the basin. An effective regional water-quality assessment strategy is based on the environmental setting, which incorporates many interrelated features, including physiography, geology, land use, climate, and hydrology.

Purpose and Scope

This report describes the natural and cultural factors that are believed to control or have a large-scale or regional influence on the current water quality of the Mobile River Basin. This information defines the environmental setting, which will be evaluated as the first step in designing and conducting a multidisciplinary water-quality assessment of the basin. Historical and recent information collected from Federal, State, and local agencies are used as baseline information in the report. The information also is available for future data analyses that could address specific water-quality issues of the study unit. A description of physiography, geology, soils, climate, hydrology, habitat, and aquatic biology that largely determine the natural background quality of water is included in this report. A description of the cultural features of population, and land- and water-use practices defining the human influence on water quality also is included.

Acknowledgments

The authors are grateful for the assistance provided by members of the Mobile River Basin NAWQA Liaison Committee who represent Federal, State, local, and private agencies in Alabama, Georgia, Mississippi, and Tennessee. Additionally, the authors recognize Chris Jackson, Joanne Richardson, Joseph F. Connell, and Amy C. Gill for their data compilation efforts.

ENVIRONMENTAL SETTING OF THE MOBILE RIVER BASIN

The environmental setting of the Mobile River Basin is a complex combination of natural and human

Figure 1. Location of the Mobile River Basin, Alabama, Georgia, Mississippi, and Tennessee.

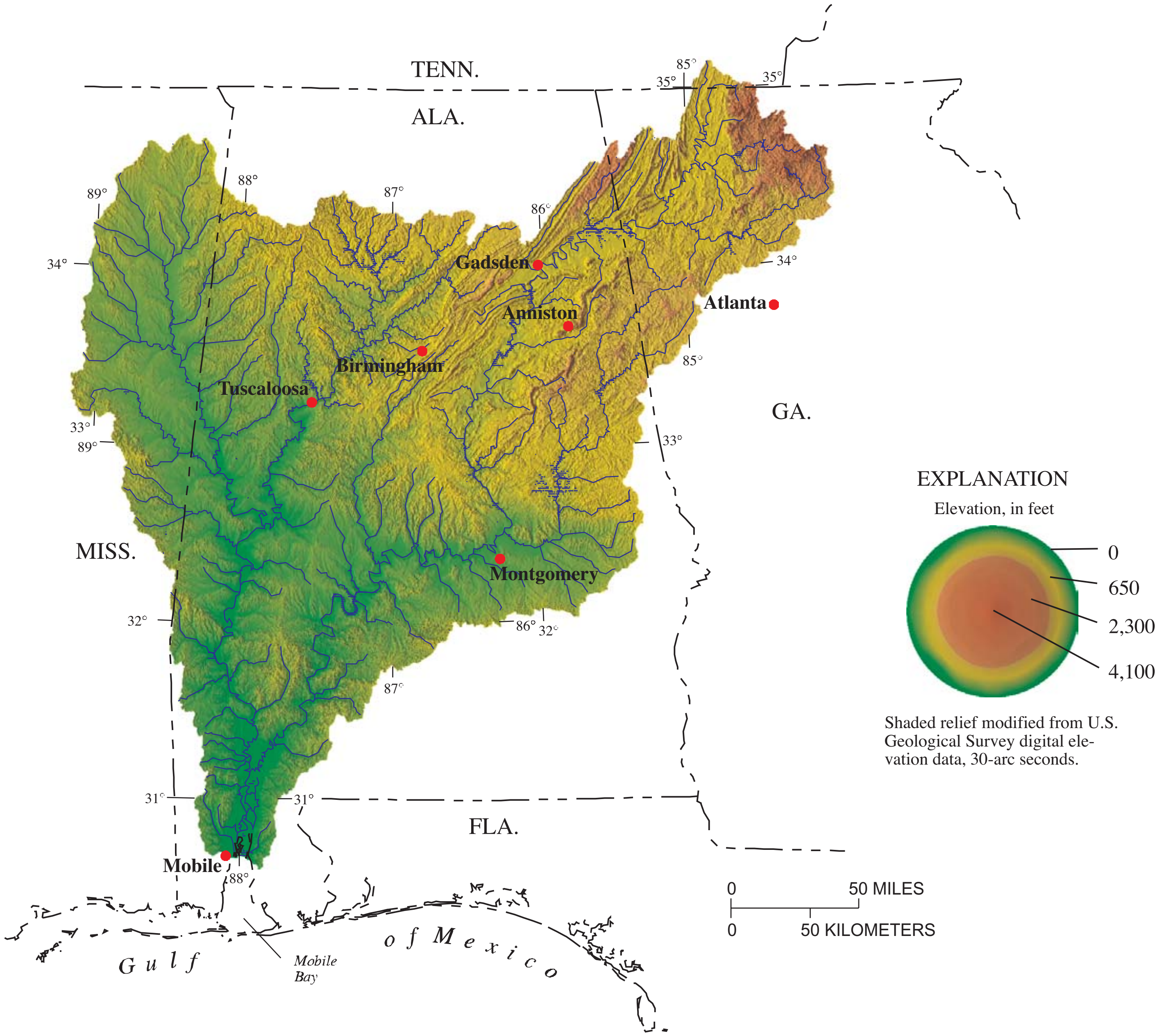


Figure 2. Topography of the Mobile River Basin.

factors. This diversity, in part, comes from the basin landscape, which ranges from steep mountains and plateaus in the northeast to broad, flat plains and rolling hills to the south and west (fig. 2). This variable landscape correlates with natural changes in geology and hydrology. Cultural influences in the basin include abundant rural expanses of forested areas, cropland, and pastures that are interspersed with cities and small towns. These combinations of natural and human factors are the principal influences on water quality.

Natural Factors

The physiography, geology, soils, climate, hydrology, and ecology of the Mobile River Basin all combine to create a unique, diverse setting. The geology and soils are the primary factors affecting the chemical composition of ground and surface waters. These natural factors discussed in this report are those which generally control water-quality characteristics in the absence of human activities.

Physiography

The Mobile River Basin encompasses parts of five physiographic provinces (fig. 3). Fifty-six percent of the basin lies within the East Gulf Coastal Plain section of the Coastal Plain Physiographic Province (referred to in this report as the Coastal Plain Physiographic Province). The northeastern part of the basin lies, from west to east, within the Cumberland Plateau section of the Appalachian Plateaus Physiographic Province (referred to in this report as the Cumberland Plateau), the Valley and Ridge Physiographic Province, the Piedmont Physiographic Province, and the Blue Ridge Physiographic Province.

Non-Coastal Plain Physiographic Provinces

About 44 percent of the Mobile River Basin lies within the non-Coastal Plain Provinces. Of these provinces, the Valley and Ridge accounts for 16 percent of the basin; the Piedmont, 15 percent; the Cumberland Plateau, 12 percent; and the Blue Ridge, 1 percent. These four provinces occupy the northern part of the study unit and include a wide range of geologic and topographic settings.

The boundary between the Coastal Plain and the non-Coastal Plain Provinces is marked by the Fall Line, or more accurately a zone along which the rivers and streams flow across resistant rocks that mark the boundary between these two provinces. River channels along the Fall Line are characterized by shoals and rapids produced by preferred erosion of the poorly consolidated Coastal Plain sediments (Journey and Atkins, 1997).

Blue Ridge and Piedmont Physiographic Provinces

The northeastern corner of the Mobile River Basin lies within the southern tip of the Blue Ridge Physiographic Province and is dominated by rugged mountains and ridges as high as 4,100 feet above sea level. The Piedmont borders the Blue Ridge Physiographic Province to the south (fig. 3). The Blue Ridge and Piedmont Physiographic Provinces are underlain mostly by Precambrian-age and older Paleozoic-age crystalline rocks that form the core of the ancient Appalachian Mountains. When first formed, the mountains would have rivaled the present day Himalayas in elevation. Over the intervening 200 million years, however, the mountains have eroded to their present level (McConnell, 1998). The Piedmont Physiographic Province is the nonmountainous part of the older Appalachians. Rarely is the land surface parallel to bedrock, and nowhere is the original surface preserved (Sanders and others, 1999). The Blue Ridge is distinguished from the Piedmont primarily by its greater topographic relief (Clark and Zisa, 1976). The Piedmont forms a well-dissected upland characterized by rounded interstream areas to the north and by rolling topography, indicative of a dissected peneplain of advanced erosional maturity, to the south (Chandler and Lines, 1974). Land-surface altitude in the Piedmont ranges from about 500 to 1,500 feet above sea level.

Valley and Ridge Physiographic Province

The Valley and Ridge Physiographic Province consists of a series of northeast-trending linear ridges and valleys underlain by alternating beds of hard and soft Paleozoic sedimentary rocks, which are highly faulted and folded and range in age from Cambrian to Pennsylvanian. Resistant sandstone and chert underlie the ridges, and softer shale and limestone underlie the valleys. Altitudes in the Mobile River Basin range from 600 to 1,600 feet above sea level on the ridges to 400 to 900 feet in the valleys (Robinson and others, 1997).

Cumberland Plateau

The north-central part of the Mobile River Basin lies within the Cumberland Plateau section of the Appalachian Plateaus Physiographic Province. The Appalachian Plateaus includes nearly horizontal layers of Mississippian- and Pennsylvanian-age rocks formed adjacent to the ancient Appalachians. Sediment eroded from the mountains was carried westward by streams and deposited in deltas in the area now called the Appalachian Plateaus (McConnell, 1998). The Cumberland Plateau consists of rock similar to the Valley and Ridge, but lacks the many folds and faults of the Valley and Ridge. This region is a submaturely to maturely dissected upland underlain by nearly flat-lying rocks of Pennsylvanian age, but the region also contains anticlinal valleys of older Paleozoic-age limestone and dolomite. Altitudes range from 1,500 to 2,000 feet above sea level in the northeast to about 500 feet above sea level in the western part of the Cumberland Plateau.

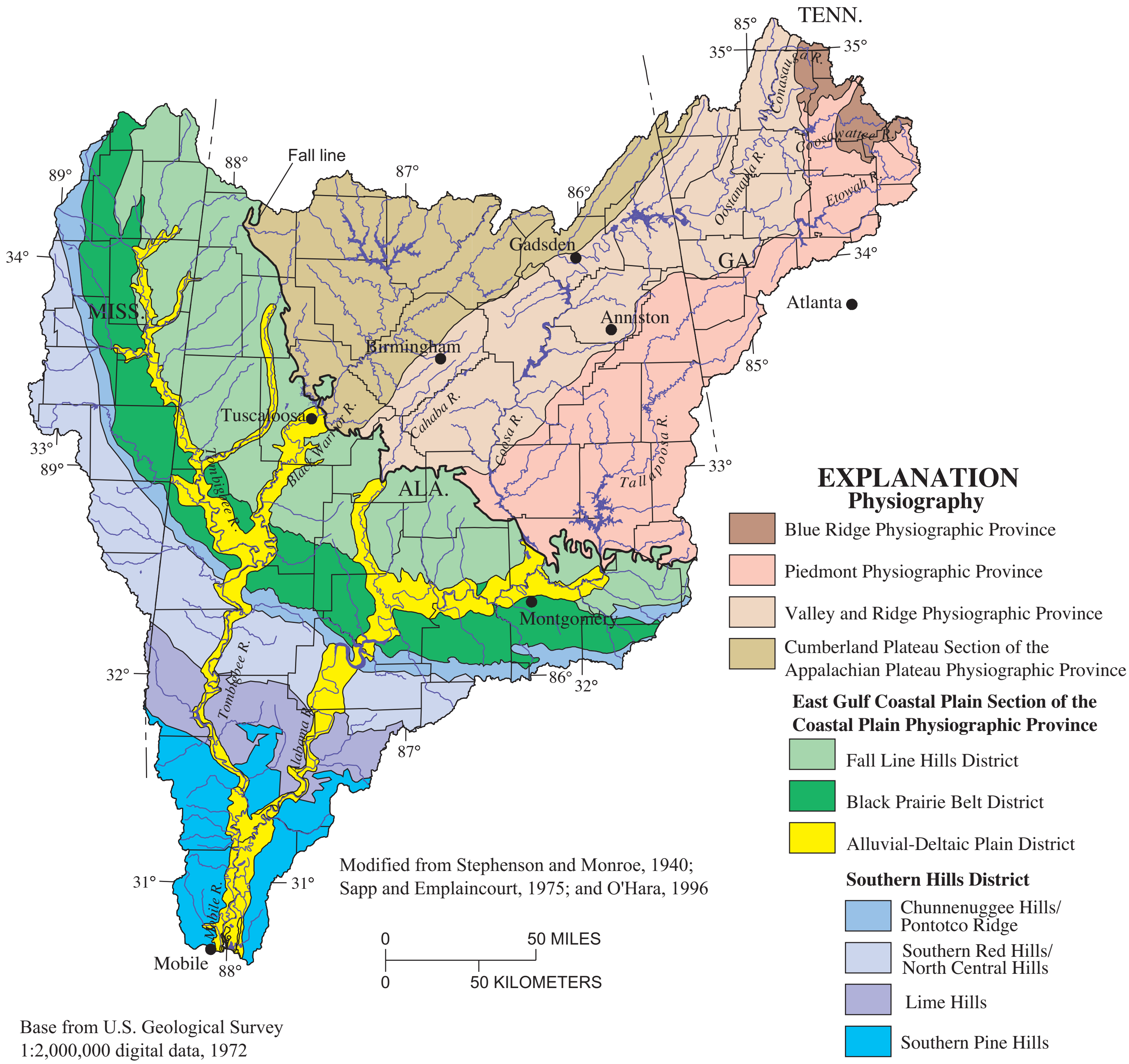


Figure 3. Physiography of the Mobile River Basin.

Coastal Plain Physiographic Province

The Coastal Plain Physiographic Province is separated into four districts: (1) Fall Line Hills, (2) Black Prairie Belt, (3) Southern Hills, and (4) Alluvial-Deltaic Plain (fig. 3). The Coastal Plain is underlain by Mesozoic- and Cenozoic-age sediments and sedimentary rocks that dip gently westward and southward at about 20 to 40 feet per mile (ft/mi) and increase to as much as 50 ft/mi near the coast (Davis, 1988). Outcrops of resistant beds form asymmetrical ridges that gently slope southward forming a series of curved, hilly belts trending southeast to east. The location of each district is determined largely by the geologic character of the underlying sediments.

The Fall Line Hills is a dissected upland with a few broad, flat ridges separated by valleys ranging from 100 to 200 feet deep. The Fall Line Hills occupies a zone where streams descend from resistant sedimentary and crystalline rocks of the Piedmont, Valley and Ridge, and Cumberland Plateau Physiographic Provinces to the less resistant sand and clay of the Coastal Plain. Altitudes range from more than 700 feet above sea level in the northwestern part of the basin to about 250 feet above sea level along the northern edge of the Black Prairie Belt.

The Black Prairie Belt lies to the south and west of the Fall Line Hills and occupies a crescent-shaped area, extending from northeastern Mississippi into central Alabama. The area is characterized by an undulating, deeply weathered plain of low relief. Valley bottoms lie at altitudes of about 250 feet above sea level (Davis, 1988). The Black Prairie Belt is underlain by chalk of Cretaceous age.

The Alluvial-Deltaic Plain is a flat expanse characterized by sinuous stream courses, swamps, and poorly defined drainage divides. The district is separated into Quaternary-age alluvial deposits of sand, gravel, clay, and silt that make up the flood plains and river terraces along the major rivers in the Mobile River system (Stephenson and Monroe, 1940), and deltaic deposits that form the flood plains along the tidally influenced streams in the southernmost part of the basin (fig. 3).

The Southern Hills (fig. 3) lies west and south of the Black Prairie Belt and is characterized by a series of hills underlain by sediments and poorly consolidated sedimentary rocks (O'Hara, 1996; Sapp and Emplaincourt, 1975). The northernmost series of hills is the Pontotoc Ridge in northeastern Mississippi and the Chunnenuggee Hills in Alabama. The Pontotoc Ridge and Chunnenuggee Hills are a pine-forested series of sand hills and cuestas (or hogback ridges) developed on chalk beds to the west and on more resistant clay, siltstone, and sandstone to the east. The North Central Hills and Southern Red Hills lie at an altitude of about 600 feet above sea level, with local relief of several hundred feet. Contained within this area is a somewhat flat-lying surface known as the Flatwoods.

The Lime Hills extend eastward from near the Alabama-Mississippi State line. Resistant sedimentary rocks contribute to relief of 200 to 250 feet from valley floors to ridge crests.

The Southern Pine Hills is the southernmost of the series of hills in the Southern Hills district. Developed on Miocene-age estuarine deposits to the north and on sand and gravel of Pliocene age to the south, the Southern Pine Hills form an elevated southward sloping dissected plain, which ranges in altitude from about 100 to 400 feet above sea level.

Geology

The major geologic units comprising the basin and described in this report were modified from King and Beikman (1974) (fig. 4). The study area can be divided into four broad categories of geologic structure: (1) flat-lying Paleozoic-age sedimentary rocks that underlie the Cumberland Plateau; (2) Paleozoic-age sedimentary rocks folded into a series of anticlines and synclines in the Valley and Ridge Physiographic Province, where resistant rocks form ridges and more easily eroded rocks underlie the valleys; (3) intensely deformed metamorphic rocks that have been intruded by small to large bodies of igneous rocks in the Piedmont and Blue Ridge Physiographic Provinces; and (4) gently dipping, poorly consolidated to unconsolidated sediments of the Coastal Plain (Miller, 1990).

The Valley and Ridge Physiographic Province is characterized by a succession of subparallel northeast-trending ridges that are composed of cherty limestone, dolomite, and sandstones; the valleys are developed in more soluble limestone, dolomite, and shale (DeBuchananne and Richardson, 1956). These Paleozoic-age rocks of fluvial and marine origin are folded, faulted, and thrusted clastic and carbonate rocks that have been only locally metamorphosed (Mooty and Kidd, 1997). Predominant rock types are, in order of abundance, carbonate rock (dolomite and limestone), shale, and sandstone (Colton, 1970).

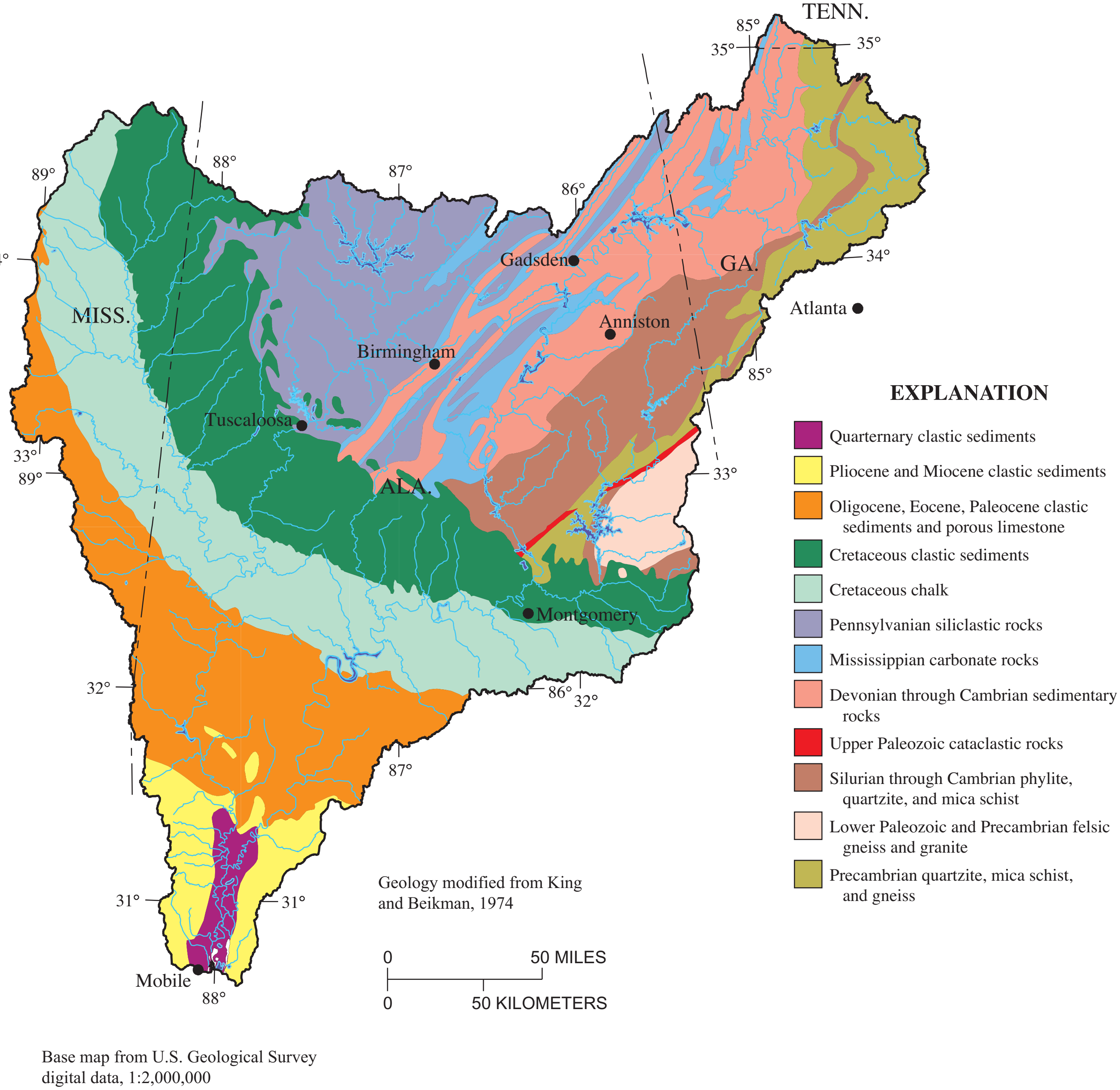


Figure 4. Generalized geology of the Mobile River Basin.

The Cumberland Plateau Physiographic Province also is underlain by rocks of Paleozoic age. These rocks are similar to those in the Valley and Ridge, but deformation of rocks is less intense than that found in the Valley and Ridge (Robinson and others, 1997). The bedrock is a sequence of mostly horizontal Pennsylvanian sandstone, shale, conglomerate, and coal and is underlain by Mississippian-age and older shale and carbonates. The Pennsylvanian-age rocks have low permeability except where fractured (Zurawski, 1978).

The Piedmont and Blue Ridge Provinces are underlain by complex sequences of igneous rocks, mostly granites and lesser amounts of diorite and gabbro, of Precambrian to Paleozoic age and extensively folded and faulted metamorphic rocks of late Precambrian to Permian age (Miller, 1990); in the Piedmont, isolated igneous rocks of Mesozoic age also are present (Chapman and Peck, 1997). The rocks are characterized by a complex outcrop and subsurface distribution pattern, and can vary significantly on the scale of a few tens of feet within the same lithologic unit. The Piedmont contains major fault zones that generally trend northeast-southwest and form the boundaries between major rock groups (Georgia Geologic Survey, 1976). The regolith covering these crystalline igneous and metamorphic rocks ranges in thickness from a few to more than 150 feet, depending upon the type of parent rock, topography, and hydrogeologic history. Regolith thickness generally is less in the Blue Ridge Province than in the Piedmont because of the steeper slopes (Schmitt and others, 1989; Brackett and others, 1991).

The Coastal Plain Physiographic Province is underlain by a thick wedge of unconsolidated to poorly consolidated clastic and carbonate rocks, which dip generally toward the west and southwest in the western part of the study area and toward the Gulf of Mexico in the southern part. Cyclic transgressions and regressions of the sea occurred during the Cretaceous and Tertiary periods, which deposited the sediments that now make up the Coastal Plain Physiographic Province (Mallory, 1993). The Cretaceous sediments are of fluvial and marine origin. Older units are exposed near the Fall Line, and progressively younger units crop out at land surface to the west and south toward the Gulf of Mexico. The thickness of sediments increases downdip to an estimated 21,000 feet near the coast (Davis, 1988).

Soils

Soil is a natural mixture of mineral and organic ingredients. The type of soil formed in a particular region is strongly influenced by the climate, parent material, landscape relief, and biological factors. These factors interact dynamically over a period of time ranging from recent events to ancient times to produce soil profiles that vary with depth and complexity.

The wide range of geologic, topographic, and climatic conditions in the Mobile River Basin produce widely varying soil types. The various soil types are used to divide the basin into seven Major Land Resource Areas (MLRA): the Eastern Gulf Coast Flatwoods, Southern Coastal Plain, Blackland Prairies, Southern Appalachian Ridges and Valleys, Sand Mountain, Southern Piedmont, and Blue Ridge (fig. 5). An MLRA is a geographic land area characterized by a particular combination or pattern of soils, climate, water-resources, land-use, and agricultural practices. Detailed county-scale soil surveys identify several major soil series within each MLRA. A soil series is a part of the land area with similar soil properties, such as color, texture, soil horizons, and depth to bedrock (U.S. Department of Agriculture, Soil Conservation Service, 1981).

The Eastern Gulf Coast Flatwoods, the Southern Coastal Plain, and the Blackland Prairies MLRAs are located within the Coastal Plain Physiographic Province. The Eastern Gulf Coast Flatwoods overlaps the Alluvial-Deltaic Plain district in the southern part of the Mobile River Basin. The soil series comprising this MLRA consist primarily of the peaty, mucky Dorovan, the sandy loamy Osier, and the loamy Cahaba series, all of which are poorly drained. The Southern Coastal Plain includes the Southern Hills district and the Fall Line Hills district of the Coastal Plain Physiographic Province. A distinction exists between soil characteristics in the Fall Line Hills and the Southern Hills districts. The soils of the Fall Line Hills district consist mainly of the Smithdale, Luverne, and Savannah soil series, which have a sandy loam or loam surface and loamy or clayey subsoil underlain by a dense, impermeable layer or fragipan. The soils of the Southern Hills district in the study area consist mainly of the Smithdale and Luverne series, which have a clayey loamy subsoil (U.S. Department of Agriculture, Natural Resources Conservation Service, 2001).

