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Laurence C. Walker
Stephen F. Austin State College

G. Loyd Collier
Stephen F. Austin State College

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BULLETIN 18 JULY 1969

GEOGRAPHY OF THE SOUTHERN FOREST REGION

(Fifth of a Series on the Silviculture of Southern Forests)

LAURENCE C. WALKER

and

G. LOYD COLLIER

Stephen F. Austin State University

SCHOOL OF FORESTRY

NACOGDOCHES, TEXAS

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STEPHEN F. AUSTIN STATE UNIVERSITY
SCHOOL OF FORESTRY FACULTY

LAURENCE C. WALKER, Ph.D.	*Dean of School and Professor of Forestry*
ROBERT D. BAKER, Ph.D.	*Professor of Forestry*
M. VICTOR BILAN, D.F.	*Professor of Forestry*
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LAURENCE C. WALKER

and

G. LOYD COLLIER

Sponsored by the Conservation Foundation

(A preface to this series is given in the first issued, *Silviculture of Shortleaf Pine*, S.F.A. Bul. No. 9.)

Stephen F. Austin State University

SCHOOL OF FORESTRY

NACOGDOCHES, TEXAS

Stand of loblolly and shortleaf pine, about 85 years old, on the main campus of Stephen F. Austin State University, in the upper Coastal Plain of Texas. The trees originated from natural seeding on cropland which was abandoned after the Civil War. Soil is Nacogdoches fine sandy loam. Understory hardwoods are sweetgum, dogwood and water oak.

Photo by U. S. Forest Service

TABLE OF CONTENTS

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NACOGDOCHES, TEXAS

INTRODUCTION

The Southern Forest Region, as here discussed, comprises the area east of the Texas and Oklahoma prairies and south of the Missouri, Ohio, and Potomac rivers, plus an extension along the Atlantic coast to central New Jersey. It embraces the range of the commercial southern pines, the productive hardwood sites of the southern river bottoms, and extensive forests of upland hardwoods. These broad forest cover types, as well as lesser ones ranging from spruce-fir, white pine, and hemlock, to eastern redcedar and baldcypress, occur in patterns determined largely by geographic factors.

The purpose of this bulletin is to describe the climatic, physiographic, geologic, and soils characteristics of the region, and to relate them, where possible, to the distribution of forest types and the suitability of sites for timber production.

Physiographically, the region includes the low elevation and relief of the Coastal Plain bordering the Atlantic Ocean and Gulf of Mexico, the irregular to mountainous slopes of the Appalachian Provinces, the Interior Highlands of Arkansas and Missouri, and the Interior Low Plateaus of Kentucky and Tennessee (Fig. 1). Each region is divisible into subregions, some

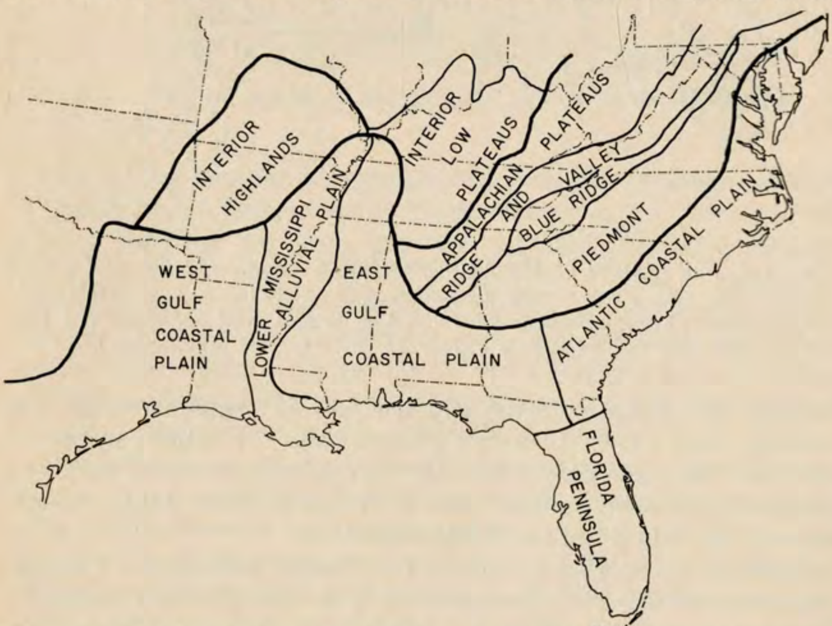

Figure 1. Physiography of the Southern Forest Region (after Fenneman, 1938).

so significant to forestry that they are discussed separately. The Piedmont of the Appalachians and the Lower Alluvial Valley of the Mississippi River are examples.

The varied materials and slopes of the physiographic regions, under the influence of climate, vegetation, and micro-organisms, have yielded soils classed mainly in the Red-Yellow Podzolic Group (Fig. 2). Typically, these soils have deep, well-developed

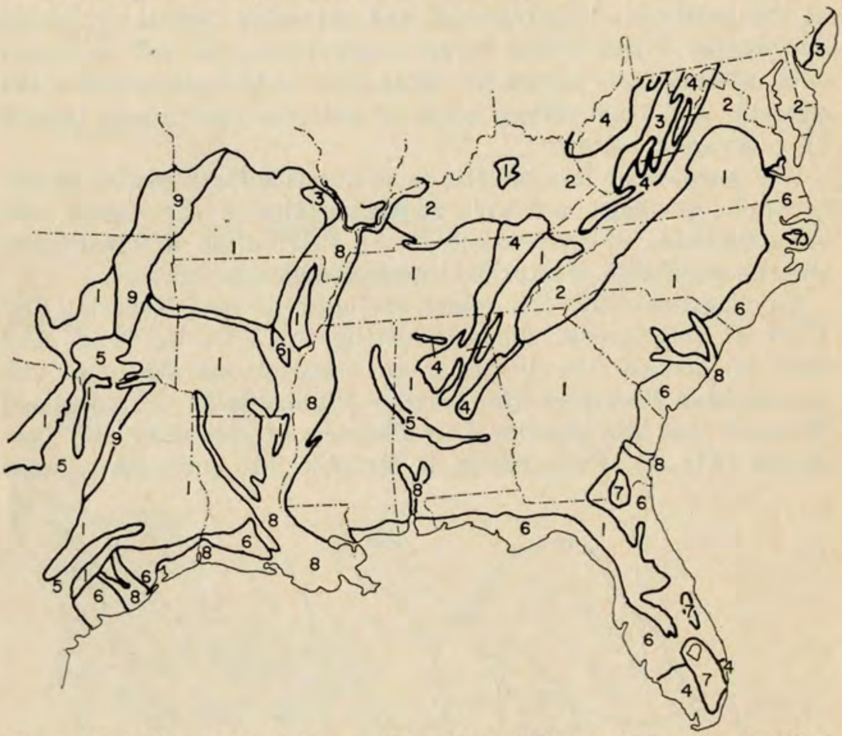

Figure 2. Soil regions of the southern United States. (1) red and yellow podzolics, (2) gray-brown podzolics, (3) podzols, (4) lithosols, (5) rendzina, (6) wiesenboden, ground-water podzol, and half-bog, (7) bog, (8) alluvium, (9) planosols (after U. S. Dept. of Agr., 1957).

profiles which are slightly acid and low in organic matter and soluble plant foods. In a few places, soils are saline; in others alkaline. Textures vary from clay through silt, to sand, and rock fragments. Peats, mucks, and other soils with high organic content occur in a few favorable situations.

Most of the region is within the Humid Subtropical climate, characterized by high temperature and abundant precipitation. Particular interest focuses on these two climatic elements because of their relation to plant growth.

Growing seasons are 180 days or longer in all but a few mountain sections and increase to more than 320 days in the southernmost part of Florida (Fig. 3). High temperatures over these

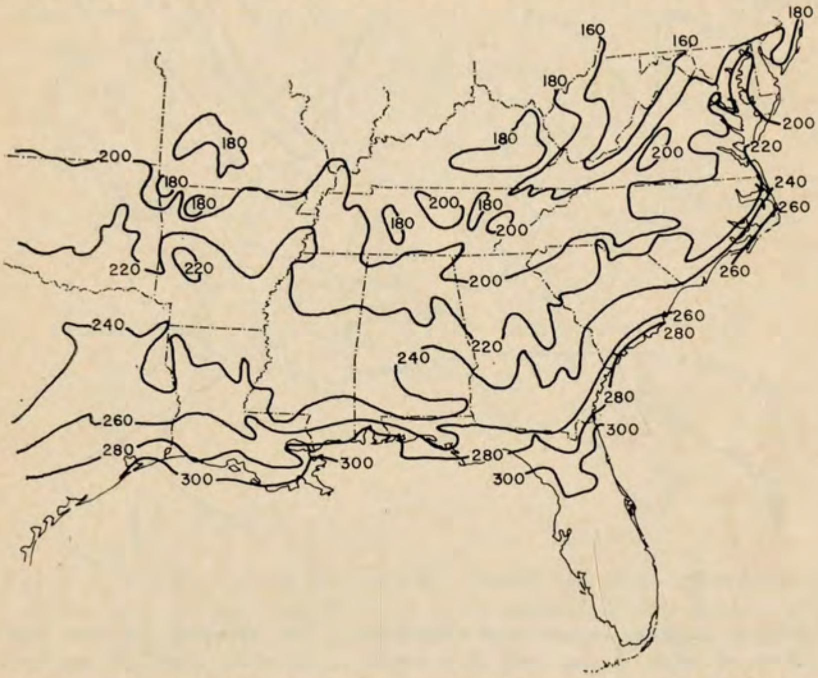

Figure 3. Average length of the growing season (after U. S. Dept. of Agr., 1941).

long growing seasons provide abundant energy for plant growth. A measure of temperature-effectiveness can be computed by adding together for each growing day the difference between its mean temperature and 40° F. The line of 800 temperature-effectiveness units approximately bisects the Southern Forest Region (Fig. 4). In comparison, the New England and Great Lakes forest regions receive 300 to 400 effectiveness units, while the forest regions of the Rocky Mountains and the Pacific Coast of the United States receive only 400 to 600.

Precipitation averages 40 to 60 inches annually except in the higher, more southerly mountains where it exceeds 80 inches (Fig. 5). Important to forestry as to crop farming is its even distribution throughout the year; most of the region gets half of its rainfall during the summer. In the southwest more rain falls in winter than in summer but, even there, summer rain averages more than 40 percent of the annual total. To the east,

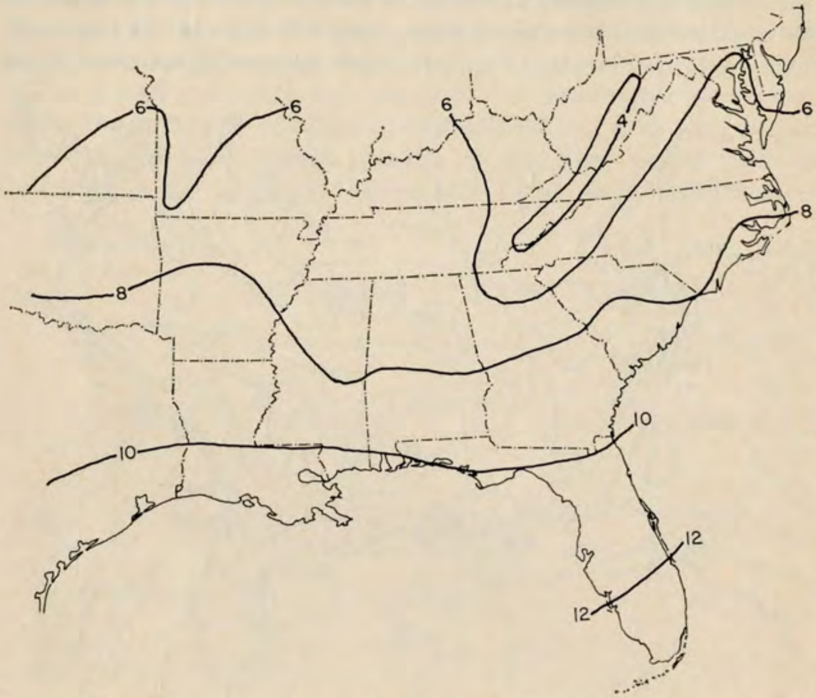

Figure 4. Average temperature effectiveness. The numbers represent hundreds of units. A day with an average temperature of 41° F. produces 1 unit, a day with an average temperature of 42° F. produces 2 units, and so on (after Livingston and Shreve, 1921).

and especially the southeast, summer rain accounts for 50 to 60 percent of the annual total; the proportion rises to slightly more than 60 percent in southernmost Florida.

Although annual and seasonal statistics for the region show that it is well-watered, the silviculturist should be aware that droughts frequently occur. Patricularly critical is the dry "spell" during the growing season that may last but for several weeks, causing trees to lose vigor and predisposing them to lethal insect attack.

