MANAGEMENT AND INVENTORY

of

SOUTHERN HARDWOODS

by

John A. Putnam, George M. Furnival, and J. S. McKnight

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CONTENTS

Management and Inventory of Southern Hardwoods

John A. Putnam,[1] George M. Furnival,[2] and J. S. McKnight[3]

The valleys and uplands of the South outside of the mountains and upper Piedmont have, since 1915, been responsible for about 45 percent of the national production of hardwood sawtimber. There are strong indications that this situation may continue indefinitely.

The lower Mississippi Valley, lower Piedmont, and southern Coastal Plain from Virginia to Texas have long been recognized by the hardwood industries as the "southern hardwood territory." The moister parts of this area are better adapted to hardwoods than to pines, and about 45 million acres in the southern hardwood territory now covered with hardwood forests should be managed for continued hardwood production.

This handbook was written to bring together

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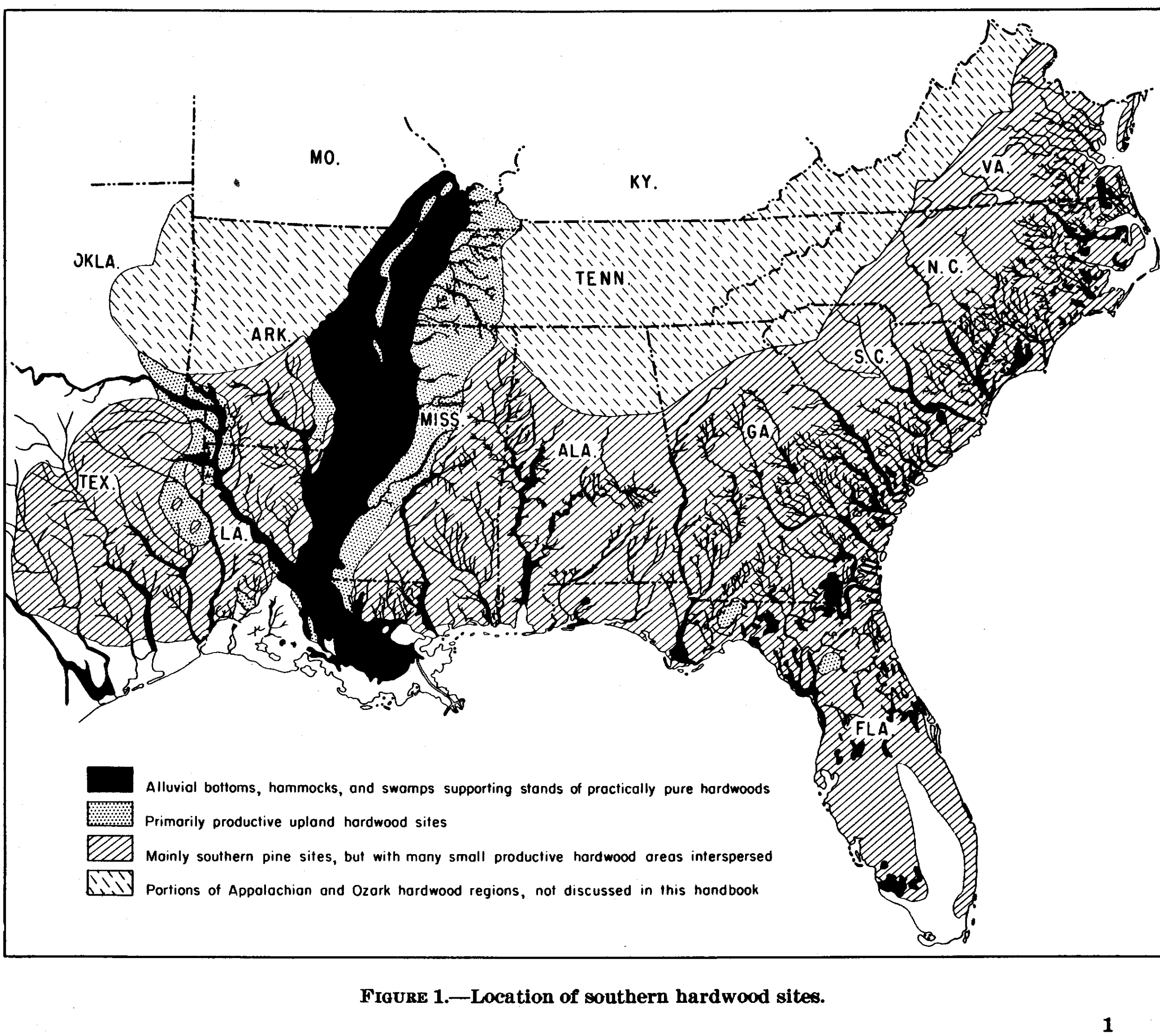

FIGURE 1.—Location of southern hardwood sites.

experience and research on the nature and management of these forests. Much is yet to be learned, but many essentials are at hand, ready to be put into practice.

The forests described here are found in bottom lands, swamps, and uplands of the southern hardwood territory (fig. 1). Included are all river and creek bottoms, branch heads, swamps, hammocks, coves, and moister upland areas supporting the growth of quality hardwoods. The discussion does not apply to the hardwoods of the Ozark, Ouachita, or Appalachian Mountains nor to those of the Highland Rim, Cumberland Plateau, or upper Piedmont. Neither does it include hardwoods growing on pine sites or other upland not adapted to them. Baldcypress and pondcypress are discussed along with the hardwoods, because stands of these species are usually intermingled with lowland hardwoods.

The authors have confined the subject to management for timber production. Though the hardwood forests are outstanding as game habitats, multiple or alternative land use is beyond the scope of the discussion.

THE FOREST

The southern hardwoods exhibit extreme variation in species and sites, in technical qualities, and in uses. Nevertheless, there is order in this diversity. Certain species occur on certain sites. Some species are intolerant and occur in even-aged stands that are often pure; most grow in mixed, many-aged communities. All are prone to the same kinds of damage. The principles of hardwood use become clear once it is understood that they are determined by the technical qualities demanded in the final product.

Species

Approximately 70 species of some commercial importance grow in the southern hardwood forests; of these, 50 or more often are found on a single large property. The species differ in form, use, value, growth rates, site requirements, ability to reproduce, and a host of other characteristics. The identification of species or species groups is not merely an interesting taxonomic problem but an absolute prerequisite of successful hardwood management and silviculture: the first task of the beginning forester is to learn to identify species quickly and accurately. The commercial species are listed here; their scientific names and other information are contained in table 4, p. 32. Any of several good dendrology texts will aid greatly in identification.

Commercial trees of southern hardwood forests

Carolina ash
Green ash and pumpkin ash
White ash

Basswood or linden

American beech

River birch

Catalpa

Atlantic or southern white-cedar
Eastern redcedar

Black cherry

Eastern cottonwood
Swamp cottonwood

Baldcypress
Pondcypress

Flowering dogwood

American or soft elm
Cedar or rock elm
Slippery elm
Winged elm

Sweetgum or redgum

Black tupelo or blackgum
Ogeechee tupelo
Swamp tupelo or swamp blackgum
Water tupelo

Hackberry and sugarberry

Hickories

American holly

Black locust
Honeylocust
Water locust

Cucumbertree
Redbay
Southern magnolia
Sweetbay

Boxelder
Florida or southern hard maple
Red maple
Silver maple
Sugar maple

Red mulberry

Black oak
Bur oak
Cherrybark oak
Chinkapin oak
Delta post oak
Durand oak
Laurel oak
Northern red oak
Nuttall oak
Oglethorpe oak
Overcup oak
Pin oak
Post oak
Shumard oak
Southern red oak
Swamp chestnut or cow oak
Swamp white oak
Water oak
White oak
Willow oak

Osage-orange

Pecan or sweet pecan
Water hickory or bitter pecan

Common persimmon

Loblolly pine
Slash pine
Shortleaf pine
Spruce pine

Sassafras

American sycamore

Butternut or white walnut
Black walnut

Black willow
Sandbar willow

Yellow-poplar

In identification, too much reliance should not be placed on leaf characteristics, for a great deal of work must be done in the winter when the trees are bare. Also, leaf form varies extremely in some species. Most foresters who deal with hardwoods depend almost entirely on the appearance of the bark, checked by the overall pattern of the leaves and twigs, as well as the general shape of the crown. Knowledge of species-site relationships is also very useful. For example, pecan and water hickory are often confused, but they occur on entirely different sites. Several similar oaks, the two principal ashes, and the three principal tupelos also can often be separated by the sites on which they occur.

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FIGURE 2.—Almost pure stand of immature sweetgum on the Tensas River in the Mississippi River Delta of Louisiana.

Two very broad species associations or general classes of forest, one characterized as white oaks-red oaks-hickory and the other as sweetgum-water oaks, cover most of the southern hardwood forest area. Within these broad associations, the species occur in both pure and mixed stands, with mixed stands predominating. The forester will find it possible to map many local areas occupied by species that tend to grow in relatively pure stands, i.e., sweetgum, some white oaks, water or "pin" oaks, ash, and yellow-poplar (fig. 2). In addition, overcup oak-water hickory, cypress-tupelo, and some of the other common mixtures approximate conventional types, such as those defined by the Society of American Foresters, and can be distinguished. Another broad and variable though less widespread association—riverfront hardwoods—is recognizable. Here cottonwood and willow commonly separate into conventional and mappable types.

Nevertheless, separation by conventional types is difficult or impossible in most hardwood forests, except for areas too small to map. The usefulness of types in hardwood management is further diminished by their relative impermanence. Fire, cutting, soil movement, changes in water regimes, and natural succession cause frequent and rapid changes in species associations in particular locations. In the discussions that follow, emphasis will be placed primarily on species. A knowledge

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FIGURE 3.—Land and vegetational development along the Mississippi River. This photo includes approximately 67 square miles of land and water. Smith Point shows successive stages of accretion from the new white sandbar to areas of reproduction and on back to sizable timber. On the extreme lower left, the sharp line between land and water indicates that the banks are caving and old alluvial land is returning to the river.

of species as related to sites, rather than of types as such, is fundamental to an understanding of hardwood communities.

Species-Site Relationships

Southern hardwood forests occur on relatively rich, deep soils having adequate moisture throughout the growing season. The bulk of these sites occur in the major alluvial valleys. The largest single area of bottom land is that of the Mississippi River Delta, where 11,600,000 acres (about 40 percent of the land area) are in hardwood forest. Adjacent uplands known as the Brown Loam Bluffs have about 4,400,000 forest acres. The total acreage of all other productive southern hardwood forest sites, both lowlands and uplands but largely the former, is about 29 million.

Major River Bottoms

An active river in an alluvial valley constantly meanders by cutting its banks and forming new land (figs. 3 and 4). Most of the soil from a caving bank is deposited at the opposite side, on the next "point bar" downstream. As the bank-cutting continues, the point bar increases in height and extent and is called new land. Finally, sediment from some spring flood raises the bar above the ordinary high-water stages, thereby graduating it from the class of new land to "front" land.

Succeeding floods that overflow the fronts deposit their coarser sediments near the bank of the river, building high, well-drained ridges or natural levees. Farther back from the banks, these waters eddy and slow while, between high floods, backwaters enter from the tributaries. Here the finer sediments are deposited, forming low, broad areas of poorly drained "slackwater" clay soils.

Within the slackwater areas are minor features of relief—low ridges, flats, and sloughs. The low ridges are more numerous than the fronts or natural levees, having been formed as banks of older, smaller, sluggish, or less permanent watercourses. *Flat* well describes the area between ridges. A flat is generally wide, with poor surface drainage, but it may be relatively high or low and either smooth or slightly uneven. Sloughs are the remaining, nearly filled channels of former watercourses.

It must be emphasized that the differences in relief are small and variable—at any one location, a low ridge is apt to be no more than 3 to 15 feet below a front, nor more than 1 to 10 feet above a flat. In the slackwater areas, relief can rarely be distinguished as such, but only by its effects. For example, the practicing forester generally distinguishes a flat by its extent, general lack of gradient, and slow drainage.

The fronts, high ridges, and slackwater areas are formed by gradual accretion and sedimentation. The action of the river, however, may also be swift and abrupt. As bends become sharp and points grow long, the river frequently shortens its course by making a "cut-off" across an intervening neck of land. The abandoned section of channel becomes an oxbow lake and, as sedimentation continues, a swamp (fig. 5). Shallow swamp may be formed when new fronts obstruct drainage from low flats.

On occasion, entire channels and floodplains may be abandoned as the river carves a whole new course, reworking old alluvium elsewhere in its valley. Thus, most alluvial bottoms have been formed and reformed by the flooding and periodic migrations of one or more large rivers. The relatively recent or present floodplains are usually referred to as first bottoms. They contain the newer deposits of alluvium and less mature soils. Areas from which the rivers migrated at a relatively early stage and in which the soils are much more mature are often loosely referred to (especially with regard to the Delta of the Mississippi River) as second bottoms or terraces, even though they may not have more elevation than the first bottom. Of course, within such areas there are no longer true fronts—only high ridges—but all the other secondary features can still be identified.