The Black Prairie Belt district and the corresponding Blackland Prairie MLRA were named for the dark surface colors of the clayey soils, which are formed from alkaline chalk or acid marine clay

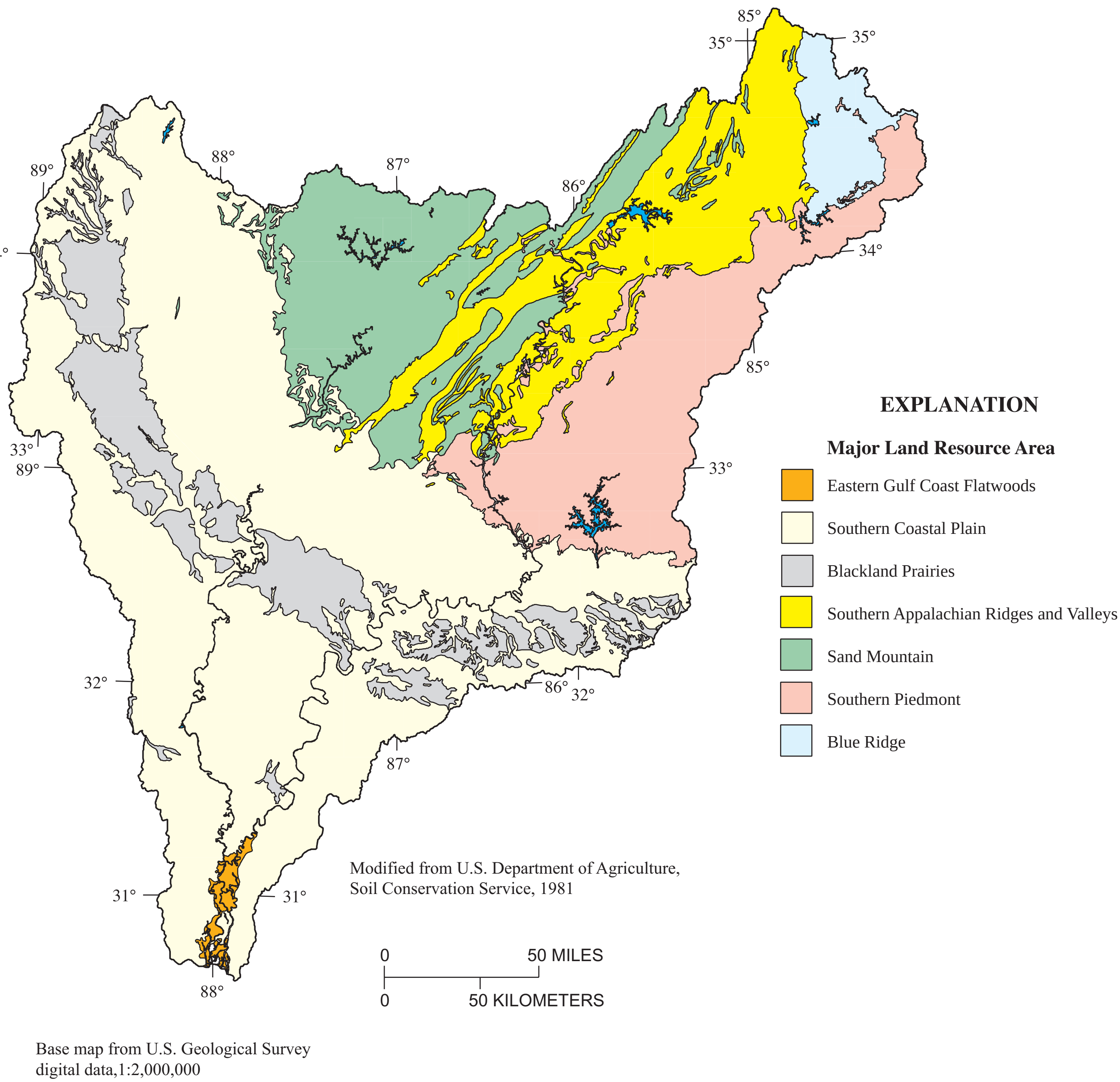


Figure 5. Major land resource areas within the Mobile River Basin.

deposits. These clayey soils (vertisols) have low infiltration; they shrink and crack when dry and swell when wet. Sumter soil series typically overlie the chalk deposits and the Oktibbeha soil series are typical of the marine clay.

The Valley and Ridge Physiographic Province is included in the Southern Appalachian Ridges and Valleys MLRA. Soils formed in the valleys in this region differ from those formed on the ridges. Soils in the valleys of the Southern Appalachian Ridges and Valleys were formed mainly in residuum of weathered limestone and are predominantly red, iron- and clay-rich types with silt loam surface textures. Decatur and Dewey soils are common soil series in the valleys. The ridges consist of cherty limestones that produce a gravelly loam and gravelly clay subsoil and a gravelly silt loam surface layer. Bodine and Fullerton soil series cover an extensive part of this landscape.

The Sand Mountain MLRA consists of soils formed on the Cumberland Plateau. The soils are derived from the predominant sandstone and shale units. The soils are gravelly to clayey loam of the Montevallo and Townley series, which are found along the steep slopes, and loamy to clayey loamy soils of the Hartselle, Wynnville, and Albertville, which are present in the valleys and found along flatter slopes.

The soils of the Southern Piedmont MLRA are formed from the weathering of crystalline rocks, such as granite, gneiss, mica schists, and slate. The soil types range from clayey loamy soils over schist and slate to gravelly loamy soils over gneiss and granite. The clayey loamy soils are predominantly Cecil, Tallapoosa, and Madison series, and the gravelly loamy soils are of Appling, Cecil, and Gwinnett series. These soils tend to be acidic and low in nitrogen and phosphorus.

The Blue Ridge MLRA comprises soils that formed within the Blue Ridge Physiographic Province from the weathering of crystalline and metamorphic rocks. Dominant soils of the Blue Ridge are moderately deep and medium textured. Ashe, Chandler, Edneyville, Porters, and Saluda series are the principal soils found on steep slopes. Clifton, Edneyville, Evard, Fannin, and Hayesville series are found on the ridge tops and side slopes of the rolling foothills. Bradson, Brevard, Dyke, Tate, and Tusquitee series are formed on foot slopes and in coves. Boulders and outcrops of bedrock are conspicuous but not extensive on mountain slopes (U.S. Department of Agriculture, Natural Resources Conservation Service, 1992).

Climate

The climate in the Mobile River Basin is warm and humid, ranging from temperate at higher elevations to subtropical near the coast. The land-surface altitude and distance from the Gulf of Mexico are major factors influencing climate in the basin. In the summer months, the Gulf of Mexico produces warm, humid air masses that move inland and provide precipitation in the form of thunderstorms, especially near the coast. Arctic fronts that move south from the midwestern part of the continent contribute most of the precipitation in the winter months.

Precipitation in the Mobile River Basin is mainly rainfall with amounts evenly distributed throughout the year; a distinct dry period usually occurs during midsummer to late fall (fig. 6), but the pattern may be disrupted by tropical depressions, storms, and hurricanes, which enter the Gulf of Mexico and move inland in the late summer and early fall. These storms may produce an overabundance of rainfall and flooding. Snowfall accumulation is rare, with annual averages generally less than an inch. Areas of the basin with higher altitudes, such as Rome, Ga., and Birmingham, Ala., have an average annual snowfall of about 2 inches.

Mean annual precipitation (fig. 6, table 1) from 1961 through 1990, ranged from 53.4 in/yr in Montgomery, Ala., in the eastern part of the basin, to 64 in/yr in Mobile, Ala., near the coast (National Oceanic and Atmospheric Administration, 1998). Mean monthly precipitation data were obtained for five National Weather Service cooperative stations located within or near the Mobile River Basin at Mobile, Montgomery, and Birmingham, Ala., Atlanta, Ga., and Tupelo, Miss. The lowest mean monthly precipitation occurred in October, and ranged from 2.45 to 3.42 inches for Montgomery and Tupelo, respectively. Generally, the highest mean monthly precipitation occurred in March and ranged from 5.77 to 6.26 inches for Atlanta and Montgomery, respectively. Exceptions included Mobile, where the highest mean monthly precipitation occurred during the periods of greatest tropical activity in July and August (6.85 and 6.96 inches, respectively), and Tupelo, where the highest mean monthly precipitation was in December (6.16 inches) and the lowest was in August (3.05 inches).

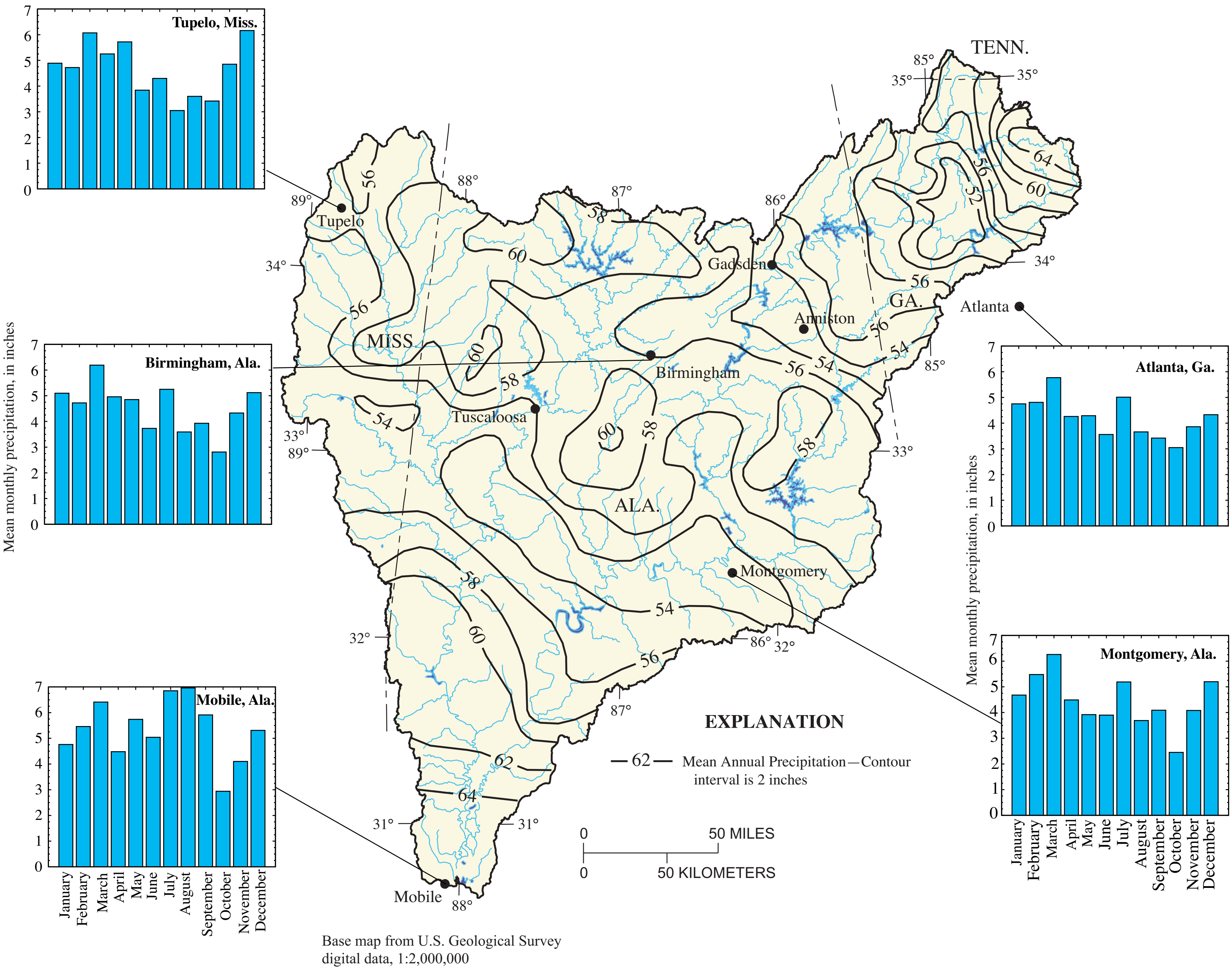


Figure 6. Mean annual precipitation for the Mobile River Basin and mean monthly precipitation for selected sites, 1961-90. (Source: Precipitation contours modified from National Oceanic and Atmospheric Administration, 1998.)

Table 1. Summary of climatic data for cooperative weather stations in the Mobile River Basin, 1961-90

[°F, degree Fahrenheit; Data from National Oceanic and Atmospheric Administration, 1998]

National Weather Service cooperative station		Mean annual temperature (°F)	Mean annual precipitation (inches)
Location	Number		
Birmingham Municipal Airport Birmingham, Alabama.	010831	61.8	54.6
Montgomery Dannelly Airport Montgomery, Alabama.	015550	64.9	53.4
Mobile Regional Airport Mobile, Alabama.	015478	67.5	64.0
Tupelo Lemons Airport Tupelo, Mississippi.	229003	61.7	55.9
Atlanta Hartsfield Airport Atlanta, Georgia.	090451	61.3	50.8

Mean annual temperatures for the Mobile River Basin ranged from 56 °F in the northeastern part of the basin to 68 °F near the coast for the period of 1961 to 1990 (fig. 7). Mean monthly temperature data were obtained for the five National Weather Service cooperative stations. The lowest mean monthly temperature was in January for all five sites and ranged from 39.9 °F in Tupelo to 49.9 °F in Mobile. The highest mean monthly temperature was in July for all five sites and ranged from 78.8 °F in Atlanta to 82.3 °F in Mobile, near the coast.

Hydrology

The Mobile River Basin has abundant water resources. The streams and rivers provide water for many uses, and ground water is available from numerous aquifers throughout the basin. Flow in the two major rivers, the Alabama and Tombigbee Rivers, is generally regulated by upstream reservoirs, flood-control and navigational locks, and dams and hydroelectric plants.

Surface Water

The Mobile River Basin comprises seven major rivers. The Mobile River is formed by the confluence of two of these major rivers (fig. 8) near Mount Vernon, Ala. (fig. 1)—the Tombigbee River to the west, which has headwaters in northeastern Mississippi, and the Alabama River to the east, which has headwaters in northwestern Georgia and the southeastern corner of Tennessee. These two river basins can be further divided into seven subbasins. The Black Warrior River is a major tributary to the Tombigbee River with the confluence near Demopolis, Ala. The Alabama River is formed by the confluence of the Coosa and Tallapoosa Rivers near Montgomery, Ala.; and the Cahaba River, also a major tributary, joins the Alabama River downstream from Selma, Ala. Downstream from the confluence of the Tombigbee and Alabama Rivers, the Mobile River has formed a deltaic plain across which flow several distributaries that drain into Mobile Bay and, subsequently, into the Gulf of Mexico (fig. 2). The Mobile River system has been estimated to contribute approximately 95 percent of the freshwater inflow to Mobile Bay (Loyacano and Smith, 1979).

Streamflow Characteristics

The total average annual surface-water discharge from the Mobile River Basin is estimated to be about 62,100 ft^3/s (U.S. Army Corps of Engineers, written commun., 1974). Approximately 47 percent of this discharge is contributed from the Tombigbee River and 52 percent from the Alabama River. Mean annual discharge data from 1923 to 1999 (fig. 9) was calulated by using available discharge data from USGS streamgaging stations. About 2,800 ft^3/s (8 percent) of the Alabama River's discharge comes from the Cahaba River, 7,300 ft^3/s (22 percent) from the Tallapoosa River, and about 16,400 ft^3/s (49 percent) from the Coosa River. The Black Warrior River is the

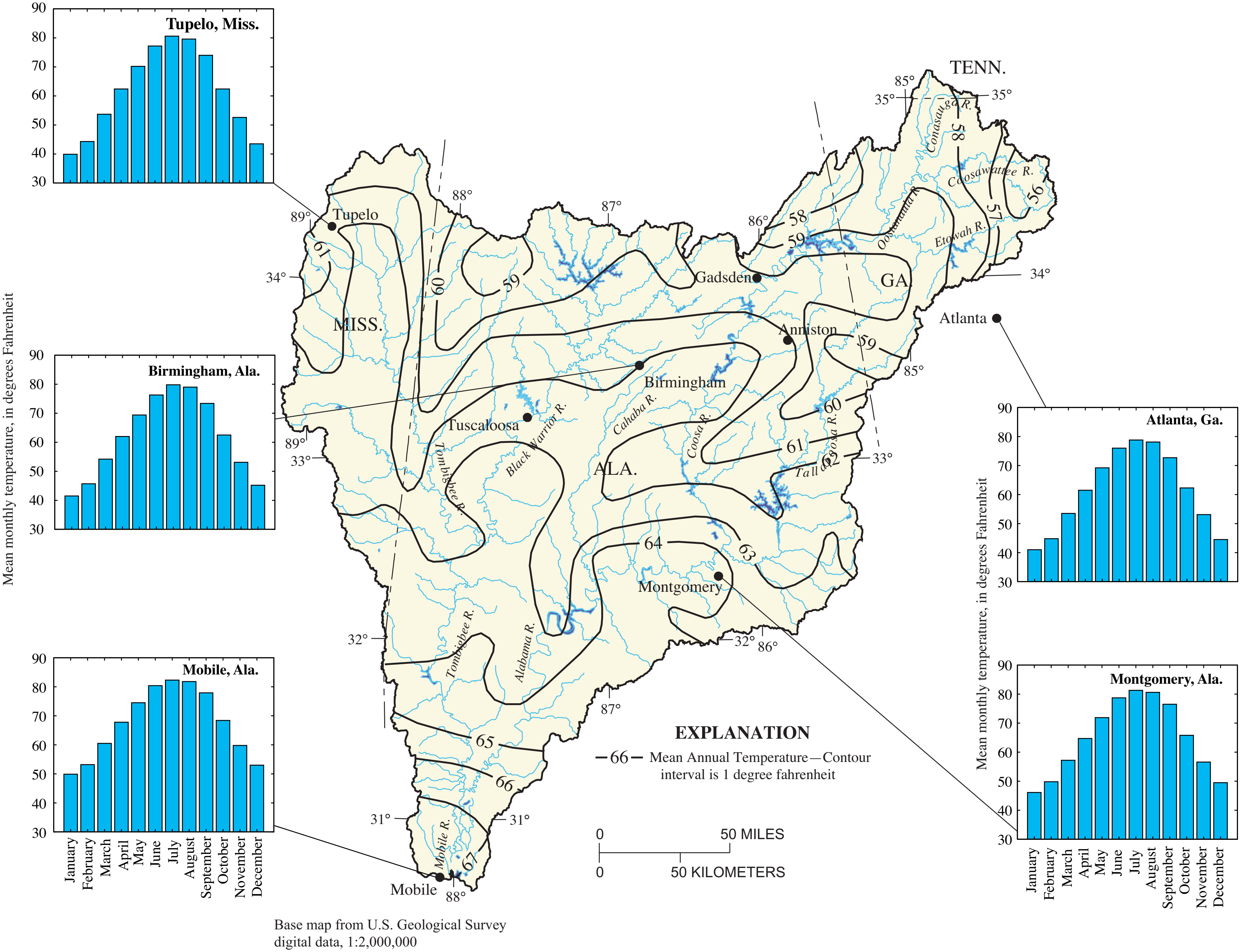


Figure 7. Mean annual temperature for the Mobile River Basin and mean monthly temperature for selected stations, 1961-90. (Source: Temperature data modified from National Oceanic and Atmospheric Administration, 1998.)

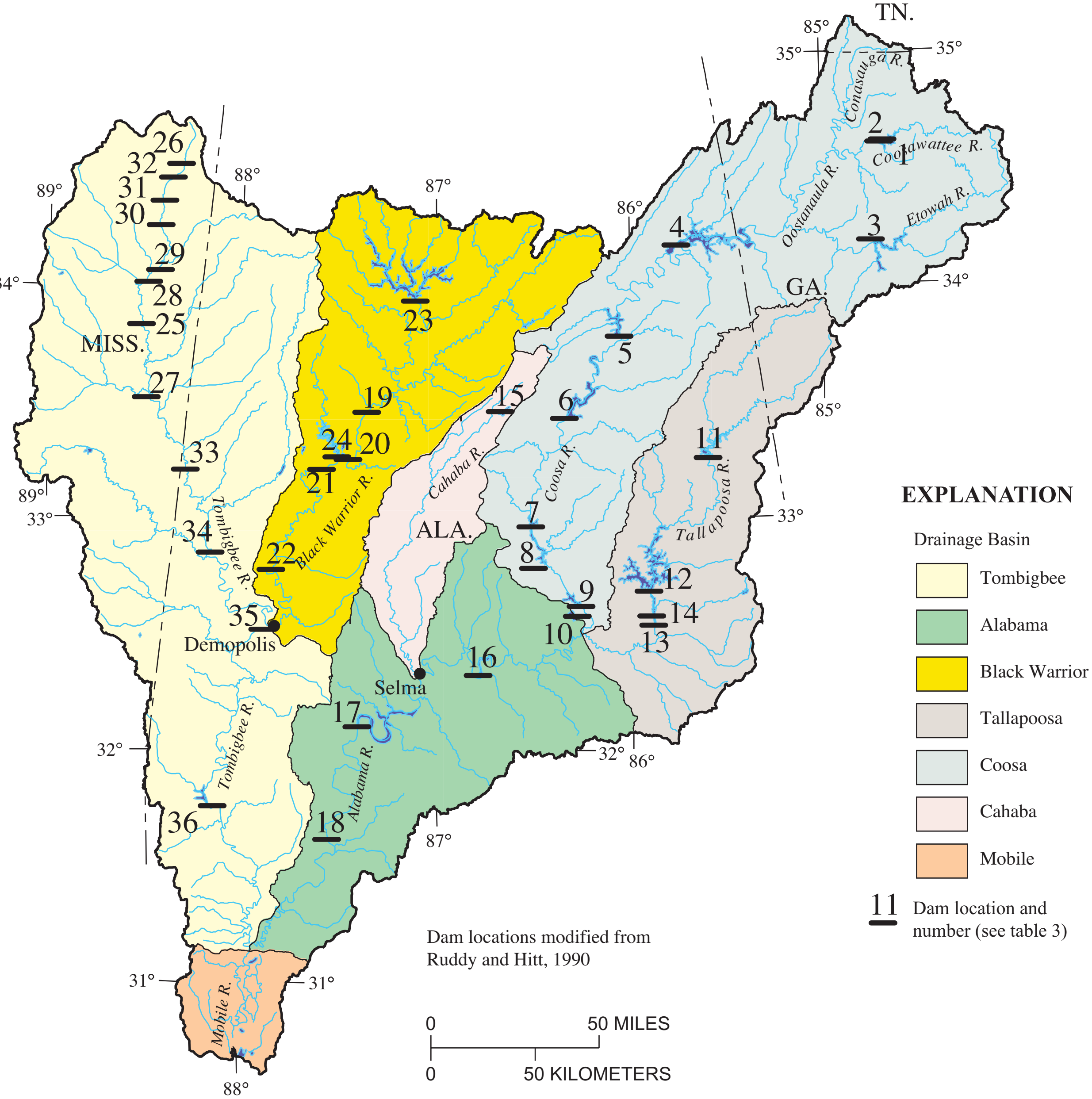


Figure 8. Major river systems and dam locations in the Mobile River Basin.

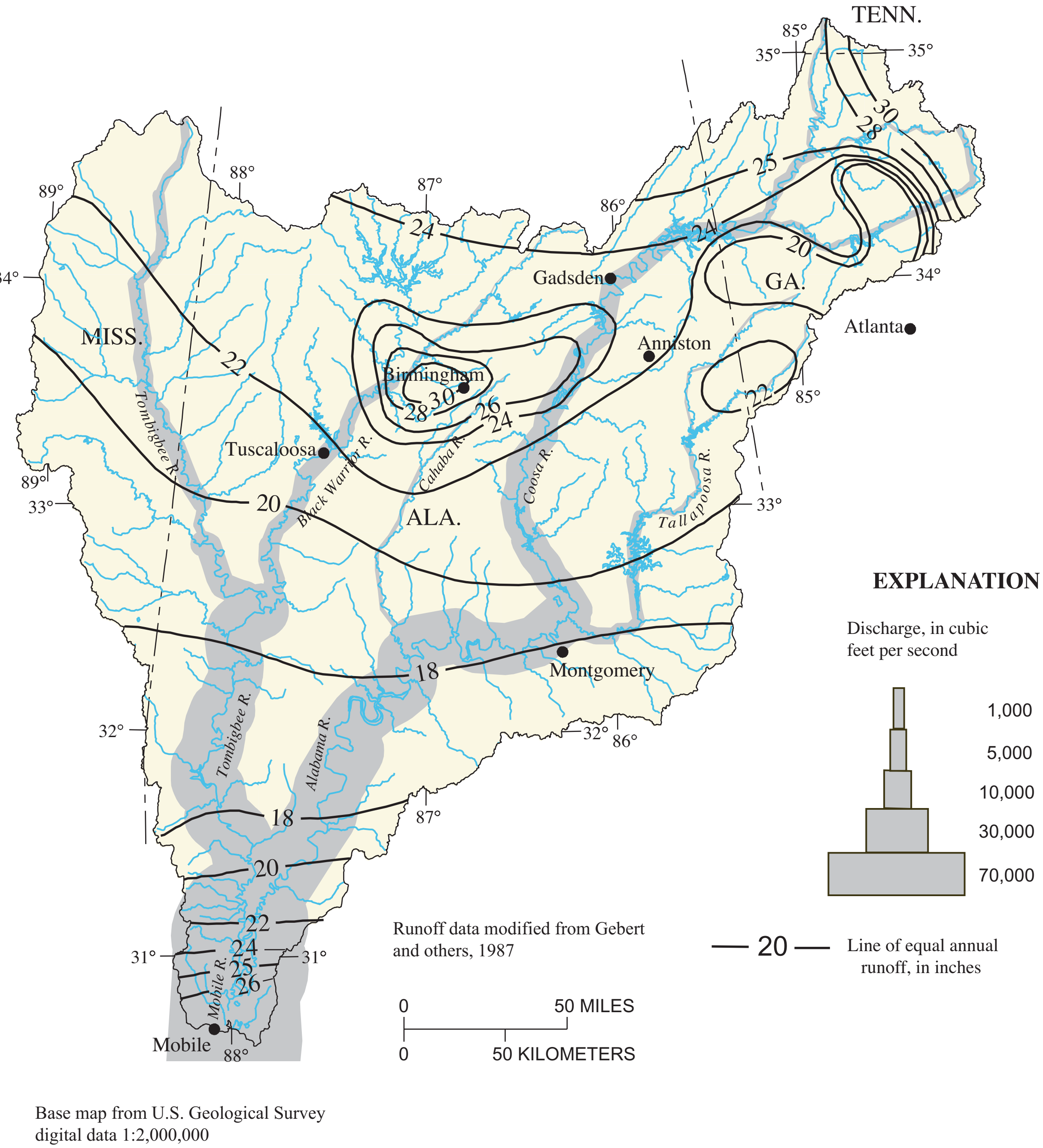


Figure 9. Mean annual runoff (1961-90) and mean annual discharge (1923-99) for the Mobile River Basin.

major contributor to the Tombigbee River, providing about 33 percent of the mean annual flow (9,900 ft^3/s).