A related problem is the mode of occurrence of the precipatation. Warm-season rainfall in the region is mainly in the form of thundershowers of high intensity and brief duration. Thunderstorms may be experienced 50 or more days per year in all but the eastern and extreme southwestern parts of the region (Fig. 6). Since the thunderstorms occur while the forest is in full foliage, the canopy intercepts some of the rainfall. Some

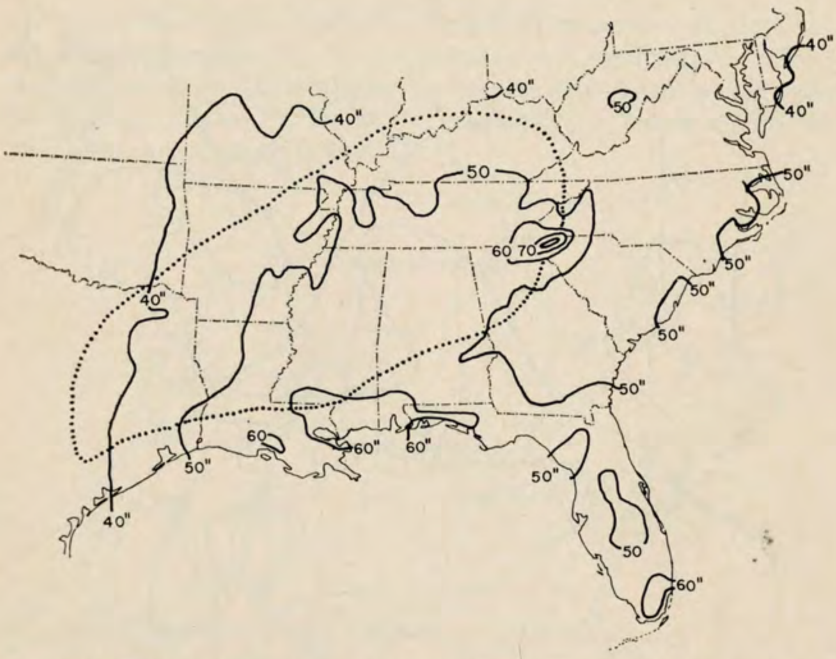

Figure 5. Average annual precipitation. Within the area outlined by the dotted line, summer rainfall is 40 to 50 percent of the annual total; elsewhere it is 50 to 60 percent (after U. S. Dept. of Agr., 1941, and Trewartha, 1961).

moisture is required to wet the leaves and stems before water can begin to reach the forest floor either by throughfall, drip, or trunk flow. Furthermore, the water held in the canopy is subject to rapid evaporation by free-flowing air. Depending on the character of the stand and the intensity of the rain, interception amounts to a reduction of 10 to 25 percent of the rainfall measured in adjacent open areas (Geiger, 1965). This factor intensifies the effects of evaporation loss and the seasonal distribution of rainfall to make the southwestern part of the region drier than other climatic indicators suggest.

Water droplets reaching the forest floor are much smaller than those falling in the open; therefore erosion is reduced (Geiger, 1965). Runoff from bare or sloping surfaces, however, is high and leads both to reduced effectiveness of the total measured rainfall, because of limited water retention, and to erosion. The old Southern term "gullywasher" expresses a tragic truth about many thunderstorms.

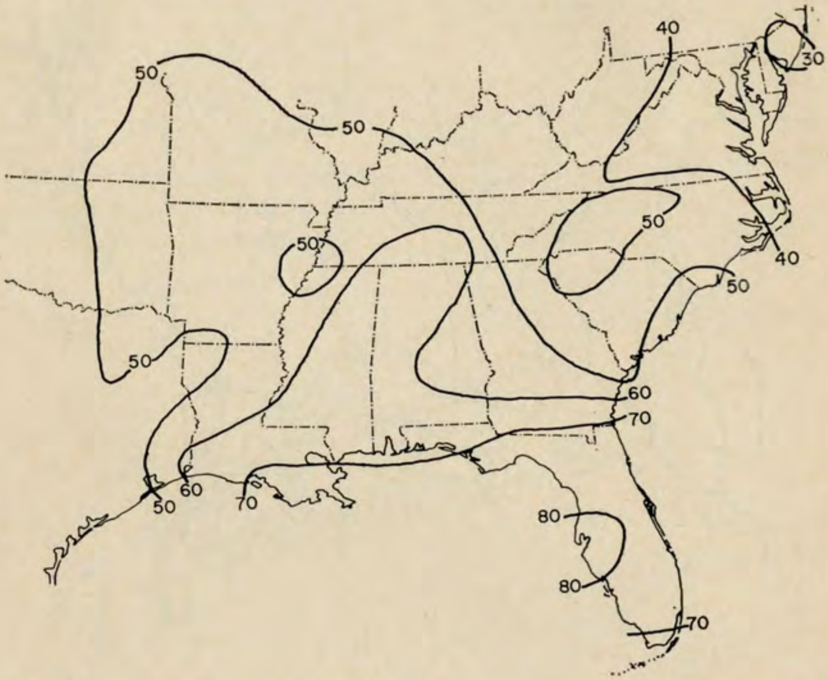

Figure 6. Average annual number of days with thunderstorms (after U. S. Dept. of Agr. 1941).

Classification and description of the many forest types occurring over this diversified region have been attempted by botanists, ecologists, foresters, and others, sometimes with widely varying objectives and results. All have been handicapped by the immensity of the area involved, the paucity of records on stand conditions before settlement, and the relatively rapid changes in stand composition that have resulted from clearing, timber harvesting, and other activities of man. Information on either original or current timber types is fragmentary, but in many areas it is sufficient to afford indications of silvicultural trends and their relation to physiographic factors.

Information on original forest types is presented in "Deciduous Forests of Eastern North America" by Braun (1950), who recorded species composition data from observations on remaining undisturbed stands and from records surviving from pioneer days. Committees of the Society of American Foresters have described 63 recognizable forest types within the southern forest region (Society of American Foresters, 1954). The periodic forest resource surveys made by Forest Experiment Stations of the Forest Service, U. S. Department of Agriculture, afford the best available information on present-day forest cover type distribution (Table 1). Broad vegetative types, based mainly on tree cover, are mapped in Fig. 7.

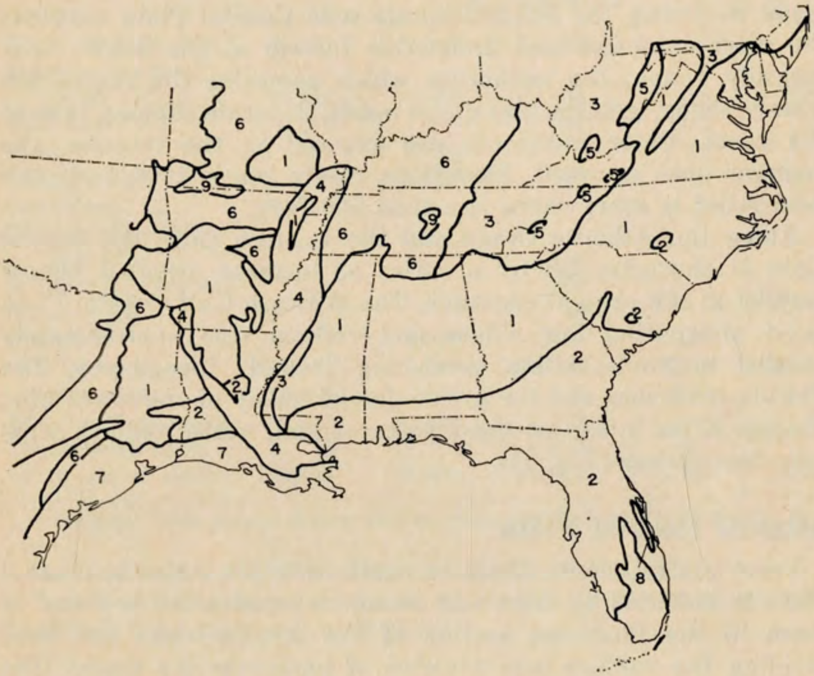

Figure 7. Potential vegetative types of the Southern Forest Region. (1) oak—hickory—pine, (2) longleaf—loblolly—slash pine, (3) oak—ash—hickory—yellow-poplar—maple—basswood—buckeye—beech, (4) oak—sweetgum—baldcypress—tupelo, (5) beech—birch—maple—hemlock, (6) oak—hickory, (7) coastal prairie, (8) Everglades grasses, (9) redcedar—bunch grass (cedar glade) (adapted from Hedlund and Jenson, 1963, and Kuchler, 1964).

COASTAL PLAIN

Physiography[1]

East and north from the western limits of southern forest types in Texas, the 320,000-square mile Coastal Plain supports the most extensive and productive forests of the South. Geologically young, the sediments which comprise the region are mainly sands, gravels, clays, and marls, in strata dipping toward the coast. Older sediments are exposed in the interior, the younger ones seaward. Elevations rarely reach 1000 feet, and local relief is everywhere less than 500 feet.

Along the Atlantic Ocean and the Eastern Gulf, the coastal plain is characterized by a series of terraces oriented almost parallel to the present coastline. The Western Gulf Coastal Plain is of alternating low ridges and valleys, also approximately parallel to the coastline, producing "belted" topography. The Florida peninsula and the great alluvial valley of the lower Mississippi River interrupt these patterns and, hence, require separate description (Fig. 1).

Atlantic Coastal Plain

From central North Carolina northward, the Atlantic Coastal Plain is indented by bays and estuaries penetrating halfway or more to the Piedmont section of the Appalachians and thus dividing the surface into a series of peninsula-like tracts. The coastal strip is characterized by long barrier beaches or islands separated from the mainland by lagoons. South of central North Carolina the barrier islands and lagoons are replaced by the ragged, marshy coastline of the Sea Island district.

From the Delaware River in the north to Georgia in the south, the Atlantic Coastal Plain is characterized by a series of broad, marine and fluvial step-like terraces separated by low, often indistinct, escarpments or zones of slightly greater seaward slope. The terraces are broader and more clearly defined in the southern half of the region.

The terrace surfaces vary as each represents (1) deposition at different periods; (2) later variations in length of exposure to subaerial weathering; and (3) varying uplift above present sea level, resulting in different degrees of dissection. In general,

[1]Sections on physiography are based on Fenneman, 1938; Atwood, 1940; Bowman, 1911; Murray, 1961; Thornbury, 1965; and Hunt, 1967.

Table 1. Approximate area of forest, by types, in the physiographic provinces of the southern United States[1]

Major Forest Type	Coastal Plain	Piedmont	Appalachian Provinces	Interior Low Plateaus	Interior Highlands
			Thousand Acres		
Longleaf-Slash Pine	21,095	593	85		
Loblolly-Shortleaf Pine	28,980	11,462	3,008	188	3,799
Redcedar[2]	244	162	304	913	932
Pond Pine	2,421	28			
Virginia Pine	139	1,723	655		
Sand Pine	422				
Pitch & Table Mountain Pine			146		
White Pine-Hemlock		12	305		
Spruce-Fir			42		
Oak-Pine	18,351	5,981	3,600	134	2,185
Oak-Hickory[3]	23,919	10,206	26,796	7,914	17,216
Oak-Gum-Cypress	30,384	2,349	240	160	1,177
Elm-Ash-Cottonwood	2,142	424	713	546	179
Maple-Beech-Birch	9		3,070	166	
TOTAL FOREST AREA	128,106	32,940	38,964	10,021	25,488

[1]Compiled from recent forest survey data supplied by U. S. Forest Service.

[2]Includes redcedar-hardwoods where separately estimated.

[3]Includes white oak, central mixed hardwoods, pin oak flats, and scrub hardwoods types where separately mapped.

the innermost terraces are older, have been lifted higher, their relief is greater, and leaching and oxidization have formed thicker weathered zones. Some of those surfaces are characterized by soils of reddish colors, hence called Redlands, especially in the upper Coastal Plain.

Toward the coast the terrace levels are not only lower in elevation and relief (hence the common designation "lower" coastal plain), but also tend to be flatter and more poorly drained. Except where drainage is so poor that permanent swamps develop, such low terraces are called "flatwoods."

The uppermost terrace surface extends to the Fall Line (the outer limit of the Piedmont) in the area north of central North Carolina. Between that point and central Georgia the elevation increases, and the terrace materials are replaced by an unterraced outcropping of sand some 20 to 50 miles in width, characteristically yellow near the Piedmont but red as the terrace is approached. This zone is variously called the "Fall Line Hills," "Sand Hills," "Fall Line Sand Hills," and "Red Hills." Maximum relief is generally 300 to 350 feet, but elevations reach almost 1000 feet in parts of Georgia and occasionally are higher than those of the adjacent Piedmont.

Much of the Atlantic Coastal Plain is poorly drained. Such areas include extensive undissected uplands like the Okefenokee Swamp in Georgia and Florida, as well as other areas where drainage is impeded. Of special interest are the elliptical **bays** found on sandy terrain, and the more extensive **pocosins** of the lower terraces. Bays are shallow depressions with well-defined sandy rims, and often contain lakes or peat swamps. A half-million bays of various sizes occur from New Jersey to northeastern Florida; since they are most frequent in the Carolinas, they are often called "Carolina bays" (Prouty, 1952). Pocosins are swamps covering a few to several thousand acres, often developed where dunes along shorelines have impeded drainage. Buell (1939) suggests that their filling with soft black muck or brown fibrous peat has been aided by the direction of the prevailing winds.

Gulf Coastal Plain

Bays and estuaries indenting the Gulf coastline and offshore barrier islands provide a pattern much like that along the Atlantic, but individual features tend to be smaller. The mainland consists of three zones of topography arranged approximately parallel to the coastline and extending with little modification from Georgia into Texas. Adjacent to the coast is a series of low and often poorly drained deltaic plains and grassy marshes. Next inland is a narrow zone of depositional terraces, called the "Pine Hills," similar to those of the Atlantic Coastal Plain, but fewer, narrower, and less distinct. The innermost and most extensive division is a zone of belted topography developed on more steeply dipping beds alternating between fine- and coarse-grained sediments. Those strata offer varying resistance to erosion and have produced a surface composed of inward-facing escarpments separated by broad vales or lowlands in typical cuesta topography.