In the strict sense, second bottoms or terraces are remnants of former floodplains, left when a general uplift or tilting of the earth's surface created a steeper riverbed which then ate its way down to a lower level. Terraces may form the major parts of the valleys of slow-moving rivers whose beds have become entrenched. Such terraces are found along the Tombigbee and the Alabama to their confluence and the Chattahoochee above the mouth of the Flint. Within the Delta, Macon Ridge in north Louisiana illustrates a true terrace. In such bottoms, active fronts are absent or vestigial and flooding is infrequent, but all the other alluvial features are present. The soils are old and well differentiated, corresponding roughly

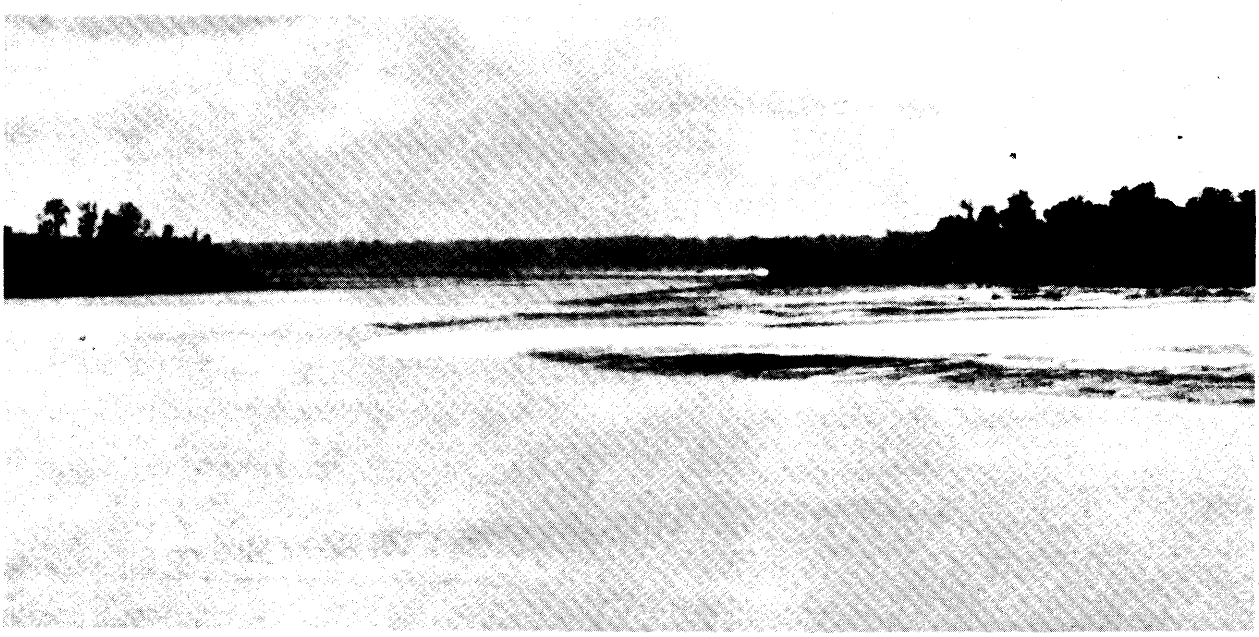

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FIGURE 4.—Newly made land along the Arkansas River in Arkansas. Willow and cottonwood reproduction is coming in toward the back of this bar.

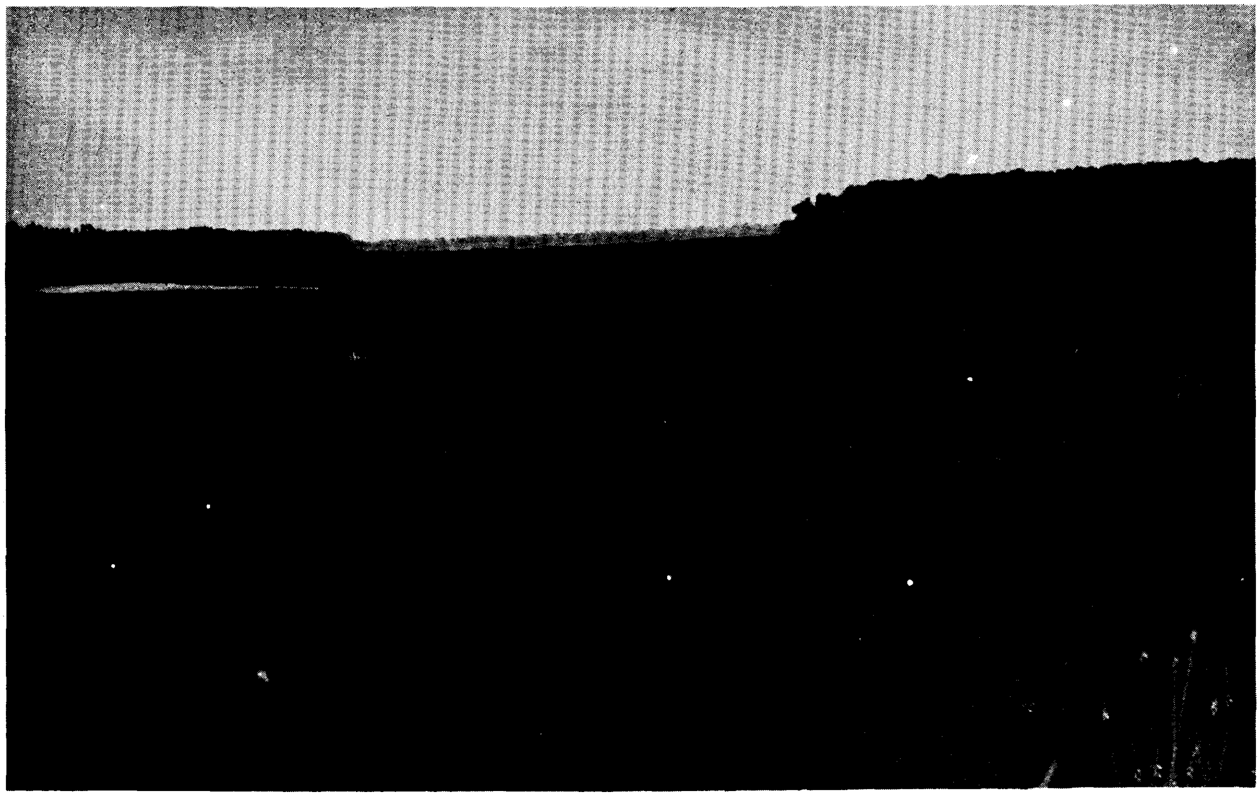

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FIGURE 5.—Willow on the low areas and cottonwood on the higher areas have covered this filled-in and abandoned bed of the Arkansas River.

to the areas of old alluvium previously described.

The bottoms of smaller fast-moving rivers and of many large creeks that flood are usually characterized by light soils and an undulating topography. Examples of such streams are the Leaf River of Mississippi, the Saline River of Arkansas, and the Calcasieu River of Louisiana. In general, site conditions parallel those of the second bottoms or older alluvium, except that the low spots, banks, and abandoned channels are similar to the corresponding first-bottom sites.

Complex but recognizable species associations (not conventional forest types) characterize the sites just described. As the sites change through the action of the river or through aging and maturing, the species associations also shift. The associations on the oldest and most stable formations, the second bottoms or terraces, have the most advanced forest succession.

On the higher, better drained bars and towheads, the pioneer species is cottonwood. When cottonwood matures, it is succeeded by the riverfront species—silver maple, American elm, hackberry, sycamore, boxelder, pecan, green ash, and sometimes, very late in this phase, sweetgum and water oak. Later a succession of the water oaks and sweetgum, with typical associates, follows on these high ridges. Ultimately, and sometimes even before graduating to second-bottom status, the best of these sites may support cherrybark oak and a few other advanced species.

High ridges in second bottoms generally are no longer subject to sedimentation. Here white oaks, black tupelo, winged elm, white ash, and hickory are found along with cherrybark and Shumard oak, water oak, and sweetgum. These species are also common in the bottoms of small, fast-moving rivers and large creeks and on the terraces of the slower moving entrenched streams. Loblolly pine often is found on the highest ridges of the second bottoms and spruce pine sometimes on ridges of the smaller Coastal Plain rivers and larger creeks.

On low, newly formed bars with fine-textured soils, the first pioneer is usually willow. If the site fails to gain elevation, remaining something of a shallow swamp, successors are baldcypress and green ash, sometimes in association with American elm, red maple, and sugarberry, followed much later by overcup oak, water hickory, and persimmon. If sedimentation is pronounced, the site may eventually approach the status of a low flat and support much Nuttall oak or, in the Southeast, laurel oak.

A similar succession occurs as sloughs, swamps, and oxbow lakes fill with sediment. Here, however, the succession is much slower and the phases are more distinct, both in time and space. In the early stages of this succession, many deep sloughs and cutoffs near the active river have excellent stands of willow. Large swamps, holding water most of the year, occur in both the first and second bottoms and here the most important species are baldcypress and tupelos. On the other hand, most of the small sloughs away from the river are now occupied by overcup oak and water hickory along with green ash, persimmon, and Nuttall oak in some situations.

In the broad slackwater areas of the first bottoms, the low ridges typically carry sweetgum, willow oak, green ash, and occasionally water oak. Sugarberry, Nuttall oak, overcup oak, red maple, American elm, and green ash are the usual species on the flats and lower ridges. In the Southeast, Nuttall oak is replaced by laurel oak. In extensive backwater areas where flooding lasts well into the growing season, the species may be primarily overcup oak and water hickory.

Species composition on low ridges of second bottoms is similar to that on the high ridges or ancient fronts. The most common species are swamp chestnut oak, cherrybark oak, Shumard oak, water oak, black tupelo, and winged elm, with some hickory and white ash. Some of the more advanced species, such as white oak, are notably absent. Here the flats are usually occupied by sweetgum, willow oak, Nuttall oak (laurel oak in Southeast), green ash, red maple, and persimmon—species characteristic of low ridges and better flats in the first bottoms. In some of the lowest, poorest drained flats and sloughs in the terraces, overcup oak and water hickory are again dominant.

Other Lowland Hardwood Sites

Soils in small creek bottoms are usually of local origin and coarser than most alluvial bottom soils. The sites are subject to considerable local changes in water level during the growing season. Some especially distinguishing species are beech, yellow-poplar, magnolia, pines, and holly, together with most of the species of the older alluvial ridges in the big bottoms. In addition, such species as cherryback oak, the better white oaks, and the hickories commonly occur. The creek bottoms may vary in width from a few hundred yards to a mile or more, but usually are narrow strips through good southern pine land. Being so intermingled with pine, good strips of hardwood forest sometimes lose their identity, but under intensive management and with well-developed markets these creek bottoms can be very important hardwood sites (fig. 6). Most of the loblolly pine in such bottoms, together with practically all the spruce pine, occurs on the more stable ridges and stream banks.

Muck swamps are not of alluvial origin, but mostly originate from impoundment of rainwater and seepage in landlocked depressions of the Coastal Plain. They also include swamps in tidal estuaries, at margins of coastal marshes, and in the deeper, more productive bays. Usually, water in these swamps is inky from accumulated organic matter and there is no firm bottom. The characteristic species are baldcypress and pondcypress, together with the so-called soft hardwoods, primarily the tupelos, sweetbay, and redbay. Atlantic white-cedar is also native here, but is now rare. The shallow ponds, strands, and pocosins in the longleaf, slash, and pond pine woods are related to the deep muck-swamp types. They support the same species, but the trees usually are stunted. Some minor blackwater streams of the lower Coastal Plain do not deposit fine alluvium and are not productive of good hardwoods. The larger ones, however, have substantial proportions of coarse alluvium or colluvium that often form productive sites for hardwood species characteristic of the terraces.

Localized areas within the Coastal Plain having ample moisture and deep soil of unusually good texture are called hammocks (or, in Louisiana, bays). They may be depressed or raised above the surrounding terrain. Although not necessarily associated with any stream, they are usually well drained and support a mixture of hardwoods including cherrybark oak, swamp chestnut oak, black tupelo, hickory, white ash, white oak, Shumard oak, and sometimes yellow-poplar and magnolia as well as the water oaks and sweetgum. Pine, usually loblolly, may be mixed with the good hardwoods on low hammocks and may predominate on high hammocks.

Upland Hardwood Sites

Two main types of productive upland hardwood sites occur in the southern hardwood region. First are the loessal soils, the primary examples being in the generally deeply dissected Brown Loam Bluffs and other uplands bordering the eastern edge of the Mississippi alluvial plain from Louisiana north (fig. 7). These deep, rich soils support excellent hardwoods. The second type of good upland site occurs largely in the rolling areas or hills of the lower Piedmont and in some richer upland areas of the upper Coastal Plain, usually within coves and ravines, on the slopes and bluffs above drainage courses, in branch heads, and along very minor nonalluvial bottom lands adjoining creeks and drains.

On a large additional upland acreage that once supported good hardwoods, misuse has depleted the soil until pine management is now more economical.

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FIGURE 6.—River birch is one of the pioneer species along small streams and sometimes along the larger rivers, particularly in the Southeast.

Although as a rule most hardwoods in the uplands reach their best development on the moist lower slopes and bottoms of coves, ravines, and streams, six topographic situations in the uplands may require different silviculture: (1) branch heads, (2) coves, ravines, and strands adjacent to streams, (3) lower slopes, (4) middle slopes, (5) upper slopes, and (6) ridges. As in the swamps and bottoms, associations are much more important than conventional forest types.

In contrast to its effect in the mountains, aspect ordinarily has a minor influence on hardwood development in these areas. Most slopes are short, even though the terrain, particularly in the Brown Loam Bluffs, may be extremely steep.

Branch heads, coves, and lower slopes may produce excellent hardwood timber. Yellow-poplar, cherrybark oak, Shumard oak, sweetgum, white ash, and sassafras do well particularly in the Brown Loam Bluffs, while farther north these bluffs and Piedmont areas grow good northern red oak. Cottonwood and sycamore are found occasionally on the best cove sites and dogwood is common on the slopes. Branch heads of the lower Coastal Plain may support mainly water oak or laurel oak with occasional white or cherrybark oak, yellow-poplar, sweetgum, magnolia, sweetbay, swamp tupelo, and pine; they exhibit some of the aspects of small bottoms or swamps.

Development of hardwood on middle slopes is fair to excellent. Well-adapted species are cherrybark oak, white oak, beech, winged elm, hickory, black oak, and southern red oak. Occasionally Shumard oak and, in appropriate latitudes, northern red oak do well. Dogwood is perhaps at its best here.

Upper slopes and ridges with deep surface soil produce acceptable hardwood growth, particularly of cherrybark oak and white oak. The conventional white oak and oak-hickory types occupy much of the good upperslope and ridge sites. When the soil on these sites is eroded, as it often is, pines are more productive than hardwoods.

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FIGURE 7.—Good white oak and cherrybark oak on the Brown Loam Bluffs near Vicksburg, Miss.