Six streamgaging stations were selected to be representative of streamflow characteristics in the different physiographic settings in the Mobile River Basin (fig. 10). Variations in streamflow were determined by analyzing discharge data collected from the six streamgaging stations. Streamflow varies seasonally in response to precipitation and evapotranspiration. The mean daily discharge shows a consistent trend across the basin with the highest median discharge occurring in February and the lowest median occurring during the summer months. Maximum mean daily discharges for the six sites occurred from January through March. Flow duration curves for the six sites were normalized for the contributing drainage areas to eliminate the effect of the different basin sizes (fig. 11). The shapes of the curves reflect the underlying soil type and geologic characteristics typical of the different physiographies in the basin. For instance, Catoma Creek in the Black Prairie Belt district has a lower base flow and tends to go dry more frequently than streams in other areas of the Mobile River Basin. Mulberry Creek in the Fall Line Hills district and the Cahaba River in the Valley and Ridge Physiographic Province have higher base flows than streams in other areas of the Mobile River Basin.

Mean Annual Runoff

Runoff is the water that drains from the land surface into stream or river channels after precipitation. Runoff is influenced by precipitation amounts, topography, geology, soil moisture, and other factors. Mean annual runoff per square mile of basin, which is computed by dividing the mean annual volume of water leaving the basin (measured as streamflow at a gaging station) by the area of that basin, is commonly used to compare runoff characteristics between basins.

Mean annual runoff within the Mobile River Basin (Gebert and others, 1987) ranges from 18 in/yr in the Montgomery area to 30 in/yr in the Birmingham area and in the Blue Ridge Mountains (fig. 9). The mean annual runoff increases in the southern part of the basin reflecting increased annual precipitation from the proximity of this area to the Gulf of Mexico. The mean annual runoff in the Birmingham area is influenced partly by the amount of urbanization and subsequent increase in impermeable area. The higher mean annual runoff in the northeastern corner of the study unit is the result of greater precipitation and steeper slopes in the Blue Ridge Mountains, which are underlain by less permeable rocks than other parts of the basin.

Ground Water

The numerous aquifers in the Mobile River Basin range in composition from unconsolidated sand to hard, fractured crystalline rocks. These aquifers, grouped into four major aquifers or aquifer systems on the basis of the different rock types and ground-water flow systems, are the Southeastern Coastal Plain aquifer system, Valley and Ridge aquifers, the Appalachian Plateaus aquifers, and Piedmont and Blue Ridge aquifers (fig. 12, table 2) (U.S. Geological Survey, 1998). In general, ground-water flow in all of the aquifers in the Mobile River Basin is south-southwest towards the Gulf of Mexico.

Southeastern Coastal Plain Aquifer System

The Southeastern Coastal Plain aquifer system includes four regional aquifers (fig. 12; table 2) and three intervening regional confining units. Rocks forming these confining units are exposed at the land surface as a series of curved bands (Miller, 1990). The regional aquifers are composed mostly of sand with minor gravel and limestone beds that locally may contain clay beds. The regional confining units are primarily clay, silt, or chalk, but locally may contain sand beds. Each of the four regional aquifers that compose the Southeastern Coastal Plain aquifer system includes several smaller aquifers. Even though the regional aquifers contain clayey confining units that locally can subdivide the regional aquifers, the overall water-yielding characteristics of the regional aquifers are similar throughout their extent.

Recharge enters the Southeastern Coastal Plain aquifer system primarily from precipitation in outcrop areas of the aquifers. After reaching the water table, most of this water moves laterally and either discharges to small streams, evaporates, or is transpired by plants. In areas where the aquifer is unconfined, water moves downward generally along short flowpaths, and then horizontally towards discharge areas. A small percentage of ground water moves into confined parts of the aquifer where most of the movement is horizontal and downdip of the aquifers, along generally long flowpaths, until the water approaches discharge points, where its movement again becomes predominantly vertical to discharge to shallower aquifers or surface-water bodies (Miller, 1990). Near the

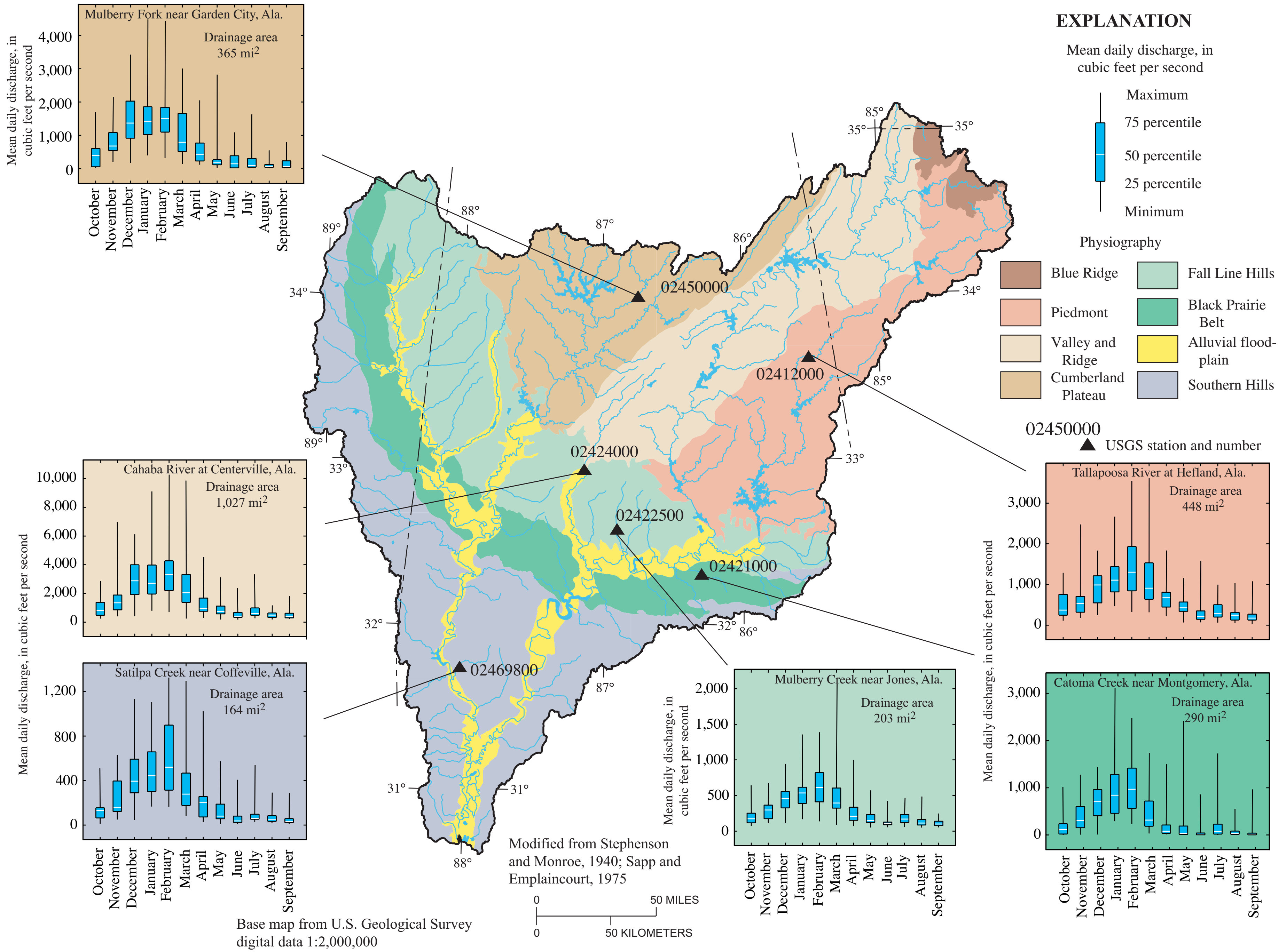
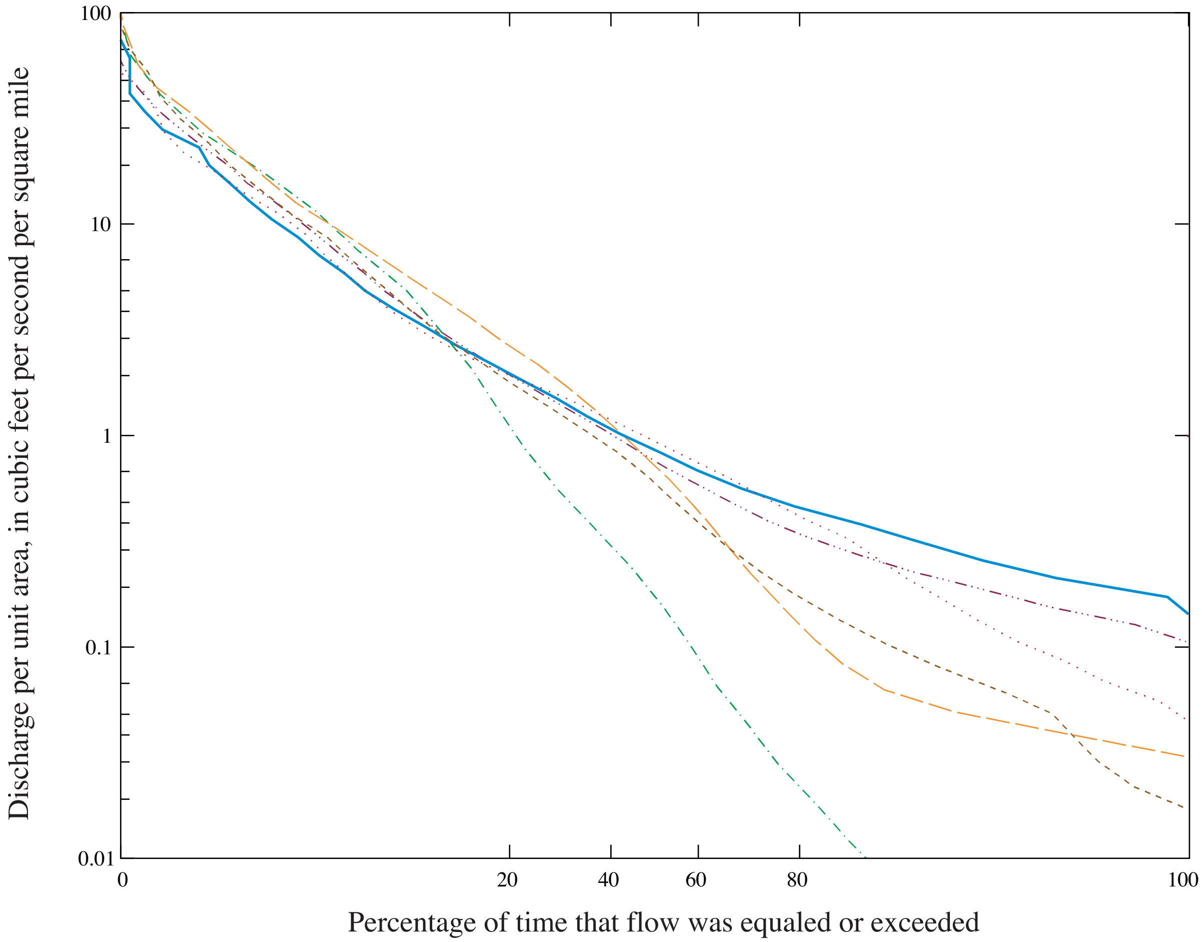


Figure 10. Locations and box plots of mean daily discharges for selected streamgaging stations for duration analysis representing the different physiographies in the Mobile River Basin.



EXPLANATION

Line type	Station number	Stream	Physiography	Drainage area (mi^2)
	02424000	Cahaba River	Valley and Ridge	1027
	02421000	Catoma Creek	Black Prairie Belt	290
	02450000	Mulberry Fork	Cumberland Plateau	365
	02422500	Mulberry Creek	Fall Line Hills	203
	02469800	Satilpa Creek	Southern Hills	164
	02412000	Tallapoosa River	Piedmont	448

Figure 11. Duration curves for selected streamgaging stations representing the different physiographies in the Mobile River Basin.

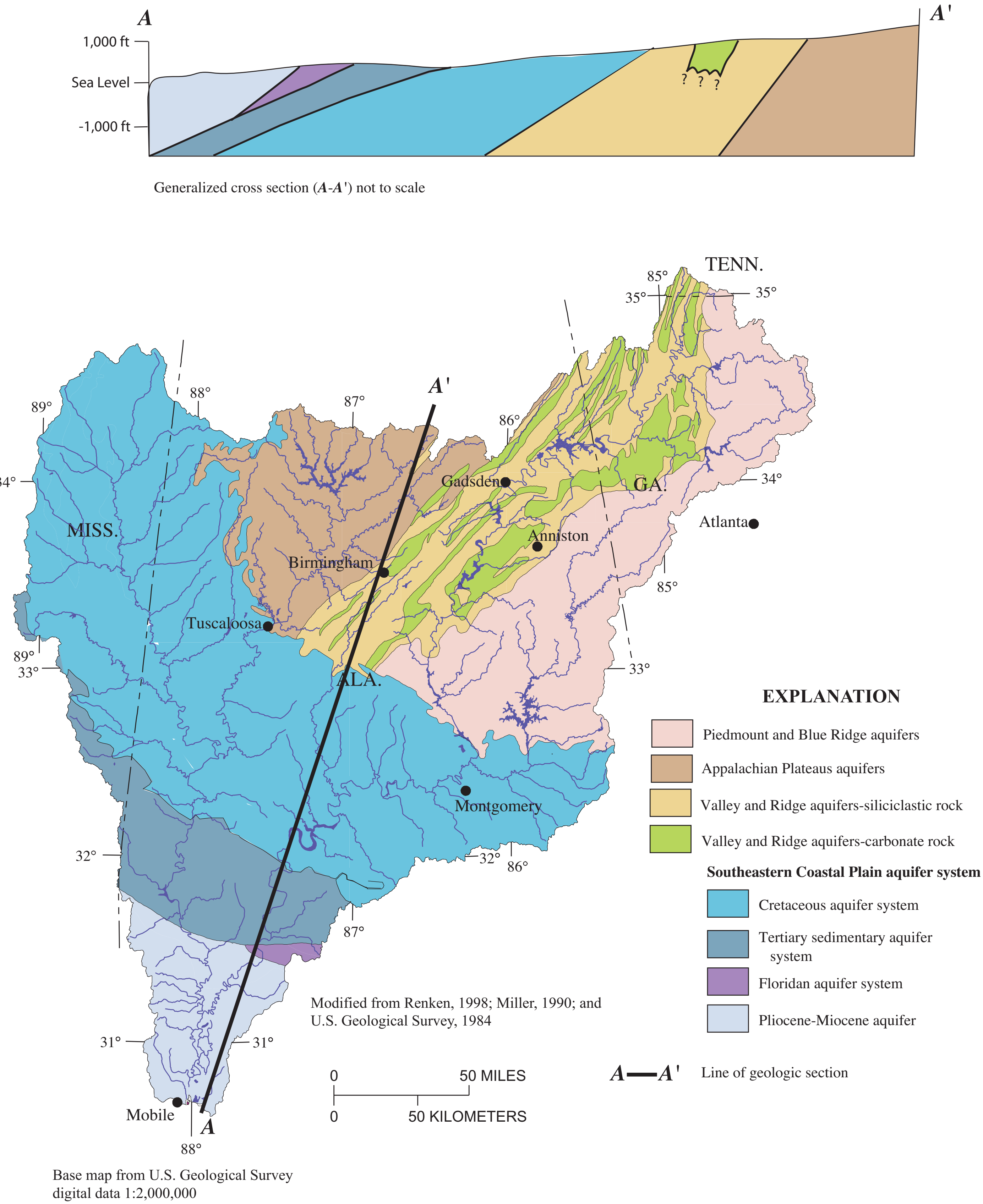


Figure 12. Major aquifer systems and generalized section in the Mobile River Basin.

Table 2. Generalized major aquifers in the Mobile River Basin

[From: U.S. Geological Survey, 1984; Mooty and Kidd, 1997; Robinson and others, 1997; Kidd and others, 1997; and Journey and Atkins, 1997.]

Major aquifer	Lithology	Geologic age	Aquifer type
Southeastern Coastal Plain aquifer system Cretaceous aquifer system	Sand and gravel of the Gordo, Coker, Eutaw, and Ripley Formations.	Upper Cretaceous	Porous media
Tertiary sedimentary aquifer system	Sand, clay, gravely sand	Paleocene to Eocene	Porous media
Floridan aquifer system	Limestone	Eocene and Oligocene	Solution conduit
Pliocene-Miocene aquifer	Sand and gravel beds of Citronelle Formation.	Pliocene	Porous media
	Undifferentiated deposits of Miocene Series.	Miocene	
Valley and Ridge aquifers	Limestone, dolomite, chert	Paleozoic	Solution conduit
	Sandstone, shale, siltstone	Paleozoic	Fracture conduit
	Sand and gravel, sandstone, sandy chalk and clay.	Cenozoic	Porous media
Appalachian Plateaus aquifers	Limestone, dolomite, chert	Paleozoic	Solution conduit
	Sandstone, shale, siltstone	Paleozoic	Fracture conduit
Piedmont and Blue Ridge aquifers	Quartzite, slate, gneiss, schist, marble, phyllite, and granite.	Precambrian to Paleozoic	Fracture conduit
	Regolith, soil, alluvium, colluvium, and saprolite.	Various ages	Porous media

coast, horizontal flow is blocked either by saltwater or by fine-grained sediments that reduce the permeability of the aquifer.

The Cretaceous aquifer system (table 2) is the basal aquifer of the Southeastern Coastal Plain aquifer system and is the most widespread of the regional aquifers in the system. The Cretaceous aquifer system consists of sand beds in the Providence Sand and the Ripley and Eutaw Formations and the Tuscaloosa Group, which includes the Gordo and Coker Formations (U.S. Geological Survey, 1984). The aquifers in this system are also known as the Chattahoochee River aquifer and the Black Warrior River aquifer (Miller, 1990). The confining units consist of chalk and clay beds in the western part of the Mobile River Basin and marine clay beds in the eastern part of the basin (Davis, 1988).

The Tertiary sedimentary aquifer system (table 2) is a thick sequence of sand with minor sandstone and gravel and a few limestone beds. The sediments composing the aquifer range in age from Paleocene to late Eocene and were deposited mostly in marine environments. The aquifer is equivalent to the Mississippi embayment aquifer system to the west and southwest and to the Pearl River aquifer in Alabama. The Tertiary sedimentary aquifer system and the Floridan aquifer system are hydraulically connected. Locally, the upper part of the Tertiary sedimentary aquifer system is known as the Lisbon aquifer and the lower part as the Nanafalia-Clayton aquifer.

The Floridan aquifer system (table 2) consists of limestone of Eocene and Oligocene age. The solution-conduit aquifer occurs in sandy carbonate rocks that have little primary porosity or permeability. Water moves through secondary porosity features, such as solution-enlarged fractures and bedding planes that form a system of interconnected conduits (Kidd and others, 1997). The Floridan aquifer system is a minor contributor of ground water in the Mobile River Basin, but is an important, high yielding aquifer in southeastern Alabama, Georgia, and Florida.

The Pliocene-Miocene aquifer (table 2) is present in the southern part of the Mobile River Basin in southwestern Alabama (fig. 12). This aquifer, the youngest regional aquifer in the Southeastern Coastal Plain aquifer system, consists of sand and gravel beds in the Citronelle Formation of Pliocene age and sand beds in the undifferentiated Miocene Series (U.S. Geological Survey, 1984). The aquifer is a source of domestic and public water supplies over extensive areas of southern Alabama (Kidd and others, 1997). The Citronelle Formation is a water-table aquifer with discontinuous sand beds controlling water levels locally (Davis, 1988). The Pliocene-Miocene aquifer is also known as the Chickasawhay River aquifer and is considered part of the Coastal Lowlands aquifer system.

Valley and Ridge Aquifers

Aquifers in the Valley and Ridge Physiographic Province consist of permeable geologic formations within folded and faulted Paleozoic sedimentary rocks. The rocks range in age from early to late Paleozoic. Most of the Valley and Ridge aquifers consist of limestone or dolomite. The carbonate rocks are productive aquifers primarily because of the solution openings in the easily dissolved limestone and dolomite. These openings, which originate as bedding planes and joints in the carbonate rocks, are enlarged by percolating slightly acidic ground water, and become linked as a series of conduits that rapidly transmit large volumes of ground water through the carbonate rocks. The easily eroded carbonate rocks form wide valley floors, which are favorable areas for recharge. Other aquifers consist of sandstone formations but yield less water than do the carbonate rocks. Much of the water from the sandstone is obtained from fractures (Mooty and Kidd, 1997). Regolith, which acts as a porous media aquifer above the carbonate-rock aquifers, contains chert rubble of Cenozoic age that stores and transmits water slowly to the underlying fractured-rock aquifer (Robinson and others, 1997).

Appalachian Plateaus Aquifers

Aquifers in the Cumberland Plateau section of the Appalachian Plateaus Physiographic Province consist of permeable stratigraphic units within flat-lying sedimentary rocks of Paleozoic age. Rocks comprising the aquifers are mostly sandstone, conglomerate, and coal of Pennsylvanian age, but in places include beds of limestone and chert of Mississippian age. A thick sequence of shale, sandstone, and coal overlies Mississippian limestone. Sandstone beds yield small volumes of water, but supply water to a large number of domestic wells because sandstone caps most of the upland plateaus in the Mobile River Basin (Stricklin, 1989).

Most of the water in both limestone and sandstone is present in fractures. In the limestone, the circulation of slightly acidic ground water has enlarged fractures by dissolution of the carbonate rock. Where vertical fractures extend to the land surface, the enlarged solution conduits may become completely or partially filled with sediment transported into them by surface streams. Where unfilled, these solution openings convey large volumes of water (Miller, 1990).

Flow in the Appalachian Plateaus aquifers is affected primarily by topography, structure, and the development of solution openings in the rocks. Recharge to the aquifers is by precipitation on the flat, mesa-like plateau tops. Water then percolates down through the interbedded Pennsylvanian rocks, primarily along steeply inclined joints and fractures. In places, shale beds retard the vertical flow and some water flows laterally along bedding planes, mostly in sandstone and conglomerate beds, and discharges as spring flow along steep valley walls. Some of the water migrates down across the thick shale confining unit into the underlying limestone aquifer (Miller, 1990).

Piedmont and Blue Ridge Aquifers

The crystalline-rock aquifers that underlie the Piedmont and Blue Ridge Physiographic Provinces in the northeastern part of the Mobile River Basin are collectively called Piedmont and Blue Ridge aquifers (Miller, 1990). Although there are considerable differences in the mineralogy and texture of the rocks composing the Piedmont and Blue Ridge aquifers, the overall hydraulic characteristics of the aquifers are similar. Locally, however, the occurrence and availability of ground water varies greatly because of the complex variability in rock type. Such variability of rock type makes describing regional ground-water flow impractical.

The Piedmont and Blue Ridge aquifers consist of crystalline bedrock overlain by regolith (unconsolidated material). Included in the regolith are: saprolite, which is a layer of earthy, decomposed rock developed by weathering of the bedrock; alluvium, which is mainly confined to stream valleys; colluvium, which consists of material transported downslope by weathering; and soil that develops on top of these layers. Because the crystalline rocks are formed under intense heat and pressure, they have few primary pore spaces, and the porosity and permeability of the unweathered and unfractured bedrock are extremely low. This does not mean, however, that these rocks will not yield water. Ground water can be obtained from the regolith and fractures in the rock. Locally, where the crystalline rocks consist of marble, the dissolving action of slightly acidic ground water has created solution openings that yield large volumes of water (Miller, 1990).

Water in the rocks of the Piedmont and Blue Ridge aquifers generally is unconfined. Locally, artesian conditions exist where wells penetrate deeply buried fractures that are hydraulically connected to recharge areas of higher altitudes or in places where the regolith is clayey and forms a confining unit (Kidd, 1989). Water enters the ground in recharge areas, which include all the land surface except the lower parts of valleys, and then percolates vertically downward through the unsaturated zone. Water reaches the saturated zone (water table) and moves laterally to points of discharge. Water discharges as springs, seeps, base flow to streams, and seepage to lakes. The water table is a subdued replica of the surface topography. The depth to the water table varies, depending mainly on topography and to a lesser extent on rainfall (Robinson and others, 1997).

Ecoregions

Areas where ecological systems are generally similar are identified as ecoregions. Ecoregions are based on coincident patterns of natural factors such as geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology (Omernik, 1987; Griffith and others, 1998). Ecoregions can provide a framework for assessing ecological conditions with respect to the natural environmental setting.

In an ecoregion hierarchy established by Omernik (1987), a Roman numeral classification scheme was adopted to prevent confusion caused by terminology associated with the different hierarchical levels. Level I divides the North American continent into 15 major ecological regions. Level II subdivides the 15 major ecological regions into 52 classes, and Level III further subdivides the 52 classes into 120 classes. The U.S. Environmental Protection Agency (U.S. EPA) has identified the following six Level III ecoregions (fig. 13) within the Mobile River Basin: (1) Southern Coastal Plain ecoregion lies within the deltaic part of the Alluvial-Deltaic Plain Physiographic district; (2) Southeastern Plains ecoregion lies within the remaining Coastal Plain Physiographic Province; (3) Southwestern Appalachians ecoregion is located in the Cumberland Plateau Physiographic Province and extends into the noncarbonate rock (ridges) of the Valley and Ridge Physiographic Province and the western part of the Piedmont Physiographic Province; (4) Ridge and Valley ecoregion includes the carbonate valleys of the Valley and Ridge Physiographic Province; (5) Piedmont ecoregion includes the eastern part of the Piedmont Physiographic Province; and (6) Blue Ridge Mountains ecoregion covers the higher altitude areas of the Piedmont, Valley and Ridge, and Blue Ridge Physiographic Provinces in the northeastern part of the basin (U.S. Environmental Protection Agency, 2000). The degree of overlap between the ecoregions and the physiography and geology of the basin indicates that the natural variations in the physiography and geology are reflected in the ecological systems.

The Southern Coastal Plain extends from South Carolina and Georgia, through much of central Florida, and along the Gulf coast lowlands of the Florida Panhandle, Alabama, and Mississippi (Omernik, 1987). In the Mobile River Basin, the ecoregion is drained by the distributaries of the Mobile Delta and freshwater streams which, in turn, drain to Mobile Bay. These meandering, low-gradient, and sandy-bottomed streams flow across flat, swampy plains and bottomlands that characterize the topography in this ecoregion. Surface elevation ranges from sea level to approximately 100 feet above sea level. The Southern Coastal Plain landscape supports forest and woodland areas with some cropland and pasture. Once covered by a forest of beech, sweetgum, southern magnolia, slash pine, loblolly pine, white oak, and laurel oak, land cover in the ecoregion is now mostly longleaf-slash pine forest, oak-gum-cypress forest in some low-lying areas, pasture for beef cattle, and urban areas (Glenn Griffith, U.S. Environmental Protection Agency, written commun., 2000).