The inner margin of the Gulf Coastal Plain extending north to the mouth of the Ohio River is not so well defined as is that of the Atlantic Coastal Plain because of the orientation of the Appalachians relative to the plain and the nature of the rocks in the two regions. From Georgia across northern Alabama and Mississippi into Tennessee, however, the innermost margin is occupied by a 50-mile wide strip of hills developed on sand. This is a continuation of the "Fall Line Hills" of the Atlantic Coastal Plain but differences in elevation are less marked. Elevations, slightly lower than in the Atlantic counterpart, reach just over 700 feet in northern Alabama; relief is only about 250 feet along the larger streams.

Departing from the general pattern of the Gulf Coastal Plain is the zone of loess-covered and deeply dissected bluffs along the eastern side of the Mississippi River alluvial lowland. These loessal hills, or "Bluff Hills," extend from the Ohio River to approximately the southwest corner of the state of Mississippi and for an east-west distance of 5 to 15 miles. Crowley's Ridge in Arkansas and Sicily Island in Louisiana are less extensive remnants of a similar zone west of the present channel of the Mississippi. The bluffs stand 125 to 250 feet above the river flood plain. Their upper 30 to 50 feet normally consist of loess, below which colluviation and mantling extend for another 50 feet in some places. The loess thins rapidly eastward, but brown loam soils indicate the presence of deposits as far as 100 miles east of the bluffs.

When loess soil is exposed, rains cause severe erosion. Among the most fertile areas of the South, the Loess Hills and the shallow loess soils to the east were largely cleared for agriculture before 1860. By the 1930's, most topsoil had eroded away and gullies were so extensive that further cultivation was hopeless. Over 60 years ago one observer noted that both industrial communities and agrarian sites literally had washed down the hills (Hilgard, 1906). Many acres are still eroding, but much of the area has been stabilized by conversion to pasture or forest.

Florida Peninsula

Southward from southern Georgia is an extensive flat-topped plateau rising abruptly from the sea floor. In the northern part of the exposed section of that plateau is a central upland reaching maximum elevations of about 300 feet and containing broad flat areas, hills, swamps, and numerous lakes. The surface is mainly sandy but underneath is soluble calcareous material on which has developed a surface of modified karst. On either side of the central upland are terraced marine lowlands normally less than 100 feet in elevation and containing old and new beach ridges with intervening swales. These marine terraces, broader on the Atlantic than on the Gulf side, account for most of the surface area of Florida.

South of the latitude of Tampa Bay the Peninsula is a broad plain with an average elevation of less than 20 feet; the surface is an almost flat marl and limestone shelf generally covered with a thin layer of peat and muck and a little sand. Perhaps 80 to 85 percent of the surface is covered by swamps (or was before recent drainage projects). The low, swampy surface is relieved by a rather continuous strip of slightly higher sandy land parallel to the east coast, and a highly fragmented counterpart along the west coast. Pines cover the higher parts of these low ridges.

The Florida peninsula continues southward as a broad submerged ridge or bank surmounted by non-forested islands, called Keys, composed entirely of calcareous materials ranging from "solid" coral to clay-size particles. Maximum elevations are about 15 feet.

Soils

Upland soils of the Coastal Plain fall mainly within the Red-Yellow Podzolic group (Fig. 2). They tend to be acidic and so strongly leached that organic matter and nutrient levels are low. The upper one to three feet are mainly yellowish or reddish with textures varying from sand to clay, although sandy loam and silty loam are common (Pearson and Ensminger, 1957).

B horizons commonly are mottled red and yellow and are more clayey. In some cases hardpans have developed, usually due to accumulation of clay. Hardpans may result from other causes, however, including aggradation, compaction, or fossil horizons (Nikiforoff, Humbert, and Cady, 1948).

Under poorly drained conditions at low elevations, groundwater podzols and similar soils are found. These tend to show an organic-rich layer at the surface underlain by a thin organic- and iron-rich hardpan which is either mottled yellow and brown or dark brown. Such soils are common from New Jersey to North Carolina (Hanna and Obenshain, 1957).

The loess-covered area east of the Lower Mississippi Alluvial Valley is characterized by brown loam soils. Leaching is strong to a depth of 10 to 20 feet, and hardpans occur within 18 inches of the surface. Because the material is easily eroded, the original **A** horizon usually has been lost and the present surface soil is the earlier **B** horizon. In studies on small headwater areas where loessal soils made up 25 to 100 percent of the watersheds, annual soil loss was 22 tons per acre from land in cultivation and 1.6 tons from grazed pasture. Loss from ungrazed, abandoned fields in sedgegrass cover and from depleted hardwood forest was 0.1 ton per acre, and from 20-year-old loblolly pine plantations 0.02 ton per acre. Annual runoff was 16 inches from the cultivated land, 15 from the pasture, 7 from abandoned fields, 5 from depleted hardwoods, and 1 from the pine plantations (Ursic and Dendy, 1965). This region contributes much of the silt load of 300 million tons carried annually by the lower Mississippi River (Bates, 1933).

Extending from central Alabama into northeastern Mississippi and terminating near the Tennessee line is the Flatwoods, a 6-to 12-mile wide soil and physiographic region. At an elevation of only 200 to 300 feet, a smooth surface has developed on an outcropping of a cold, gray, stiff, poorly drained clay. When wet, the soil is sticky; when dry, hard and cracked. The cracks in dry weather and the crayfish holes in wet are the principal conductors of oxygen to lower horizons. (A descriptive local name for this soil is "crawfish gumbo.") Flatwoods soils elsewhere are usually clay loam, sandy loam, or sand.

Soils of the northernmost part of the Atlantic Coastal Plain are members of the Gray-Brown Podzolic group. Textures are about the same as for the Red-Yellow soils described above, although less acidic and higher in plant nutrients.

Soils of the coasts are characterized by beach and dune sand, peat and muck (both common from Maryland to Florida), or marsh deposits. As a rule profiles are poorly developed (Hanna and Obenshain, 1957; Henderson and Smith, 1957).

Climate

Rainfall quantity is relatively uniform over the Coastal Plain, amounting to 40 to 50 inches annually except in a zone from central south Louisiana to western Florida and in the Miami vicinity where it is 60 or more inches. Distribution is also uniform throughout the year over most of the region. However, more rainfall is received in the cooler half-year in an inland zone extending from western Georgia to eastern Texas (Fig. 5). That zone, along with the coastal area and the Florida peninsula, has a high incidence of thunderstorms.

Most of the region has 50 or more days each year in which thunderstorms occur; in the Tampa Bay vicinity the figure reaches 80. No part of the Coastal Plain averages less than 40 thunderstorm days annually (Fig. 6).

The average frostless season is 200 days north of North Carolina, gradually increasing to about 250 days in Texas and Louisiana and 320 or more days in southern Florida (Fig. 3). Temperature effectiveness averages just under 600 units annually in the northernmost zone and increases to 1,300 at the tip of Florida (Fig. 4). The mode and seasonal distribution of rainfall combine with high temperature effectiveness and its high evaporation rates to make the southwest drier than the northern and eastern parts of the Coastal Plain.

Vegetation

Predominant cover types and sites

About 25 percent of the forests of the Coastal Plain are bottomland types, most of which occur within the lower Mississippi Alluvial Plain (See page 31). Other major stream courses within the Coastal Plain support similar forests.

Figure 8. Longleaf pine, on terrace sites in the Coastal Plain, typically develops tall straight stems, prized for poles, piling, and sawlogs. The central tree (with band), because of its form and other superior characteristics, will be used as a parent in tree breeding programs. South Carolina. Photo by U. S. Forest Service.

Major upland types include loblolly pine-shortleaf pine—23 percent of the total Coastal Plain forest; longleaf pine-slash pine—17 percent; oak-pine—14 percent; and oak-hickory—19 percent (Table 1). About 2 percent is classed as pond pine, occurring mostly in the Atlantic section, while types classed as red-cedar, sand pine, and Virginia pine each make up less than 0.3 percent of the total. The proportion of hardwood in upland types, and the relative area occupied by types where hardwoods predominate, are believed to have increased during the past century, although much abandoned farmland now grows pure pine.

The longleaf pine-slash pine type predominates on sandy flatwoods where hardpans underlie the surface soils (Fig. 8). The type seldom regener-

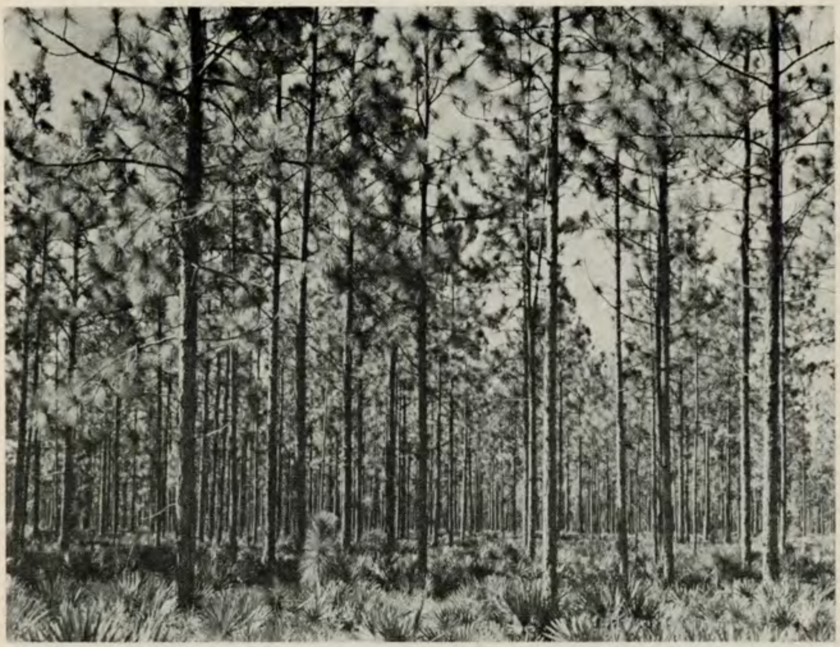

Figure 9. Twenty-five year old longleaf pine, of natural origin, on Coastal Plain terrace site in Georgia. The understory of saw-palmetto is typical of many flatwoods sites. Photo by Georgia Forestry Commission.

ates naturally to the same two principal components, but, rather, converts to pure stands of either species (Fig. 9, 10). While both require a mineral seedbed for germination, 2- to 5-year-old longleaf pine stands need fire for brown spot needle blight control while slash pine seedlings of this age rarely survive burning. This difference in resistance to fire makes it rare for these species to pass the seedling stage together. Turkey oak and other scrub oaks frequently are found with longleaf pine. Blackgum and red maple are more likely to accompany slash pine, which prefers the more moist sites. Slash pine is not found naturally west of the Mississippi, but planted stands have been established in Texas, Louisiana, and southern Arkansas.

Loblolly pine, so called by the pioneers because it occurred in the "loblollies"—muddy holes—along the Atlantic coast, is found throughout the Coastal Plain except in lower peninsular Florida. It is often accompanied by shortleaf pine, sweetgum,

Figure 10. Slash pine, about 30 years old, naturally reseeded following harvest on a terrace site in the Coastal Plain, Georgia. Photo by Georgia Forestry Commission.

oaks, and hickories (Frontispiece). The latter species, tolerant of shade, reproduce under the canopy of the pines, whereas the pines seldom do so. Hence, in time, pure loblolly pine, shortleaf pine, or loblolly pine-shortleaf pine mixtures become pine-hardwood cover types and, upon elimination of the conifers by lightning (they are the tallest trees), insects (several beetles kill them), fire, or harvest, ecologic succession progresses to an oak-hickory climax type. Lesser broad-leaf species will also invade the stand, making, under some conditions, a truly mixed-hardwood, unevenaged forest. On some sites, such as the Red Hills of Florida, the climax forest may be magnolia-beech (Kurz, 1944). Openings in stands may result in the entrance here and there of a few pines while, under the canopies and in the openings, eastern redcedars may germinate and grow.

Although considered a moist site species, loblolly pine has wide site tolerance and is often found on relatively dry areas. It is frequently associated with longleaf pine, and when fire is excluded may replace the latter, especially after harvests. Shortleaf pine may invade with the loblolly pine in some areas. Loblolly pine is the species in the "Lost Pines," three "islands" totaling some 40,000 acres about 75 miles west of the East Texas pineries. It is also the principal conifer in the Big Thicket of southeastern Texas where many hardwoods are in the association, forming a temperate zone mesophytic jungle.

Old-field stands of shortleaf and loblolly pines are common throughout the Coastal Plain. Where a seed source is available, they occupy the mineral seedbed exposed by abandonment of cultivated land. Where seed is scarce, or where brush, forbs, or grass sod has captured the site, old-field stands are sparse, giving rise to "wolf" trees of poor form. Ecologic succession throughout the lower Coastal Plain is represented by a case in North Carolina where abandoned fields are covered by crabgrass and horseweed in the second year and these are overtopped by aster and ragweed in the third year, and broomsedge is dominant until shaded by pine in the fifth year. In the lowest areas,

Figure 11. Upland forest, almost entirely of post oak, in the Texas Post Oak Belt. Similar oak and oak-hickory forests fringe the western edge of the commercial forest region in Oklahoma. Photo by Texas Forest Service.

blackberry bushes accompany the broomsedge (Kaufman, 1948).

Spruce pine is rarely found in pure stands. It is associated with loblolly pine and hardwoods in the second bottoms and on the moist fringes surrounding longleaf pine stands. Pond pine is found in the pocosins and flatwoods of the Atlantic Coast, sand pine in the Florida peninsula and the West Florida sandhills, and Atlantic white-cedar, baldcypress and pond-cypress in the swamps. These types are discussed subsequently and in appropriate monographs of this series.