Stand Origins

Present-day hardwood stands reflect the varying tolerances and growth rates of the species that compose them. They also show the influence of fires and other calamities, past logging or agricultural use of the land, flooding, sedimentation, or erosion. Most stands are a hodgepodge of species and age classes ranging from seedlings to mature trees.

The southern hardwoods are intolerant of shade. Sugarberry, hackberry, mulberry, beech, dogwood, holly, magnolia, the bays, red maple, boxelder, the elms, Osage-orange, persimmon, and the hickories form exceptions to this statement, but most of these species are not favored in management. Therefore, adequate advance reproduction of sapling size and of desirable species seldom develops except in openings large enough to provide sunlight for a substantial part of the day.

Given an ample seed source and freedom from fire and grazing, most openings in a hardwood forest regenerate naturally (fig. 8). The sunlight that is necessary for seedling growth also

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FIGURE 8.—Most openings in hardwood stands will regenerate if provided a seed source and protection from fire and grazing. Sweetgum, green ash, and willow oak are evident in this opening.

induces a jungle of weeds, vines, briers, cane, and brush so thick that individual seedlings, though numerous, must be searched for in the welter. Such brush-patch beginnings are typical of most southern hardwood forest types, with the condition most aggravated in the bottom lands. Unless the seedlings are thick enough to form a complete cover in themselves, they apparently must use the competition as a nurse crop. The need seems to be for enough low cover to prevent baking or puddling of the soil. Perhaps soil temperatures are involved, along with the protection from browsing afforded by thorny vegetation.

Sometimes dense ground cover of erect habit, such as brier, herbaceous weeds, and cane, originates ahead of the reproduction. If it gets to be 7 or 8 feet tall, it will create sufficient overhead shade to hamper the establishment of tree reproduction. Harm from most vines is usually quite localized, but peppervine and honeysuckle, originating in advance, may form impenetrable mats under which little reproduction can survive. This condition is usually the result of overcutting and recurrent fires. Brief descriptions of some of the more important weed-tree, shrub, and vine species appear on page 11.

Except on problem areas, close examination of the average brush patch will reveal seedlings and small saplings, ordinarily from several hundred to a few thousand per acre. Many of these young trees will be seemingly overwhelmed by ground cover, about two-thirds may be of the least desirable species, and half may be crooked, forked, bushy, or suppressed. Nevertheless, within a few years after the area appears the most hopeless, a very promising stand of saplings will emerge and the jungle will melt away under its shade. Such sapling stands generally contain between 400 and

1,200 well-established trees per acre, the majority dominants and codominants of desirable species and form. At this stage, moreover, the better species and the best formed trees tend strongly to grow the most vigorously and to assert dominance, and hence to suppress many of the undesirables.

Silviculturally important weed species of southern hardwood forests [1]

American hornbeam or blue beech (*Carpinus caroliniana*) and **eastern hophornbeam** (*Ostrya virginiana*) are both commonly called ironwood. They occur mainly on terraces of minor streams, but are also common on well-drained terrace or outwash sites in major bottoms. In the uplands, they occur on all sites. In recent years both have been used for pulpwood. They are very tolerant and are pests when they occur in dense patches.

Planertree (*Planera aquatica*) occurs widely in swamps, deep sloughs, and low, poorly drained flats throughout the bottom lands. It is not found in the uplands. It is a small, poorly formed tree that can easily take over sites where fire has destroyed desirable species.

Roughleaf dogwood (*Cornus drummondii*), commonly called swamp dogwood, is a shrub that grows widely on low ridges and better drained flats of the bottom lands. Occurrence is usually sparse, but it can preempt open areas.

Swamp-privet (*Forestiera acuminata*) occurs widely in the bottom lands and can be a serious pest on wet flats and shallow sloughs. At times, solid stands preclude desirable reproduction.

Hawthorn (*Crataegus* spp.) is widely distributed on ridges and well-drained flats of the bottom lands and on all better upland sites. It is generally a scattered understory tree but may make thickets in openings.

Common buttonbush (*Cephalanthus occidentalis*), sometimes called buttonball, is a shrub restricted to deep sloughs and swamps. It often becomes prolific in openings after heavy cutting and fire, and ruins many swamp sites.

Possumhaw or deciduous holly (*Ilex decidua*) generally grows on stiff bottom-land soils of the flats or low ridges. It is a pest in small openings where reproduction of timber species is sought.

Dwarf palmetto (*Sabal minor*) occurs widely on silty clay soils but is a nuisance primarily in the lower Mississippi Valley south of the Louisiana line, where it may form high, dense stands.

Southern bayberry or southern waxmyrtle (*Myrica cerifera*), a shrub of the lower Coastal Plain, fringes and occasionally invades the bottom lands.

Live oak (*Quercus virginiana*) makes a tree of large diameter but with a swollen, buttressed base and large limbs starting near the ground. It is most abundant and reaches largest size on rich hammocks and low ridges of the Atlantic and east gulf coasts.

Fetter-bush (*Lyonia lucida*) is a small evergreen shrub common in the swamps of the east coast, often making a complete ground cover.

Peppervine (*Ampelopsis arborea*), locally called buckvine, is common on tight clay soils. It tends to take over the site when stands are severely depleted and burned.

Trumpetcreeper (*Campsis radicans*) is similar to peppervine and found on like sites, but differs in that it readily climbs trees.

Poison-ivy (*Toxicodendron radicans*) is common on all sites except very wet ones. It often grows as a dense stand on the ground, but also climbs trees. In the climbing form, stems may be 3 to 6 inches in diameter.

Grape (*Vitis* spp.), common on well-drained sites and most soils, forms large vines that often weigh down saplings and aggressively climb large trees.

Supplejack (*Berchemia scandens*), common on all except very wet sites, is a vine that chokes and deforms trees by winding itself about them as it climbs.

Redvine or ladies'-eardrops (*Brunnichia cirrhosa*), common on tight clay soils, is a ground vine that makes a low mat inhibiting tree reproduction.

Morning-glory (*Ipomoea* spp.) sometimes becomes noxious in limited areas in creek bottoms, drained swamps, and hammocks of the Southeast.

Japanese honeysuckle (*Lonicera japonica*) is an introduced pest, particularly serious in the small bottoms of the Piedmont. It forms a low dense mat that prevents reproduction, and climbs and deforms saplings and small poles.

Kudzu-vine (*Pueraria lobata*), a cultivated vine often planted for erosion control, sometimes invades the edges of forest stands. It can smother large trees and is also a serious fire hazard after frost has killed the leaves.

A few species, especially Nuttall oak, willow oak, water oak, laurel oak, and overcup oak, will germinate profusely beneath a complete canopy, but the seedlings invariably die back to the root-collar within 3 years unless they are released. Others, such as the ashes and most oaks, germinate more or less plentifully throughout the stands, and scattered individuals or groups may develop for some years in the partial light of small openings. Without release, they dwindle away before reaching pole size. Still other species, such as the tupelos and sweetgum, germinate sparsely and endure briefly under any closed overstory, though they may start profusely in small openings and survive so long as top light is available.

The tolerant species persist and grow poorly under shade but quickly form dense stands when released, thus preventing reproduction of intolerant species that may be more desirable. Nevertheless, when given an equal start in the open, more desirable intolerant species will outgrow less desirable tolerants.

Certain species characteristically originate and develop in almost pure stands of even age. Cottonwood and willow require absolutely bare, moist, mineral soil for the first few weeks of growth. Any low ground cover, especially sod, greatly hampers them. At no time will these species tolerate any overhead shade, even from weeds. They endure long flooding and silt deposition. Seedling stands are extremely dense (50,000 to 500,000 seedlings per acre) and develop very rapidly.

Cottonwood asserts dominance promptly. Stands on good sites usually remain fully stocked throughout their life unless they are cut or meet catastrophe. Willow stagnates early; the dense, fully stocked condition of the stands breaks down within the first 30 years through excessive, almost simultaneous mortality. Because of their extreme intolerance and their requirement of mineral soil for germination, cottonwood and willow rarely succeed themselves.

[1] Most of these species, and some others, are illustrated in: L. C. Maisenhelder. *Understory plants of bottomland forests.* U.S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 165, 40 pp., illus. 1958.

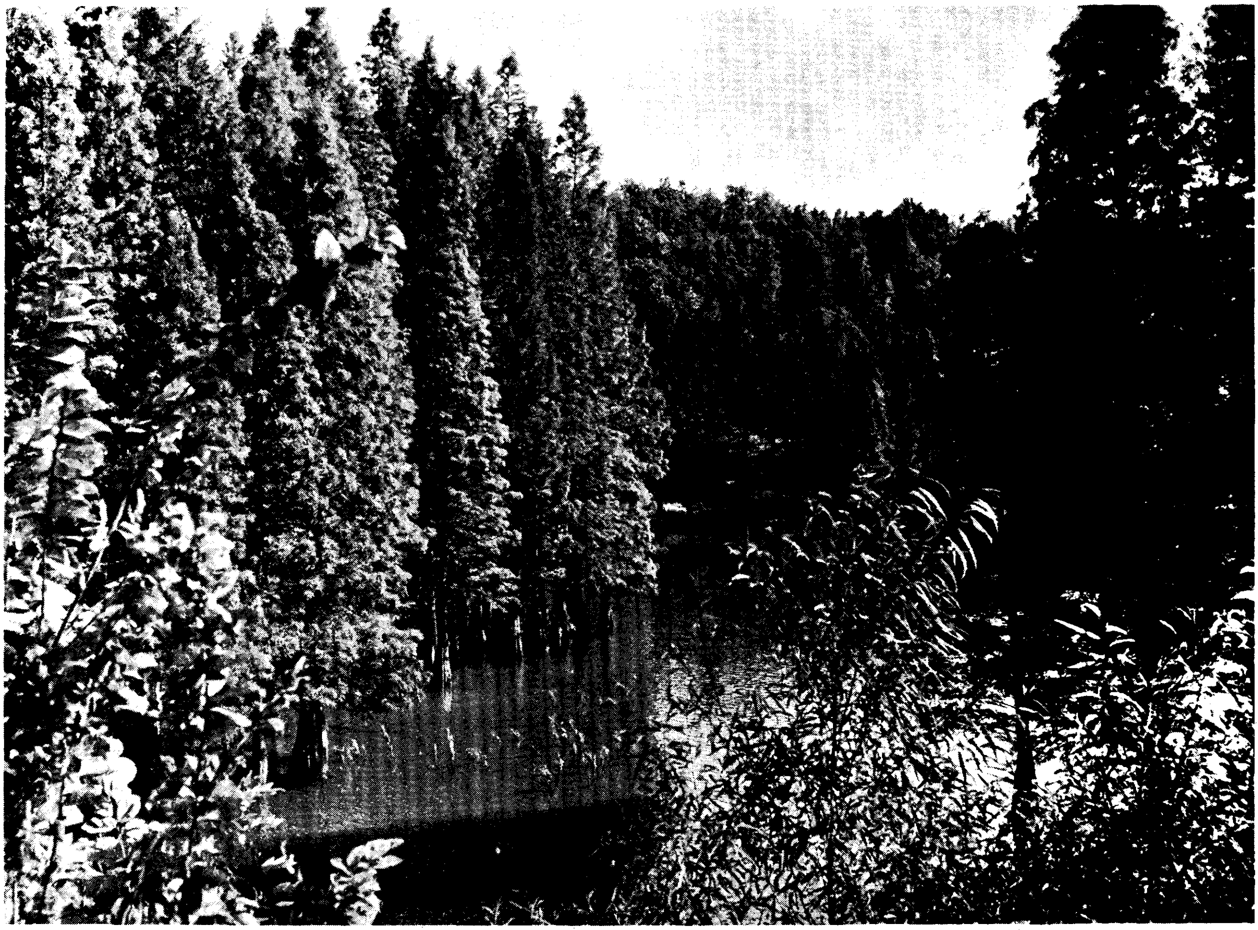

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FIGURE 9.—Twenty-year-old cypress on a lakeshore in northeast Mississippi. This photo illustrates one step in the gradual invasion of an oxbow lake by stages correlated with sedimentation and water levels.

Baldcypress often occurs in pure, dense, even-aged stands (fig. 9). It will regenerate well only in swamps where seedbeds are moist, where competitors are unable to cope with flooding, and where ground cover is limited to annual herbs. Seeds will germinate even if water subsides as late as midsummer, but seedlings and saplings are only moderately tolerant and are not aggressive against other competition. When the trees have grown above seasonal high water, they develop rapidly. Because most baldcypress stands are very crowded and the species asserts dominance poorly, growth slows early in life, practically to the point of stagnation, and the weaker trees succumb slowly over a long period of years. Isolated baldcypress trees may be found on low sites with all major associations; their presence usually indicates that past site conditions have changed.

Swamp and water tupelos occur in swamps or wet areas, usually as even-aged stands. They seed regularly and copiously. As soon as high water recedes, the seedlings leaf out and run up unbranched shoots that get above high-water stages in one to three growing seasons. In shallow swamps, reproduction of these two species is fairly sure and prompt, barring fire and overhead competition. As with baldcypress, overstocked stands tend to stagnate but endure indefinitely.

In deep swamps, both tupelo and baldcypress regeneration from seed depend on good seedfall and germination followed by freedom from prolonged inundation during the growing season. The shallow but relatively permanent coastal swamps pose an essentially similar problem. Tupelo and baldcypress in these swamps grow in typically pure even-aged stands. Depending on how water levels have influenced reproduction, extensive stands will generally represent two or three age groups. When in association with baldcypress, tupelo is usually the younger component; in association with sweetbay, tupelo is usually the older component.

Even-aged stands of sweetgum often come in on old fields and other areas where mineral soil is exposed. Once they germinate, sweetgum seedlings can withstand very heavy competition from herbaceous plants. Many even-aged sweetgum stands are of sprout origin, most often from trees killed back by fires or floods. Oaks and some other species occasionally develop even-aged stands, particularly the pin oaks in wet flats and other red oaks where the stands originate from sprouts or where seed has been moved to a favorable situation by floodwater. The even-aged pure stands of yellow-poplar or of white oak that are common in certain upland areas are usually the consequence of fire or clearcutting.