The Southeastern Plains ecoregion covers an extensive part of the Mobile River Basin. The landscape is smooth to irregular plains or flatlands separated in some places by curved bands of asymmetrical ridges and rugged hills. Surface elevation ranges from as little as 25 feet above sea level in the southernmost plains to over 400 feet above sea level in the hills. The streams draining this ecoregion are generally low gradient with silty and sandy substrates. Forest and woodland areas are prevalent and are a part of the mosaic of cropland, pasture, and urban areas which dot the landscape. The natural vegetative cover includes oak, hickory, pine, and southern mixed forests. The dominant soils are formed from the weathering of the underlying clastic sediments and are better drained than soils of the Southern Coastal Plain. Soils overlying clayey or chalk deposits, however, are poorly drained.

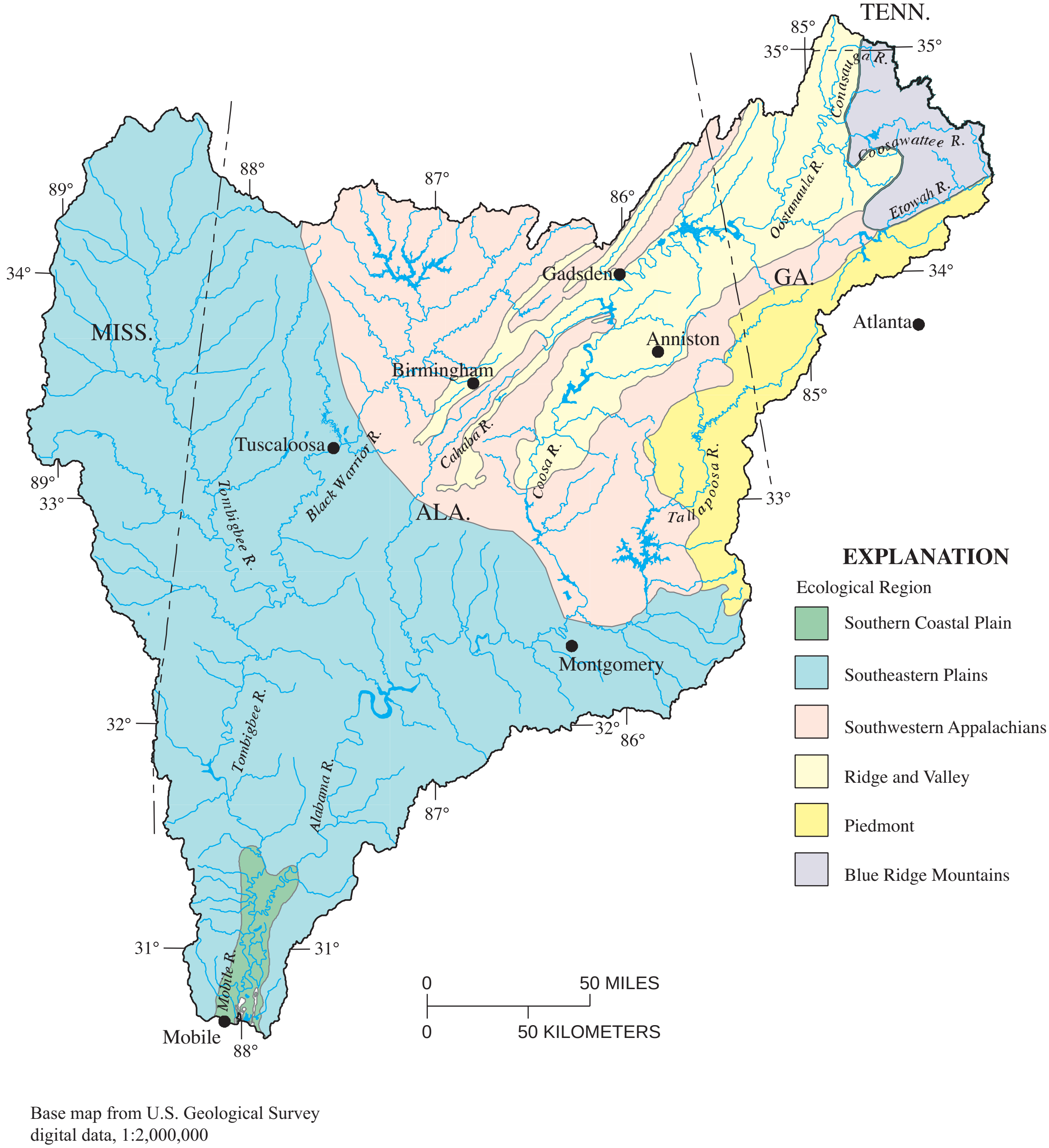


Figure 13. Ecological regions of the Mobile River Basin. (Modified from Omernik, 1987.)

The Southwestern Appalachians ecoregion extends from Kentucky to Alabama. These open low mountains contain a mosaic of forest and woodland with some cropland and pasture. The landscape is dominated by plateaus, hills, and mountains and is drained by streams of moderate gradient with cobble, gravel, and bedrock substrates. The surface elevation ranges from about 250 feet above sea level in the southwest to about 1,100 above sea level in the northeast. Oak, hickory, pine, and mixed forest of maple, tuliptree, oak, and linden are the natural forest cover for this area (Omernik, 1987).

The Ridge and Valley ecoregion ranges in elevation from 600 to over 1,600 feet above sea level and is drained by moderate to high-gradient streams with cobble, gravel, and bedrock substrates. As a result of extreme folding and faulting, the roughly parallel ridges and valleys vary in width, height, and geologic materials, including limestone, dolomite, shale, siltstone, sandstone, chert, mudstone, and marble. Springs and caves are numerous. Cropland and pasture are prevalent with some woodland and forest. The dominant vegetative cover is Appalachian oak forest.

The northeast-southwest trending Piedmont ecoregion, considered the nonmountainous part of the old Appalachian Highlands by physiographers, is a transitional area between the mostly mountainous ecoregions of the Appalachians to the northwest and the relatively flat coastal plain to the southeast. The area is underlain by Precambrian and Paleozoic metamorphic and igneous rocks with moderately dissected irregular plains with some hills. Surface elevation ranges from about 500 to 600 feet above sea level to the southwest in Alabama, to 1,500 to 1,700 feet above sea level in Georgia near the foot of the Blue Ridge Mountains. Once largely cultivated, much of this region has reverted to pine and hardwoods. The soils are finer textured and lower in organic matter and nutrients than the soils of the coastal plain regions.

The Blue Ridge Mountains ecoregion extends from southern Pennsylvania to northern Georgia, varying from narrow ridges to hilly plateaus to more massive mountainous areas with high peaks. The Blue Ridge Mountain part of the Mobile River Basin is in the northeasternmost part of the basin. This ecoregion accounts for only a small amount of the entire basin but has distinctive characteristics. The rugged mountains and ridges have surface elevations ranging from about 3,000 to 4,700 feet above sea level and are drained by high-gradient streams with cobble, gravel, and bedrock substrates. The landscape is covered mostly by ungrazed woodlands and forests.

Aquatic Ecology

The diverse aquatic habitats in the Mobile River Basin sustain one of the richest aquatic fauna in North America. The basin's endemic fauna include 40 fishes, 33 mussels, 110 aquatic snails, as well as a variety of turtles, aquatic insects, and crustaceans (U.S. Fish and Wildlife Service, 1998a). However, contaminants and modification of aquatic habitat such as impoundments, channelization, dredging, and mining over the past few decades have resulted in the presumed extinction of at least 15 mussels and 38 aquatic snails (Appendix A). The basin also has 39 species of aquatic animals and plants that are currently protected under the Endangered Species Act of 1973 (U.S. Fish and Wildlife Service, 1986), including 11 fish, 17 mussels, 7 snails, 2 turtles, and 2 plants (Appendix B). A review of other candidate species may substantially increase the number of species listed under the act (U.S. Fish and Wildlife Service, 1998b).

The Endangered Species Act of 1973 was established by the Federal government to protect endangered species. This act groups species in peril into two categories: endangered or threatened. A species is considered endangered when it is in danger of becoming extinct throughout all or a significant portion of its range. A threatened species is likely to become endangered in the near future in all or a significant part of their range (U.S. Fish and Wildlife Service, 1986).

Cultural Factors

Human activities have affected water quality and quantity in the Mobile River Basin. A series of locks and dams on rivers throughout the basin have increased flood control, improved navigation, provided hydroelectric power, and promoted many recreational activities. These dams also have had negative effects on the aquatic ecology of the region. The presence of the dams have resulted in lowered temperatures and dissolved oxygen concentrations in the tailwaters of the dams, thus adversely affecting the natural aquatic population and the distribution of fish. The lakes impounded by these dams now support different arrays of aquatic ecology than would be found in naturally free-flowing rivers. In addition to the physical alterations of the river system, as population growth in the Mobile River Basin has increased, forested and agricultural land use has changed to more urban and industrial applications, resulting in an increase in demand for water and other resources.

Study Unit Stratification

An environmental framework was developed for the Mobile River Basin to isolate the effects of natural and human factors that are thought to be the most important in affecting water quality and quantity. Characterizing this environmental framework is an important element in each study-unit investigation of the NAWQA Program. The environmental framework divides a study unit into several subareas (not necessarily contiguous) that have homogeneous combinations of those natural and human factors believed to be relevant to water quality (Gilliom and others, 1995). This process is called stratification. The identified strata provide a unique spatial framework to be used for (1) conducting a retrospective analysis of water quality, (2) evaluating study priorities and approaches for assessing water-quality conditions, (3) designing the monitoring program, and (4) making comparative assessments of water quality and ecosystems within the Mobile River Basin and among the hydrologic systems across the Nation. Natural factors in the Mobile River Basin include geology, physiography and aquifer systems. Human factors include agricultural land use, mining, forested land use, and urbanization.

The Mobile River Basin was stratified based on the physiography with the Alluvial-Deltaic Plain district of the Coastal Plain Physiographic Province separated into the Deltaic deposits and the Alluvial aquifer (fig. 14). Land and water use in the Mobile River Basin are evaluated based on this stratification. County-level data for agricultural and water-use activities and population distribution were weighted to provide estimates for each strata based on the area of the county within each strata. These weighting approaches may give inaccurate results in areas where the population distribution, water-use, or agricultural activities vary greatly across a county, but the error introduced in this step is not significant for the strata encompassing large areas and multiple counties.

Reservoirs

The surface-water system in the Mobile River Basin is regulated by 36 dams that influence the hydrology of the basin (fig. 8, table 3). Streamflow in the Alabama River is affected by 10 reservoirs and hydroelectric plants upstream in the Coosa River Basin; 4 reservoirs and hydroelectric plants on the Tallapoosa River; and 3 navigational locks and dams on the Alabama River. The Cahaba River, a major tributary to the Alabama River, drains 1,820 square miles in central Alabama and is the largest free-flowing river in the Mobile River Basin. The Cahaba River Basin has only one reservoir, Lake Purdy (table 3), on the Little Cahaba River. The Tombigbee River is affected by 12 navigational locks and dams on the main stem. The Black Warrior River, a main tributary to the Tombigbee River, is affected by four navigational locks and dams and two reservoirs, Lake Tuscaloosa and the Lewis Smith Reservoir (table 3). The Tombigbee River is part of the Tennessee-Tombigbee waterway.

The Tennessee-Tombigbee waterway, a 234-mile navigation channel connecting the Tombigbee River to the Tennessee River, was completed in 1985 and is the largest manmade water-resource project built in the United States. The major features of the waterway are 12 locks and dams, a 12-foot-deep and 280-foot-wide canal, and 234 miles of navigation channels. The 12 locks are used to raise or lower barges and boats a total of 341 feet, the difference in elevation between the two ends of the waterway (The Tennessee Tombigbee Waterway Development Authority, 2001).

Land Use

Based on 1991 land-use data (U.S. Environmental Protection Agency, 1992), about 70 percent of the basin is forested, while agriculture, including livestock, aquaculture, row crops, and pastureland, accounts for about 26 percent of the study unit. Agricultural land use (fig. 15) is concentrated in an area corresponding to the Black Prairie Belt district of the Coastal Plain Physiographic Province. No agricultural activities are associated with the Deltaic deposits due to the prevalence of poorly drained soils. Urban areas account for only 3 percent of the total land use; however, the areal coverage of the metropolitan statistical areas (MSA) may indicate more urban influences.

Agriculture

The primary row crops produced in the Mobile River Basin include corn, soybeans, cotton, wheat, and sorghum. Cultivation of corn is well distributed throughout the Coastal Plain Physiographic Province with the greatest acreage in the Southern Hills and Fall

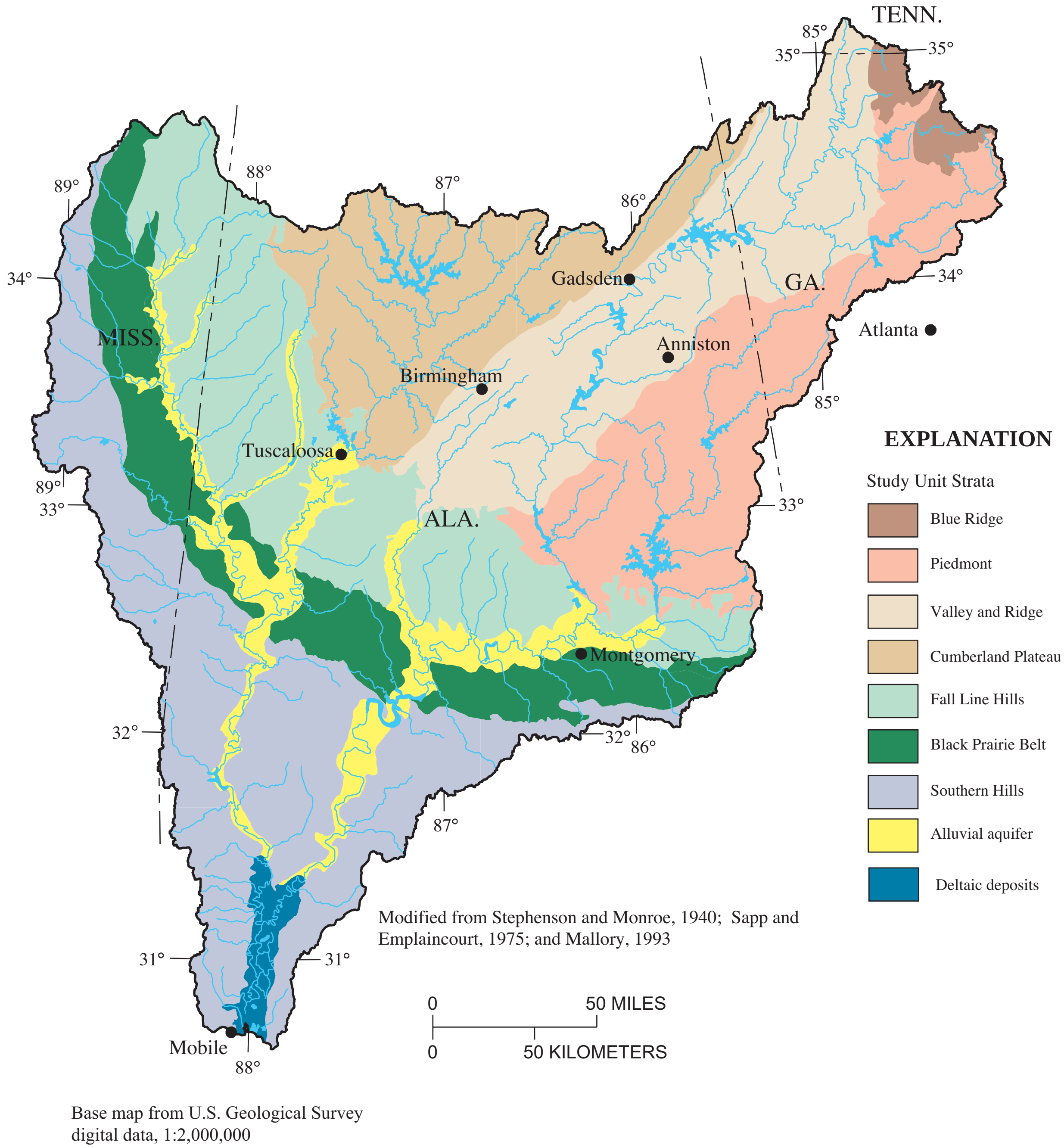


Figure 14. Study unit stratification of the Mobile River Basin.

Table 3. Dams and associated impoundments in the Mobile River Basin

[mi², square miles; --, data not available; FC, flood control; N, navigation; P, power; WS, water supply; WQ, water quality; FW, fish and wildlife; R, recreation; USACOE, U.S. Army Corps of Engineers; APC, Alabama Power Company]

No. (see fig. 8)	Name of dam	Associated impound-ment	River	Agency	Date constructed or operational	Princi-pal use	Location	River mile	Total drainage area (mi^2)	Full power or normal pool data	
										Surface area (acres)	Storage capacity (acre-feet)
						Coosa River Subbasin					
1	Carters	Carters Lake	Coosawatte River	USACOE	1974	P, FC, R	Murray County, Ga.	[5]26.8	[4]373	[4]3,220	[1]472,800
2	Carters re-regula-tion	--	Coosawatte River	USACOE	1975	P, FC, R	Murray County, Ga.	[5]25.3	[5]520	--	[1]17,600
3	Allatoona	Allatoona Lake	Etowah River	USACOE	1949	P, FC, R	Bartow County, Ga.	[5]47.0	[4]1,120	[4]19,200	[1]367,000
4	Weiss	Weiss Lake	Coosa River	APC	1961	P, FC, R	Cherokee County, Ala.	[2]226.1	[2]5,270	[4]28,300	[2]360,400
5	H. Neely Henry	H. Neely Henry Reser-voir	Coosa River	APC	1966	P, FC, R	Calhoun County, Ala.	[2]146.8	[2]6,596	[4]11,235	[2]120,850
6	Logan Mar-tin	Logan Martin Reservoir	Coosa River	APC	1964	P, FC, R	St. Clair County, Ala.	[2]98.5	[2]7,743	[4]15,260	[2]273,300
7	Lay	Lay Lake	Coosa River	APC	1914 1968	P, FC	Chilton County, Ala.	[2]51.0	[2]9,053	-- [4]6,700	[2]144,994 [2]262,774
8	Mitchell	Mitchell Lake	Coosa River	APC	1923	P, R	Chilton County, Ala.	[2]36.8	[2]9,778	[4]5,800	[2]172,000
9	Jordan	Jordan Lake	Coosa River	APC	1929	P, R	Elmore County, Ala.	[2]18.9	[2]10,102	[4]4,800	[2]236,200
10	Walter Bouldin	Jordan Lake Diversion	Coosa River	APC	1967	P	Elmore County, Ala.	--	--	[4]920	[4]230,000
						Tallapoosa River Subbasin					
11	Harris	Harris Reser-voir	Tallapoosa River	APC	1982	P, FC, R	Randolph County, Ala.	[2]139.0	[2]1,453	--	--
12	Martin	Lake Martin	Tallapoosa River	APC	1926	P, FC, R	Tallapoosa County, Ala.	[2]60.6	[2]2,984	[4]38,300	[4]250,000
13	Thurlow	Thurlow Res-ervoir	Tallapoosa River	APC	1930	P	Tallapoosa County, Ala.	[6]49.7	[6]3,308	[4]585	[4]11,000
14	Yates	Thurlow Res-ervoir	Tallapoosa River	APC	1928	P, R	Tallapoosa County, Ala.	[6]52.7	[6]3,293	[4]1,920	[4]26,000

Table 3. Dams and associated impoundments in the Mobile River Basin—Continued

No. (see fig. 8)	Name of dam	Associated impound-ment	River	Agency	Date constructed or operational	Princi-pal use	Location	River mile	Total drainage area (mi^2)	Full power or normal pool data	
										Surface area (acres)	Storage capacity (acre-feet)
Cahaba River Subbasin											
15	Lake Purdy	Lake Purdy	Little Cahaba River	Birming-ham Water Works Board	1911 ([4]1964)	WS, R, FC	Jefferson County, Ala.	[8]4.3	[4]46.0	[4]1,050	[3]17,500
Alabama River Basin											
16	Robert F. Henry Lock and Dam	[4]Jones Bluff Lake	Alabama River	USACOE	1971	P, N, R	Lowndes County, Ala.	[6]245.4	[4]16,300	[4]12,510	[4]234,200
17	Millers Ferry Lock, Dam, and Powerhouse	William "Bill" Dannelly Lake	Alabama River	USACOE	1970	P, N, R	Wilcox County, Ala.	[6]142.3	[4]20,700	[4]17,200	[4]331,800
18	Claiborne Lock and Dam	Claiborne Lake	Alabama River	--	1969	N	Monroe County, Ala.	[6]81.8	[6]21,473	[4]5,930	[4]96,360
Black Warrior Subbasin											
19	John Hollis Bankhead Lock and Dam	Lake Bank-head	Black Warrior River	APC	1928 (1975)	N	Jefferson County, Ala.	[2]153.6	[2]3,981	[4]9,200	112,000 (usable capacity) [4]288,000
20	Holt Lock and Dam	Holt Lake	Black Warrior River	USACOE	1976	N	Tuscaloosa County, Ala.	[2]135.1	[2]4,219	[4]3,296	115,000 (usable capacity)
21	William Bacon Oliver Lock and Dam	William Bacon Oliver Lake	Black Warrior River	USACOE	[4]1940	N	Tuscaloosa County, Ala.	[2]125.9	[2]4,820	[4]2,220	[4]12,500
22	Selden Lock and Dam	Warrior Lake	Black Warrior River	USACOE	1946	N	Hale County, Ala.	[2]49.6	[2]5,810	[4]7,800	[4]54,000
23	Lewis Smith	Lewis Smith Reservoir	Sipsey Fork River	APC	1960	P, FC	Walker County, Ala.	[2]13.5	[2]945	[4]21,000	394,000
24	Lake Tusca-loosa Dam	Lake Tuscaloosa	Black Warrior River	City of Tusca-loosa	1971	WS, FC, R	Tuscaloosa County, Ala.	--	[2]416	[4]5,885	[4]130,000
Tombigbee River Basin											
25	Aberdeen Lock and Dam	Aberdeen Lake	Tombigbee River	USACOE	1981	N	Monroe County, Miss.	[6]363.0	[4]2,170 [6]2,047	[4]4,121	[4]31,564
26	Whitten Lock and Dam	Bay Springs Lake	Tombigbee River	USACOE	1985	N	Tisho-mingo County, Miss.	--	[4]68.2	[4]6,700	[4]180,000

Table 3. Dams and associated impoundments in the Mobile River Basin—Continued

No. (see fig. 8)	Name of dam	Associated impound-ment	River	Agency	Date constructed or operational	Princi-pal use	Location	River mile	Total drainage area (mi²)	Full power or normal pool data	
										Surface area (acres)	Storage capacity (acre-feet)
Tombigbee River Basin—Continued											
27	Stennis Lock and Dam	Columbus Lake	Tombigbee River	USACOE	1978	N	Lowndes County, Miss.	[6]325.3	[4]4,440	[4]8,910	[4]59,483
28	Amory Lock	Lock "A" Pool	Tombigbee River	USACOE	1981	N	Monroe County, Miss.	--	--	[7]914	--
29	Glover Wilkins Lock	Lock "B" Pool	Tombigbee River	USACOE	1981	N	Monroe County, Miss.	--	[4]1,226	[4]2,718	[4]19,039
30	Fulton Lock	Lock "C" Pool	Tombigbee River	USACOE	1981	N	Lowndes County, Miss.	--	--	[4]1,642	[4]13,221
31	John Rankin Lock	Lock "D" Pool	Tombigbee River	USACOE	1985	N	Itawamba County, Miss.	--	--	[4]1,992	[4]24,869
32	G.V. "Sonny" Montgom-ery Lock	Lock "E" Pool	Tombigbee River	USACOE	1985	N	Itawamba County, Miss.	--	--	[4]851	[4]6,926
33	Tom Belville Lock and Dam	Aliceville Lake	Tombigbee River	USACOE	1979	N, R	Pickens County, Ala.	[6]287.4	[4]5,750	[4]8,300	[4]60,400
34	John C. Heflin Lock and Dam	Gainesville Lake	Tombigbee River	USACOE	1978	N, R	Greene County, Ala.	[6]238.8	[4]7,220	[4]6,400	[4]45,290
35	Demopolis Lock and Dam	Demopolis Lake	Tombigbee River	USACOE	1928 ([4]1955)	N	Marengo County, Ala.	[2]171.2	[2]15,385	[4]1,000	[4]150,000
36	Coffeville Lock and Dam	Coffeville Lake	Tombigbee River	USACOE	1960 ([4]1962)	N	Choctaw County, Ala.	[2]74.7	[2]18,417	8,500	[4]190,800

[1] Stokes and McFarlane (1994)
[2] Pearman and others (1997)
[3] Strickland (1994)
[4] Ruddy and Hitt (1990)
[5] U.S. Army Corps of Engineers (1985b)
[6] U.S. Army Corps of Engineers (1985a)
[7] The Tennessee Tombigbee Waterway Development Authority (2001)
[8] Rollins and others (1987)

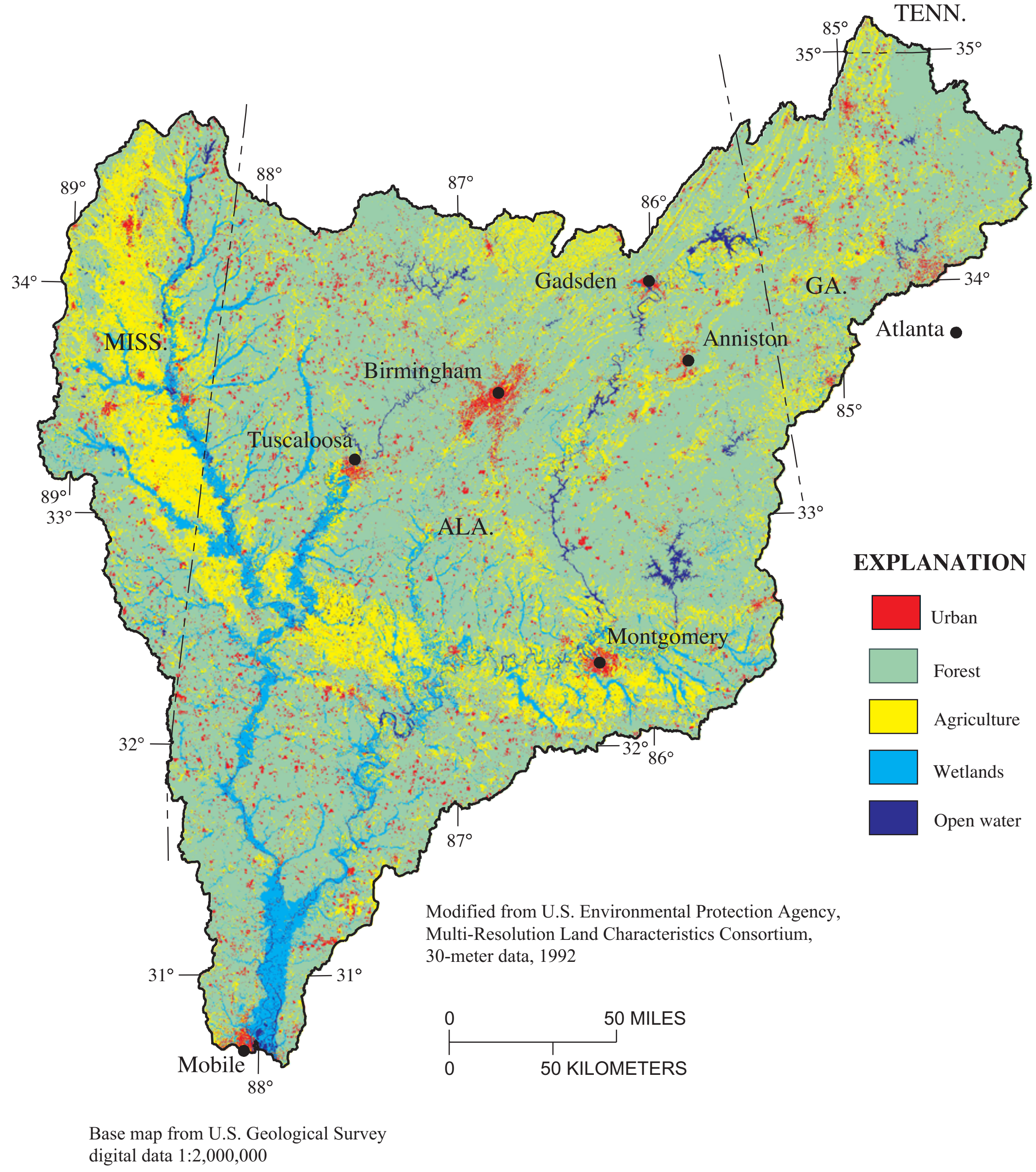


Figure 15. Land use in the Mobile River Basin.