Upland hardwood types, constituting nearly a fifth of the Coastal Plain forests, are in part native and in part the result of past use. Narrow bands of hardwoods occur along drainages and minor streams in areas otherwise dominated by pines. In parts of northern Mississippi, western Tennessee, and Kentucky, hardwood forests extend continuously over the uplands and are typically oak-hickory. The forests of the Texas Post Oak Belt (Fig. 11), and similar dry, sandy sites, though less productive, are classed as oak-hickory type. Considerable land originally in pine, especially on sandhill sites, reverted after cutting to essentially pure scrub hardwoods. Perhaps even more extensive are the areas where removal of pines from pine-hardwood stands has left little but hardwoods as growing stock. The most prevalent hardwoods on these well-drained sandy loam or fine sandy loam soils are flowering dogwood, southern red oak, and sweetgum. Oak prevails on the drier sites; sweetgum on more moist sites.

The best sites—for both pines and hardwoods—are the small valleys where soils are immature and composed of alluvium derived from silty or sandy loams. The soil is porous to a depth of 3 feet or more, the A horizon is deep, moisture is continuously adequate, and subsoils are well-drained. Intermediate sites in the Coastal Plain frequently occur on sandy loams or silt loams with shallow A horizons and heavier, more impermeable B horizons.

A key to forest types in Arkansas, related to topography and soil, is given in Table 2.

Table 2. Forest type occurrence as related to topography and soils in the Arkansas Coastal Plain (after Turner, 1937).

Topography and Soils	*Forest Type*
A. Small and medium-sized stream floodplains.	
1. Drainage fair to good. Soils with relatively deep, loose A horizon, permeable B horizon. Soils are Ochlockonee sandy loams and silt loam, Bibb very fine sandy loam, Amite fine sandy loam, Myatt very fine sandy loam, Hannahatchee fine sandy loam, and Cahaba fine sandy loam.	Loblolly pine—white oak Willow oak—water oak—Nuttall oak—overcup oak Sweetgum—red maple
2. Drainage poor to fair. Soils with relatively shallow or clayey A horizon and impermeable B horizon. Soils are Bibb clay, silt loam and phases of very fine sandy loam, Trinity clay, Ochlockonee clay, and Leaf silt loam.	Water oak—willow oak
B. Coastal plain terraces.	
1. Caddo silt loam terrace.	
a. Fair surface and subsoil drainage, fairly deep to deep silty A horizon. Soils are Caddo silt loam and phases of Lufkin silt loam.	Hickory—swamp chestnut oak—white oak Loblolly pine—white oak Loblolly pine—shortleaf pine
b. Poor surface drainage, subsoil drainage fair. Soil, Caddo silt loam.	Wet prairie
2. Caddo sandy loams, Lufkin and Crowley silt loam terraces.	
a. Fair surface drainage, shallow A horizon, and B horizon less permeable than that of Caddo silt loam. Soils are Caddo fine and very fine sandy loams, and Lufkin silt loam.	Loblolly pine Loblolly pine—willow oak—red maple—cherryback oak
b. Flatter phases of the above soils, drainage poorer.	Willow oak Water oak—willow oak

c. Poor surface drainage, shallow A horizon and very impermeable (hardpan) B horizon. Soil, Crowley silt loam.	Wet prairie.
C. Rolling coastal plain soils. Sandy loams with medium depth A horizon; B horizon relatively permeable sandy clay. Soils are Ruston, Susquehanna, Norfolk, Orangeburg, and Greenville sandy, gravelly, or silty loams, and phases of Caddo sandy loams.	
1. Slope 1 to 10 per cent.	Loblolly pine—white oak Loblolly pine Shortleaf pine Shortleaf pine—white oak Loblolly pine—shortleaf pine
2. Slope 10 to 25 per cent or more.	
a. South, east, and west slopes, except narrow ravines, valleys or gulleys.	Shortleaf pine Shortleaf pine—post oak Post oak—blackjack oak Post oak
b. North slopes, deep or narrow ravines, valleys or gulleys.	Shortleaf pine—white oak Black oak—post oak Black oak—hickory White oak—black oak—southern red oak
D. Rolling coastal plain soils. Extremely sandy soils, with much sand throughout all horizons; drainage good to excessive. Soils are Ruston, Susquehanna, Norfolk, and Orangeburg sands.	Shortleaf pine Shortleaf pine—post oak Post oak—blackjack oak
E. Rolling coastal plain soils. Clays, clay loams, etc. Very heavy, often limestone soils. Soils are Sumter clay, Houston clay.	Post oak—blackjack oak Osage-orange—winged elm Upland prairie

Unique Sites and Communities

The **Post Oak Belt** of Texas, from 50 to 100 miles wide, forms a transition between the pine and oak-pine types to the east and the tall-grass prairies (now mostly farmed) to the west. Stands are dominated by post and blackjack oaks but may include several other oaks and hickories (Fig. 11). Except in the most favorable sites, tree growth is slow and form is poor. Stand density declines from east to west, the border with the prairie often being a savannah. Bluestems and other prairie bunch grasses appear as understory plants. Generally trees occur on the more broken terrain where soils are sandy, while flatter areas with clay soils, originally grass sites, are now farmed or in pasture. It is suggested that planting and management of loblolly pine within the Belt may be economically feasible. Evidences are (1) the relict stands of the species near the western edge of the Post Oak Belt; (2) results of studies with seedlings (Bilan and Stransky, 1966); and (3) growth on more than 200 plantings within the Belt, half of which are more than 10 years old.

Figure 12. Mixed hardwood forest on loessal soil, in the Bluff Hills of the Gulf Coastal Plain, Mississippi. Photo by U. S. Forest Service.

In the **Bluff Hills** east of the Mississippi River, well-managed deep loess soils support fast-growing stands of high-quality hardwoods (Fig. 12). Where the aeloian mantle thins to less than 2 feet, loblolly, longleaf, or shortleaf pines may occur in mixture with hardwoods of poorer form. Large areas of severely eroded cropland have been planted to loblolly pine, or have reseeded naturally to this species or to shortleaf pine.

The **Sandhills** of the Georgia-South Carolina Fall Line share with those of Northwest Florida and the peninsular "Big Scrub" the handicap of excessive drainage through deep, coarse sands (Fig. 13). Retaining moisture only a few days after rains, the topsoils

Figure 13. Deep, coarse sands, whether in the Fall Line Hills, the Northwest Florida Sandhills, or in less extensive areas elsewhere in the Coastal Plain, bear sparse stands of scrubby oaks, or revert to scrub oak after pines are harvested. Blackjack, bluejack, post and turkey oaks are common species.

afford a poor environment for seedlings. In Florida, only the local strains of the xeric sand pine reseed consistently (Fig. 14), though much of the West Florida Sandhill area once supported longleaf pine. Slash pine occupies favorable sites in both sandhill areas. Loblolly and longleaf pines occur with scrub hardwoods in the Fall Line Sandhills, but strenuous measures are necessary to regenerate them after harvests (Fig. 15). In all three regions blackjack, bluejack, and turkey oaks are strong competitors of pine. The "Pine Barrens" of southern New Jersey are also excessively drained sites, where pitch pine, shortleaf pine, and scrub oaks comprise the tree vegetation.[1]

The term **Flatwoods**[2] is applied to a number of extensive areas of low relief within the Coastal Plain, usually limited to pine

[1]See Harshberger (1916) and Little and Moore (1953) for ecology of the pine barrens.

[2]See also the discussions of Arlen (1959) and Stevenson (1960) for definitions and the historic account of Hilgard (1906).

and pine-hardwood sites. Such areas occur on the lower terraces along the Atlantic and Gulf coasts, or on interior belts where clays or other soft sediments have developed flat topography. The coastal flatwoods, mostly at elevations below 25 feet, are poorly drained but not permanently inundated. Although soils are usually sandy, root development is often limited by high water tables or hardpan. Loblolly pine and numerous hardwoods

Figure 14. Sand pine, on the upland sandhills of central Florida, occurs in pure, evanaged stands which have seeded in after fires. Mature trees are relatively small, useful chiefly for pulpwood. Ocala National Forest. Photo by U. S. Forest Service.

are supported by these sites throughout the region, pond pine and Atlantic whitecedar are common along the Atlantic coast, longleaf pine may be present south of Virginia, and slash pine east of the Mississippi River. The Big Thicket area, inland from the Texas coast, is generally similar though site quality may be better due to more favorable permanent water tables (Parks, 1938; Parks and Cory, 1938).

Interior flatwoods soils are typically fine textured, with moderate to poor internal drainage, though often permeable for tree roots to depths of 6 feet or more. Plant nutrients are usually

Figure 15. Sandhill site in the Upper Coastal Plain of South Carolina, occupied by scrub oaks and a sparse stand of longleaf pine. Oaks must be controlled to insure establishment of a new pine stand by planting or seeding. Photo by South Carolina Commission of Forestry.

adequate; some excellent loblolly pine sites are flatwoods. Besides loblolly pine, which occurs on most interior flatwoods, these belts support shortleaf pine and many hardwoods, notably the red oaks and post oak (Donahue, 1937).

Swamps occupy large areas of the Coastal Plain. Although coastal salt water marshes and some adjacent swamplands such as the Everglades of southern Florida are essentially treeless, most inland swamps are timbered. These include the extensive Big Cypress, Okefenokee, and Dismal swamps in Florida, Georgia, North Carolina, and Virginia. Baldcypress occurs in nearly all deep swamps (Fig. 16). Other species, with varying tolerance for inundation, include pond pine, blackgum, water tupelo, Atlantic whitecedar, green ash, sweetbay, and magnolia. Specially recognized types of swamps include the sharply defined elliptical depressions known as **bays,** and the larger, low-lying **pocosins** (Prouty, 1952; Marschner, 1959). Most common on upper terraces in the Carolinas, and of undetermined origin, bays vary from slightly wet depressions to deep swamps or lakes. Pocosins are waterlogged areas in lower terraces, ranging up to several thousand acres in extent. Soils are black muck or brown peat up to 6 feet in depth, usually supporting stands of pond pine (Fig. 17) or Atlantic whitecedar. Many pond pine sites can be converted to faster-growing loblolly pine with effective water management (Woods, Copeland, and Ostrom, 1959; Vande Linde, 1960).

Certain waterlogged soils, usually adjacent to swamps, may support a grassland vegetation, with few if any trees. Such sites, called "savannahs" in the southeast and "prairies"[1] west of the Mississippi River, may support pines if local surface drainage is provided (Wackerman, 1929).

Areas of slow, subterranean drainage contain peat formed from hydrophytes. Better-drained areas have a more finely divided peat or muck formed from woody-plant residues, while thick

Figure 16. Basal swellings and unique "knees" growing from submerged roots are adaptations that probably help enable baldcypress to grow, often in pure stands, in deep swamps throughout the Coastal Plain. Seedlings are killed by prolonged inundation; reproduction of baldcypress after cutting is rarely successful.

beds of acid sandy loam produce half-bog soils. The low pH (<4.5) limits nutrient availability.

Sand dunes and **salt-spray sites**[2] are common on barrier islands

[1]Not to be confused with grassland types occurring further west, or the "blackland prairies" developed on calcareous parent materials in Alabama, Mississippi, Arkansas, and Texas.

[2]See also, for causes of damage and ecology, Oosting, 1942, 1945; Kurz, 1939; Doutt, 1941; Boyce, 1954; Woodcock, 1957; Moss, 1940; Lutz, 1941; for stabilization, Stern and Voigt, 1959; Oosting, 1942; Fenley, 1948; Kroodsma, 1937.

Figure 17. Survivors of a pond pine stand destroyed by repeated wildfires on a pocosin site, Atlantic Coastal Plain. Normally too waterlogged for good tree growth, but inflammable when dry, these organic soils are more productive when drained and planted to loblolly pine.

and on strips of the mainland up to one mile wide along the Atlantic and Gulf coasts. Deep, infertile sites, subject at frequent intervals to storm-blown salt or temporary flooding by seawater, favor xeric, salt-tolerant shrubs and trees such as waxmyrtle, yaupon, and live oak. On extreme sites, especially where winds keep beach sand in movement, few woody plants become established until grasses, sedges, and other low vegetation have stabilized the surface. On more favorable sites, however, pines may be present despite frequent salt-spray damage, as on the barrier islands off the Mississippi Gulf coast.

Domes, ranging in area from less than one to more than 100 acres, occur in the lower Florida peninsula. So named because of the gradual increase in height of the baldcypress trees from the grass periphery to the center, the domes are variously attributed to fire, grazing, and drainage.

LOWER MISSISSIPPI ALLUVIAL PLAIN OR "DELTA"

Physiography

A physiographic feature unlike the general pattern of the Gulf Coastal Plain is the lower alluvial valley of the Mississippi River, called "the Delta" locally and in forestry literature (Fig. 1). It interrupts the prevailing east-west orientation of the coastal plain with a north-south belt of alluvial soils bearing distinctive bottomland hardwood forests.