Water, standing or moving, may prevent establishment of reproduction whenever it submerges seedlings after the beginning of their active growing season. Species vary in their tolerance to submergence. Seedlings are more likely to survive short periods under water if the water is clear and cool than if it is warm and turbid.

While dormant, the species native to sites subject to flooding are very little affected, even when completely under water. If they are submerged in advance of the growing season, some will stay dormant well into the spring and begin growth after the water goes down. Baldcypress, green ash, and tupelo will endure in this manner at least halfway through the growing season. Most stands of overcup oak and water hickory, together with the persimmon and green ash often associated with them, owe their establishment to tolerance of early season floods that kill off earlier flushing vegetation that would take over a drier site. These species normally break dormancy as much as a month later than other species. Regeneration of all species will fail if floods in the growing season repeatedly kill back seedlings before they attain enough height to keep their tops above water.

On the great bulk of the forest, the soil itself has little bearing on the success of reproduction. Where coarse, loose sand lies at the surface or under a thin veneer of fine material, however, seedlings will fail because the summer water table is normally too deep to deliver moisture through the sand. Such sites are very limited in area. They are important probably only in the Mississippi Delta, principally between the levees. In the bottom lands, the very fine-textured clay soils (which hold water against great tension) in the lowest backwater flats and the occasional hardpan basins in the terraces both have sparser stands than more pervious sites and remain bare longer. The exceptions are the thickets of poor willow oak commonly found on the latter sites.

F-485935

FIGURE 10.—Complete destruction of a hardwood stand by wildfire. All litter and reproduction have been wiped out. The large trees are blackened to a height of 20 feet. Beneath the charred bark is dead cambium.

F-482589, 485933

FIGURE 11.—The butt swell and hole at the base of this swamp chestnut oak are external evidence of hollow. Right photo shows the extent of the rot.

When fine clay soils are cultivated for a long period or overrun by repeated hot fires and exposed to the sun, their humus content oxidizes and they become puddled and dry to rocklike hardness, incapable of growing anything but weeds for many years.

Damaging Influences

Damaging influences at work in southern hardwoods are largely those that plague forests the world over. Sometimes destruction is violent and wholesale, as when an unusually hot fire kills everything in its path or a shifting river cuts away a section or two of land. But most damage is unspectacular, often deceptively so.

Wildfires, practically all of them man-caused, are the greatest scourge of hardwood forests. During average and wet years, fires are so infrequent that only a minimum protection system is needed. But occasional prolonged droughts can result in holocausts far beyond the power of existing fire control organizations to cope with.

Hot fires kill or severely damage practically all saplings and poles and many sawtimber trees (fig. 10). Even low-intensity fires destroy most of the reproduction and scar larger trees. Many dense patches of peppervine (buckvine), ironwood, and other forest weeds originate by sprouting and flourish when fire kills off the seed source and shade of more desirable vegetation. Fire is one of the most important causes of degeneration and failure to reproduce in the cypress-tupelo swamp forests. In the muck-swamp phase of such forests, fires that occur during extreme

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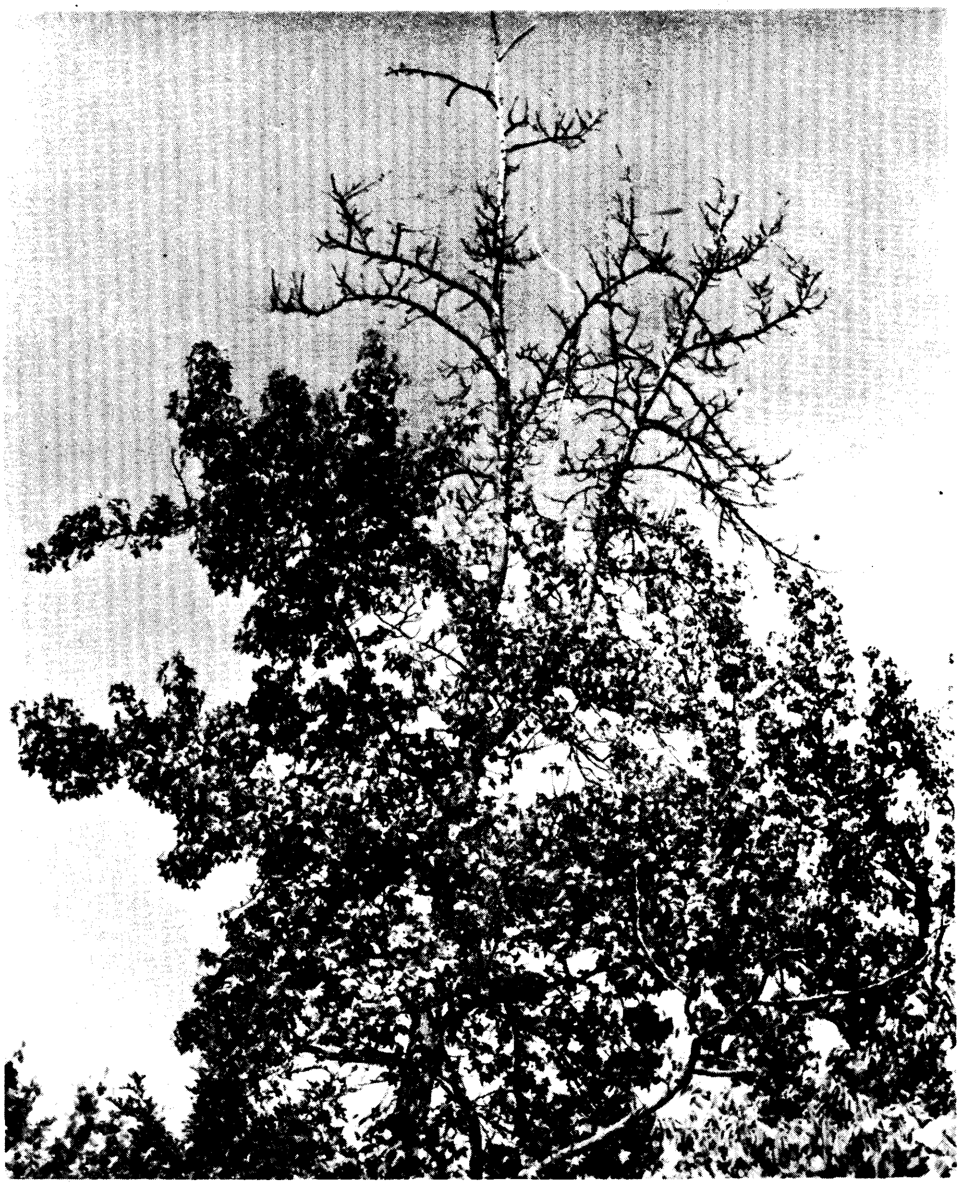
FIGURE 12.—Two important cankers on red oak: *Poria spiculosa* on left and *Polyporus hispidus* on right.

droughts may seriously deteriorate the site by consuming the organic soil.

Of the diseases that afflict hardwoods, the most serious are caused by fungi that rot the heartwood. Heart rots are the chief cause of cull in southern hardwood stands, and about 90 percent of the rot enters the base of the trees through wounds caused by fire. Typically, rot reaches the heartwood about 4 years after a tree is wounded and thereafter works upward at rates varying with the species of tree and fungus.

The average rate of upward spread of established heart rots has been found to be 2.0 feet per decade for overcup oak and sugarberry; 1.6 feet per decade for water hickory; 1.3 feet per decade for red oaks; 1.3 feet per decade for green ash; 0.9 foot per decade for sweetgum and elm. A stand may be riddled with heart rot and still



F-486591

FIGURE 13.—Dieback (blight) in sweetgum.

appear healthy to casual view, for the original wounds often become inconspicuous in time and many of the fungi do not form conks or cankers under southern conditions (fig. 11).

Several of the cankers on southern red oaks always have heart rot behind them. That caused by *Polyporus hispidus* is sunken and elongated, often several feet in length (fig. 12). Another canker, caused by *Poria spiculosa*, produces swellings around old branch stubs. Rots behind these cankers develop much more rapidly than butt rots. Cankers are sometimes mistaken for mechanical injuries, but a mechanical injury is free of bark and gets smaller each year as it becomes covered by new callus tissue, while a canker often retains dead bark and usually increases in size. Some types of cankers develop pitted protuberances somewhat resembling burls, while others become recessed.

Root rots in hardwoods are not a major problem except where clay soils fluctuate between saturation and extreme dryness, as in some willow oak stands. Neither are top rots very serious, since they tend to affect the less valuable knotty portion of the bole. The two most economically serious top rots are the dry, yellow heart rot of ash and the peck in baldcypress.

In contrast to most hardwood diseases, the blight or dieback of sweetgum sometimes wipes out entire stands. Soil factors that contribute to a shortness of available water during period of rainfall deficiency appear responsible. The first indication is a thinning of part of the crown (fig. 13). The thinning gradually spreads, sometimes rapidly and sometimes slowly. If favorable moisture conditions return before deterioration has progressed too far, some trees will recover. Blight has been most severe during droughts and on sites considered least suited to sweetgum.

Oak wilt has not yet been found in the most important hardwood forests of the Deep South. Its two southernmost extensions are in north Arkansas and east Tennessee. Recent research has shown that *Ceratocystis fagacearum*, the fungus that causes the wilt, will not survive in twigs longer than 3 days at temperatures of 95° F. or higher. This fact suggests that the wilt may never be as serious in the warmer sections of the South as it has become farther north.

Hardwoods are attacked by numerous fungi that spot or kill the leaves. Thus anthracnose sometimes browns and kills the leaves of sycamore and oak. Leaf blister of oak, characterized by blistering, wrinkling, and curling of leaves, occasionally causes excessive defoliation. If severe defoliation occurs early in the growing season, it may lower the vigor of the tree so much that growth is seriously reduced.

Insect epidemics that lay waste entire stands are rare in southern hardwoods; even individual trees are seldom killed after they reach sapling size. Yet enormous losses are caused annually, chiefly by borers and bark scarrers. The holes, bark pockets, stains, and other blemishes caused by these insects do not destroy the wood (as the heart rots do), but greatly lower the value of the product by limiting the number and size of the defect-free pieces that can be cut from the log or lumber (fig. 14).

Most important hardwood specimens are susceptible to this kind of damage, with oaks being the worst afflicted (table 1).

Defoliating insects sometimes weaken and slow the growth of large trees, and sometimes kill young ones.

Trees of low vigor or on poor sites appear to be the most susceptible to insect damage. The control of hardwood insects is a subject that has hardly been scratched.

The action of water may damage the forest (fig. 15). Total submergence for long periods beginning after the breaking of dormancy will kill all reproduction. Baldcypress and willow are able to withstand such inundation for the longest periods. Permanent flooding will cause complete mortality even though water covers only the base of the trees. Tolerance of this condition varies with species. For example, yellow-poplar will survive such flooding for less than 2 weeks, whereas baldcypress and tupelo may live for years after the normal summer water level has been raised. Artificial drainage will decelerate growth or kill older trees if it permanently lowers the water table. Prolonged droughts cause mortality

F-485944, 485945

FIGURE 14.—Insects that tunnel in living trees can seriously degrade hardwoods. *Left:* Grub emergence hole in overcup oak kept open by carpenter ants. *Right:* In the wood 3 inches beneath the bark.

TABLE 1.—*Important insect damage in living southern hardwood and cypress trees*

Type of damage	Tree species	Occurrence	Economic importance	Insect species
HOLES				
Grub damage. Large holes and long tunnels anywhere in tree trunks.	Most oaks, especially overcup, willow, Nuttall, laurel, and water oak. Also black oak and white oak on dry sites and cherrybark oak on poor, impervious soils.	Throughout the bottom lands, but especially in backwater areas. Also on poor, high, dry upland sites.	Perhaps most important oak defect in all forests. Largely responsible for the poor reputation of overcup oak. Causes extreme degrade and loss of value.	Beetles—roundhead borers, *Romaleum*, *Goes*, *Stenodontes* spp., and others. Moths—carpenter worm, *Prionoxystus* spp.
Grub damage. Usually clustered in lower tree trunks.	Cottonwood	Wherever cottonwood grows. Serious only on poor sites; aggravated or extended by drouth.	Important. Clustered holes may weaken young trees so that they break off. Holes degrade wood for lumber and veneer.	Cottonwood borer, *Plectrodera scalator*. Poplar borer, *Saperda calcarata*.
Spot worm. A very small hole filled with dust and often surrounded by a narrow zone of brown-stained wood.	Overcup oak	In backwater areas of river and stream bottoms; perhaps usually on tight silty clay soil.	Of great local importance in some areas. Can reduce otherwise FAS lumber to Sound Wormy grade. Culls tight cooperage stock.	*Agrilus* sp., probably *acutipennis*.
Flag or spot worm. Attacks living trees repeatedly.	Soft maple, yellow-poplar, and white oak group—post oak especially.	In maple in river bottoms throughout the South. Common in white oak group on upland sites.	Degrades veneer and lumber. Culls tight cooperage staves.	Columbian timber beetle, *Corthylus columbianus*, an ambrosia beetle.
Pinholes in weakened and damaged trees. The small, round, open holes become surrounded by dark sap-stained areas.	Oaks, sweetgum, the pecans, ash, and American elm; in fact, sapwood of most species.	Throughout the South	Minor in living trees. Attack indicates low vigor or dead cambium. (Serious in old logs and fresh-cut lumber.)	Ambrosia beetles. *Platypus* spp. *Xyleborus* spp.
Borer damage in root collars and stems of young trees.	Cottonwood, willow	General along lower Mississippi River and tributaries.	Weakens stems of young trees, so that they break easily.	A clearwing borer, *Paranthrene dollii*.
BARK SCARS				
Bark scarrer damage. A patch of inner bark is killed and the wood surface is stained. When overgrown, damage appears as a stained area with ingrown bark. Often occurs throughout a log.	Overcup oak, laurel oak, willow oak, water oak, Nuttall oak, sycamore, and, on poor sites, cherrybark oak, the tupelos, hickory, and yellow-poplar. Black oak and white oak on high, dry sites.	Throughout the South on poorer sites.	Second only to grub damage in most bottom-land oaks, and sometimes worse. Especially bad in overcup oak. May reduce black and tupelo gum veneer to core-stock grade.	Little-known species of sap-feeding beetles (Nitidulids) chiefly responsible.