Line Hills districts (figs. 16 and 17). Soybeans cover the greatest acreage and is almost as well distributed as corn with the greatest concentrations in Mississippi. Cotton is the second highest acreage crop and is concentrated in selected areas in the Valley and Ridge and Cumberland Plateau Physiographic Provinces and in the Coastal Plain Physiographic Province (Fall Line Hills district, Black Prairie Belt district, Southern Hills district, and Alluvial aquifer). The greatest acreage of wheat is concentrated in selected areas in the Southern Hills district, Black Prairie Belt district, and the Alluvial aquifer of the Coastal Plain Physiographic Province. Sorghum acreage is not as prevalent as other crops but is evenly distributed across the basin, except in the Blue Ridge Physiographic Province and in Deltaic deposits where no sorghum is produced (U.S. Department of Agriculture, National Agricultural Statistics Service, 1997).

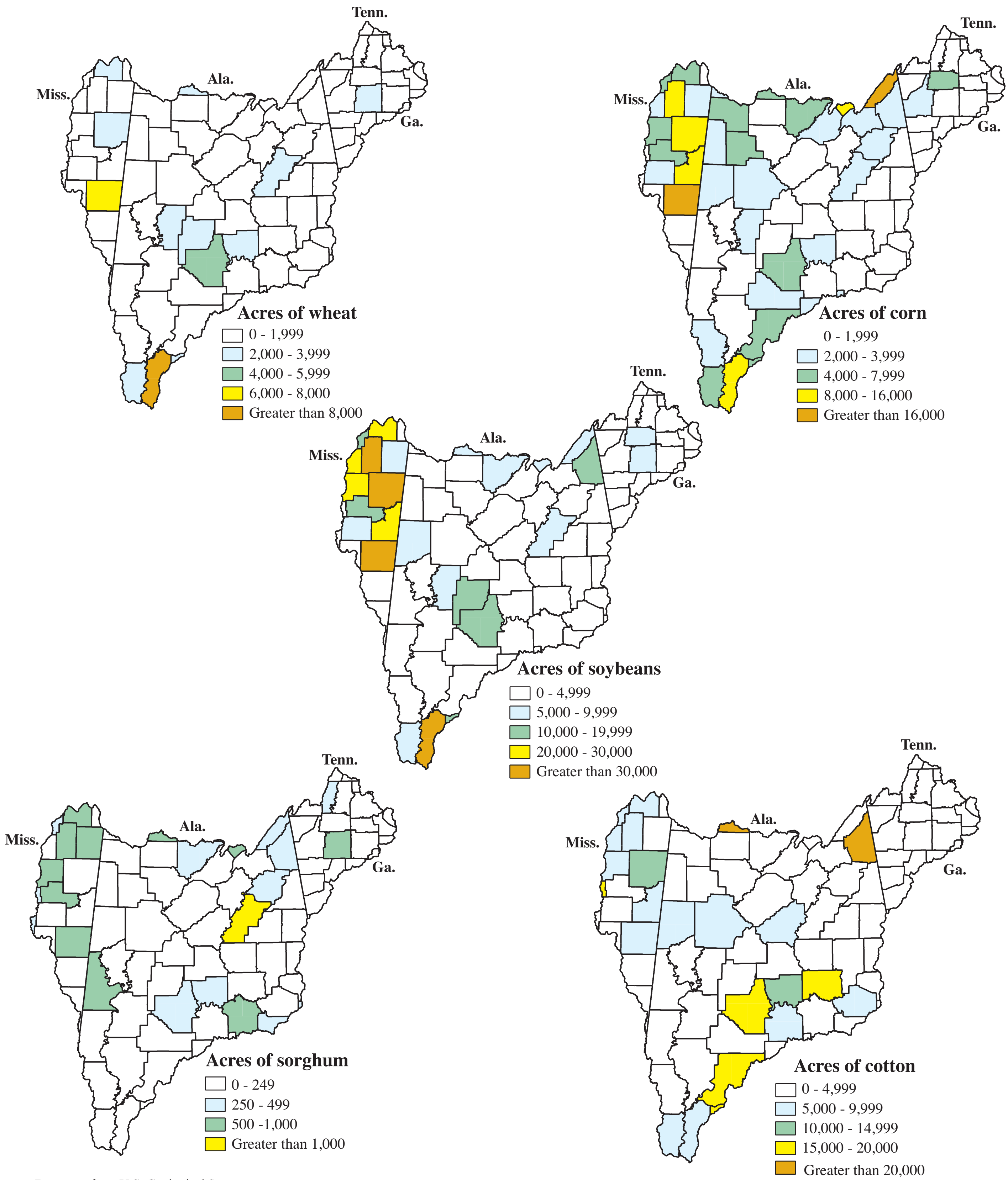
Livestock production in the Mobile River Basin includes poultry, cattle, and swine. The greatest density of swine production is in the Cumberland Plateau Physiographic Province (figs. 18 and 19). Poultry operations are concentrated in the northern part of the Mobile River Basin in Alabama and Georgia. Chicken production is greatest throughout the Blue Ridge and Cumberland Plateau Physiographic Provinces but also is prevalent in the Valley and Ridge and the Piedmont Physiographic Provinces. Broilers by far comprise the largest chicken operations. Cattle production is ubiquitous with the highest density of production in the Blue Ridge, Cumberland Plateau, and Valley and Ridge Physiographic Provinces. Few large cattle feedlots operate in the Mobile River Basin, and the majority of cattle are raised for beef on pastureland (U.S. Department of Agriculture, National Agricultural Statistics Service, 1997).

Urban

The total population for the Mobile River Basin was about 3,673,100 people in 1990 based on estimates of county population (U.S. Bureau of the Census, 2001). Urban areas account for only 3 percent of the total land use; however, the areal extent of the MSAs may indicate more urban influences. The MSAs include urban areas outside metropolitan boundaries and can include adjacent counties. Seven MSAs are delineated in the Mobile River Basin and include Montgomery, Mobile, Tuscaloosa, Birmingham, Gadsden, Anniston, and Atlanta (fig. 20). The cities with their entire MSAs included in the study area are Birmingham with a 1990 population of 839,942; Montgomery, 292,517; Tuscaloosa, 150,522; Anniston, 116,032; and Gadsden, 99,840 people (U.S. Bureau of the Census, 1998). Anniston lies entirely within the Valley and Ridge Physiographic Province whereas Birmingham and Gadsden lie mostly within the Valley and Ridge Physiographic Province with some area in the Cumberland Plateau Physiographic Province. Montgomery and Tuscaloosa lie mostly within the Alluvial aquifer of the Coastal Plain Physiographic Province, and Mobile lies mostly within the Southern Hills district of the Coastal Plain Physiographic Province. Part of the Atlanta MSA lies in the Piedmont Physiographic Province of the Mobile River Basin. The most concentrated areas of population lie within the Valley and Ridge and Cumberland Plateau Physiographic Provinces in Alabama and the Piedmont Physiographic Province in Georgia. The Blue Ridge Physiographic Province has the lowest overall population density but has the highest rate of growth, reflecting a 62-percent increase in population from 1970 to 1990 (table 4). The Piedmont Physiographic Province experienced a 60-percent growth from 1970 to 1990, resulting from urban sprawl in the Atlanta area. The Mobile River Basin experienced an overall growth of 23 percent for the same time period.

The population in urban areas is increasing faster than in rural areas, resulting in increasing water-quality concerns. Urban and residential areas can affect the quality and quantity of water resources by altering the physical hydrology and by adding waste products to water bodies. As urbanization increases, the amount of impervious area increases, thus decreasing the amount of water that would naturally infiltrate into the soil. Increased runoff can alter the magnitude and timing of storm peaks, increasing the likelihood of localized flooding. Urban runoff also can transport large nonpoint-source loads of sediment and inorganic and organic constituents from paved surfaces, parks, lawns, and golf courses. Point sources of contamination from urban areas can include sewage-treatment facilities, industrial discharges, landfills, and leaking underground storage tanks.

Nonpoint-source contamination in urban areas is a common contributor to water body impairment. Although associated with agricultural activities, pesticides and fertilizers are applied to urban land at greater rates per unit area than typically applied to agricultural land, thus contributing to water-quality impairment. Lawns, gardens, parks, and golf courses are subject to intense pesticide application. Insecticides used largely



Base map from U.S. Geological Survey
digital data 1:2,000,000

Figure 16. Agricultural crop production by county area in the Mobile River Basin for 1992. (Modified from U.S. Department of Agriculture, National Agricultural Statistics Service, 1997.)

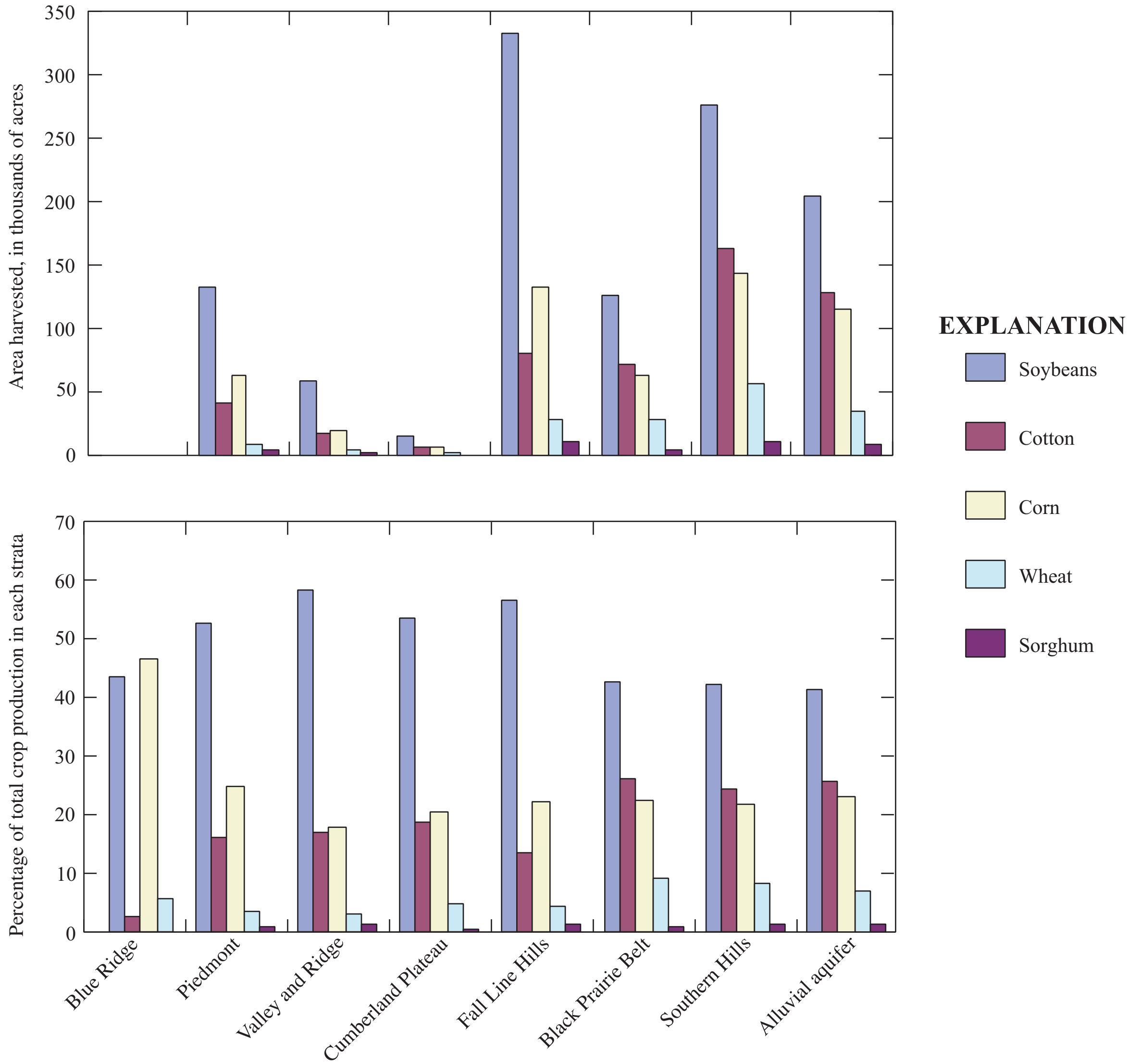
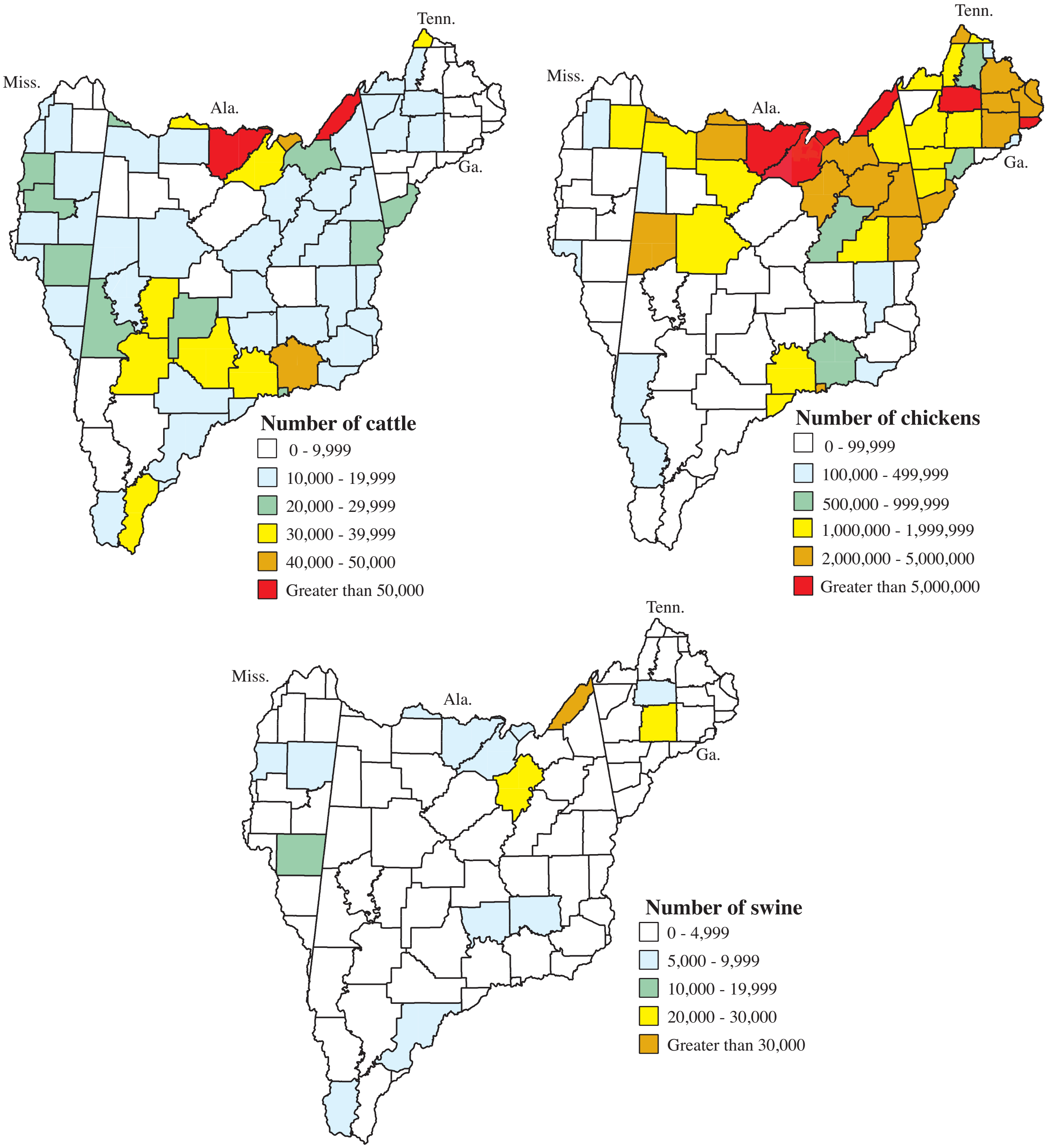


Figure 17. Agricultural crop production by strata for the Mobile River Basin in 1992.

around homes and in gardens, parks, and commercial areas are frequently detected in urban streams at levels of concern for aquatic life and may be a significant obstacle for restoring urban streams. Because chemical applications for urban use are not as stringently regulated as for agricultural purposes, the levels of pesticides found in streams in urban areas nationally generally is comparable to levels of pesticides found in streams in agricultural areas, with higher levels of herbicides in agricultural areas and higher levels of insecticides in urban areas (U.S. Geological Survey, 1999).

Mining

Coal mining, the predominant mineral extraction activity for the Mobile River Basin, is concentrated in the Cumberland Plateau and the Valley and Ridge Physiographic Provinces and some adjacent areas in the Fall Line Hills district in Alabama (fig. 21). Alabama ranks 15th in coal production among coal-producing states, yielding high-volatile A bituminous coal (U.S. Office of Surface Mining, 2000). Alabama has four coal fields that are part of the great Appalachian coal basin—Plateau, Warrior, Cahaba, and Coosa fields (fig. 21). Total coal reserves in Alabama are estimated at 4.8 billion tons; of that amount, an estimated 3.1 billion tons are recoverable reserves. Prior to 1986, surface mining was the predominate extraction method; but in 1999, about 75 percent of the coal was mined from underground. As of September 30, 2000, 27 permitted surface mines and 10 permitted underground mines were actively



Base map from U.S. Geological Survey
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Figure 18. Livestock production by county in the Mobile River Basin for 1992. (Modified from U.S. Department of Agriculture, National Agricultural Statistics Service, 1997.)

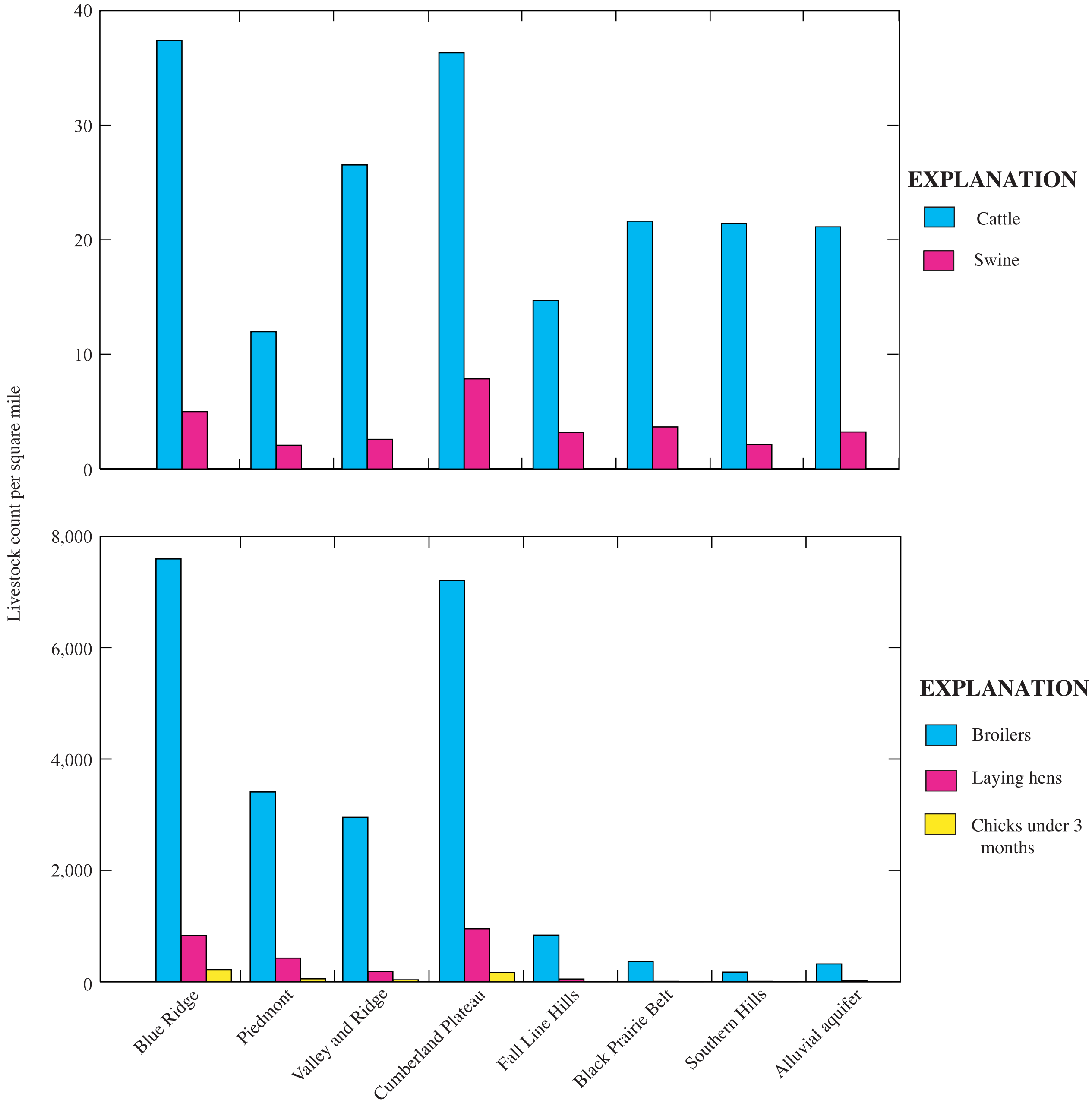


Figure 19. Livestock production by strata for the Mobile River Basin for 1992.

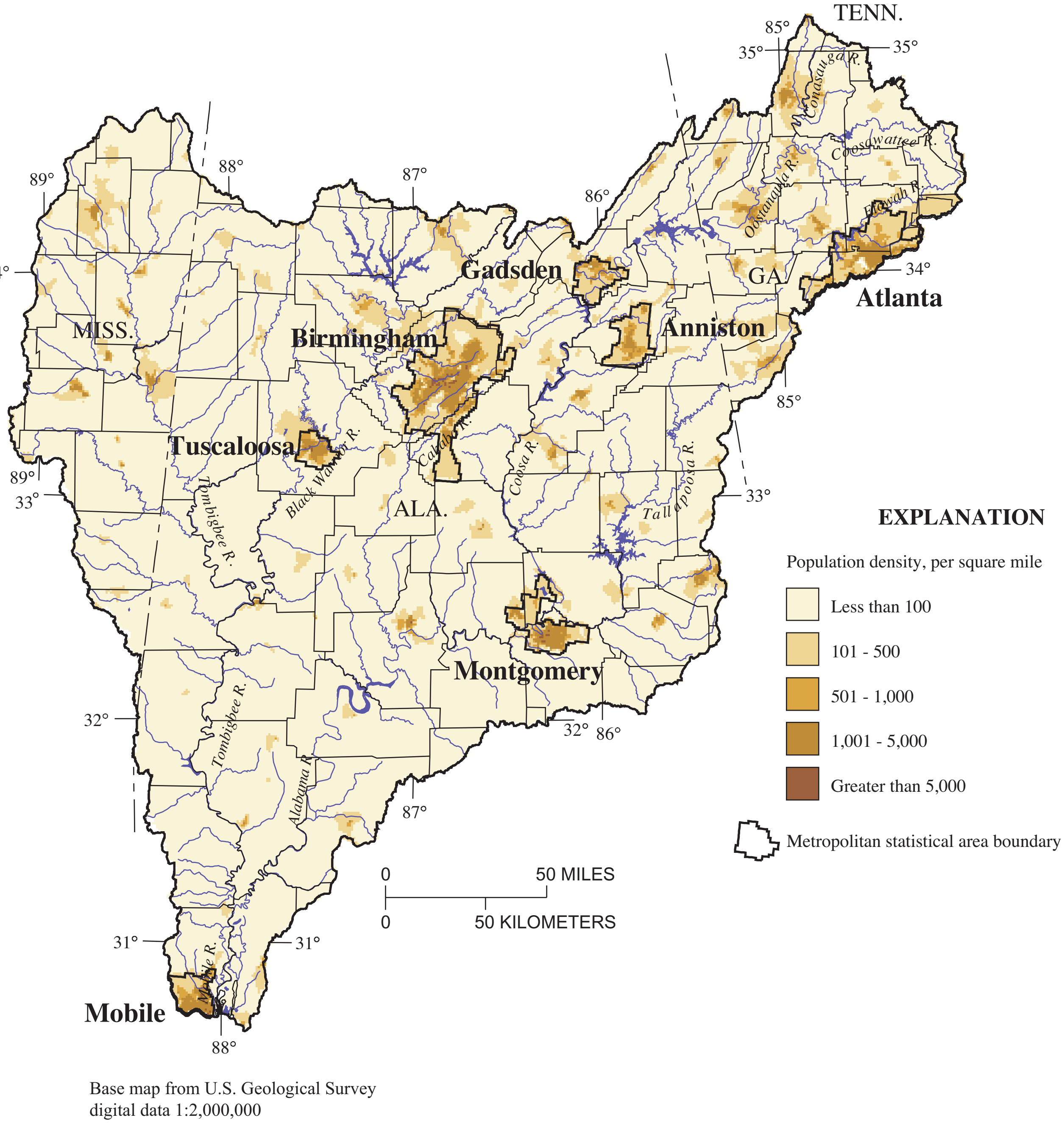


Figure 20. The 1990 population density and metropolitan statistical areas in the Mobile River Basin. (Modified from Price and Clawges, 1999.)