The Mississippi is an aggrading river which has built an alluvial plain more than 500 miles long and 25 to 125 miles wide in a large structural trough between the Appalachians and Ozarks. Because of the modification by silt deposition, the average valley gradient is less than 8 inches per mile and land slopes downward from the river to lower flood basins within the flood plain. These flood basins range in size from local areas of a few hundred acres to major regions embracing numerous subbasins, such as those drained by the Yazoo River in Mississippi, the St. Francis and Black rivers in Arkansas, and the Tensas and Atchafalaya rivers in Louisiana. Except between Memphis and Vicksburg, the Mississippi River channel currently lies near the eastern margin of the flood plain at the foot of the Bluff Hills. In the past it has meandered throughout the plain, producing a landscape of old terraces that represent stages of valley fill, with many cutoff meanders or oxbow lakes and low ridges marking the location of old natural levees along the stream channel.

Soils and Climate

The soils of the alluvial plain are well supplied with nutrients other than nitrogen. Texture varies with the velocity of the floodwaters by which they were deposited. Coarsest materials, mostly fine sands and sandy loams, are found on natural levees adjacent to present or former river channels where floodwaters flow most rapidly. Progressively finer sediments tend to drop out as floodwaters spread from the main channel leaving little but clays to be deposited in the "back swamps." Differences in aeration due to these texture gradients and to differences in surface drainage have marked effects on soil productiveness, either for forest or agricultural uses. Soil patterns may be extremely complicated in areas where remnants of natural levees from old meanders are unrelated to the present channel (Donahue, 1937; Grissom, 1957).

Artificial levees and other protection works have greatly reduced flooding on much of the Mississippi floodplain. No major overflow of the main river has occurred since 1927. This protection and improved local drainage have lowered water tables and encouraged widespread land clearing for agriculture. Reduction of areas available for forestry in protected basins has increased silvical interest in unprotected lands, called **battures,** lying between the artificial levees and the river channel. Light-textured and fertile, these lands often support excellent stands of cottonwood and willow.

Average annual precipitation ranges from about 45 inches in the north to 60 inches in the south. Dry periods have little effect on the growth of forests on these poorly drained soils. Temperature effectiveness ranges from 700 units in the north to 1000 in the south.

Vegetation

Forest types of the Delta are related to the elevation of the land; slight differences cause significant changes in species composition (Fig. 18). Hence, flats, fronts, "new" land, ridges, and

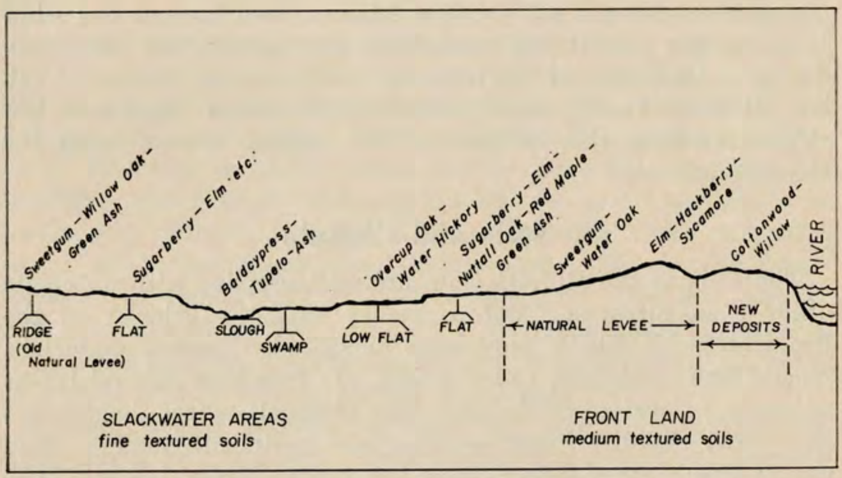

Figure 18. Idealized section across a portion of the Mississippi Alluvial Plain, illustrating relationships between topographic position, soils and major tree associations. Vertical scale exaggerated.

swamps are often characterized by certain tree groups. About 70 species of commercial importance occur, usually in mixed stands. Along the river front are eastern cottonwood and willows, while further back pure stands of sweetgum (Fig. 19), water oak, white oak, or ash may be found. Mixed stands on the ridges—slight rises of a few inches to a few feet above the surrounding flat—may be predominantly white, red, and water oaks, hickories, sweetgum, baldcypress, blackgum, and water tupelo (Putnam, Furnival, and McKnight, 1960). Table 3 summarizes type occurrence in major river floodplains in Arkansas.

Figure 19. Sweetgum stand on well-drained site in the Alluvial Plain of the Mississippi River, Bolivar County, Mississippi. The largest tree measured 58 inches in diameter at breast height in 1969. Photo by Mississippi Forestry Commission.

The present forest has resulted from fire, tornado, logging, agriculture, flooding, sedimentation, and erosion, leaving a mixture of species and age classes ranging from seedlings to mature trees. Many kinds intolerant of shade become established in the openings; others develop in the understories of older stands. Generally, seedbeds must be moist, but not flooded and, for many species like the willows and cottonwoods, the mineral soil must be exposed.

Baldcypress is found in swamps where water is too deep for competitive species. It occurs in pure, dense, evenaged stands. Where single stems are found mixed with hardwood forests, a change in the physiography of the site during the life of the stand has probably occurred. Perhaps man or nature has diked or drained the land or moved the soil. Distribution of species by sites was described by Lentz (1931). Composition of major bottomland forest types and their soil and drainage requirements were presented by Putnam (1951). (For Crowley's Ridge, see Turner, 1937.)

Table 3. Forest type occurrence as related to topography and soil in major river floodplains of Arkansas (after Turner 1937).

Topography and Soils	*Forest Type*
A. First bottoms.	
1. Very wet; wholly or intermittently submerged. Soils with relatively shallow A horizon and heavy clay B horizon, such as Portland clay and Portland silty clay loam, Miller clay, Sharkey clay, Waverly silt loam, and clay loam.	Baldcypress Water tupelo
2. Submerged only during flood time.	
a. Poorly drained sites with impervious subsoil, and relatively shallow A horizon. Soils are Sharkey clay, Waverly clay, Yazoo silt loam and silty clay loam, and Collins silt loam.	Willow oak Sweetgum—Nuttall oak—willow oak Eastern cottonwood Oak—elm—ash
b. Somewhat better drained sites with less impervious subsoil. Soils are Miller fine sandy loam and very fine sandy loam, Sarpy very fine sandy loam and silty clay loam, Portland very fine sandy loam and Yahola very fine sandy loam and silt loam.	Eastern cottonwood Sweetgum Sweetgum—cherrybark oak Willow oak—swamp chestnut oak—cherrybark oak
B. Second bottoms (terraces).	
1. Sites with poor drainage, shallow silty, silty clay or clay A horizon and impervious B horizon. Soils are Brewer clay, Muskogee silt loam, Calhoun silt loam.	Willow oak Sweetgum—Nuttall oak—willow oak
2. Sites with medium drainage and soils intermediate as regards permeability of B horizon. Soils are Bastrop clay, Brewer silt loam, Oliver silt loam, and Muskogee very fine sandy loam.	Sweetgum Sweetgum—cherrybark oak Willow oak—swamp chestnut oak—cherrybark oak

3. Fair to good drainage. Soils with relatively permeable B horizons. Soils are Brewer very fine sandy loam and silt loam, Reinach and Lintonia loamy sand, fine sandy loam, and silt loam.	Hickory—swamp chestnut oak—white oak Loblolly pine Loblolly pine—white oak

PIEDMONT

Physiography

The Piedmont Province, extending from above the Potomac to Alabama, is the easternmost section of the Appalachian Highlands. It is narrow in the north—only 50 miles wide in Maryland—broadening to 125 miles in North Carolina, but narrowing again further south. Elevations range from 300 to 1,200 feet above sea level.

The Piedmont, often referred to as a plateau, was once worn away almost to a plain by erosion, then uplifted, and subsequently dissected to produce the present undulating surface. The rocks of this region are very old and most of them have been metamorphosed. Gneisses and schists, along with some marble and quartzite, cover about half of the surface area and tend to form uplands. About 20 percent of the surface consists of granite whose resistance to erosion also tends to produce uplands and some striking isolated features, the most notable being Stone Mountain in Georgia. An additional 20 percent of the surface consists of rocks only slightly metamorphosed with slate a principal component. These softer rocks, found along the eastern margin of the Piedmont, from southern Virginia to Georgia, dominate the so-called "Carolina Slate Belt." This belt is characterized by valleys at lower than prevailing elevations. Another 5 percent of the Piedmont surface consists of unmetamorphosed and noncrystalline rocks, sometimes with crystalline intrusions and occurring mainly as scattered small regions of lower elevation, developed on beds of red sandstone, conglomerate, or silt.

Soils

Piedmont soils mainly are in the Red-Yellow Podzolic group with either sandy loam or clay loam textures and slightly acid profiles. Mineral nutrient content of virgin soil, except for nitrogen, is fairly high (Pearson and Ensminger, 1957). Soils developed on acidic rocks with high silica content (e.g., granite, including its metamorphosed forms) are usually coarser textured and lower in base elements than those formed on basic rocks. Soils derived from horizontal beds of schists are thin and dry, while vertical beds of schists produce deep, well-drained soils. Sandy surface soils occasionally occur as a result of leaching of clay particles. Soils of the Carolina Slate Belt are silty at all depths; other areas contain large gravel deposits. Subsoils of the province usually are finer in texture than are the surface soils.

Few regions of the United States have experienced such severe soil erosion as the Piedmont. Widespread clearing and continuous cultivation of row crops in a region of sloping surfaces, porous surface layers over heavier subsoils, intense storm rainfall, and little snow, have left the region seriously eroded. Every part has lost 25 percent or more of its topsoil; from southern Virginia southward more than three-fourths of the region has lost three-fourths or more of the loamy topsoil (U. S. Dept. of Agr., 1957).

Erosion has removed the loamy surface materials exposing the reddish subsoils, often plastic clay which cannot absorb an inch of water in 36 hours (Southeastern For. Exp. Sta., 1951). Not only do these presently exposed surface soils inadequately absorb water, they also have little organic matter needed for improving soil physical structure and tree vigor.

Most Piedmont forest land is Class VII on the Soil Conservation Service land capability scale; little is of better quality than Class IV (Southeastern For. Exp. Sta., 1949).

Climate

Annual rainfall is 40 to 50 inches throughout the region (Fig. 6); approximately one-third of it occurs during the summer. The growing season is from 180 to 210 days in length (Fig. 4). Temperature efficiency ranges from 600 units in the north to 800 in Georgia (Fig. 5).

Vegetation

Before the intrusion of white settlers into the Georgia Piedmont, nearly half of that area was occupied by pine-mixed hardwood stands, over one-third supported only hardwoods (principally oaks and hickories on "red lands"), and pure pine stands were found on soils derived from sandstone or granitic rocks (Nelson, 1957).

Figure 20. Mixed loblolly and shortleaf pine in the Piedmont Plateau of Georgia, established by natural seeding on abandoned cropland. The original forest was probably hardwood. Photo by Georgia Forestry Commission.

At present the forests of the Piedmont Province are classed as 35 percent loblolly pine-shortleaf pine, 18 percent oak-pine, 31 percent oak-hickory, 7 percent oak-gum-cypress, 5 percent Virginia pine, and 2 percent or less of longleaf pine-slash pine and elm-ash-cottonwood (Table 1). The loblolly pine-shortleaf pine type (Fig. 20), while well distributed throughout the region, occupies more land in Georgia and South Carolina than in any other Piedmont States. Longleaf pine-slash pine and oak-gum-cypress types are principally in Georgia, while the Virginia pine type is concentrated mainly in Virginia and North Carolina. Oak-pine and oak-hickory types occupy large areas throughout the province, accounting for almost one-half of the forested area.

Much of the Piedmont is so severely eroded that it has been abandoned for agronomic use and returned to forest. Left to natural succession, abandoned fields may remain for several years in annual and biennial forbs before broomsedge, and eventually pines, become dominant.[1] Transition to pines is generally more rapid on heavier soils than on lighter ones (Odum, 1960). In recent years a great deal of abandoned land has been converted to pine forest by planting (Fig. 21).

Encroachment of undesirable hardwoods is an important obstacle to good forest management in Piedmont uplands. Frequent crops of windblown seed, exposed mineral soil seedbeds, and superior growth rates combine to favor pines on old-field

[1]Hursh and Crafton (1935) list the herbaceous vegetation indicating soil conditions on recently abandoned fields of the Piedmont.

Figure 21. Twenty-year-old slash pine planted on abandoned cropland, Piedmont Plateau, Georgia. Site is a level ridge-top, and less severely eroded than much Piedmont land. Although not native north of the Coastal Plain, slash pine has proved productive on many Piedmont sites. Photo by Georgia Forestry Commission.

sites. Shade tolerance, however, permits hardwoods to become established as an understory within about 20 years. Poor sites are usually invaded by buckthorn, wildplum, and sweetgum. On better-than-average sites, more desirable hardwoods, such as flowering dogwood, oaks, yellow-poplar and hickory may appear. Slower-growing than the pines, and usually unmerchantable when pines are harvested, hardwoods frequently so dominate sites as to prevent pine regeneration.

Hardwoods are more aggressive on northern and eastern slopes than on drier southern and western exposures. As soil moisture is limiting under the latter conditions hardwoods, unable to subsist, early give way to pine. An important invader on all sites is sweetgum: it grows to good form on fine-textured moist soils, but is of lower grade on coarse, upland soils. On poor sites, dogwood appears as an occasional tree (and incidentally helps improve the quality of the soil), but in deep surface soils of fine texture, it may take over large areas.

SOUTHERN APPALACHIAN PROVINCES

Physiography

West of the Piedmont are three additional sections of the Appalachian Highlands (Fig. 1). From east to west those divisions are the Blue Ridge Province, the Ridge and Valley Province, and the Appalachian Plateaus.