ABNORMAL GROWTHS				
Ridges of abnormal wood and ingrown bark that develop from bark lesions.	Sweetgum	Scattered on good bottom-land sites throughout coastal areas of the South.	Causes a lumber and veneer defect similar to a small catface or large bark scar. Serious degrade over limited areas.	Cause not known, but insects are suspected.
Ribbed swellings in the trunk near the ground.	Sycamore	Occasional throughout the South.	Abnormal wood growth and ingrown bark cause a lumber and veneer degrade.	Cause not known, but insects are suspected.
Twig-borer attacks kill terminals and stunt growth.	Cottonwood	In the Delta generally. Concentrated in plantings near cultivated lands.	Young nursery and plantation trees and natural reproduction seriously damaged. Height growth is halved and poor branchy form results.	A moth, *Gypsonoma* sp., probably *haimbachiana*.
GALLS				
Galls that girdle oak twigs and kill the leaves and buds.	Willow oak, southern red oak, and water oak.	In Ouachita and Saline River bottoms in Arkansas especially, but probably endemic throughout the South. Periodic buildups.	In extreme cases may kill trees in 2 or 3 years. Locally very important. Nearly 20 million board feet of willow oak died in one area a few years ago. The only serious killer yet noted.	Cynipid gall wasps, *Andricus* spp.
DEFOLIATION				
Defoliation by tent caterpillars.	Sweetgum, blackgum, pecans, hackberry, and hickories.	Endemic throughout the South. Periodic local outbreaks.	May be serious, especially if defoliation is repeated 2 years or more. Slows growth and occasionally kills.	Forest tent caterpillar, *Malacosoma disstria*.
Defoliation	Cypress	Periodic outbreaks	Defoliation slows growth and weakens trees.	Cypress looper, *Anacamptodes pergracilis*.
Defoliation	Cottonwood and willow	Throughout Mississippi Valley. Probably throughout range of species.	Periodic local buildups serious. May injure young cottonwoods in plantations and nurseries.	Cottonwood leaf beetle, *Chrysomela scripta*.
Partial defoliation by leaf miners.	Cottonwood and willow	General distribution. Localized outbreaks.	Growth loss due to partial destruction of leaves.	Cottonwood blotch leaf miner, *Paraleucoptera albella*.
Partial to complete defoliation.	Nuttall oak, cherrybark oak, southern red oak, and overcup oak.	Red and Yazoo River backwater areas, and Tensas basin of Louisiana; bluffs near Yokena, Miss.	Weakens trees and slows growth. Repeated attacks may cause death. Damage not fully evaluated.	Oak leaf miner, *Baliosus ruber*.
Reddening of cypress foliage. Partial defoliation.	Cypress	Recently common in the mid-Delta. Reduced by heavy rain, probably related to hot dry weather cycle.	Importance not known. Growth is reduced and weakened trees may be damaged by other agencies.	Red spider mites. *Tetranychus* spp.

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FIGURE 15.—These trees are growing in an area where water is impounded every fall and held until spring. Such seasonal impoundments are popular means of attracting migrating ducks. They may also benefit timber growth, especially in dry summers and on heavy clay soils, because they increase the amount of water going into soil storage. However, water impounded during the greater part of two or three successive growing seasons will seriously damage timber and, in one or two more seasons, kill it all.

and induce insect attack (fig. 16). Unless the change in water regime is too abrupt or prolonged, many top-killed stems will sprout again, however.

In the uplands, erosion may so deplete the site as to preclude growth of quality hardwoods. Some of the sediment washed downgrade may be deposited during overflows in both upland and bottom-land forests, where it may kill most hardwoods unless the siltation is extremely light and gradual. Cottonwood, willow, baldcypress, and tupelos survive heavy siltation but even cypress and the tupelos succumb in extreme cases.

Ice storms may break the upper crown or big limbs out of large trees and bend or break off small ones (fig. 17). Most trees eventually rebuild their crowns, but at the cost of temporarily diminished rate of growth, epicormic branching, and fungal infections that enter through broken stubs. On rare occasions, ice carried by floodwater breaks young trees and wounds large ones.

Tornadoes and hurricanes may snap the main stem or break portions of the crown of some trees, but do their main damage by uprooting trees growing on saturated ground.

Where regeneration is being sought or nurtured, grazing by livestock is a serious threat. In fact, grazing of any practical intensity will preclude effective sustained-yield management. Cattle browse some of the best species of trees, including ash, oak, and yellow-poplar (fig. 18). Luckily, sweetgum, is a less palatable species. Trees not completely killed by grazing are set back and malformed. If heavy grazing is allowed or the woods are browsed when the ground is wet, the cattle may compact the soil and damage the roots sufficiently to admit rot.

Hogs are not so bad an influence as cattle, but in heavy concentrations they will eat all seed in an oak or pecan forest. They are a special threat to the better white oaks. Generally, there is little conflict between wildlife and good hardwood management. However, overpopulations of deer will severely browse reproduction. Rabbits feed on the seedling bark and new growth of a variety of species and can harm hardwood plantations, particularly in the spring. Beavers are increasing in many localities, and sometimes have caused the flooding of large areas along small streams. Nutria or coypu have seriously damaged baldcypress plantations by clipping or uprooting young seedlings, but these exotic mammals are currently a threat only in the swamps of south Louisiana.

F-485939

FIGURE 16.—Severe droughts may destroy considerable volumes of timber, particularly on sandy sites or on heavy soils that normally have ample moisture.

Utilization

The fundamentals of utilizing and marketing hardwoods conform to very definite patterns and customs that are unique in themselves and quite different from the pattern for softwoods. The essential requirements of hardwood utilization in turn profoundly affect the objectives of management and the type and intensity of silviculture.

Although most hardwood timber is sawn, only a small portion of the product is used for structural purposes, and that mainly for railroad stock and local construction. Instead, most hardwood lumber is consumed by factories as raw material that is remanufactured into articles sawn from the clear wood between defects.

Hardwood timber products range from extremely valuable, fine face veneers to dunnage that cannot be sold for half the cost of manufacture. Furniture, flooring, trim, handles, plywood, baskets and crates, toys, shuttles, athletic equipment, implement parts, chopping blocks, special pulps, chemicals, and charcoal are among the better known products. The myriad uses for hardwoods make utilization a complicated but fascinating subject.

Hardness, toughness, grain or figure, and other qualities of defect-free wood influence the product into which lumber of a given species is channeled. In addition, the kind and distribution of defects in an individual tree of a given species affect the total value obtainable from the tree as well as the product into which the wood is manufactured. One sweetgum tree may produce high-value veneer logs; another may yield at best only low-grade crating lumber or crossties. The same tree that has valuable material in it will also contain worthless or low-value wood. Often whole trees, because of relatively small size, poor form, or defects, will cut out only low-value cordwood, posts, or local-use lumber. Markets for these products from hardwoods are marginal over most of the South at present. Generally, freedom from defect is more important than species in determining the value of an individual tree.

The primary uses of hardwoods can be broadly classified as (1) veneer logs and bolts, (2) lumber logs, (3) cooperage logs and bolts, (4) small dimension or specialty logs or bolts, (5) piling, (6) posts and props, and (7) cordwood bolts (table 2). There is a surplus of trees that will satisfy requirements for cordwood, posts and props, and

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FIGURE 17.—Some of these trees were killed by an ice storm during the previous winter; others were so bent that they will die or form culls. Those with broken tops may survive, but the height of the break will determine the usable length.

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FIGURE 18.—Lack of advanced reproduction in grazed area on the left, as compared with the ungrazed area on the right, demonstrates the effect of heavy cattle grazing in hardwood stands.

construction-lumber logs, and a shortage of trees suitable for veneer bolts or factory-lumber logs. Hence, face-veneer bolts may sell for several hundred dollars per thousand board feet, while the price for structural logs may not cover cost of harvesting, except in the most accessible locations.

Quality and Marketing

Each broad use class involves several different categories of product, and there are grades within each product category. Utilization of particular trees should be aimed at obtaining the maximum possible difference between harvesting plus manufacturing costs and product selling price. The initial step toward this end is to buck the tree so as to contain most of the defects in as few and as short lengths as possible. Each piece must also be directed into the product that will return the greatest profit. Such channeling will require either coordinated logging or a log concentrating and sorting facility. Unfortunately, the latter is practically nonexistent.

The greatest single use of southern hardwoods is for factory lumber. Table 3 synopsizes the standard grades for factory-lumber logs; these grades, developed by the U.S. Forest Products Laboratory, are designed to sort logs according to yield of lumber as graded by rules of the Na-

TABLE 2.—*Utility classes for southern hardwoods*

Product	Primary form	Value	Minimum scaling diameter	Species	Markets
VENEERS					
Face	Logs and bolts	Highest	24 to 30 inches for slicing, 16 to 18 for turning.	Sweetgum, maples, ash, pecan, sycamore, walnut, cherry, and all but water oaks. Prime logs of other cabinet woods on occasion.	Good but widely dispersed and highly discriminating markets always available. Highest quality imperative. Very long hauls the rule. Lack of concentrated volumes and of reliable middlemen are greatest difficulties.
Commercial	Logs and bolts	High to very high.	12 inches; very rarely 10.	Yellow-poplar, sweetgum, tupelos, cottonwood, sweetbay, sycamore, but occasionally also the maples, the oaks (except for water oaks), ash, soft elm, magnolia, and most other species.	Same as for face veneer but in less degree.
Package	Logs and bolts	Medium	12 inches, occasionally 10.	Most soft-textured species, but especially sweetgum, the tupelos, yellow-poplar, cottonwood, sycamore, sweetbay, and soft elm.	Concentrated in fruit- and truck-farming districts. Good where within reach. Quality generally comparable to factory lumber logs.
COOPERAGE					
Tight	Usually bolts	Medium to very high.	14 inches	White oaks principally. Minor amounts of red oaks, gum, ash, and sycamore.	Widely scattered and mostly migratory. Very good if present. Highest quality material is demanded, but by short lengths. Sometimes hauled far to central plant.
Slack	Bolts and logs	Low to medium	12 inches, occasionally 10.	Principally sweetgum, soft elm, hackberry, and sycamore, but most other soft species are still used.	Few and scattered. Tend to be independent as to log supply. Use dwindling in competition with paperboard and veneer.
LUMBER					
Factory	Logs	Medium to high	12 inches; 10 for certain species, superior quality, or special cases.	Oaks, sweetgum, the tupelos, and ash are backbone of trade, but all species are taken.	Almost universal outlet for reasonably good timber. Mills accumulate logs from wide radius. Structural and local-use production incidental.
Structural	Logs	Low to medium	Generally 10 inches; special situations, 8.	Mostly oaks and gums, with minor amounts of the other firm to hard species for railroad items, etc. Most soft species may be but seldom are made into standard structural boards.	Generally available but erratic. Usually small local or migratory mills selling through jobbers and producing mill-run factory lumber, often incidentally to pine lumber.
Shipping container	Logs and bolts	Low	8 to 10 inches	Soft-textured hardwoods preferred but hard species also used.	Localized in relation to industrial or farm market, usually in conjunction with package veneer.
Local-use	Usually logs	Very low to low	About 8 inches	Anything that is mostly sound and somewhat straight.	Active but erratic in better developed agricultural and industrial areas where timber is

					scarce. Negligible elsewhere. The lumber goes into farm and temporary structures, car blocking, grain door boards, and miscellaneous items including mine timbers. Mills are all small and mostly migratory; they cut some mill-run standard lumber incidentally.
DIMENSION STOCK AND SPECIALTIES.	Usually bolts	High to very high.	Generally 10 inches but variable with species and product—dogwood 4½ or 5 inches.	All staple species for furniture. Oaks, hickories, ash, dogwood, and persimmon for handles, vehicle and implement parts, athletic goods, textile-mill specialties, etc.	Production of furniture dimension from round timber is largely limited to Piedmont and east coast. Other specialty markets are widely scattered, mostly migratory in cycles, and often restricted to small amounts. Persimmon limited to Memphis, Tenn.
PILING	Piece	Medium to high.	5 to 8 inches	Most hard or tough, firm species for either subsurface or temporary purposes. Especially baldcypress in Mississippi Valley.	Irregular, dependent on local construction, except baldcypress. Handled largely through jobbers but often directly with construction contractors.
POSTS AND PROPS	Piece	Low to medium	3 inches	Principally the oaks, but all strong, firm woods for mine props and temporary posts. Without preservative treatment only naturally durable species—Osage-orange, mulberry, baldcypress, sassafras, and white oaks—have reasonable service life.	Almost strictly local and special in mining and agricultural areas. As yet, little commercial use is made of preservatively treated hardwood posts, but an increased demand might provide an outlet for thinnings. Practically all species treat well.
CORDWOOD					
Pulpwood	Bolts	Low	4 inches; occasionally 5.	Has been only the soft-textured woods, principally sweetgum, the tupelos, cottonwood, and willow. Now much oak is used at a few points and use of most other species seems in sight.	Volumes still small except for certain species and localities in Mississippi Valley and on east coast. Handled by dealers. Often shipped great distances.
Chemicalwood	Bolts and sticks	Very low	4 inches; diameters 7 inches and larger must be split.	Principally the oaks and hickories.	Very meager. The few important users supply themselves largely from landclearing operations and improvement of their own forests. A waning industry, despite increase in domestic use of charcoal. Both coal and natural gas yield the same products cheaper.
Fuelwood	Bolts, poles, and chunks.	Lowest	Variable but as low as 2 inches.	Principally oaks, hickories, and ash, but all species are used to some extent.	Although a tremendous aggregate volume is used by farmers and others, practically no commercial market exists. There are local opportunities to improve and expand commercial distribution and thus provide an outlet for culls and tops.

tional Hardwood Lumber Association.[4] Hardwood lumber grading (and, indirectly, log grading) depends on the proportion of the surface measure of the board that can be recovered by a maximum number (or less) of saw cuts removing defects and leaving clear wood of specified minimum size or larger. These pieces of residual clear wood are used to make the various products discussed earlier.