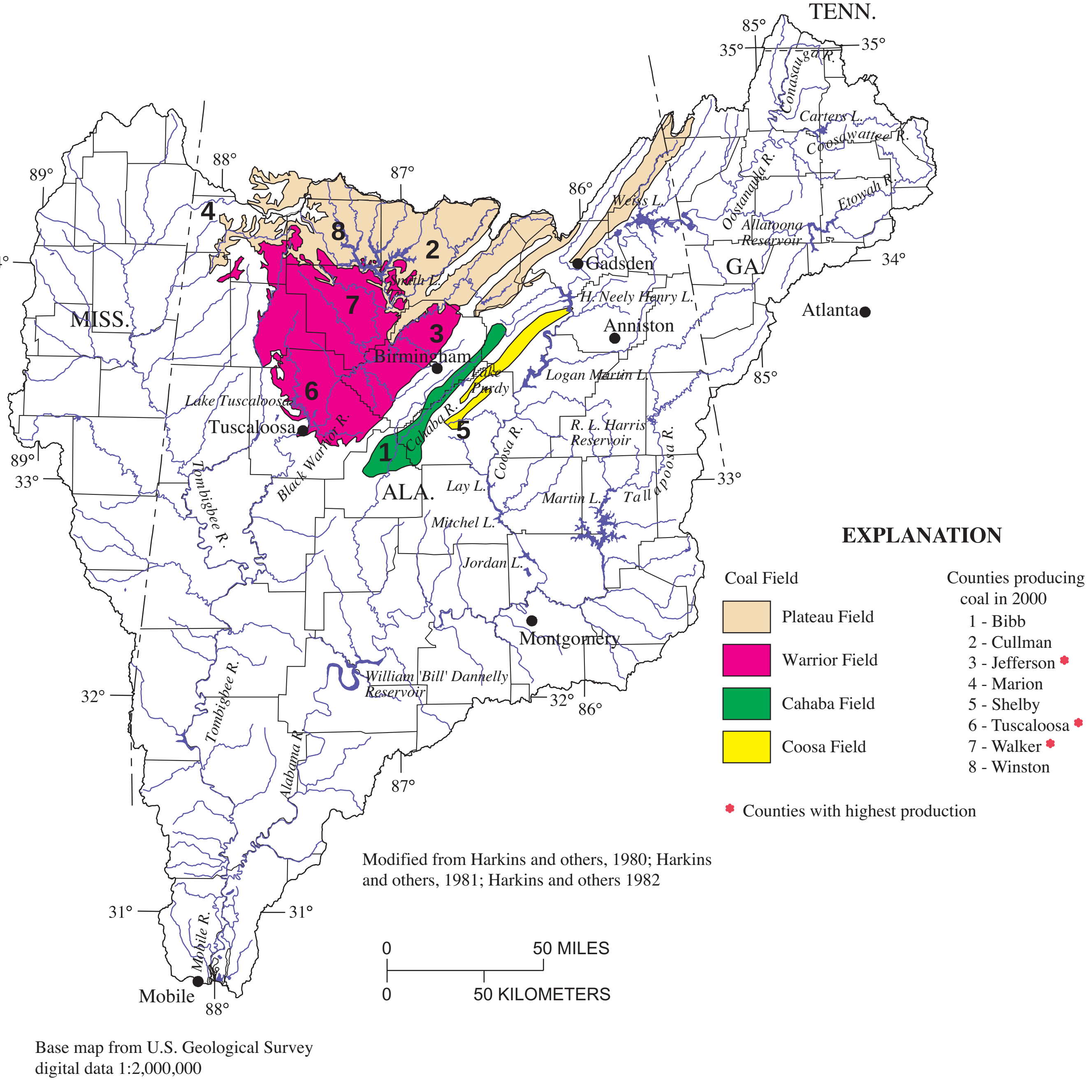


Figure 21. Coal fields of the great Appalachian coal basin located in the Mobile River Basin.

Table 4. Population in the Mobile River Basin by strata, 1970-90

[Data from the U.S. Bureau of the Census, 2001; mi^2, square miles; pop, population]

Strata	Population			Area (mi^2)	Density 1990 (pop/mi^2)	Population change	
	1970	1980	1990			1970-90	Percent
Deltaic deposits	38,900	45,900	50,000	508	98	11,100	29
Alluvial aquifer	140,800	156,300	159,000	3,123	51	18,200	13
Blue Ridge	14,700	18,800	23,800	542	44	9,100	62
Southern Hills district	361,700	402,500	411,700	9,156	45	50,000	14
Fall Line Hills district	296,300	344,800	353,700	7,497	47	57,400	19
Black Prairie Belt district	242,500	271,800	280,600	4,271	66	38,100	16
Cumberland Plateau	637,600	711,300	713,100	5,335	134	75,500	12
Valley and Ridge	836,100	963,000	1,024,900	6,820	150	188,800	23
Piedmont	411,200	515,600	656,300	6,427	102	245,100	60
Total for Mobile River Basin	2,979,800	3,430,000	3,673,100	43,679	84	693,300	23

producing coal in nine Alabama counties: Bibb, Cullman, Jackson (not in Mobile River Basin), Jefferson, Marion, Shelby, Tuscaloosa, Walker, and Winston. Approximately 85 percent of the coal comes from Jefferson, Tuscaloosa, and Walker Counties. In Alabama, approximately 103,300 acres have been identified as disturbed by surface coal mining and reclamation operations (U.S. Office of Surface Mining, 2000) (fig. 22). The abandoned strip mine areas are potential sources of acid mine drainage and sediment.

Water Use

The Mobile River Basin has abundant surface-water and ground-water resources. Water from streams and aquifers in the Mobile River Basin is used for municipal, industrial and rural water supplies, irrigation, and the generation of energy. Instream water uses include hydroelectric-power generation, wastewater assimilation, recreational boating, fish and wildlife habitat, and swimming.

Basinwide, surface-water use (excluding power generation) is about three and a third times greater than ground-water use (table 5) (Price and Clawges, 1999). The greatest surface-water use is for thermoelectric power generation where water is withdrawn for cooling and then discharged back into the water body. Consumptive water use for power generation in Alabama in 1995 was about 1 percent of the total water withdrawn for thermoelectric power generation (Price and Clawges, 1999). Water withdrawn for power generation is about an order of magnitude greater than that for any other water-use category and is greatest in the middle and southern parts of the Mobile River Basin (fig. 23). The next largest surface-water uses are industry and commercial use and public water supply. Most of the industrial and commercial usage is in the southern part of the study unit and near Gadsden, Ala., in the northern part of the study unit (fig. 23). Most (72 percent) of the public drinking-water supply in the basin is withdrawn from surface-water resources, and the spatial distribution generally corresponds to population densities. Mining and agricultural water use also correspond to those land-use activities.

Table 5. Estimated water use in the Mobile River Basin, 1995

[Mgal/d, million gallons per day; data from Price and Clawges, 1999]

Category	Total withdrawal (Mgal/d)	
	Surface water	Ground water
Public water supply	518	200
Domestic water supply	0	50.3
Power generation	3,035	2.6
Industrial and commercial	457.6	47.1
Mining	7.4	4.1
Livestock	94.3	16.4
Irrigation	40.6	15.0
Total	4,152.9	335.5

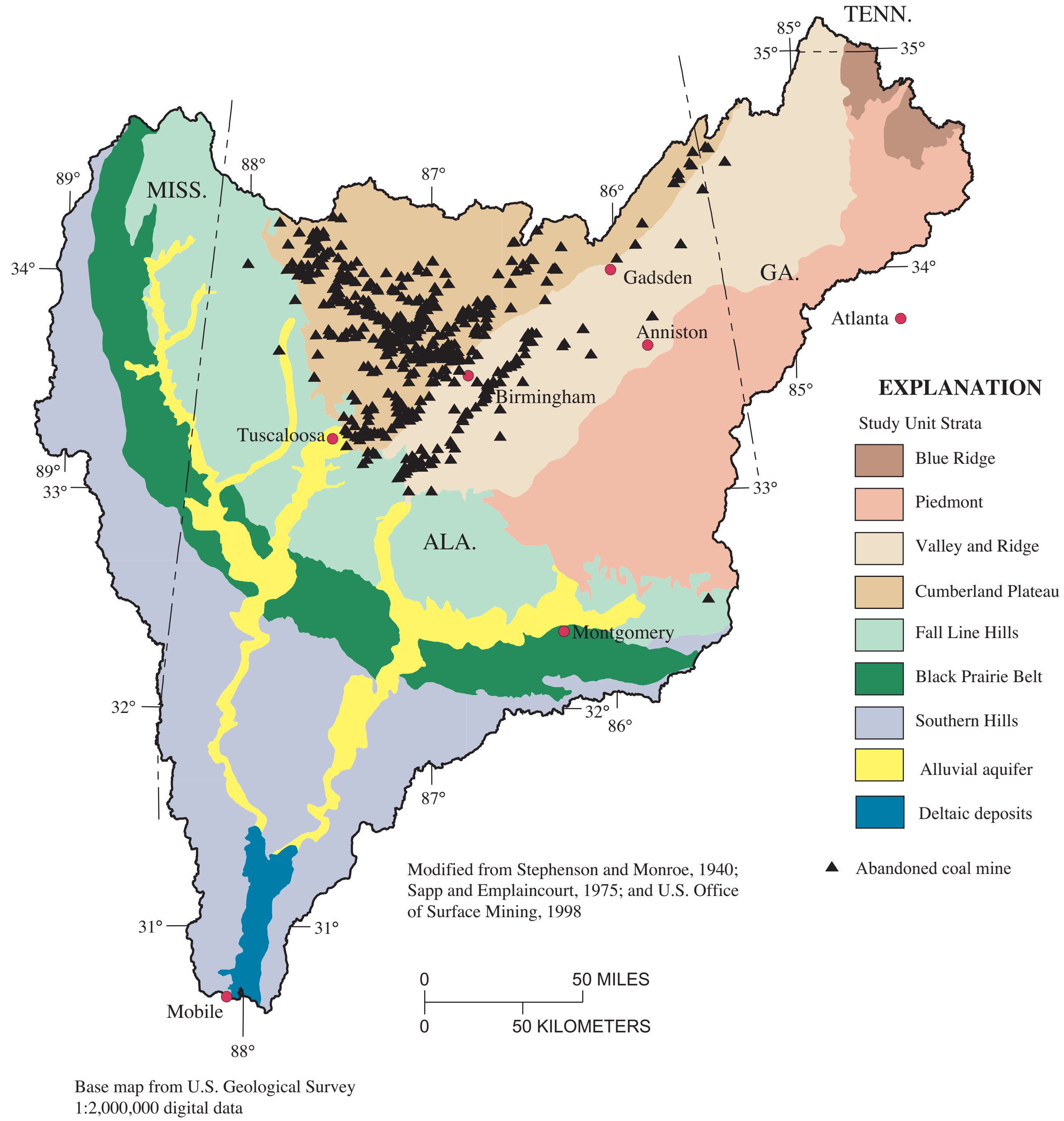
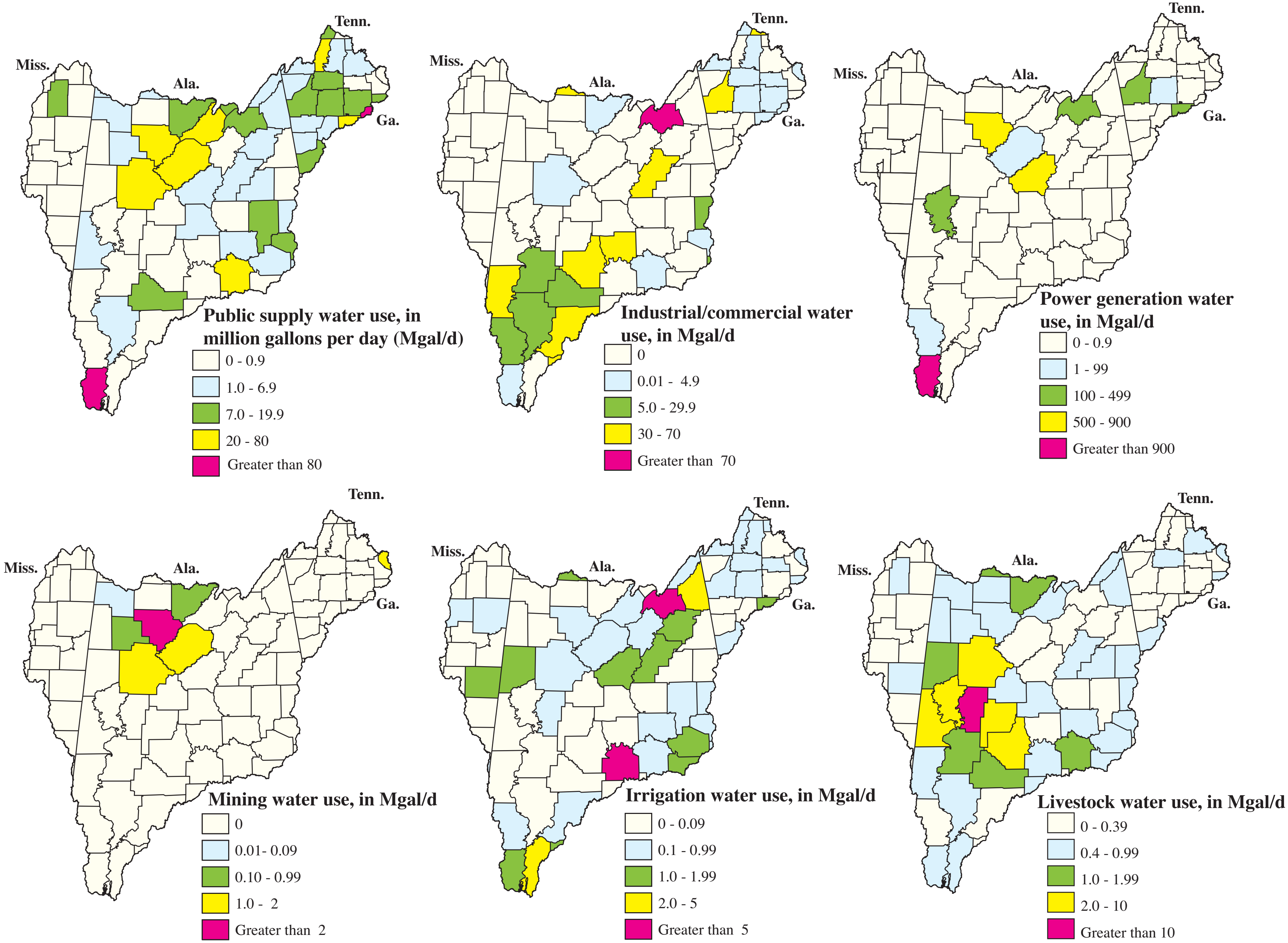


Figure 22. Location of abandoned coal surface mines in the Mobile River Basin.



Base map from U.S. Geological Survey
1:2,000,000 digital data

Modified from Price
and Clawges, 1999

Figure 23. Surface-water use in million gallons per day (Mgal/d) by county area in the Mobile River Basin, 1995.

In the Coastal Plain Physiographic Province (Fall Line Hills, Black Prairie Belt, Southern Hills, Alluvial aquifer, and Deltaic deposits), surface-water use is low in Mississippi, but high in Alabama and usually is related to industrial use (fig. 23). Generally, surface-water use is greatest in the Valley and Ridge, Cumberland Plateau, Southern Hills, and Piedmont because of power generation, public water supply, and industrial and commercial withdrawals (fig. 24). Water use for these four areas is related to the presence of urban areas and the resulting population distribution.

Basinwide, ground-water use is less than surface-water use for all categories with the exception of domestic water supply, which consists of rural wells and springs (table 5) (Price and Clawges, 1999). Public drinking-water supply constitutes 60 percent of all ground-water withdrawals. Ground water is the main public water-supply source for the Fall Line Hills district, Black Prairie Belt district, and the Alluvial aquifer in the Coastal Plain Physiographic Province (fig. 24). In the other physiographic provinces, surface water is the main source of public water supply. Domestic and public water-supply use (fig. 25) corresponds to areas with the largest population densities. Industrial and commercial ground-water use is greatest in the Fall Line Hills and Black Prairie Belt districts of the Coastal Plain Physiographic Province in Mississippi, the Southern Hills district of the Coastal Plain Physiographic Province in Alabama, and the Valley and Ridge Physiographic Province in Georgia. Agricultural water use for livestock is greatest in the Fall Line Hills, Black Prairie Belt, and Southern Hills districts, and the Alluvial aquifer of the Coastal Plain Physiographic Province and Cumberland Plateau Physiographic Province. Ground-water use for irrigation is greatest in the Southern Hills district and the Deltaic deposits of the Coastal Plain Physiographic Province. Ground-water use for mining has a greater spatial distribution than does surface-water use for mining.

WATER-QUALITY ISSUES

Water quality in the Mobile River Basin is highly variable and influenced by many natural and human factors. One valuable source of information about water quality in basins in each State is the State 305(b) report to Congress, which is prepared every 2 years. Another source of information is the Toxics Release Inventory (TRI), published by the U.S. EPA, which provides insight into the potential sources of contaminants present in the Mobile River Basin.

State 305(b) Reports

Impairment of the water quality in stream and ground-water systems can cause the water to be designated as partially supporting or nonsupporting their intended use. Impairment can be caused by both point and nonpoint sources of contamination, such as runoff from urban, agricultural, or forested land, flow regulation, and industrial point sources. In 1994 and 1995, over 9,460 river miles within the Mobile River Basin were assessed. These assessments were made available in the 305(b) water-quality reports to Congress by the Alabama Department of Environmental Management (1996), the Georgia Department of Natural Resources—Environmental Protection Division (1996), and the Mississippi Department of Environmental Quality (1996).

Based on the 1996 State 305(b) water-quality reports, approximately 74 percent of the assessed river and stream miles within the Mobile River Basin were considered to be fully supporting of their classified uses; 15 percent, partially supporting; and 11 percent, nonsupporting. Nonsupporting and partially-supporting stream miles are placed on the State 303(d) list. Several factors were identified as the source for the impairment of the partially and nonsupporting river miles. In 1996, organic enrichment and dissolved oxygen depletion, elevated nutrient concentrations, and siltation were cited most frequently as the sources of impairment for the greatest number of river miles (fig. 26). Bacteria, acidic pH, and elevated metal concentrations also contributed a large percentage to the impairment.

The percentage of river miles that support the designated use classification, and the causes and sources of impairment of the rivers varied among subbasins. Only 64 percent and 67 percent of the river miles assessed in the Cahaba River Basin and Coosa River Basin, respectively, were considered fully supporting of their intended use (fig. 27). The cause of impairment for the Cahaba River Basin was similar to the Mobile River Basin in general; organic enrichment, low dissolved oxygen, elevated nutrient concentrations, and siltation were cited as primary causes of impairment. The sources for the impairment in the Cahaba River Basin were attributed primarily to urban sources, including construction, storm sewers, and

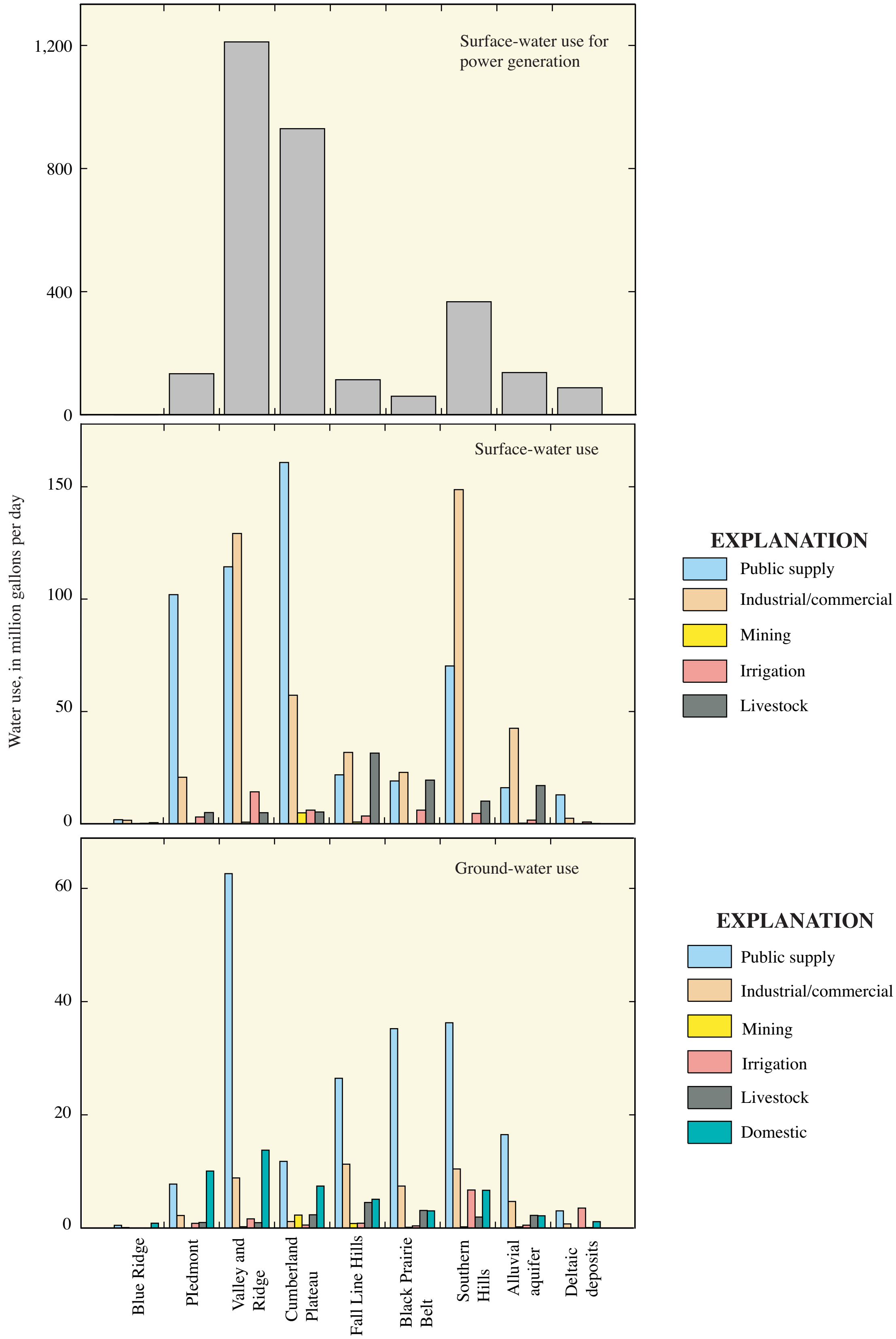
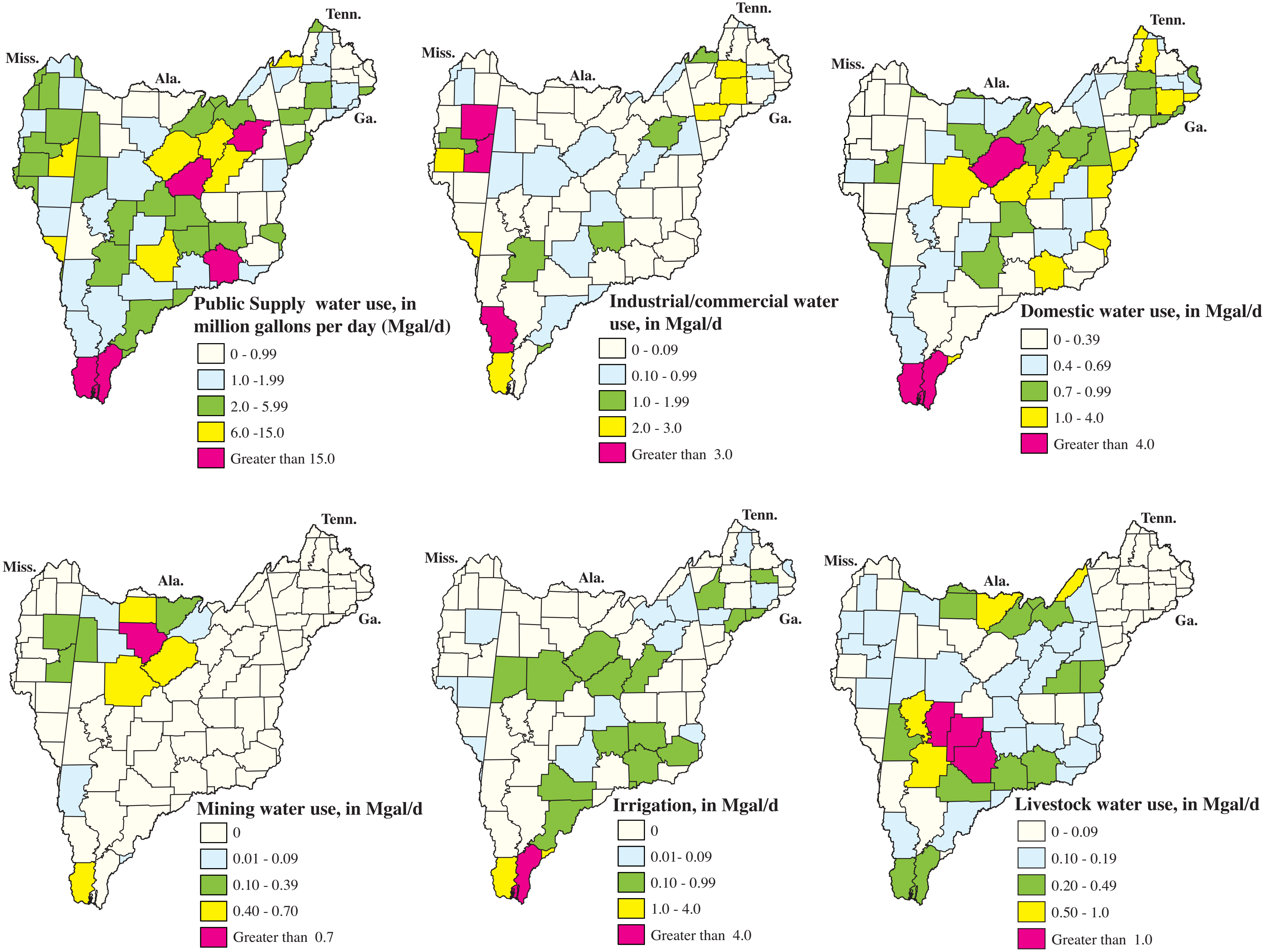