Blue Ridge Province

This province is a distinctly mountainous belt, 5 to 80 miles wide, extending from Pennsylvania to Georgia. Standing 1000 to 4000 feet above the Piedmont, it displays the highest elevations and most rugged topography east of the Rocky Mountains. The region is broadest and highest in the south. North of the Roanoke River the mountains compose a single ridge (the Blue Ridge) or one major ridge flanked by subsidiary ones. Southward, closely-spaced ridges form a mountainous upland with a prominent escarpment 1500 to 2500 feet high overlooking the Piedmont. Here, the name Blue Ridge is applied locally only to the escarpment and to the ridges forming the divide between the Atlantic and Mississippi drainages. This part of the province as a whole is often referred to as the Southern Appalachian mountains. The highest elevation, Mt. Mitchell in North Carolina, is 6684 feet above sea level.

As in the Piedmont, the rocks of the Blue Ridge Province are primarily metamorphic, with gneisses, schists, quartzites, and slates particularly common. In the south, however, are thick accumulations of old sediments such as siltstone, sandstone, and conglomerate.

Ridge and Valley Province

This division of the Appalachian region is 50 to 75 miles wide and lies between the Blue Ridge Province and the Appalachian Plateaus except in the extreme south where the Blue Ridge is absent and the Ridge and Valley Province adjoins the Piedmont. The rocks of the Ridge and Valley Province are quite unlike those of the areas to the east. Conglomerates, shales, and sandstones predominate, but there are significant occurrences of limestone as well. These younger and softer materials have been subjected to lateral pressures which have built a topography of long, narrow, often remarkably even-crested ridges separated by narrow valleys. Sandstone is exposed in most of the ridges, while the valley rocks tend to be limestones and shales. The ridges are most prominent in the northern sector; south of the Knoxville, Tennessee, area, the ridges are so minor that the entire region appears as a valley.

The eastern part of the province, at the western foot of the Blue Ridge, is a series of connected valleys extending from Pennsylvania to Alabama, commonly called the Great Valley or Appalachian Valley. The low gradients and fertile soils developed from the limestone and shale of the Great Valley long have attracted migrants and settlers.

Appalachian Plateaus

These consist of rocks much like those of the Ridge and Valley Province, but here uplift has not been accompanied by lateral pressures sufficient to build strongly folded forms. Instead, the rocks are nearly horizontal, but stream dissection has formed a surface of hills and low mountains. Nearly everywhere elevations are higher than in the Ridge and Valley Province, and the region is bounded by outfacing escarpments or dissected mountain fronts on all sides. The eastern boundary, from West Virginia to Alabama, is a prominent escarpment 500 to 1000 feet in height. In contrast, the western boundary, from the Ohio River to Alabama, is a minor escarpment dissected into promontories and buttes locally known as the "Knob Belt."

The Appalachian Plateaus Province from the Kentucky River northward bears the local name Allegheny Plateau. Its eastern escarpment is known as the Allegheny Front or, where strongly dissected, the Allegheny Mountains. The name Cumberland Plateau is given the southern section of the Appalachian Plateaus. Here, because of more resistant rocks than in the north, dissection usually is not as great. Cumberland Front is the name given the prominent eastern escarpment except in the most dissected areas where it is called the Cumberland Mountains.

Soils[1]

In the Blue Ridge Province, soils on all but the steepest slopes are members of the Gray-Brown Podzolic group. They usually are relatively sandy, contain much organic matter, are acid, low in available phosphorus and nitrogen, and low to high

[1]Based on Pearson and Ensminger, 1957; Winters, 1957.

in potassium. Profiles almost everywhere are shallow; subsoils are usually permeable and well-drained.

The Ridge and Valley Province contains the most complex soil patterns of any section of the Appalachian Highlands (Fig. 2). In the northern part of the region some soils on the highest slopes are Podzols, grading into Gray-Brown Podzolics at lower elevations. These give way to Red-Yellow Podzolics in the extreme south. Soils of the ridges are either shallow and high in stone fragments (Lithosols) or sandy, depending on parent materials. Soils of the valleys are mostly rich, dark loams derived from limestone, sometimes containing fragments of chert and flint. Shale-derived soils are less fertile, less well-drained, and often shallow. Intense weathering has produced slightly acid profiles even where the parent material is limestone.

In the Appalachian Plateaus, upland soils are either Gray-Brown Podzolics or Lithosols except in the southern extremity where Red-Yellow Podzolics occur. Surface soils are shallow, acid, mostly fine sandy loam or silt loam, and low in organic matter and plant nutrients. The fine textured soils, whether derived from sandstone or shale parent materials, may produce crusts following rains and drying winds which prevent seedling emergence and reduce water infiltration.

Climate

Average precipitation for the Southern Appalachian Provinces is between 40 and 60 inches except at the highest elevations, where it exceeds 80 inches (Fig. 5). The varied topography of the region causes local variation in precipitation, the higher elevations generally receiving most. Annual precipitation at mountain stations separated by less than 5 miles may vary by more than 10 inches.

Topography also affects forest sites because of the angle at which the soil surface intercepts the rays of the sun. South facing slopes steeper than 10 degrees intercept insolation nearly at right angles and thus receive maximum amounts of heat. Rainfall is thus evaporated sooner, sites are drier, forest fires more frequent, and tree growth is slower than on north slopes. As high soil temperatures accelerate decomposition of organic matter and because erosion is more rapid, soils are shallower and less fertile. To a lesser extent western slopes, exposed to direct sunlight in the afternoon when the atmosphere is warm, are drier than those facing east. Wherever slopes are steep, north and northeast facing slopes tend to be much more productive than those facing south and southwest.

Temperature effectiveness for the region is from less than 400 to more than 600 units (Fig. 4).

In the spruce-fir forests of North Carolina and Tennessee, occurring above 5500 feet, temperature in the growing season averages 10° F. to 15° F. cooler than at the base of the mountains, while precipitation is 50 percent greater. Shanks (1954) found the cool, super-humid climate of the area is approached at sea level altitudes only in northern New England and adjacent Canadian provinces and the coastal region of the Pacific Northwest. Hence, vegetation of the Southern Appalachian spruce-fir zone is similar to that of the Adirondack boreal forest (Crandall, 1958) and the New England coast. However, trees in the southern spruce-fir forests grow faster and taller (Oosting and Billings, 1951).

Vegetation

Diverse geology and wide ranges in elevation and latitude contribute to the widely varying forest vegetation of the southern Appalachian provinces. Although hardwood types predominate (Fig. 22), conifers are important in certain situations. In

Figure 22. Cove sites in the Blue Ridge Province support mixed stands in which many of the most valuable hardwoods attain optimum development. Sosebee Cove, Chattahoochee National Forest, Georgia. Photo by U. S. Forest Service.

the southern extremity, oaks and hickories are displaced at high elevations by beech and maple. A similar transition occurs from south to north at a constant elevation. On drier sites—especially in the south—yellow pines (pitch, Virginia, shortleaf) may occur in pure stands or in mixture with oak-hickory types. Eastern hemlock and, less frequently, white pine also occur with hardwoods where moisture is ample. Spruce-fir forests occupy high elevations in the Blue Ridge Province almost as far south as Georgia and in the northern part of the Appalachian Plateaus.

Recent surveys report 69 percent of the forest of the Southern Appalachian provinces in the oak-hickory type. Nine percent is classified as oak-pine, and a total of 12 percent as coniferous types—including 1.7 percent in Virginia pine and 8 percent in loblolly-shortleaf (Table 1). Reports of 0.4 percent of the forest in pitch pine and Table-Mountain pine, 0.8 percent in white pine-hemlock, and 0.1 percent in spruce-fir types may not reflect the full importance of some of these species which also occur as a component of other types. The oak-hickory type, as reported in these state-wide surveys, includes a large variety of hardwood species, many of high commercial value. Eight percent of the area's forest is classed as maple-beech-birch.

Figure 23. Young stand of yellow-poplar, seeded naturally on land bared by logging or agriculture; Blue Ridge Province, Georgia. Soil on this north-facing lower slope is deep, permeable, moist and fertile — an excellent site for this valuable, fast-growing species.

Both yellow-poplar (Fig. 23) and white pine are initial species in ecologic succession on many sites of the several provinces following clear-cutting, catastrophe, or abandonment of agricultural land. Pure vigorous yellow-poplar stands are most likely to be limited to the coves and lower slopes, while white pine, though making rapid growth on such sites, may be found on all aspects and within wide elevation limits. Eastern hemlock and Carolina hemlock, able to germinate in the duff of pine and yellow-poplar and to grow in the shade, encroach until eventually these species, either singly or together, become major components of the forest.

Until the 1930's, American chestnut was a predominant species throughout the Appalachian provinces. The most versatile species in the region, it was resistant to insects and disease, and its attractive wood, endowed with minimal warp and twist, was ideal for furniture and interior trim. Its durability when in contact with soil or exposed to the elements made the wood useful for fence posts, poles and pilings, shingles, and siding; its high tannin content supported an extensive tanning-extract industry; its edible fruit was highly palatable to both man and wildlife; and its aesthetically pleasing form was valued for shade-tree use. It was able to grow, from seed or sprouts, on most sites from coves to ridges.

About 1904, a lethal fungus, *Endothia parasitica,* entered, the United States, probably through the port of New York, and immediately began to spread northward and southward, infecting and destroying American chestnut. The pathogen, a native of China, apparently reached America in shipments of nursery stock (Beattie and Diller, 1954).

American chestnut is not in danger of becoming extinct, but its future as a timber tree is not promising. Sprouts from roots of disease-killed trees sometimes escape the blight long enough to bear fruit. Seeds germinate and young trees may survive to produce nuts before succumbing to the fungus. In the early 1960's a few healthy stems remained at elevations above 4500 feet in the southernmost Blue Ridge region. While there is little promise that disease-resistant trees will be found among the survivors, years of cross breeding have produced a few blight-resistant hybrids with some of the characteristics needed for good timber trees (Diller and Capper, 1969).

Blue Ridge Province

Perhaps the richest variety of tree species in the world's temperate zones occurs in the Blue Ridge Province. Though most types found at lower elevations are variations of the broad oak-hickory association, stand composition varies widely with site and locality.

Typically the best sites, producing fast-growing trees of good form, are the narrow stream bottoms and the adjacent colluvial slopes; also favorable are the north- and east-facing slopes where soils are deeper and better watered and contain more organic matter than those facing south and west. Stands may include varying proportions of northern red, black, and white oaks, hickories, American basswood, yellow-poplar, white ash, blackgum, black locust, sugar maple, black cherry, American elm, magnolias, and other hardwoods. Hemlock is a common associate of hardwoods on these sites; white pine may also occur, particularly on north-facing slopes.

On drier sites, including south- and west-facing slopes and ridge tops (up to about 4000 feet in the south), hardwoods are likely to include black, southern red, scarlet, and chestnut oaks, hickories, red maple, blackgum, and a number of small trees and shrub species. These may be accompanied at high elevations by pitch or Table-Mountain pines and at lower levels by shortleaf or Virginia pines, either of the latter two also forming pure stands.

At elevations above 3000 feet in the south, and as low as 1000 feet in the north, elements of the northern forest types become increasingly important. Sugar maple, beech, and yellow birch associate with the oaks and yellow-poplar on fertile sites, or occur in mixture—with or without other northern species—at elevations up to 5500 feet. Above 3500 feet in the south, red spruce may be present in mixture with hardwoods, and most areas at the highest elevation bear pure stands of red spruce or red spruce-Fraser fir. Similar spruce-fir stands are located at lower elevations farther north.

An example of the climatic and physiographic influence on vegetation is the Roan Mountain area of northern Tennessee. Beech-maple types are climax at elevations from 3500 to 5500 feet, but spruce, fir, and yellow birch may be important components. Above 5500 feet, the spruce-fir type is climax; yellow birch is an associate (Brown, 1941).

In the Smoky Mountains, Whitaker (1956) recognized 15 important vegetation types, two of which are treeless. Their occurrence is related primarily to elevation and moisture availability. Deciduous forests predominate at lower elevations, while spruce, spruce-fir, and heath bald types predominate above 4500 feet. The cove hardwoods type, occupying stream bottoms and moist lower slopes, is dominated by hemlock, silverbell, buckeye, basswood, sugar maple, and birch, while yellow-poplar and American beech are important in many stands. Red, white, and chestnut oaks dominate stands on intermediate sites, and occur most extensively on south- and east-facing slopes. Driest sites have pine overstories, Virginia pine dominating at lowest elevations, pitch pine at 2200 to 3200 feet, and Table Mountain pine up to 4500 feet. Whitaker classes the stands in which the latter 2 species occur as heaths because of dense shrub understories.

UNIQUE SITUATIONS—**Beech gaps,** locally important above 5000 feet in the Appalachians, are usually found on south-facing slopes of local dips in east-west ridges. These gaps are small islands of gnarled, broken, deciduous trees in dense stands with sharply marked boundaries. The persistence of beech has been attributed to its ability to withstand strong winds that funnel through the gaps even when the weather is calm elsewhere (Russell, 1953). In contrast to adjacent spruce-fir forests, the thin leaf mold under beech is attributed to high nutrient levels in beech foliage which stimulate organic matter decomposition by micro and macro-organisms. The pH is about 5 under beech and less than 4 under conifers in the high Appalachians.

Balds of the highlands are treeless, dome-shaped, summits on well-drained sites. Although most are grass covered, ericaceous heaths and alders also occupy such sites. Balds have been attributed to Indian activity (Wells, 1956), game and cattle browsing and ice storms (Brown, 1941, 1953), exposure to high winds (Whitaker, 1956), and post-glacial climatic fluctuations (Mark, 1958).