This principle contrasts strikingly with that applied to grading yard or structural lumber, the product into which most coniferous wood goes. The reason for the difference is that a piece of yard or structural lumber is graded and used as a single board or timber which can contain a number of defects so long as they do not seriously weaken it, while a piece of factory lumber is destined for remanufacture into several smaller defect-free pieces. Any imperfection or blemish in factory lumber limits a clear cutting and is therefore a defect. This is true regardless of the nature of the defect: distribution of the defects is more important than their number, size, or character. In yard or structural lumber, the seriousness of defects depends on their number, size, and character—that is, whether they will weaken the piece, allow leakage, or adversely affect paint retention. Distribution or spacing of defects is much less important.

Grades 1 and 2 factory-lumber logs find ready markets at fair to excellent prices nearly everywhere in the southern hardwood region except in the southeastern Coastal Plain and in Texas. The proportion of grade 3 and poorer logs that may be included varies with the nature of the timber, the general market conditions, the species and sizes involved, and whether the mill is cutting structural bill stock (material cut on special order) or remanufacturing low-grade lumber into factory parts or flooring. Most mills buy timber over a wide territory (commonly on a 100-mile radius) and log it largely or entirely through contractors. Jobbers supply many of the factory-lumber logs used by large mills.

There are no commonly accepted specifications for veneer, cooperage, small dimension, or specialty logs and bolts, but local grades are commonly applied independently by the various buyers. As in factory-lumber production, these local grades or customs and practices are directed at the proportion of clear or otherwise suitable cuttings that can be obtained.

Logs or bolts for face and commercial veneer (fig. 19), tight cooperage, and specialty products are usually much in demand—sometimes for end-products that could be made from lower quality material. Rarely are present-day stands exploited primarily or solely for face or commercial veneer, because stands containing more than a minor proportion of logs of suitable species, size, and quality are few and far between. Usually, the harvest of veneer logs (often tight-cooperage and specialty logs, also) is integrated with lumber operations, especially where done by a jobber (fig. 20).

On the other hand, manufacturers of high-value products such as cooperage or specialty items may have operators culling scattered cut-over stands over vast areas and making light cuts of a single, easily harvested product. High-grade veneer logs may be hauled hundreds of miles to market once they have been brought to roadside or railside.

Logging, concentrating, sorting for highest use, and inspecting scattered valuable material are difficult, especially where many small tracts are involved and markets are distant. For best marketing under these conditions, well-financed and experienced contract loggers or jobbers with complementary markets for logs and bolts are needed—but usually are lacking. Moreover, much of the primary cooperage and specialty manufacture into rough blanks is done by small, temporary, and migratory plants. The total result is an occasional lack, real or apparent, of suitable markets for the best timber in many localities, even for high-value products that can be economically harvested in small amounts as a single-product operation.

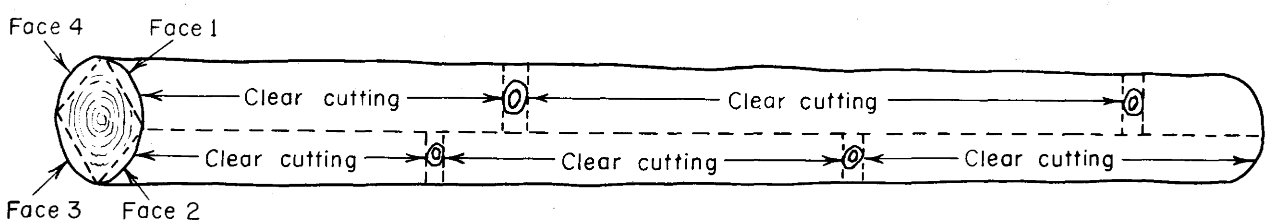
In the Southeast, by contrast with the general situation, commercial veneers and plywood are the most important hardwood products, with package veneer a close second in volume. Manufacture of standard factory lumber is underdeveloped in many localities. Thus there is a shortage, at least in the higher grades, of the once-abundant gums and tupelos that are now heavily used for veneer. On the other hand, good oaks and mixed hardwoods, suitable for factory lumber, are sometimes hard to market. A better balance between sawtimber and veneer markets in that region would improve the situation for the timber owners. The same is true of east Texas, except that the package industry predominates there and sweetgum and the tupelos are less abundant.

Structural lumber (principally ties and timbers) is generally a much less important use for southern hardwoods than factory lumber or veneer. The two major types of hardwood struc-

[4] The log grades can be obtained free from the U.S. Forest Products Laboratory, Madison 5, Wis., by requesting Report D1737A, *Hardwood log grades for standard lumber and how to apply them.* The lumber rules are issued annually, at a small price, by the National Hardwood Lumber Association, 59 E. Van Buren Street, Chicago 5, Ill. *Log defects in southern hardwoods,* Agriculture Handbook 4 of the U.S. Department of Agriculture, clarifies the defect terminology used in the log grades.

TABLE 3.—*Hardwood log grades for factory lumber*

Grading factors	Grade 1			Grade 2				Grade 3
POSITION IN TREE	Butt	Butt and upper		Butt and upper				Butt and upper
SCALING DIAMETER .... inches	[1]13–15	16–19	20+	[2]11+	12+	12+	12+	8+
LENGTH WITHOUT TRIM .... feet	10+	10+	10+	10+	8–9	10–11	12+	8+
CLEAR CUTTINGS ON EACH OF 3 BEST FACES								
Length, minimum .... feet	7	5	3	3	3	3	3	2
Number, maximum	2	2	2	2	2	2	3	No limit
Proportion of log length required in clear cuttings	5/6	5/6	5/6	2/3	3/4	2/3	2/3	1/2
SWEEP ALLOWANCE (maximum, in relation to gross volume)								
Logs with less than 1/4 of end in sound defects .... percent	15			30				50
Logs with more than 1/4 of end in sound defects .... percent	10			20				35
CULL PLUS SWEEP ALLOWANCE (maximum, in relation to gross volume) .... percent	40			[3]50				[4]50
END DEFECT	Sound end defects, such as medium to heavy mineral stain in hard maple and yellow-poplar and slight dote in yellow birch on the small end of the log, shall not exceed one-half the log diameter for grade 1 logs and for grade 2 logs under 16 inches, and not exceed three-fifths the log diameter on grade 2 logs 16 inches and larger. Excess will lower the log one grade. When the defect is not concentrated in one spot, its extent is taken as the sum of the individual occurrences. Slight stain is not a defect.							



[1] Ash and basswood butts can be 12 inches if otherwise meeting requirements for grade 1.
[2] Ten-inch logs of all species can be grade 2 if otherwise meeting requirements for grade 1 bolts.
[3] Sixty percent cull deduction permitted in grade 2 if log is otherwise of grade 1 quality.
[4] Sixty percent cull deduction permitted in grade 3 if log is otherwise of grade 2 quality.

tural lumber are heavy structural material and construction boards (local-use lumber may be structural or nonstructural). The more important is heavy structural material. This type includes chiefly standard railroad, bridge, and dock items such as crossties, switchties, timbers, car and bridge decking, and crossing planks. Such material is mostly "Sound, Square Edge," which is a standard grade; but the class also includes a wide range in quality and end use from select car stock and prime ship timbers to sheet piling. Production of heavy structural material is rarely integrated with that of factory lumber, and it is usually sawn by operators with little knowledge of the factory lumber they sometimes sell as a byproduct. Timber requirements and grade criteria are fundamentally similar to those in softwood structural uses. It is regrettable that product procurement practices and marketing difficulties have worked against integrated manufacture of both factory lumber and structural material by the more substantial operators, since the two products would complement one another closely in utilizing the full harvest from a hardwood forest.

Railroads either procure their structural material directly from producers or from treating plants acting as agents or wholesalers. Demand

F-485918

Figure 19.—Face veneer logs command the highest price. This prime figured "red" sweetgum log contains 1,936 board feet.

for structural material is erratic, specifications are ambiguous, and rejection after arbitrary inspections is not unknown. This discourages producers of factory lumber from entering the structural market (except for special orders), even though its prices and requirements would seem to make it an attractive outlet for low-grade logs.

Since producers of structural material compete with producers of factory lumber for timber, they frequently cut high-quality material into structural items that could just as well be made from lower quality material. It would be desirable if structural lumber production could be better coordinated with production of items requiring high-quality timber. Additional timber could be saved for more demanding uses if beech, winged elm, and hickory could be promoted for heavy structural use along with the oaks, tupelos, and sweetgum that are now favored almost exclusively. The water oaks and overcup oak are avoided for structural use because large timbers of these species tend to check excessively. A solution to this difficulty would further conserve high-quality timber.

Another commercial category of hardwood structural material is construction boards, produced from most of the soft-textured species but mainly from yellow-poplar, the tupelos, and sweetgum. Construction boards are simply standard width, 1-inch lumber dried, dressed, and graded much the same as softwood yard lumber. Not much is produced except during building booms. It is mostly devoted to subflooring and sheathing in temporary structures. However, great expansion of this use would doubly benefit the country—by conserving the supply of softwood sawtimber and by providing a market for a vast oversupply of otherwise practically worthless hardwoods that are competing with better trees for growing space and that cannot now be harvested or deadened without a direct cost which many landowners are unwilling to incur.

The last of the three structural categories is local-use lumber. It includes all locally sawn and used material, both domestic and industrial, not generally handled in organized commercial channels. The chief items are farm lumber, mine timbers, box or crating lumber, grain doors, pallet

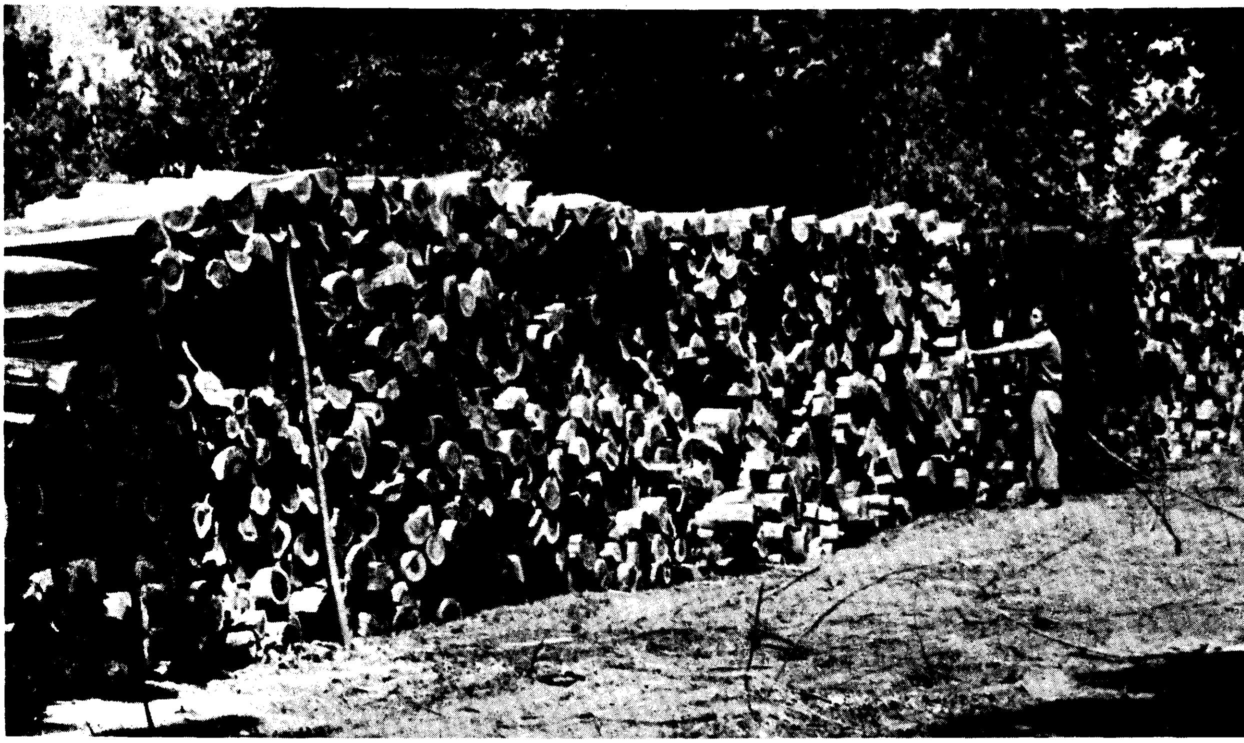
F-485922

FIGURE 20.—Good saw logs are also a premium product of the hardwood forest.

stock, dunnage, and car blocking. Low-grade and malformed logs from stands of scrap timber are necessarily the prevalent raw material but high-grade logs are generally misused whenever encountered. Although the aggregate of this class of product is large nationally, the South produces a relatively small proportion. With the growth of southern population and industry, though, the output of local-use lumber probably will increase.

Piling is a relatively minor hardwood used in the South. Most of the tough hardwood species that develop well-formed stems are occasionally made into piling, but only locally and sporadically. They are seldom treated and are used almost exclusively for either temporary purposes or underground foundation work. Baldcypress piling spasmodically enjoys good demand in the Mississippi River Delta. Whether a dependable piling market could be developed for most hardwood species is questionable, although production is already expanding notably with development of shipments outside the region. There is no pole use worth consideration.

Posts and mine props are also minor hardwood use classes in the South. Mine-prop use depends more upon proximity to the mines than upon forest types and species. Very little of the southern hardwood forest is well situated in this respect, except in north Alabama, where mine-wood cut-



F-485917

FIGURE 21.—More and more pulpwood is being cut from southern hardwoods.

ting decimates the stands. Decay-resistant species, such as old-growth baldcypress and mulberry, are used widely for fence posts—so much, in fact, that the supply is about exhausted in most stands accessible to agricultural communities. Most nondurable species can be preservatively treated by simple methods adapted to domestic and local production.