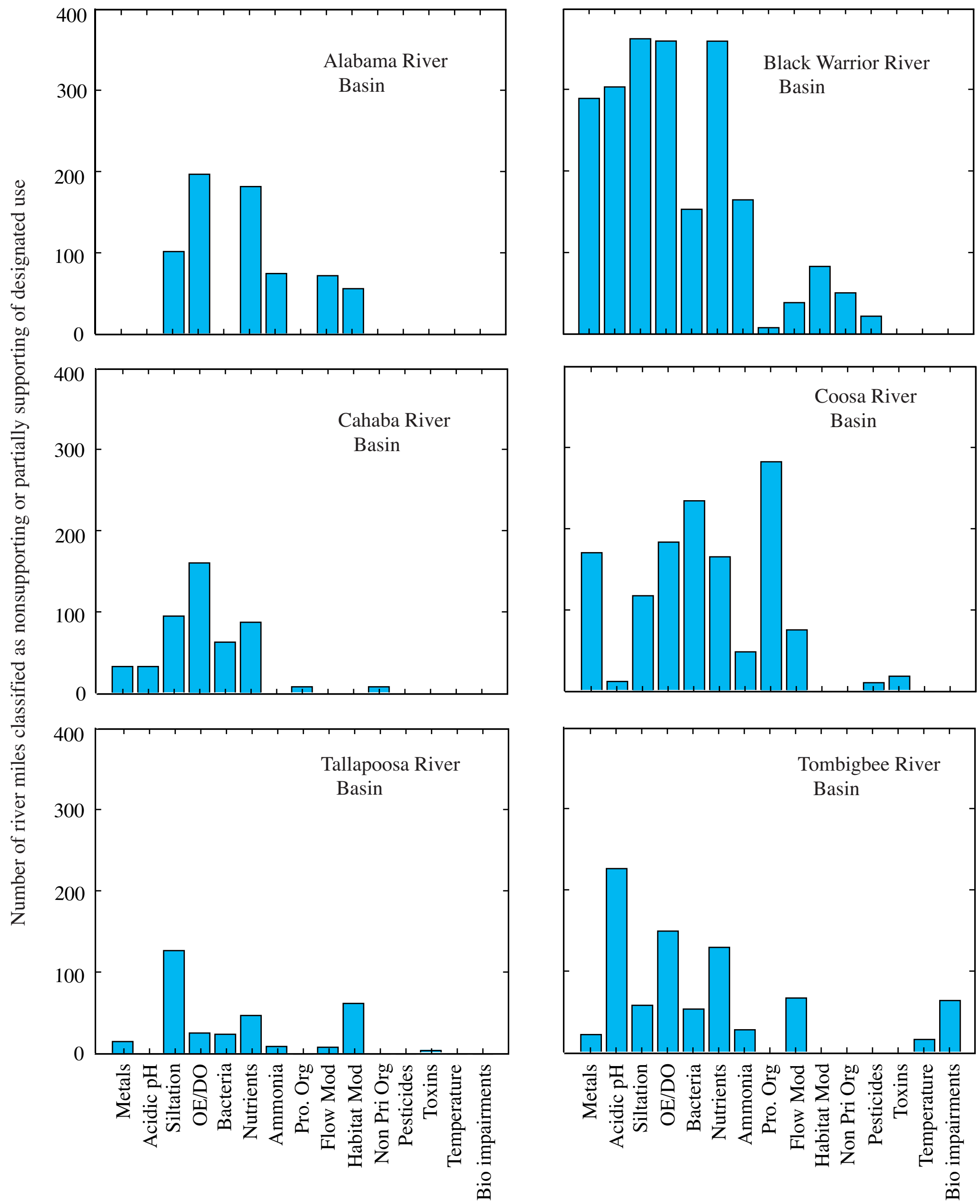
Figure 24. Water use by strata in the Mobile River Basin, 1995.



Base map from U.S. Geological Survey
1:2,000,000 digital data

Modified from Price
and Clawges, 1999

Figure 25. Ground-water use in million gallons per day (Mgal/d) by county area for the Mobile River Basin, 1995.



EXPLANATION

OE/DO	Organic enrichment/dissolved oxygen depletion
Pro. Org	Priority organics (mostly polychlorinated biphenyls)
Flow Mod	Flow modification
Habitat Mod	Habitat modification
Non Pri Org	Non-priority organics
Bio impairments	Biological impairments

Figure 26. Causes for segments of rivers in the Mobile River Basin to be placed on the 1996 State 303(d) lists.

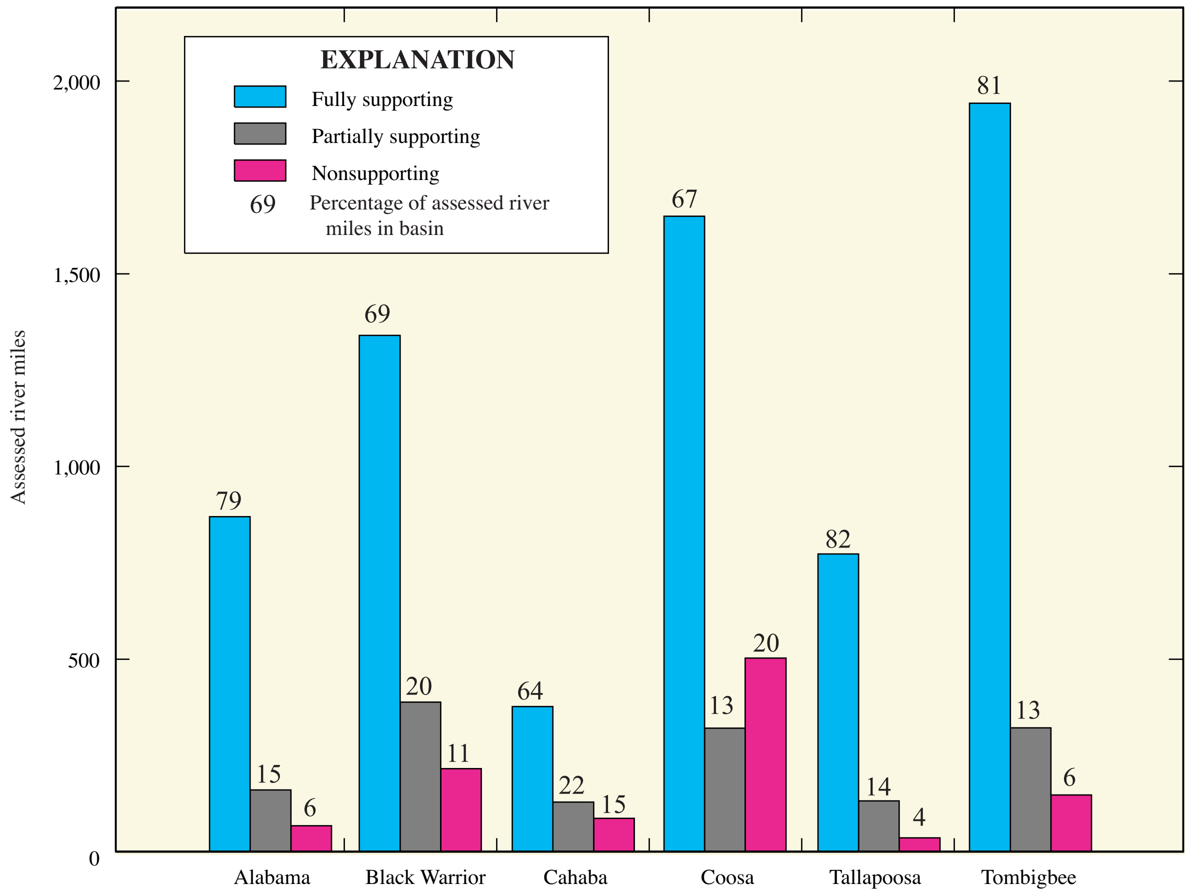
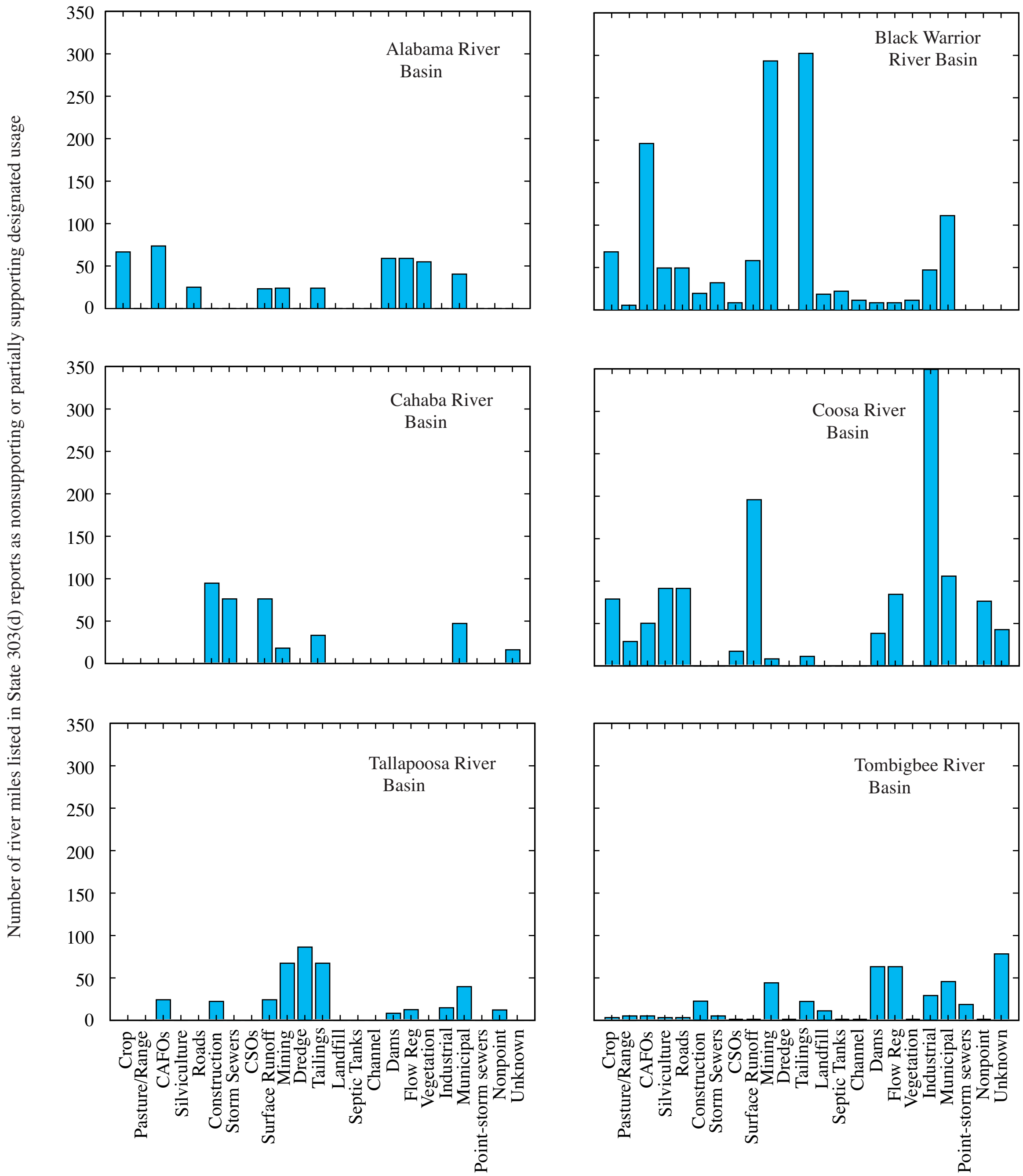


Figure 27. Classification of assessed river miles for supporting intended use in the Mobile River Basin from the 1996 State 305(b) reports.

surface runoff (fig. 28). Priority organics [mainly polychlorinated biphenyls (PCBs)] and pathogens were considered the primary causes of impairment in the Coosa River Basin and were attributed to industrial sources. In the Black Warrior River Basin, 69 percent of the assessed river miles were classified as fully supporting their intended use. Impairment of the Black Warrior River Basin was attributed more to elevated metals, acidic pH, and siltation associated with the greater surface mining activities in that region than in the other basins (figs. 26 and 28). The three remaining subbasins in the Mobile River Basin had percentages of fully supporting river miles greater than that of the entire Mobile River Basin (74 percent): Tallapoosa River Basin (82 percent), Alabama River Basin (79 percent), Tombigbee River Basin (81 percent). Impairment of surface-water segments in the Tallapoosa River Basin primarily was attributed to siltation and habitat modification resulting from dredging and mining activities. The Alabama River's problems stemmed primarily from siltation, organic enrichment and nutrients resulting from agricultural and municipal activities, and flow modification from dams. The sources of impairment in the Tombigbee River Basin were identified as acidic pH, organic enrichment, reduced dissolved oxygen levels, and nutrients resulting from municipal sources, dams, mining, and other unknown or unlisted sources.

The utilization of the State 305(b) reports to summarize water-quality conditions in the basin has some limitations. Assessments and reporting methodologies vary from state to state, and the extent of the investigations are influenced by available funding levels and other local issues. Areas with known water-quality problems are targeted for investigation, which results in a somewhat biased representation of the prevalence of impaired water bodies. Additionally, classification of the causes of impairment and sources of contamination vary among states. Nevertheless, these reports are the most comprehensive ongoing summarization of water-quality conditions available. These reports incorporate data collected by many



EXPLANATION

CAFOs	Combined animal feedlot operations
CSOs	Combined sewerers overflows
Dredge	Dredging operations
Channel	Channel modifications
Flow Reg	Flow regulation

Figure 28. Sources of contamination causing segments of rivers in the Mobile River Basin to be placed on the 1996 State 303(d) lists.

governmental agencies and provide biennial snapshots of conditions throughout the basin and the Nation.

Toxics Release Inventory

The Toxics Release Inventory (TRI), published by the U.S. EPA, is a valuable source of information regarding toxic chemicals that are being used, manufactured, treated, transported, or released into the environment. The TRI requires the reporting of estimated amounts of toxic chemical releases but does not mandate that facilities monitor these releases. In 1998, releases included a combination of atmospheric releases (81,800,000 pounds), landfill (11,300,000 pounds), and discharges directly into the water (3,030,000 pounds). The TRI provides the first comprehensive overview of toxic chemical contamination from manufacturing facilities in the United States; however, the TRI does not cover toxic chemicals that reach the environment from non-industrial sources, such as dry cleaners or auto service stations. The TRI also does not distinguish between amounts that could have been released continuously over the course of the year or possibly in a single large release. Though the TRI data base is a starting point for assessing possible health effects resulting from industrial chemical use, the user cannot ascertain levels of exposure or risk without combining TRI information with information from other sources. The location and magnitude of toxic chemical releases reported in the TRI for 1998 in the Mobile River Basin are shown in figure 29 (U.S. Environmental Protection Agency, 2001).

SUMMARY

The Mobile River Basin is the sixth largest river system in the United States covering about 44,000 square miles and is the fourth largest in terms of flow, having an average annual discharge of about 62,100 ft^3/s. The basin encompasses parts of Alabama, Georgia, Mississippi, and Tennessee. The Mobile River is formed from the confluence of the Tombigbee and the Alabama River systems. These rivers are regulated by dams and reservoirs that strongly influence the hydrology of the basin.

The physiography and geology were used to stratify the Mobile River Basin into nine subunits that represent areas of relative geologic and physiographic homogeneity. This stratification provides a spatial framework in which natural variability in water quality can be quantified and the effects of human-related factors can be assessed. Five physiographic provinces are included in the Mobile River Basin. The southern part of the basin is located in the East Gulf Coastal Plain section of the Coastal Plain Physiographic Province. The northeastern part of the basin lies within the Cumberland Plateau section of the Appalachian Plateaus Physiographic Province, the Valley and Ridge, the Piedmont, and the Blue Ridge Physiographic Provinces. The study unit can be divided into four broad categories of geologic structure that relate to the physiography. From north to south these are (1) flat-lying Paleozoic sedimentary rocks that underlie the Cumberland Plateau Physiographic Province, (2) Paleozoic rocks folded into a series of anticlines and synclines in the Valley and Ridge Physiographic Province where resistant rocks form ridges and soft rocks underlie valleys, (3) intensely deformed metamorphic rocks of the Piedmont and Blue Ridge Physiographic Provinces that have been intruded by small to large bodies of igneous rocks, and (4) gently dipping, poorly consolidated to unconsolidated sediments of the Coastal Plain Physiographic Province.

The wide range of geologic, topographic, and climatic conditions in the Mobile River Basin produce widely varying soil conditions. These different soil conditions are used to divide the basin into seven geographic land areas (Major Land Resource Areas) characterized by a particular combination or pattern of soils, climate, water resources, land use, and agricultural practices.

The climate in the Mobile River Basin is warm and humid, ranging from temperate to subtropical near the coast. In the summer, precipitation moves inland from the Gulf of Mexico. In the winter, precipitation is attributed to arctic fronts that move south from the midwestern part of the continent. Mean annual precipitation for 1961 through 1990, ranged from 53.4 inches per year in Montgomery, Ala., to 64 inches per year in Mobile, Ala. Mean annual runoff ranged from 18 inches per year in the Montgomery area to 30 inches per year in the Birmingham area and in the Blue Ridge Mountains. The mean annual runoff increases in the southern part of the basin reflecting increased annual precipitation. Runoff in the Birmingham area is influenced partly by increased urbanization and the resulting increase in impermeable areas. The higher runoff in the northeastern corner of the study unit is a result, in part, of high precipitation, increased slopes, and the low permeability of the soil

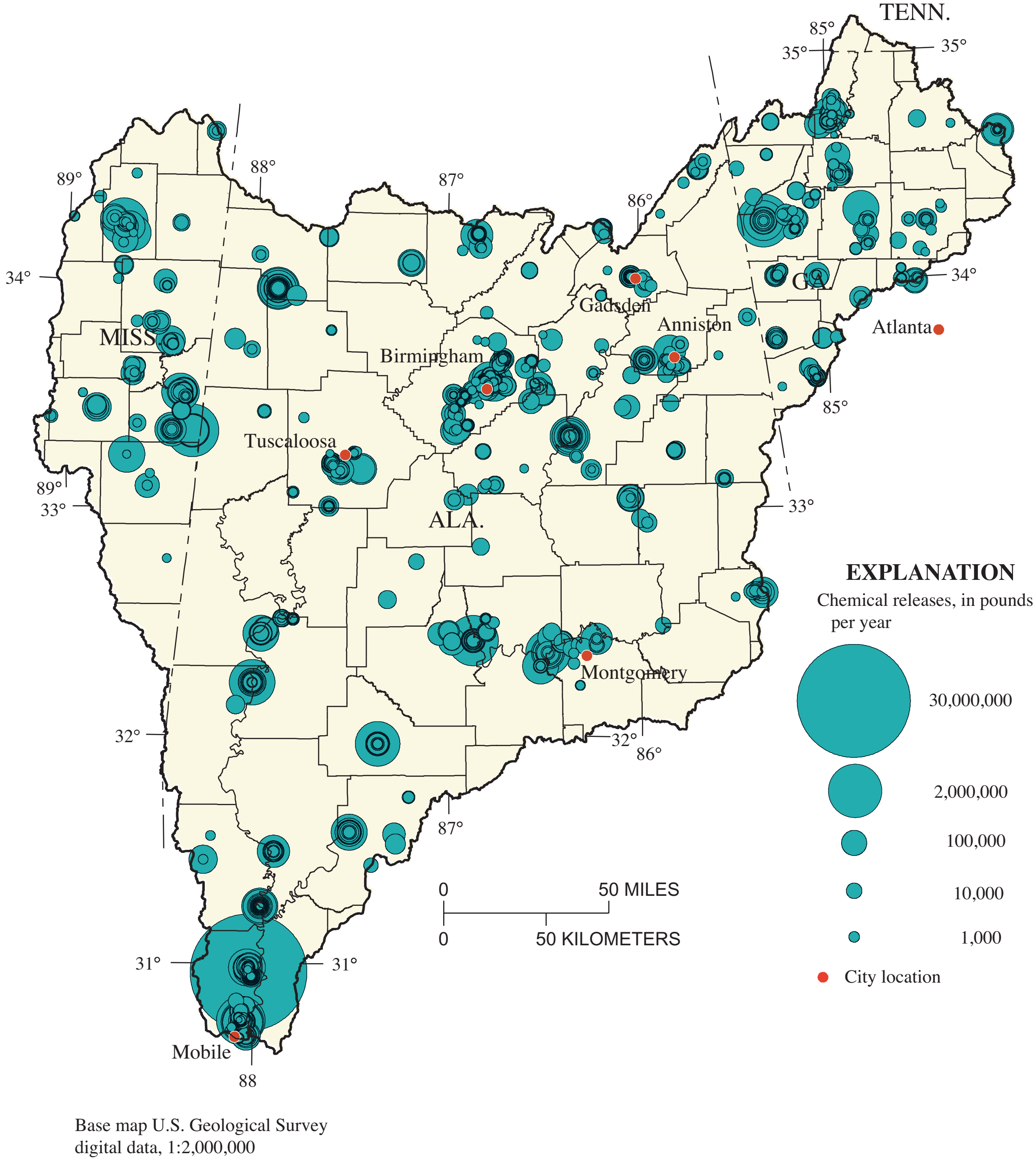


Figure 29. U.S. Environmental Protection Agency Toxic Inventory Release sites in the Mobile River Basin for 1998. (Modified from U.S. Environmental Protection Agency, 2001.)

and rock underlying the Blue Ridge Mountains. For the same time frame (1961 through 1990), the mean annual temperatures ranged from 56 ^{o}F in the northeastern part of the basin to 68 ^{o}F near the coast.

The aquifers in the Mobile River Basin range in composition from unconsolidated sand of the Southeastern Coastal Plain aquifer system to hard crystalline rocks of the Piedmont and Blue Ridge aquifers. These aquifers have been grouped into four major aquifers or aquifer systems on the basis of rock types and ground-water flow systems: Southeastern Coastal Plain aquifer system, Valley and Ridge aquifers, Appalachian Plateaus aquifers, and Piedmont and Blue Ridge aquifers.

Six Level III ecoregions are designated within the Mobile River Basin: (1) Southern Coastal Plain ecoregion, (2) Southeastern Plains ecoregion, (3) Southwestern Plains ecoregion, (4) Ridge and Valley ecoregion, (5) Piedmont ecoregion, and (6) Blue Ridge Mountains ecoregion. The degree of homogeneity among the ecoregions, and the physiography and geology in the Mobile River Basin indicates that the natural variations in the physiography and geology are reflected in the variations of the ecological systems of the basin.

The diverse aquatic habitats in the Mobile River Basin sustain one of the richest aquatic fauna in North America. Endemic fauna include 40 fishes, 33 mussels, 110 aquatic snails, as well as a variety of turtles, aquatic insects, and crustaceans. However, contaminants and modification of aquatic habitat such as impoundments, channelization, dredging, and mining have resulted in the presumed extinction of at least 15 mussels and 38 aquatic snails. The basin is habitat for 39 species of aquatic animals and plants that are currently protected under the Endangered Species Act, including 11 fish, 17 mussels, 7 snails, 2 turtles, and 2 plants.

Land use in the Mobile River Basin is a heterogeneous mixture of forest, agricultural, and urban areas. Most (about 70 percent) of the basin is forested; agriculture, including livestock (poultry, cattle, and swine), aquaculture, row crops (cotton, corn, soybeans, sorghum, and wheat), and pasture land, accounts for about 26 percent of the study unit. The highest concentration of agricultural land use is along the Black Prairie Belt district of the Coastal Plain Physiographic Province. Urban areas account for only 3 percent of the total land use; however, the areal extent of the metropolitan statistical areas may indicate more urban influences.

The total population for the Mobile River Basin was about 3,673,100 people in 1990. The highest population density is within the Valley and Ridge and Cumberland Plateau Physiographic Provinces in Alabama and the Piedmont Physiographic Province in Georgia. The Piedmont Physiographic Province experienced a 60-percent increase in population from 1970 to 1990, as a result of urban sprawl in the Atlanta area. The Blue Ridge Physiographic Province has the lowest overall population density, but had the highest rate of population growth from 1970 to 1990. The Mobile River Basin experienced an overall population growth of 23 percent for the same time period.

Coal extraction has been the primary mining activity in the Mobile River Basin. Coal mining is concentrated in Alabama in the Cumberland Plateau and Valley and Ridge Physiographic Provinces and some adjacent areas in the Fall Line Hills district. Alabama ranks 15th in coal production among coal-producing states. Alabama has four coal fields that are part of the great Appalachian coal basin: Plateau, Warrior, Cahaba, and Coosa fields.

The Mobile River Basin has abundant water resources. Water from streams and aquifers in the Mobile River Basin is used for municipal, industrial and rural water supplies, irrigation, and the generation of energy. Other water uses include hydroelectric-power generation, wastewater assimilation, recreational uses, and fish and wildlife habitat. Hydroelectric power generation uses the greatest amount of surface water where the water is withdrawn for cooling and then discharged back into the water body. Basinwide, surface-water use (excluding hydroelectric-power generation) is about three and a third times greater than ground-water use.

Water quality in the Mobile River Basin is influenced by many natural and human factors. Impairment of water quality can cause water bodies to be designated as partially supporting or nonsupporting of their intended uses. Impairment can be caused by point and nonpoint sources of contamination, such as runoff from urban, agricultural, or forested land, flow regulation, and industrial point sources. The 1996 State 305(b) reports documented the assessment of over 9,460 river miles within the Mobile River Basin by State environmental agencies. Approximately 74 percent of the assessed river and stream miles were considered to be fully supporting of their classified uses;

15 percent, partially supporting; and 11 percent, nonsupporting. The U.S. Environmental Protection Agency Toxic Release Inventory serves as a source of information about toxic chemicals released into the environment. A number of Toxic Release Inventory sites are located in the Mobile River Basin and reported total releases of about 93 million pounds in 1998. These toxic chemical releases are self-reported estimates by industry and are a combination of atmospheric, land, and water releases, all of which may potentially affect water quality.