Small barren areas, or **galled spots** occur where old-field succession has failed to develop on abandoned farms. According to Allard (1942), these are due to nutritional deficiencies; inadequate phosphorus may prevent invasion by nitrogen-fixing legumes needed for normal plant succession.[1]

The **Copper Basin** is a 23,000-acre "desert" on the Tennessee-Georgia boundary where smelter fumes, forming sulphuric acid, have destroyed the vegetation, exposing the land to severe erosion. Soil has been removed in places to a depth of 16 feet (Rothacher, 1954). Air and ground temperatures in the denuded area are higher in summer and lower in winter, and evaporation is much greater than in the surrounding forest (Hursh, 1948).

[1]Hursh and Grafton (1935) list plant indicators of site potential on recently abandoned fields of the lower slopes in the Blue Ridge Province.

Although the fumes now are largely controlled, air near the smelters is still hazardous to plants. Re-establishment of a vegetative cover is the primary need on these sites, but loss of topsoil, excessive drainage through gullies, and the harsh microclimate due to the absence of vegetation make plant establishment difficult, even beyond the current toxic zone. Seeding of fume-resistant grasses offers most promise on the most severely eroded areas and, where trees can be established, pitch pine is preferred because of its extensive root system. Virginia pine is a second choice. Loblolly pine makes good height growth, but survival is poor. Cultivation prior to planting improves survival chances for all species (Allen, 1950).

Ridge and Valley Province

The rich valley soils of this province, usually derived from limestone, originally bore stands of high-quality oaks, black walnut, yellow-poplar, American chestnut, hickories, and other hardwoods. Chestnut was more abundant here than in any other southern region. Eastern redcedar was a common associate, usually where soils were shallow. Pines were generally absent because calcareous parent materials formed soils with high pH. These sites are now mostly in agriculture; only culled-over remnants of the valley forests remain. Within the Tennessee River Valley, large areas of bottom lands and adjacent valley soils have been inundated by power and flood control dams.

Ridge soils within the province, predominantly formed from sandstone or sandstone and shale, are less fertile and often stony. Most of the existing forests are on these sites. Cover types are variations of oak-hickory or oak-pine in the south and oak-yellow-poplar or white pine-hemlock-hardwood farther north. Pitch, Virginia, and shortleaf pines occur singly or together, or in mixture with hardwoods on dry sites in the southern part of the province; farther north and on high ridges, white pine is prevalent. All of the pines as well as yellow-poplar pioneer on abandoned fields or severely disturbed sites. Occasionally ridges in this province are capped by dolomite, the alkaline nature of which is indicated by the absence of acidophilous plants such as mountain laurel, rhododendron, and wild azalea.

A survey of six ridge and valley counties in Tennessee and Georgia showed 54 percent of the land in forest in 1959. Of this, 24 percent was in softwood types, 31 percent hardwoods, and 45 percent mixed. The proportion of softwood types would be somewhat lower in the northern part of the province (Ogden, 1959).

An interim guide (Minckler, 1941), based on early results of widespread planting tests in the Ridge and Valley Province, recommended yellow-poplar, black walnut, white ash, and white and shortleaf pines for planting on north-facing slopes with deep soils. Only shortleaf pine was recommended for the shallow-soil southern slopes and ridges. Virginia pine, which is also suitable for planting on these dry sites, was not listed, probably because of its limited marketability at that time.

Appalachian Plateaus

Like the other provinces of the Appalachians, the Cumberland and southern Allegheny Plateaus are predominantly regions of hardwood forests (Fig. 24). American Chestnut was once a major component, although less important than in the Ridge and Valley Province to the east. Shortleaf pine occurs widely, sometimes in pure stands, but more commonly in mixture with the oak-hickory type, in the Cumberland Plateau especially. Shortleaf, pitch, and Virginia pines are also found in limited areas on the Allegheny Plateau in West Virginia, white pine and eastern

Figure 24. Mixed hardwood stand on lower slope site. Allegheny Plateau, West Virginia. Photo by U. S. Forest Service.

Figure 25. Virgin spruce forest on Spruce Knob, Allegheny Plateau, West Virginia, in 1927. Photo by U. S. Forest Service.

hemlock occur in mixture with hardwoods as far south as the Cumberland Mountains in Tennessee. Spruce-fir types on high mountains in West Virginia (Fig. 25) have been restricted in area by reproduction failures after logging.

On the Allegheny Plateau, oaks are more prevalent on dry than on moist sites. Carvell and Tryon (1959) have suggested that rank growth of ferns may keep moist sites too cool during critical periods for oak seeds to germinate. Huckleberry and other dry site shrubs and herbs are common in the understory of oak stands, particularly after regeneration.

Recent forest resource surveys (Sternitzke, 1962; Ferguson, 1964; Gansner, 1968) classify a little over 10 percent of the forest in the Plateaus Province as coniferous types. Slightly over 6 percent are classified pure softwood, including 5.5 percent in southern pines (shortleaf, pitch, and Virginia), less than 0.5 percent white pine, and under 0.2 percent eastern redcedar and spruce-fir types. About 5 percent of the province is classed as oak-pine.

Braun (1950) indicates that the southern pines were very minor components of the original forests of this region except on isolated xeric sites; evidently these species have increased since settlement, particularly on abandoned fields, south-facing slopes, and shallow soils above sandstone cap-rocks. White pine (Fig. 26), on the other hand, is probably less abundant than under virgin conditions when it occurred on a variety of sites, especially in the eastern portions of the province. Hemlock continues to occur in the coves and lower slopes, even extending south of the Tennessee River into Alabama.

Hardwood types, constituting nearly 90 percent of the forests of the province, are predominently oak-hickory (62 percent),

Figure 26. White pine, 60 to 70 years old, Allegheny Plateau, West Virginia. Young white pines in foreground have reseeded naturally in openings left by removal of overstory trees in partial harvest cut. Photo by U. S. Forest Service.

maple-beech (13 percent), and "central mixed hardwoods" (10 percent). The latter type, mapped by the U. S. Forest Service only in Kentucky, corresponds roughly with the "mixed mesophytic forest" identified by Braun (1950) as the prevailing original stand of the Appalachian Plateau Provinces. Had it been mapped in Tennessee and West Virginia, a higher proportion of the total forest area of the province would be so designated. Besides oaks and hickories, the mixed hardwoods type includes substantial proportions of yellow-poplar, blackgum, ash species, basswood, sycamore, buckeye, elms, black walnut, and butternut. This type, like the maple-beech type with its associated hemlock and white pine, occupies coves, north-facing slopes, and other deep, moist sites. Uplands tend to have fewer species of oak and hickory; some of them are oak-pine type. Land clearing and decades of logging have reduced the proportion of the more valuable species in the overstories. Surveys indicate, however, that second-growth stands of potentially high value are approaching merchantable size in large areas of the Appalachian Plateaus.

INTERIOR LOW PLATEAUS

Physiography

Located between the Appalachian Plateaus and the northernmost part of the Coastal Plain adjoining the Mississippi River Floodplain is an extensive, predominantly limestone, upland division of the Interior Plains physiographic province known as the Interior Low Plateaus (Fig. 1). This region is formed along the summit and flanks of the Cincinnati Arch, a broad upwarp approximately parallel to the trend of the Appalachian structures. The summits of the arch, originally domed in two places, were subsequently eroded away to produce topographic depressions—the Lexington Plain, or Bluegrass Region, of Kentucky and the Nashville Basin of Tenessee.

Surrounding the Nashville Basin, and separating it from the Bluegrass Region, is an extensive plateau with upland altitudes of 700 to 1300 feet. Those parts adjacent to the Cumberland Plateau and the areas south and west of the Nashville Basin, known as the Highland Rim, are mainly flat to rolling upland areas, but, along their borders, deeply entrenched streams produce a steep and rugged topography. The Pennyroyal Section of the Highland Rim, occupying most of the area between the Nashville and Bluegrass basins, is a region of karst topography and broad gently-rolling interstream uplands, originally in prairie grass and now largely in cultivation. Further northwestward in Kentucky is a portion of the Shawnee Hills section, locally called the Western Coalfields, where soils have developed largely from sandstones and shales.

On the limestone of the Lexington Plain, topography is gently undulating except along major streams where dissection is deep. A belt of steep hills formed on shales surrounds the inner basin. The Nashville Basin has a similar inner surface except where spurs of the adjacent Highland Rim project well into its central region as hilly outliers 300 to 400 feet high. Both basins have been widely cleared for agriculture.

Soils

From a few miles north of the Tennessee-Kentucky boundary northward, soils of the Interior Low Plateaus are grouped with the Gray-Brown Podzolics; southward, Red-Yellow Podzolics prevail. Most of the Highland Rim Plateau is underlain by cherty limestones which weather, particularly on steep slopes, into stony soils. Although chert fragments help retard erosion, soil productivity is low. A narrow band of relatively chert-free limestone extends across Tennessee adjacent to the Cumberland Plateau. Soils in that zone are somewhat more productive than those elsewhere on the Highland Rim Plateau. Soils on smooth uplands are Planosols—strongly leached surface soils over clay pans at 20 to 24 inches.

The best soils of the Interior Low Plateaus are in the Nashville and Bluegrass basins where highly phosphatic parent material has weathered into deep, residual, slightly acid, fine-textured soils of dark brown surface horizons underlain by reddish-brown or yellowish-brown subsoils. Sometimes, however, bedrock is found at shallow depths.

Climate

The climate of the Interior Low Plateaus is not markedly different from that of the Appalachian Plateaus. Rainfall amounts to 40 to 55 inches. The growing season is 180 to 200 days, and temperature effectiveness ranges between 500 and 700 units.

Vegetation

The calcareous origin of much of the soil of the Interior Low Plateaus results in a small percentage (3 percent) of forests in pine types—and a higher than average proportion (9 percent) in types containing eastern redcedar (Table 1). That nearly 80 percent of the present forests of the region are classed as oak-hickory types obscures the great variety of species occurring there and the effect of local topography on stand composition.

Braun (1950) describes the original forests of this province as transitional between the mixed mesophytic of the Appalachian Plateaus and the oak-hickory types of the prairie-transition zone to the west. Numerous major vegetative components formed a mosaic in response to local environment. Karst underdrainage in many areas impaired sites for tree growth while favoring grasses and switch cane, giving rise to grasslands, open savannah-like forests, and the so-called "barrens" of Kentucky. Such open types, interspersed with stands containing species of the mixed forest, were found in the Nashville Basin, the Blue grass Region, and in the Pennyroyal. In the Knobs and

Eastern Highland Rim, many stands were mixed mesophytic; westward these types were less frequent and confined to favorable local situations. From the Nashville Basin west to the Tennessee River, lower slopes afforded sites on which better hardwoods reached good development, but upper slopes and ridges bore stands of xeric species—post, blackjack, and black oaks, and hickories.

Because much of this province is level and its soils fertile, much land has been cleared for agriculture. In Kentucky, for instance, only about one-third of the land was forested in 1968. Heavy cutting has depleted high-quality sawtimber volume, but stocking of most species appears adequate for the future if not cut prematurely. Walnut, however, has been severely overcut in recent years; it is estimated that nearly one-third of Kentucky's walnut volume is in isolated trees in the non-forested sections, such as the Bluegrass. Redcedar has also been depleted; shallow-soil cedar glades are invaded by scrub hardwood types. Pine is concentrated in the Highland Rim south of the Nashville Basin and in the Western Coalfields near the Ohio River. Pine plantations on abandoned farm lands and on spoilbanks from strip-mining account for appreciable acreages of this type.

INTERIOR HIGHLANDS

Physiography

Interior Highlands refers to two elevated physiographic provinces of unequal size and dissimilar character (Fig. 1). The larger, lying north of the Arkansas River, is a region of broad plateaus and low mountains called the Ozark Plateaus. South of it is the smaller Ouachita Province.

Ozark Plateaus

The Ozark Plateaus are formed on a broad, domed upwarp consisting mostly of limestone and dolomite and bounded by lowlands on all sides. The axis of the upwarp is displaced east of center so that slopes to the east are 70 to 80 feet per mile and those to the west are only 10 to 20 feet. Many Ozark limestones and dolomites contain large amounts of chert; soils derived from them are rocky and may be mantled with chert fragments. Karst features are common, but generally less prominent than on the Interior Low Plateaus. Major outcroppings of rocks other than limestones and dolomites are found in the St. Francois Mountains—a group of low peaks atop the upwarp axis—where igneous rocks are exposed, and in the Boston Mountains—the high and extremely dissected southern section—where sandstones and shales predominate. Altitudes in the Boston Mountains rise to more than 2200 feet.

Drainage from the plateaus is radial and the south-flowing streams have produced the most dissection. The valleys tend to be deep and steep-walled with narrow terraces providing favorable sites for timber growth. The interfluves are broad and relatively flat, especially in southern Missouri where they are commonly called prairies. Local relief on the Ozark Plateaus varies from as little as 100 feet to as much as 1000 feet along major streams.

Ouachita Province

The Ouachita Province is a region of linear folds like those of the Ridge and Valley Province of the Appalachians. In the north, the valley of the Arkansas River occupies a structural and topographic trough 25 to 35 miles in width, most of which lies only 300 to 600 feet above sea level. Low ridges produced by minor folding are prominent features of the southern part of the valley.