The volume of hardwood used for pulp has risen sharply in the past few years and the rise promises to continue and accelerate (fig. 21). The bulk of the cordage is from sweetgum, the tupelos, cottonwood, willow, and yellow-poplar, but most other species are now pulped. The increasing use of oak is most significant, as it gives foresters a means of improving the very large acreage occupied by oak or oak mixtures.

Pulpwood production and procurement methods do not vary materially between hardwood and pine. As in pine, many high-quality trees go into pulpwood through the vagaries of lump-sum purchase and single-product harvest. Pulpwood producers also often overcut pole-size stands of sweetgum, thus ruining much potential high-quality material for the future. On the other hand, pulpwood operators have not yet found economical ways of salvaging the greater part of bolt material now left in the woods during sawtimber logging.

Fuelwood is one of the several principal uses of round hardwood timber. Most of the use is on farms, although some wood is sold in towns and cities adjacent to hardwood stands. Fuelwood cutters, if unsupervised, usually gravitate toward the straightest and clearest growing stock. This same high-grading for low-value uses has occurred where fence posts and mine props have been harvested by unsupervised farm laborers and single-product loggers. Harvests of items such as fuelwood and pulpwood, which can be made from small or defective timber, should be limited to silvicultural operations instead of being allowed to devastate a stand.

Utilization of hardwoods for chemical wood or charcoal is local and limited. Values are so low that most of this round material is produced incidentally to landclearing.

Logging

The methods and equipment for logging southern hardwoods reflect the variety of species, sites, and utilization.

Because the trees are usually large and the tops often lopsided, felling to avoid breakage requires skill. Dropping a tree on a large limb can split the trunk, and improper undercutting or backsawing will pull splinters that destroy much of the value of the butt log, especially for veneer. Power saws are used for most felling and bucking,

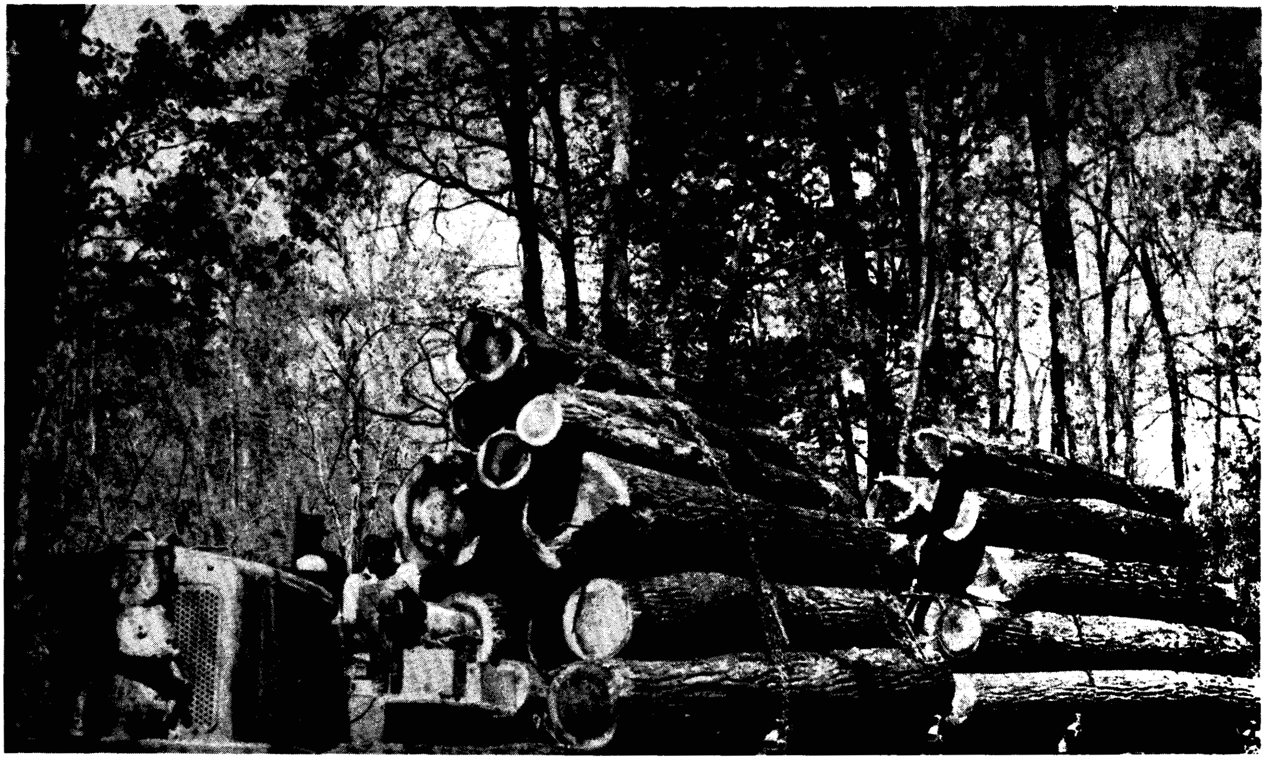


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FIGURE 22.—In some bottom lands outside of swamps, chiefly along the Mississippi River, Athey wagons with track-type wheels are used for short hauls in wet weather.

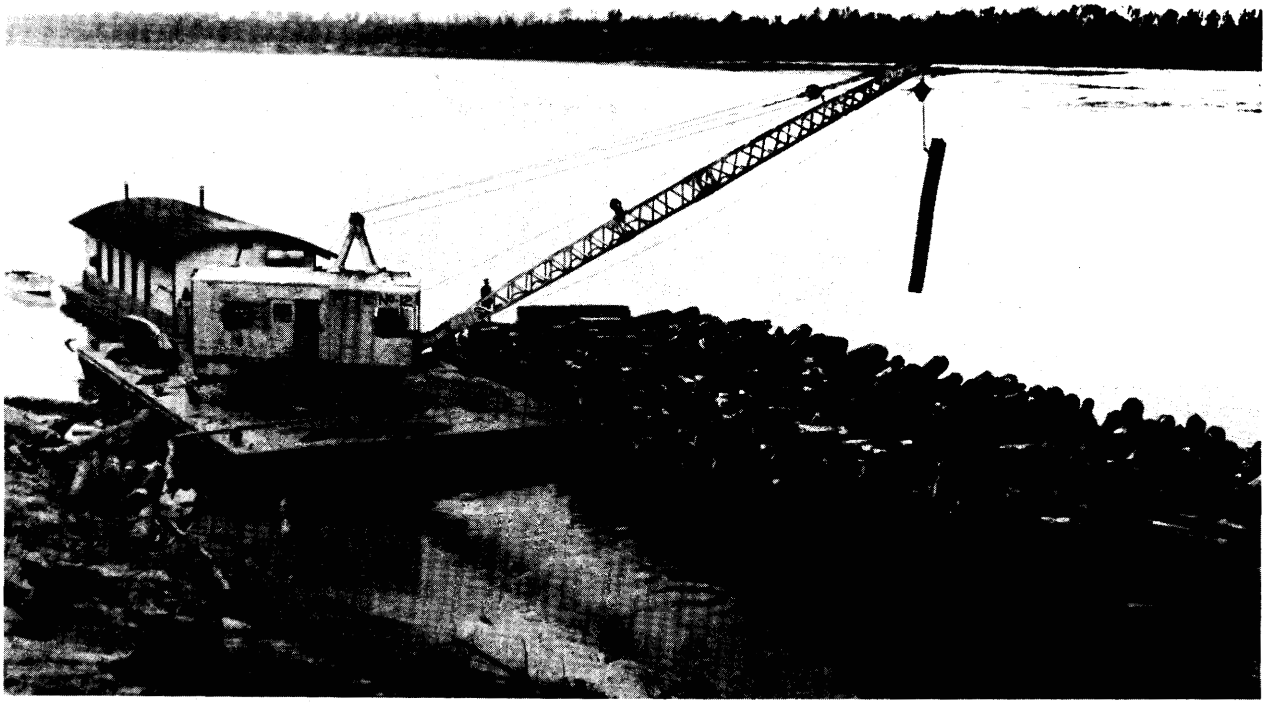

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FIGURE 23.—Along large rivers, logs and pulpwood are barged to mills.

but methods of felling must be varied with species and products. Numerous veneer and specialty operators still do not allow felling by power saws because of predisposition to carelessness on the part of many sawyers.

Logs are usually bucked where the trees are felled, except that in the Southeast long lengths are frequently skidded and occasionally hauled to the mill. Common lengths are 12, 14, and 16 feet, the expectation being to produce 40 to 50 percent of 14- and 16-foot lumber. Rarely, a sizable high-grade 10-foot lumber log is admitted, while 9-foot and 18-foot face-veneer logs are not uncommon. Short bolts are the rule for pulp and chemical wood, and tree lengths for piling. Veneer, staves, and specialties may be handled as either logs or bolts; some mills purchase both.

Bucking should be supervised so as to minimize the intermingling of high-quality and low-quality material in the same log. Improper laying off of logs can turn a veneer log into a saw log or convert a factory-lumber log into a structural or local-use log, with great loss in value.

Ground skidding or simple bunching with crawler tractors is the usual practice on favorable terrain in both bottom lands and uplands, although tractor attachments may be used to winch logs to the banks of small swamps or sloughs and uphill from narrow drains or valleys. Most bottom-land swamps dry out in late summer and are then not difficult to log. Large muck swamps are a different proposition; they seldom dry out and their bottoms are very soft. Here diesel skidders with high-lead rehaul are used to ground-skid logs to the banks or to temporary railroads, or more commonly, to truck runways built into the swamp. Flotation logging is still practiced in one deep swamp in Louisiana (by enclosing timbered tracts with levees and pumping in water); but the once-common practices of floating out on natural floods and of pullboating are nearly lost arts.

Almost all loading is done with an A-frame attached to a truck chassis or crawler tractor. On small jobs, particularly in the uplands, skidding tractors are still used to load logs by cross-haul or with a "tree-block." Some self-loading

TABLE 4.—*Southern hardwood species*

Approved [1] common and scientific name	Other common names	Occurrence in bottom lands	Occurrence in uplands	Growth rate
ASHES				
Carolina ash (*Fraxinus caroliniana*).	Florida ash, pop ash, water ash, swamp ash.	Common as a small tree on wet sites in bottoms of smaller alluvium bearing and blackwater streams of Coastal Plain and in borders of tidal and muck swamps.	Probably none	Medium to good up to small pole size. Soon stagnates.
Green ash and pumpkin ash (*F. pennsylvanica* and *F. profunda*).	Swamp ash, water ash, red ash, cane ash.	Principal bottom-land ashes, widely distributed on new sediments and in first bottoms except in deep swamps. Most common in flats and shallow sloughs. On older sediments or terraces, in flats and sloughs only.	Very rare. Occasionally in wettest coves and in branch heads above the lower Coastal Plains.	Medium
White ash (*F. americana*).	Cane ash, ash, Biltmore ash.	Widely distributed but limited to ridges and high hummocky flats of older alluvium or terraces and to hammocks, outwashes from uplands, and creek bottoms.	Only important upland ash; widely but sparsely distributed on better sites. Best on lower slopes in ravines and coves.	Medium

See footnote at end of table.

truck systems are used for bolts and small logs, but common practice for pulpwood is still hand loading at the stump.

Most hardwood logs are hauled by truck from the woods to the rail siding, barge landing, or mill. In wet weather track-type wagons and sulkies, or logging arches pulled by heavy crawler tractors, are used to reach the river bank or hard road (fig. 22); occasionally, heavy plank runways are needed to get the trucks into and out of the loading area. Rail shipment is common for hauls of more than 50 miles, because of the advantage of milling-in-transit rates. On the major navigable streams, some rafting or pontoon operations can still be seen, but these have largely been replaced by barge or truck methods (fig. 23).

Dry-weather logging or access roads are generally inexpensive, especially in the bottom lands where the terrain is level and rock is not encountered. Permanent roads for wet-weather hauling are costly to build and maintain, and are usually deemed impractical. So that they can run during the rainy winter season, when many logging operations must shut down, most mills stockpile logs in the fall after danger from insects and stain is past.

The seasonal aspects of logging are an important consideration in managing a forest properly. Operations must be timed to take advantage of dry weather where wet-weather logging would be impossible. In large swamps, accessible only after exceptionally prolonged dry weather, conventional thinning and partial cutting may not be feasible. A further limitation on the forest manager is that prevalent logging techniques and equipment are designed for relatively large jobs involving only a single sawtimber product or, at most, two related sawtimber products such as factory-lumber logs and veneer logs. It is usually difficult to find a logger prepared or disposed to work very small acreages or to make light cuts of mixed commodities. Industrial users often trade logs among themselves, though, and there is some possibility that timber brokerage or log-jobbing activities could be developed for cuts involving several products.

and chief softwood associates [1]

Tolerance	Reproduction	Susceptibility to damage	Value and primary uses	Remarks
Intolerant. Seedlings medium.	Prolific in openings. Adequate to absent under varying degrees of shade.	Fire, drouth, and grazing have disastrous effects. Reproduction may recover once or twice through sprouting.	Fuel and, potentially, pulpwood. Thus far, practically a weed. Seldom produces a minimum saw log. Wood is all soft textured or brash.	Extreme care imperative not to confuse reproduction with green ash.
Intolerant. Seedlings moderately tolerant.	Prolific on bare, moist soil in openings. Adequate on any sites not totally preempted by ground cover or dense overstory. Seedlings must be released early. Sprouts very efficiently. Seed dispersal is excellent. Good for planting.	Very susceptible to fire. Hot fires often consume large trees. Moderately susceptible to dieback during drouth, especially on lowest sites and heaviest soils. Grazing serious. Upper stem heart rot often severe in overmature trees.	High value. Factory lumber and small dimension. Most important for long handles, implement stock, athletic goods, and paneling. Some face veneer.	On wet sites commonly develops swollen (pumpkin) butts which are brash and can be used only for trim and furniture stock. Outstandingly clear, but occasionally very crooked or short boled on lowest sites. Impractical to distinguish the two species in practice.
Intolerant. Seedlings moderately tolerant.	Prolific on all but poorest sites, wet or dry. Best in small openings but will start in any but full shade or matted ground cover. Seedlings need early release. Sprouts well. Good for planting.	Very susceptible to fire and grazing.	Same as green ash----	Consistently of good form and texture except on driest sites, where it is brash. Runs exceptionally well to upper grades.