REFERENCES

Alabama Department of Environmental Management, 1996, Water quality report to Congress for calendar years 1994 and 1995: Alabama Department of Environmental Management, 278 p.

Brackett, D.A., Steele, W.M., Schmitt, T.J., Atkins, R.L., Kellam, M.F., and Lineback, J.L., 1991, Hydrogeologic data from selected sites in the Piedmont and Blue Ridge provinces, Georgia: Georgia Geologic Survey Information Circular 86, 160 p.

Chandler, R.V., and Lines, G.C., 1974, Water availability, Chambers County, Alabama: Geological Survey of Alabama Special Map 133, 29 p., 10 figs., 1 plate, 4 tables.

Chapman, M.J., and Peck, M.F., 1997, Ground-water resources of the Upper Chattahoochee River Basin in Georgia and Subarea 1 of the Apalachicola-Chattahoochee-Flint and Alabama-Coosa-Tallapoosa River Basins: U.S. Geological Survey Open-File Report 96-363, 43 p.

Clark, W.Z., and Zisa, A.C., 1976, Physiographic map of Georgia: Georgia Geological Survey SM-4, reprinted 1988, scale 1:2,000,000.

Colton, G.W., 1970, The Appalachian Basin—Its depositional sequences and their geologic relationships, *in* Fisher, G.W., Pettijohn, F.J., Reed, J.C., and Weaver, K.N., eds., Studies of Appalachian geology—Central and southern: New York, Wiley, p. 5-47.

Davis, M.E., 1988, Stratigraphic and hydrogeologic framework of the Alabama Coastal Plain: U.S. Geological Survey Water-Resources Investigations Report 87-4112, 39 p.

DeBuchananne, G.D., and Richardson, R.M., 1956, Groundwater resources of East Tennessee: Tennessee Division of Geology Bulletin 58, pt. 1, 393 p.

Gebert, W.A., Gracyzk, D.J., and Krug, W.R., 1987, Average annual runoff in the United States, 1951-80: U.S. Geological Survey Hydrologic Investigations Atlas HA-710, scale 1:7,500,000, 1 sheet.

Georgia Department of Natural Resources—Environmental Protection Division, 1996, Water quality in Georgia 1994-1995: Georgia Department of Natural Resources—Environmental Protection Division, as required by Section 305(b) of the Clean Water Act, 191 p.

Georgia Geological Survey, 1976, Geologic map of Georgia: Georgia Geological Survey Map 3, 1 sheet, scale 1:500,000.

Gilliom, R.J., Alley, W.M., and Gurtz, M.E., 1995, Design of the National Water-Quality Assessment Program—Occurrence and distribution of water-quality conditions: U.S. Geological Survey Circular 1112, 33 p.

Griffith, G.E., Omernik, J.M., and Azevedo, S.H., 1998, Ecoregions of Tennessee. (2 sided color poster with map, descriptive text, summary tables, and photographs): U.S. Geological Survey, Reston, Va., scale 1:940,000.

Harkins, J.R., and others, 1980, Hydrologic assessment, eastern coal province, area 23, Alabama: U.S. Geological Survey Open-File Report 80-683, 76 p.

______1981, Hydrology of area 22, eastern coal province, Alabama: U.S. Geological Survey Open-File Report 81-135, 72 p.

______1982, Hydrology of area 24, eastern coal province, Alabama and Georgia: U.S. Geological Survey Open-File Report 81-1113, 81 p.

Hirsch, R.M., Alley, W.M., and Wilber, W.G., 1988, Concepts for a national water-quality assessment program: U.S. Geological Survey Circular 1021, 42 p.

Journey, C.A., and Atkins, J.B., 1997, Ground-water resources of the Tallapoosa River Basin in Georgia and Alabama—subarea 5 of the Apalachicola-Chattahoochee-Flint and Alabama-Coosa-Tallapoosa River Basins: U.S. Geological Survey Open-File Report 96-433, 48 p.

Kidd, R.E., 1989, Geohydrology and susceptibility of major aquifers to surface contamination in Alabama, area 5: U.S. Geological Survey Water-Resources Investigations Report 88-4083, 28 p.

Kidd, R.E., Atkins, J.B., and Scott, J.C., 1997, Groundwater resources of the Alabama River Basin in Alabama—subarea 8 of the Apalachicola-Chattahoochee-Flint and Alabama-Coosa-Tallapoosa River Basins: U.S. Geological Survey Open-File Report 96-473, 52 p.

King, P.B., and Beikman, H.M., 1974, Geologic map of the United States: U.S. Geological Survey, scale 1:2,500,000, 3 sheets.

Lamb, G.M., 1979, Sedimentation in Mobile Bay, *in* Loyacano, H.A., Jr., and Smith, P.J., eds., 1979, Symposium on the Natural Resources of the Mobile Estuary, Alabama, Mobile, Ala., May 1979: U.S. Army Corps of Engineers, Mobile, p. 7-13.

Leahy, P.P., Rosenhein, J.S., and Knopman, D.S., 1990, Implementation plan for the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 90-174, 10 p.

Leahy, P.P., and Wilber, W.G., 1991, National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 91-54, 2 p.

Loyacano, H.A., Jr., and Smith, P.J., eds., 1979, Symposium on the Natural Resources of the Mobile Estuary, Alabama: U.S. Army Corps of Engineers, Mobile, 290 p.

Mallory, M.J., 1993, Hydrogeology of the southeastern Coastal Plain aquifer system in parts of eastern Mississippi and western Alabama; Regional Aquifer-System Analysis—southeastern Coastal Plain: U.S. Geological Survey Professional Paper 1410-G, 57 p.

McConnell, D., 1998, Landforms of the United States: accessed July 27, 2001, at URL:http://lists.uakron.edu/geology/natscigeo/Lectures/land/landform.htm

Miller, J.A., 1990, Ground water atlas of the United States—Segment 6—Alabama, Florida, Georgia, and South Carolina: U.S. Geological Survey Hydrologic Investigations Atlas 730-G, 28 p.

Mississippi Department of Environmental Quality, 1996, Mississippi 1996 Water quality assessment—Federal Clean Water Act, Section 305(b) report: Mississippi Department of Environmental Quality, Office of Pollution Control, 337 p.

Mooty, W.S., and Kidd, R.E., 1997, Ground-water resources of the Cahaba River Basin in Alabama—subarea 7 of the Apalachicola-Chattahoochee-Flint and Alabama-Coosa-Tallapoosa River Basins: U.S. Geological Survey Open-File Report 96-470, 36 p.

National Oceanic and Atmospheric Administration, 1998, U.S. monthly precipitation for cooperative and National Weather System sites: accessed February 26, 2002, at URL: http://www.ncdc.noaa.gov/ol/climate/online/coop-precip.html

O'Hara, C.G., 1996, Susceptibility of ground water to surface and shallow sources of contamination in Mississippi: U.S. Geological Survey Hydrologic Investigations Atlas HA-739, 4 plates.

Omernik, J.M., 1987, Ecoregions of the conterminous United States: Annals of the Association of American Geographers, v. 77, no. 1, map (scale 1:7,500,000), p. 118-125.

Pearman, J.L., Stricklin, V.E., Cole, P.W., and Psinakis, W.L., 1997, Water-resources data, Alabama, water year 1996: U.S. Geological Survey Water-Data Report AL-96, 456 p.

Price, C.V., and Clawges, R.M., 1999, Digital data sets describing water use, toxic chemical releases, metropolitan areas, and population density of the conterminous United States: U.S. Geological Survey Open-File Report 99-78.

Renkin, R.A., 1998, Ground water atlas of the United States—Segment 5—Arkansas, Louisiana, Mississippi: U.S. Geological Survey, Hydrologic Investigations Atlas HA-730-F, 28 p.

Robinson, J.L., Journey, C.A., and Atkins, J.B., 1997, Ground-water resources of the Coosa River Basin in Georgia and Alabama—subarea 6 of the Apalachicola-Chattahoochee-Flint and Alabama-Coosa-Tallapoosa River Basins: U.S. Geological Survey Open-File Report 96-177, 53 p.

Rollins, H.C., Sedberry, F.C., Pearman, J.L., and Duvail, T.R., 1987, Water resources data, Alabama, Water Year 1986: U.S. Geological Survey Water-Data Report AL-86-1, 307 p.

Ruddy, B.C., and Hitt, K.J., 1990, Summary of selected characteristics of large reservoirs in the United States and Puerto Rico, 1988: U.S. Geological Survey Open-File Report 90-163, 295 p.

Sanders, B., Bellamy, M., and Spornick, C., 1999, The Bartram Trail: accessed 5/21/01, at URL: http://www.bartramtrail.org/pages/Bartram_Trail/phys.html

Sapp, D.C., and Emplaincourt, J., 1975, Physiographic regions of Alabama: State of Alabama Geological Survey Map 168, 1 plate, scale 1:1,000,000.

Schmitt, T.J., Atkins, R.L., Brackett, D.A., Steele, W.M., White, R.K., Ligon, T.J., and Crawford, T.J., 1989, Hydrogeology of saprolite and hard rock aquifers in the Blue Ridge and Piedmont of northeastern Georgia and northwestern South Carolina, *in* Fritz, W.J., ed., Excursions in Georgia Geology: Georgia Geological Society Guidebook, v. 9, no. 1, p. 179-210.

Stephenson, L.W., and Monroe, W.H., 1940, The upper Cretaceous deposits: Mississippi State Geological Survey Bulletin 40, 296 p.

Stokes, W.R., III, and McFarlane, R.D., 1994, Water-resources data for Georgia, water year 1993: U.S. Geological Survey Water-Data Report GA-93-1, 663 p.

Stricklin, V.E., 1989, Geohydrology and susceptibility of major aquifers to surface contamination in Alabama, area 3: U.S. Geological Survey Water-Resources Investigations Report 88-4120, 17 p.

———1994, Streamflow and water-quality data for Lake Purdy and its tributaries, Jefferson and Shelby Counties, Alabama, Water Years 1987-91: U.S. Geological Survey Open-File Report 93-498, 32 p.

The Tennessee Tombigbee Waterway Development Authority, 2001, Waterway description and components, accessed April 24, 2001 at http://tenntom.org/descript.htm

U.S. Army Corps of Engineers, 1985a, Alabama-Mississippi stream mileage tables with drainage areas: U.S. Army Corps of Engineers, Mobile District, 276 p.

———1985b, Florida-Georgia stream mileage tables with drainage areas: U.S. Army Corps of Engineers, Mobile District, 233 p.

U.S. Bureau of the Census, 1998, State and metropolitan area data book, 1997-98, table B-1, accessed April 25, 2001, at http://www.census.gov/Press-Release/metro02.prn

———2001, County population estimates, accessed April 30, 2001, at http://www.census.gov/population/www/estimates/countypop.html

U.S. Department of Agriculture, National Agricultural Statistics Service, 1997, Agricultural census of the United States, 1997, accessed July 31, 2001, at http://www.nationalatlas.gov/agcensusm.html

U.S. Department of Agriculture, Natural Resources Conservation Service, 1992, Major Land Resources Areas of Georgia, accessed February 12, 2001, at http://www.ga.nrcs.usda.gov/mlra15/gasoilnt/gamptxt.html

———2001, Soils map of Alabama, accessed June 3, 2001, at http://www.ga.nrcs.usda.gov/mlra15/alsoilnt/algsm.html

U.S. Department of Agriculture, Soil Conservation Service, 1981, Land resource regions and major land resource areas of the United States: USDA Agricultural Handbook No. 296, 156 p.

U.S. Environmental Protection Agency, 1992, Multi-Resolution Land Characteristics Consortium, National Land Cover Data, accessed on July 31, 2001, at http://www.epa.gov/mrlc/nlcd.html

———2000, Level III Ecoregions of the continental United States (revision of Omernik, 1987): Corvallis, Oreg., U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory, Map M-1.

———2001, Toxics Release Inventory (TRI) Program, accessed February 7, 2001, at http://www.epa.gov/tri/

U.S. Fish and Wildlife Service, 1986, Endangered species: U.S. Fish and Wildlife Service, FWS-OES-8/86.

———1998a, Technical/Agency draft Mobile River Basin Ecosystem Recovery Plan, Jackson Mississippi, 112 p.

———1998b, The Endangered Species Program, accessed November 7, 2000, at http://endangered.fws.gov/

U.S. Geological Survey, 1984, National water summary, Hydrologic events and selected water-quality trends and ground-water resources: U.S. Geological Survey Water-Supply Paper 2275, 467 p.

———1998, Principal aquifers of the 48 contiguous United States, accessed February 9, 2001, at http://www-atlas.usgs.gov/aquifers.html

———1999, The quality of our Nation's waters—nutrients and pesticides: U.S. Geological Survey Circular 1225, 82 p.

U.S. Office of Surface Mining, 1998, Abandoned mine land inventory system—High priority coal-related problems database, accessed August 1, 2001, at http://www.osmre.gov/aml/inven/zamlis.htm

———2000, Annual evaluation summary report for the regulatory and abandoned mine lands reclamation programs administered by the State of Alabama for evaluation year 2000, October 1, 1999 to September 30, 2000, 28 p.

Zurawski, A., 1978, Summary appraisals of the Nation’s ground-water resources—Tennessee Region: U.S. Geological Survey Professional Paper 813-L, 35 p.

APPENDIXES

Appendix A. Aquatic species extirpated from or extinct in the Mobile River Basin

[All taxa listed are endemic to the Mobile River Basin. Extinct species have not been reported for 20 or more years. N/A, No recorded common name for these species (Source: U.S. Fish and Wildlife Service, 1998a)]

Common name	Scientific name	Federal status
	FISH	
Lake sturgeon	*Acipenser fulvescens*	Extirpated
	MUSSELS	
Deertoe mussel	*Truncilla truncata*	Extirpated
Coosa elktoe	*Alasmidonta maccordi*	Extinct
Tombigbee moccasinshell	*Medionidus macglameriae*	Extinct
Warrior pigtoe	*Pleurobema rubellum*	Extinct
Highnut	*Pleurobema altum*	Extinct
N/A	*Pleurobema hartmanianum*	Extinct
Longnut	*Pleurobema nucleopsis*	Extinct
True pigtoe	*Pleurobema verum*	Extinct
Yellow pigtoe	*Pleurobema flavidulum*	Extinct
Alabama pigtoe	*Pleurobema johannis*	Extinct
N/A	*Pleurobema aldrichianum*	Extinct
Hazel pigtoe	*Pleurobema avellanum*	Extinct
Alabama clubshell	*Pleurobema troschelianum*	Extinct
Brown Pigtoe	*Pleurobema hagleri*	Extinct
Coosa pigtoe	*Pleurobema murrayense*	Extinct
Warrior pigtoe	*Pleurobema rubellum*	Extinct
	SNAILS	
Umbilicate pebblesnail	*Clappia umbilicata*	Extinct
Cahaba pebblesnail	*Clappia cahabensis*	Extinct
Short-spire elimia	*Elimia brevis*	Extinct
Fusiform elimia	*Elmia fusiformis*	Extinct
High-spired elimia	*Elimia hartmaniana*	Extinct
Constricted elimia	*Elimia impressa*	Extinct
Hearty elimia	*Elimia jonesi*	Extinct
N/A	*Elimia lachryma*	Extinct
Ribbed elimia	*Elimia laeta*	Extinct
N/A	*Elimia macglameriana*	Extinct
Rough-lined elimia	*Elimia pilsbryi*	Extinct
Pupa elimia	*Elimia pupaeformis*	Extinct
Pygmy elimia	*Elimia pygmaea*	Extinct
Cobble elimia	*Elimia vanuxemiana*	Extinct
Closed elimia	*Elimia clausa*	Extinct
N/A	*Elimia gibbera*	Extinct

Appendix A. Aquatic species extirpated from or extinct in the Mobile River Basin—Continued

Common name	Scientific name	Federal status
	SNAILS—Continued	
Excised slitshell	*Gyrotoma excisa*	Extinct
Striate slitshell	*Gyrotoma lewisii*	Extinct
Pagoda slitshell	*Gyrotoma pagoda*	Extinct
Ribbed slitshell	*Gyrotoma pumila*	Extinct
Pyramid slitshell	*Gyrotoma pyramidata*	Extinct
Round slitshell	*Gyrotoma walkeri*	Extinct
Agate rocksnail	*Leptoxis clipeata*	Extinct
Interrupted rochsnail	*Leptoxis foremanii*	Extinct
Maiden rocksnail	*Leptoxis formosa*	Extinct
Rotund rocksnail	*Leptoxis ligata*	Extinct
Lirate rocksnail	*Leptoxis lirata*	Extinct
Black mudalia	*Leptoxis melanoidus*	Extinct
Bigmouth rocksnail	*Leptoxis occultata*	Extinct
Coosa rocksnail	*Leptoxis showalterii*	Extinct
N/A	*Leptoxix torrefacta*	Extinct
Striped rocksnail	*Leptoxis vittata*	Extinct
Oblong rocksnail	*Leptoxis compacta*	Extinct
Shoal sprite	*Amphigyra alabamensis*	Extinct
N/A	*Neoplanorbis carinatus*	Extinct
N/A	*Neoplanorbis smithi*	Extinct
N/A	*Neoplanorbis tantillus*	Extinct
N/A	*Neoplanorbis umbilicatus*	Extinct

Appendix B. Aquatic species in the Mobile River Basin listed under the Endangered Species Act of 1973

[From U.S. Fish and Wildlife Service, 1998b]

Common name	Scientific name	Federal status	General endemic range	Cause
		FISH		
Alabama sturgeon	*Scaphirhynchus suttkusi*	Endangered	Mobile River system, in Alabama and Georgia.	Attributed to over fishing, loss and fragmentation of habitat, and water degradation.
Amber darter	*Percina antesella*	Endangered	Conasauga River, Ga. and Tenn., and Etowah River and Shoal Creek, Ga.	Limited range, proposed reservoir, and water-quality degradation.
Blue shiner	*Cyprinella caerulea*	Threatened	Cahaba River, Ala. and Coosa River and tributaries in Ala., Ga., and Tenn.	Due in part to loss and fragmentation of habitat associated with reservoir construction as well as degradation of water quality.
Cahaba shiner	*Notropis cahabae*	Endangered	Main stem of Cahaba River, Ala. in Bibb, Perry, and Shelby counties.	Adverse habitat alterations and water-quality degradation from residential, industrial, and commercial development.
Cherokee darter	*Etheostoma scotti*	Threatened	Upper Etowah River and two of its tributaries (Long Swamp and Amiclala Creek) in Ga.	Impoundments, degraded water quality, and loss of benthic habitat by siltation.
Conasauga logperch	*Percina jenkinsi*	Endangered	Upper Conasauga River, Tenn. and Ga.	Limited range, proposed reservoir, and water-quality degradation.
Etowah darter	*Etheostoma etowahae*	Endangered	Upper Etowah River and two of its tributaries (Long Swamp and Amiclala Creek) in Ga.	Degraded water quality and loss of benthic habitat by siltation.
Goldline darter	*Percina aurolineata*	Threatened	Cahaba and Coosa River drainages; including the Little Cahaba, Coosawatte, Ellijay, and Cartecay Rivers.	Water-quality degradation and loss of habitat.
Gulf sturgeon	*Acipenser oxyrhynchus desotoi*	Threatened	Historical range extends from Lake Pontchartrain, La. to Tampa Bay, Fla.	Over-exploitation by fishermen, habitat modification, and water-quality degradation. Impoundments may restrict reproduction.
Pygmy sculpin	*Cottus pygmaeus*	Threatened	Coldwater Spring, Calhoun County, Ala.	Water contamination of the subsurface aquifer for Coldwater Spring.
Watercress darter	*Etheostoma nuchale*	Threatened	Four springs in the Black Warrior River watershed, Jefferson County, Ala.	Limited range, increasing urbanization, and potential ground-water contamination.

Appendix B. Aquatic species in the Mobile River Basin listed under the Endangered Species Act of 1973—Continued

Common name	Scientific name	Federal status	General endemic range	Cause
		MUSSELS		
Inflated heelsplitter	*Potamilus inflatus*	Threatened	Tombigbee, Black Warrior, and Coosa Rivers, Ala.	Impacts to habitat from channel modification, impoundments, pollution, and dredging.
Alabama moccasinshell	*Medionidus acutissimus*	Threatened	Mobile River drainage basin, which includes the Alabama, Tombigbee, Black Warrior, Cahaba, and Coosa Rivers and their tributaries.	Habitat modification, sedimentation, eutrophication, and pollution.
Black clubshell	*Pleurobema curtum*	Endangered	Tombigbee River above Pickensville, Ala. and in Miss.	Habitat modification including impoundments and channelization.
Coosa moccasinshell	*Medionidus parvulus*	Endangered	Mobile River drainage basin, which includes the Cahaba River, Sipsey Fork, Black Warrior River, and Coosa River.	Habitat modification, sedimentation, eutrophication, and pollution.
Dark pigtoe	*Pleurobema furvum*	Endangered	Mobile River drainage in parts of Ala., Ga., Miss., and Tenn.	Loss of habitat and water-quality degradation.
Fine-lined pocketbook	*Lampsilis altilis*	Threatened	Mobile River drainage basin, which includes the Alabama, Tombigbee, Black Warrior, Cahaba, Tallapoosa and Coosa Rivers and their and tributaries.	Habitat modification, sedimentation, eutrophication, and pollution.
Flat pigtoe	*Pleurobema marshalli*	Endangered	Tombigbee River between Columbus, Miss. and Epes, Ala.	Habitat modification from navigational impoundments.
Heavy pigtoe	*Pleurobema taitianum*	Endangered	Main stem Tombigbee, Alabama, Cahaba, and Coosa Rivers, Ala. and Miss.	Impoundments, agricultural runoff, sand and gravel mining.
Orangenacre mucket	*Lampsilis perovalis*	Threatened	Alabama River and tributaries; tributaries of the Tombigbee and Black Warrior Rivers; Cahaba River and tributaries.	Habitat modification, sedimentation, eutrophication, and pollution.
Ovate clubshell	*Pleurobema perovatum*	Endangered	Tombigbee River Basin, Ala. and Miss., Black Warrior and Cahaba River Basins, Ala., Alabama River, Ala., Coosa River Basin, Ala., Ga., and Tenn., Chewacla, Uphapee, and Opintlocco Creeks in the Tallapoosa River Basin, Ala.	Habitat modification, sedimentation, eutrophication, and water-quality degradation.

Appendix B. Aquatic species in the Mobile River Basin listed under the Endangered Species Act of 1973—Continued

Common name	Scientific name	Federal status	General endemic range	Cause
		MUSSELS—Continued		
Southern acornshell	*Epioblasma othcaloogensis*	Threatened	Coosa and Cahaba River Basins above the Fall Line, Ala., Ga., and Tenn.	Habitat modification, sedimentation, eutrophication, and water-quality degradation from point and nonpoint sources.
Southern clubshell	*Pleurobema decisum*	Endangered	Entire Mobile River Basin except for the Mobile Delta.	Habitat modification, sedimentation, and water-quality degradation.
Southern combshell	*Epioblasma penita*	Endangered	Alabama, Cahaba, and Coosa Rivers, Ala., Tombigbee River Basin, Miss. and Ala., Black Warrior River below Fall Line, Ala.	Channelization and impoundment, sedimentation, and water-quality degradation. Sand and gravel mining and agricultural runoff.
Southern pigtoe	*Pleurobema georgianum*	Endangered	Mobile River drainange in parts of Ala., Ga., Miss., and Tenn.	Loss of habitat and water-quality degradation.
Stirrupshell	*Quadrula stapes*	Endangered	Tombigbee, Alabama, and Black Warrior Rivers, Ala. and Miss.	Impoundments and nonpoint source pollution.
Triangular kidneyshell	*Ptychobrancus greeni*	Endangered	Mobile River drainange in parts of Ala., Ga., Miss., and Tenn.	Loss of habitat and water-quality degradation.
Upland combshell	*Epioblasma metastriata*	Endangered	Black Warrior and Cahaba River Basins, Ala., Coosa River Basin, Ala., Ga., and Tenn.	Habitat modification, sedimentation, eutrophication, and water-quality degradation from point and nonpoint sources.
		SNAILS		
Cylindrical lioplax	*Lioplax cyclostomaformis*	Endangered	Black Warrior, Cahaba, Alabama, and Coosa Rivers and their tributaries in central Ala.	Impoundments and water-quality degradation.
Flat pebblesnail	*Lepyrium showalteri*	Endangered	Black Warrior, Cahaba, Alabama, and Coosa Rivers and their tributaries in central Ala.	Impoundments and water-quality degradation.
Lacy elimia	*Elimia crenatella*	Threatened	Black Warrior, Cahaba, Alabama, and Coosa Rivers and their tributaries in central Ala.	Impoundments and water-quality degradation.
Painted rocksnail	*Leptoxis taeniata*	Threatened	Black Warrior, Cahaba, Alabama, and Coosa Rivers and their tributaries in central Ala.	Impoundments and water-quality degradation.

Appendix B. Aquatic species in the Mobile River Basin listed under the Endangered Species Act of 1973—Continued

Common name	Scientific name	Federal status	General endemic range	Cause
		SNAILS—Continued		
Plicate rocksnail	*Leptoxis plicata*	Endangered	Black Warrior, Cahaba, Alabama, and Coosa Rivers and their tributaries in central Alabama.	Impoundments and water-quality degradation.
Round rocksnail	*Leptoxis ampla*	Threatened	Black Warrior, Cahaba, Alabama, and Coosa Rivers and their tributaries in central Alabama.	Impoundments and water-quality degradation.
Tulotoma snail	*Tulotoma magnifica*	Endangered	Coosa River Basin from St. Clair Co., Ala. to Alabama River, Clarke/Monroe Co., Ala.	Impoundments and point and nonpoint source pollution.
		TURTLES		
Alabama red-belly turtle	*Pseudemys alabamensis*	Endangered	Mobile Delta	Habitat alterations of rivers for navigation and flow modifications.
Flattened musk turtle	*Sternotherus depressus*	Threatened	Locust Fork, Mulberry Fork, and Sipsey Fork of the Black Warrior River, Ala.	Habitat modification, sedimentation, and water-quality degradation.
		PLANTS		
Harperella	*Ptilimnium nodosum*	Endangered	Little River on Lookout Mountain and Town Creek on Sand Mountain, Ga. and Ala.	Flow and stream bank modification, siltation, and pollution.
Kral's water-plantain	*Sagittaria secundifolia*	Threatened	Little River on Lookout Mountain, Town Creek on Sand Mountain, Sipsey Fork of the Black Warrior River, Ga. and Ala.	Stream bank modification, siltation, and pollution.