The remainder of the Province is composed of the Ouachita Mountains, an area about 100 miles wide and 225 miles east to west, consisting of narrow, east-west folds and intervening valleys formed mainly on sandstones and shales. Elevations are as low as 500 to 600 feet in the east but rise to about 2600 feet near the Oklahoma boundary. Local relief is as much as 1500 feet.

Soils

Soils of the Interior Highlands are classed as Red-Yellow Podzolics except for small zones of Planosols (Fig. 2). Soils of the Ozark Plateaus are very similar to those of the Interior Low Plateaus. On the smooth interfluves with cherty limestone bedrock, soils have a relatively impervious fragipan about 22 inches below the surface which interferes with water movement and root penetration. Steep slopes have Lithosols high in concentrations of chert fragments. Soils derived from the cherty limestone are strongly acid and low in available nutrients. The best soils and the most luxuriant forests are developed on the relatively pure limestones.

Sandstone of the ridges of the Ouachita Mountains produces shallow, stony soils of low fertility which are managed almost exclusively for forests. The shales of the valleys yield more productive, finer-textured soils, most of which have adequate internal drainage for good tree growth.

Climate

Rainfall in the region ranges from 40 to 50 inches (Fig. 5). In the Ozark Plateaus, summer rainfall exceeds that of winter. In the Ouachita Mountains, maximum precipitation occurs in the spring. In both provinces, serious summer droughts occur frequently, presenting major problems to forest management as well as to agriculture. The growing season averages 180 to 210 days; temperature effectiveness is about 700 units.

Because of the prevailing east-west orientation of the Ouachita Mountain ranges, increased insolation on south-facing slopes affects more of the forested land than in other mountainous regions. This, combined with the erratic rainfall and high temperature efficiency, limits a large part of the mountain section to forest types adapted to poor soils and dry sites.

Vegetation

Present forests of the Interior Highlands are classified as 68 percent oak-hickory, occurring on upland sites, and 5 percent other hardwood types, mostly in the bottoms (Table 1). Loblolly pine-shortleaf pine types (here almost exclusively shortleaf) make up 15 percent of the forest area and pine-hardwoods another 7 percent. Greatest concentrations of shortleaf pine are on south- and west-facing slopes in the Ouachita Mountains of Arkansas and easternmost Oklahoma, where extensive pure pine stands have been maintained under public and industrial management (Fig. 27). Lesser concentrations occur on ridges ad-

Figure 27. These 70-year old shortleaf pines in the Ouachita Mountains have typically good form, although growth has been slowed by the limited rainfall on a ridge site. Ouachita National Forest, Oklahoma. Photo by U. S. Forest Service.

jacent to the Arkansas River Valley and northward along the eastern escarpment of the Ozarks, on south- and west-facing slopes in the Boston Mountains, on sandy and some cherty soils on the Springfield Plateau, and over extensive areas underlain by dolomite and sandstones on the Salem Plateau in southern Missouri.

Original hardwood forests of the Interior Highlands were rich in variety of species and value of timber products. Especially along streams and on lower slopes, white oak, black walnut, black cherry, elm, sycamore, sugar maple, and eastern redcedar attained large diameter and excellent form. On drier slopes and ridges, stands of red and black oaks, hickories, and other more xeric hardwoods prevailed, usually as poorly developed, marginally merchantable trees. Similar stands occupied excessively drained sites resulting from karst topography on the limestone plateaus of the Ozarks.

Eastern redcedar now occurs primarily on shallow soils, usually over relatively chert-free limestone. Although heavily cut for posts and lumber, there are indications that the type is maintaining itself and, perhaps, may be invading the over-grazed grasslands of the "glade" type in southwest Missouri. Maple (1957) reported growth rates for eastern redcedar on deeper soil high enough to indicate possibilities for economic culture in this region where post and lumber markets are available for material of small sizes.

In western Missouri, extreme northwestern Arkansas, and eastern Oklahoma, the oak-hickory type consists of more xeric species—post and blackjack oaks, hickories, and other species common to the Texas Post Oak Belt. Stems are short and poorly formed, and growth is slow. As the prairie is approached, the forest is more open and has a bunch grass understory. Attempts have been made to convert large tracts of this transitional type to pastureland, but results have not always been successful. The most economic use of such lands has yet to be determined.

The distribution of the predominantly hardwood types is closely related to soils and slopes (Table 4). Read (1950) notes

Table 4. Forest type occurrence as related to topography and soils in the Ozark and Ouachita Mountains of Arkansas (after Turner, 1937).

Topography and Soils	*Forest Type*
A. South, east, and west slopes, except deep ravines and valleys.	
1. Sandstone soils.	
a. Sites with not excessive slope, A and B horizons not shallow nor excessively stony. Soils are phases of Hanceville fine sandy loam and very fine sandy loam,	Black oak—white oak Shortleaf pine—black oak—white oak

Upshur loam and fine sandy loam, and Conway silt loam.	
b. Intermediate sites, between a and c. Soils as above.	Shortleaf pine Shortleaf pine—post oak Post oak Black oak—hickory
c. Sites with excessive slope and/or with shallow A and B horizons, or with excessive stone in A and B horizons. Soils are phases of Hanceville shale loam, Hanceville stony loam. Upshur stony loam, Talladega stony silt loam, and land classified as "rough-stony."	Shortleaf pine Post oak—blackjack oak Shortleaf pine—post oak Scrub oaks—winged elm—hickory Shortleaf pine—scrub oaks—winged elm—hickory
d. Rather poorly drained, inter-range flats, and broad, flat, shallow-soiled ridge tops. Soils with shallow A and/or B horizon, or impervious B horizon. Soils are Gasconade silt loam, phases of Conway silt loam.	Post oak—black oak—elms Prairie
2. Limestone soils	
a. Sites with not excessive slope; A and B horizons not shallow nor excessively stony. Soils are phases of Baxter silt loam, Clarksville silt loam, Hagerstown silt loam, Decatur silt loam, and Izard fine sandy loam.	White oak—black oak—northern red oak Black oak—white oak Shortleaf pine—black oak—white oak
b. Intermediate sites between a and c. Soils as above.	Shortleaf pine Shortleaf pine—post oak Post oak Black oak—hickory
c. Sites with excessive slope, or A and B horizons shallow and/or very stony. Soils are phases of soils named in a, and Clarksville stony loam, Baxter gravelly silt loam, and Lebanon silt loam.	Shortleaf pine—post oak Scrub oak—winged elm—hickory Eastern redcedar

B. North slopes, deep gulleys, ravines and coves.	
1. Sites with not excessive slope; A and B horizons not shallow nor excessively stony. Soils are phases of Upshur, Decatur, Hagerstown, Baxter, Clarksville, and Izard silt and sandy loams.	White oak—black oak—northern red oak Shortleaf pine—white oak (rarely)
2. Rather steep sloping sites, or sites with soils having shallower or stonier A and B horizons.	Black oak—post oak Shortleaf pine (rarely)
C. Stream valleys.	
1. Small stream valleys with narrow floodplain. Alluvial soils, usually with considerable sand, gravel, stone, or silt. Soils are Atkins silt loam, Huntington loam, Pope silt loam, Waynesboro loam, Wabash silt loam, etc.	Soft maple—river birch—American elm—eastern cottonwood—sycamore Silver maple—American elm River birch—sycamore Post oak—black oak—elms

hardwoods on north- and east-facing slopes and shortleaf pine on southern and western exposures of deep, cherty, silt loam developed on the Boone formation. Shallow, silty clay soils derived from pure limestone, such as the St. Joe formation, support eastern redcedar predominantly, although poor quality hardwoods occur. Shortleaf pine, however, is never found on such soils. Shallow, poorly drained sandy clay derived from sandstones supports productive stands of hardwoods on both north- and south-facing slopes, with shortleaf pine on the poorest southern exposures. Table 5 summarizes Read's recommendations for forest management on these sites.

Table 5. Species best suited for Forest Management on specific sites in the Arkansas Ozarks (after Read, 1950).

Geologic Formation and Type of Soil	Species Best Suited to Forest Management	
	South Slopes	North Slopes
Boone chert and limestone Deep cherty silt loam	Shortleaf pine	White oak Northern red oak Black oak White ash Black cherry

St. Joe limestone Shallow silty clay	Eastern redcedar	Eastern redcedar
Joachim sandy limestone Moderately deep sandy clay	Shortleaf pine White oak Black oak Eastern redcedar	White oak Northern red oak Black oak White ash
Newton sandstone Shallow, poorly drained, sandy clay	Eastern redcedar	Eastern redcedar
Deep loamy sand	Shortleaf pine White oak Southern red oak	White oak Red oaks Black walnut White ash Black oak Blackgum

Large stream valleys of the Ozark Plateaus support well-stocked stands of mixed hardwoods; silver maple, river birch, elm, sycamore, and cottonwood (Turner, 1935). Poor pine sites are found in mountainous areas where stony or gravelly steep slopes have site indices of 35 to 50.

A LOOK AHEAD

These pages attempt to describe the geography of the forests of the South as they once were and as they are today. For some lands, history has altered the course of ecologic transition, and this has been noted. Never has the use of land been altered so rapidly by man in so short a period as within the past century. As the story of man continues to be written, so too will changes in land use and the nature of forests be noted.

Man's use of the land and its resources often sets in motion natural processes that cause permanent change. Frequently the results are destructive; sometimes catastrophic. Erosion from cleared slopes removes topsoil developed over thousands of years and gullies from poorly engineered roads lower the moisture regime of the soil and degrade forest sites. Although the forests of the South have shown remarkable ability to reoccupy lands clearcut for timber, burned, or cleared for agriculture, new stands are usually of different species than were those under virgin conditions. Pines, sweetgums, yellow-poplar, or scrub oaks may now dominate rehabilitated sites where once vigorous stands of beech-birch-maple, chestnut, or oak-hickory-pine covered the land. Hence, the forests in much of the region have been modified more or less severely by previous land use.

Forestry practices, as well as the vegetative composition of the forest, will continue to be affected by land-use transition. Conversion of timber-producing forest lands to residential communities, factories, and reservoirs; or withdrawal of forests for watersheds, game preserves, parks, and scientific studies of the environment will necessitate intensifying practices on remaining lands to supply the nation's fiber needs. Site changes, and the necessity for highest production, will rarely permit reversion to original timber types. These managed forests will, however, be subjected to the same geographic and climatic influences as their predecessors; foresters who manage them will be most successful when they are guided by wise consideration of the ways these factors are expressed in the native forest types.

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APPENDIX

Common and scientific names of species mentioned in the text.

Trees and Shrubs

Alder	*Alnus spp.*
Ash, green	*Fraxinus pennsylvanica*
white	*americana*
Azalea	*Azalea spp.*
Baldcypress	*Taxodium distichum*
Basswood, American	*Tilia americana*
Beech, American	*Fagus grandifolia*
Birch, river	*Betula nigra*
yellow	*alleghaniensis*
Blackberry	*Rubus spp.*
Blackgum	*Nyssa sylvatica*
Buckeye	*Aesculus spp.*
Butternut	*Juglans cinerea*
Cherry, black	*Prunus serotina*
Chestnut, American	*Castanea dentata*
Cottonwood, eastern	*Populus deltoides*
Dogwood, flowering	*Cornus florida*
Elm, American	*Ulmus americana*
winged	*alata*
Fir, Fraser	*Abies fraseri*
Hackberry	*Celtis occidentalis*
Hemlock, Carolina	*Tsuga caroliniana*
eastern	*canadensis*
Huckleberry	*Vaccinium spp.*
Locust, black	*Robinia pseudoacacia*
Magnolia	*Magnolia spp.*
Maple, red	*Acer rubrum*
silver	*saccharinum*
sugar	*saccharum*
Mountain-laurel	*Kalmia latifolia*
Oak, black	*Quercus velutina*
blackjack	*marilandica*
bluejack	*incana*
cherrybark	*falcata var. pagodaefolia*
chestnut	*prinus*
live	*virginiana*
northern red	*rubra*
Nuttall	*nuttallii*
overcup	*lyrata*
pin	*palustris*

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Oak, post	*Quercus stellata*
scarlet	*coccinea*
southern red	*falcata*
swamp chestnut	*michauxii*
turkey	*laevis*
water	*nigra*
white	*alba*
willow	*phellos*
Osage-orange	*Maclura pomifera*
Pine, loblolly	*Pinus taeda*
longleaf	*palustris*
pitch	*rigida*
pond	*serotina*
sand	*clausa*
shortleaf	*echinata*
slash	*elliottii*
spruce	*glabra*
Table-Mountain	*pungens*
Virginia	*virginiana*
white	*strobus*
Pondcypress	*Taxodium distichum var. nutans*
Redcedar, eastern	*Juniperus virginiana*
Rhododendron	*Rhododendron spp.*
Silverbell	*Halesia spp.*
Spruce, red	*Picea rubens*
Sugarberry	*Celtis laevigata*
Sweetbay	*Magnolia virginiana*
Sweetgum	*Liguidambar styraciflua*
Sycamore, American	*Platanus occidentalis*
Tupelo, water	*Nyssa aquatica*
Walnut, black	*Juglans nigra*
Waxmyrtle	*Myrica spp.*
White-cedar, Atlantic	*Chamaecyparis thyoides*
Willow	*Salix spp.*
Yaupon	*Ilex vomitoria*
Yellow poplar	*Liriodendron tulipifera*

Forbs and Grasses

Aster	*Aster spp.*
Broomsedge	*Andropogon virginicus*
Bluestems	*Andropogon spp.*
Crabgrass	*Digitaria sanguinalis*
Horseweed	*Frigeron canadensis*
Ragweed	*Ambrosia spp.*

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