TABLE 4.—*Southern hardwood species and*

Approved [1] common and scientific name	Other common names	Occurrence in bottom lands	Occurrence in uplands	Growth rate
BASSWOOD (*Tilia* spp.)	Linden, linn	Rare—only on oldest and best terraces and in creek bottoms.	Sparse on moist sites in broken terrain near drainages. Best on middle or lower slopes in ravines or coves.	Medium
BEECH, AMERICAN (*Fagus grandifolia*).	Beech	Widely in creek bottoms and occasionally on ridges of old alluvium or terraces in minor river bottoms and in hammocks.	Common as individuals or groups on middle and lower slopes in rough terrain or bluffs and in well-drained coves and branch heads.	Poor
BIRCH, RIVER (*Betula nigra*)	Red birch, black birch, water birch.	On new river fronts and along banks of minor streams. Usually in fringes. Not found below Memphis in Delta but goes to coast on secondary streams and along drains in hammocks.	Rare in branch heads or wet coves.	Good
CATALPA (*Catalpa* spp.)		Scattered on high sites Largely an escapee.	Scattered on better sites. Occasionally planted.	Good to excellent, according to site.
CEDARS				
Atlantic white-cedar (*Chamaecyparis thyoides*).	Southern white-cedar, white cedar, swamp cedar, juniper.	Rare, but pure stands are still found in muck swamps of the eastern gulf coast and South Atlantic Coastal Plain.	None	Fair to poor (has usually grown in overstocked, stagnated stands).
Eastern redcedar and southern redcedar (*Juniperus virginiana* and *J. silicicola*).	Cedar, red cedar, juniper.	Scattered, individual, small understory tree. Very uncommon, especially on new alluvium. Not indigenous. Not uncommon in high hammocks.	Prefers limestone soils. Usually grows to commercial timber size on upper slopes in rough terrain. Widely scattered but nowhere plentiful.	Poor after sapling stage.
CHERRY, BLACK (*Prunus serotina*)	Cherry	Very sparse but scattered throughout on oldest alluvium and outwashes from uplands. Often in hammocks.	Best on moist, well-drained soil. Lower slopes and sometimes best middle slopes. Occasional scattered trees.	Slow to medium

See footnote at end of table.

chief softwood associates [1]—Continued

Tolerance	Reproduction	Susceptibility to damage	Value and primary uses	Remarks
Moderately tolerant	Poor in South. Much of it from stump and root sprouts following cutting or fire.	Very susceptible to fire and birdpeck. Butt rot from stools and roots common.	Medium to low value in South because of scarcity, small size, and poor form. Factory lumber and commercial veneer—farm gates. Pulpwood.	
Very tolerant	Erratic. Generally sparse but persistent; needs to start in shade ahead of competition. Root sprouts common.	No special problem. Hollow stem is rather common, the result of rot originating from dead roots or very old, small fire scars.	Low value because of exceptional prevalence of overgrown pin knots. Factory lumber and crossties. Some package veneer. Not consistently used.	Because of its tolerance, it may eliminate better species from best sites.
Intolerant	Prolific on moist, bare, mineral soil.	Very susceptible to fire. "Sugar streak" inhibits use for face veneer and factory lumber. Some mortality from drouth and sedimentation.	Commercial and package veneers. Rarely for lumber and then mostly by box factories. Pulpwood. Low value and not consistently used.	Short-lived, second- or third-rate tree.
Tolerant	Poor from seed, but sprouts readily.	Extremely susceptible to fire.	Fence posts only	Foliage-eating catalpa worm is popular fish bait.
Very tolerant	Prolific annual seeder. Erratic and generally inadequate but often in dense, pure stands on old burns.	Very susceptible to fire, especially through destruction of organic soil on typical sites.	Very valuable as light, easily worked, naturally durable wood. Structural lumber, poles, posts, specialties such as chests, vats, boats.	Naturally grows in very dense even-aged stands.
Tolerant	Moist mineral soil over limestone best but will develop stands and persist on high, dry limestone sites.	Very susceptible to fire. Host for cedar-apple rust fungus.	Standard lumber and small dimension for chests, cabinets, novelties, and specialties—pencil stock. Valuable posts.	Common old-field tree. Valuable source of bird food. Smallest minimum size for merchantable saw logs of any American species.
Moderately tolerant	Sparse but persistent. Moist, exposed mineral soil best.	Tent caterpillar. Black knot, a fungus, causes swelling of branches. Mineral streaks and gum spots sometimes develop.	Generally very valuable for standard lumber and face veneer. Most important for furniture. Values in South likely to be low because of scattered, sparse supply and mediocre size and form.	Wilted leaves are poisonous to livestock. Fruit valuable for wildlife.

TABLE 4.—*Southern hardwood species and*

Approved [1] common and scientific name	Other common names	Occurrence in bottom lands	Occurrence in uplands	Growth rate
COTTONWOODS				
Eastern cottonwood (*Populus deltoides*).	Cottonwood, poplar.	Widely distributed, but mostly on newly deposited soil along major streams, recently abandoned fields and rights-of-way, clean burns, wet spots in pastures, and banks of small drainages and ditches. Rare and poor on very heavy soils or dry sites.	On best cove sites or immediately on or next to stream beds. Occasionally on ditch banks or in wet pastures.	Excellent; 6 to 8 inches in diameter in 10 years is ordinary.
Swamp cottonwood (*P. heterophylla*).	Black cottonwood, bigleaf cottonwood.	Widely scattered in shallow swamps, in deep sloughs, and along often-flooded creek bottoms. Wet spots in low hammocks on east coast.	None	Good to excellent
CYPRESS				
Baldcypress (*Taxodium distichum* var. *distichum*).	Cypress, red cypress, yellow cypress, white cypress.	Swamps, deep sloughs, borders of old lake beds, poorly drained flats. Low spots and abandoned channels in creek bottoms. Commonly originates as dense, even-aged stands, with or without the tupelos.	None	Generally poor, but medium when young and if released before completely suppressed.
Pondcypress (*T. distichum* var. *nutans*).	Cypress, black cypress.	Shallow piney woods swamps, perched ponds, sloughs, wet flats of lower Coastal Plains east of Mississippi River, and some branch heads. These sites are rarely alluvial, usually lack deep muck bottom, and often will support slash pine.	None	Very poor above sapling or small pole size. May respond to severe thinning on best, deepest sites.
DOGWOOD, FLOWERING (*Cornus florida*)	Dogwood	Rare in bottoms of major rivers and streams. Often common in bottoms of minor streams and hammocks, in better drained situations.	Common on better moist soils with good drainage.	Poor, but responds to release very well.

See footnote at end of table.

chief softwood associates [1]—Continued

Tolerance	Reproduction	Susceptibility to damage	Value and primary uses	Remarks
Most intolerant	Reproduces abundantly and quickly but only on wet mineral soil. Continued moisture and top light imperative. Sprouts very well. Pure stands of even age predominate. Plantings of unrooted cuttings survive well.	When weakened by drouth or poor sites, susceptible to boring by grubs. Very susceptible to decay and mortality after fire and, on unfavorable sites, to drouth. Grazing is serious threat. Leaf beetles and twig borers occasionally serious in reproduction, especially plantings.	Factory and box lumber. Package and commercial veneer. Pulpwood. Highly prized for high proportions of clear wood; light and tough. One of few premium package woods.	Fastest growing tree in North America. Of major importance only in the lower Mississippi Valley.
Moderately intolerant.	Erratic and sparse. Individuals persist in partial shade, groups in small openings; stands do not develop.	No special problem	Minor species. Box lumber, package veneer, pulpwood. Not sought in its own right.	Commonly associated with baldcypress and tupelos in swamps of the Coastal Plains and the older alluvium of the bottoms.
Tolerates much side but no overhead competition. Stagnates for long periods before dying. Asserts dominance poorly.	Erratic, largely because of occasional inundation during growing season and lack of seed sources (because of fire and destructive logging). Averages poor but is occasionally excellent in openings. Prolonged soaking of seed promotes germination when conditions become favorable. Good planting prospect. Sprouting is of little significance.	When sites dry out, fires cause great basal damage and deteriorate some sites. Very old trees prove to be "pecky," especially if once damaged by wind or ice.	Highly prized for durability and working qualities. Factory and structural lumber, piling. Boat and tank stock from top grades of lumber	Sappy second growth not durable but has superior working qualities and knots are small and sound.
Tolerates side competition or light slash pine overstory. Stagnates and does not assert dominance.	Normally dense but often retarded by flood or drouth.	Fire disastrous. Overmature trees pecky.	Structural lumber, crossties, boxes, and crates, and occasionally posts.	Smaller, and usually shorter and rougher than baldcypress. Contributes little to cypress lumber industry and many sites are logically convertible to pine management. Species distinction may be partly silvical rather than botanical.
Very tolerant	Good in shade. Considerable reproduction from sprouts.	Incasement of numerous strands of bark, causing cull or "grape vine" stem, is unusual defect.	Specialties, primarily shuttle blocks.	Prized as ornamental. Large proportion of stems too crooked for commercial uses.

TABLE 4.—*Southern hardwood species and*

Approved [1] common and scientific name	Other common names	Occurrence in bottom lands	Occurrence in uplands	Growth rate
ELMS				
American elm (*Ulmus americana*).	Elm, soft elm, white elm, water elm, gray elm, red elm.	Widely, except in deep swamps. Especially on flats in newer alluvium.	Uncommon except on moist, deep soils.	Medium. Good on well-drained flats. Varies greatly with available light.
Cedar elm (*U. crassifolia*).	Rock elm, southern rock elm, hard elm.	Widely on high flats, poorly drained low ridges; usually impervious silty clay soil. Restricted to bottoms of major streams of lower Mississippi Valley and gulf coast.	None	Poor
Slippery elm (*U. rubra*).	Red elm, soft elm.	Occasionally on banks of secondary streams, mostly in northern and western parts of territory.	Occasionally on deep, rich soils in coves to upper slopes, largely to west and north.	Medium
Winged elm (*U. alata*).	Hard elm, rock elm, cork elm.	Widely on ridges and high flats of older alluvial soils or terraces. General in creek bottoms and hammocks.	Common on all but wettest sites. Best development on lower and middle slopes.	Poor to medium
GUMS, TUPELOS				
Sweetgum (*Liquidambar styraciflua*).	Redgum, gum	On almost all but the wettest sites. Best development generally on clay loam ridges of newer alluvium; next best on occasional well-drained, silty clay loam flats on newer alluvium and in hammocks.	Very wide occurrence, but develops well only on best lower slope, cove, and branch head sites. Lacking on highest, driest sites.	Medium to good
Black tupelo (*Nyssa sylvatica* var. *sylvatica*.	Blackgum	Throughout bottoms but only on ridges and high flats of older silty alluvium; general in creek bottoms.	Widely scattered. Best development on lower slopes and coves. Elsewhere inferior in size and form.	Poor to medium

See footnote at end of table.

chief softwood associates [1]—Continued

Tolerance	Reproduction	Susceptibility to damage	Value and primary uses	Remarks
Tolerant	Becomes established in understory. Grows well when released. Comes in well in openings amongst ground cover, but seldom on bare areas. Sprouts prolifically.	Sapsucker attack common. Heart rots commonly follow fire wounding. Often short and crooked because of early suppression, and full of adventitious knots from same cause or from release after suppression.	Low to medium value. Factory lumber, slack cooperage, and bending stock. Commercial and package veneer. Has been good staple utility species but acceptability now depreciated partly by practice of mixing in winged elm.	Good second-rate tree. Tendency towards poor form. Epicormic twigs common, otherwise exceptionally clear.
Tolerant	Scattered. Persists beneath overstory. Survives grazing in bush form. Not a notable sprouter.	No special problem	Local-use lumber. Sparingly for factory lumber and heavily high-graded. Pallets. Extremely hard wood, so cannot be used with other elms.	Third-rate tree. Severe epicormic branching degrades upper logs. Fluted, odd-shaped stems are common.
Tolerant	Becomes established as an understory tree. Also starts in brushy stand openings and on sod.	No special problem	Low to medium value. Similar uses to American elm but dark brownish-red color complicates furniture use. Better grain and texture than American elm. Favored for farm use, gates, cribs, corrals, wagon stock.	Second-rate tree. Tendency to limbiness. Poor form, epicormic branching on dry sites.
Tolerant	Prolific in openings. Becomes established sparsely in understory. Combats ground cover and sod. Survives grazing as bushes. Sprouts prolifically.	No special problem	Low value. Sparingly for local-use and factory lumber; generally severely high-graded for latter and used to adulterate soft elm stocks. Not preferred for package and veneer use. Acceptable for ties.	Small tree. Stunted and gnarled on poor, dry sites, but elsewhere of very good form.
Intolerant. Will combat most ground cover as reproduction. Asserts dominance well but hopeless in understory.	Very easy to obtain in full light with good seed source. Sprouts efficiently from both roots and stumps. Pure, even-aged stands are not uncommon, especially on old fields. Good planting prospects.	On poorer sites, tops die as trees mature. Susceptible to drouth or lowered water table. So-called gum blight seems related to site factors that affect availability of water. Large pockets of ingrown bark common near gulf coast.	Broad utility and high values. Face, commercial, and box veneer. Factory lumber and small dimension for furniture and interior trim. Crossties, slack cooperage. Is principal hardwood pulping species.	Most widely distributed and broadest utility of any southern hardwood species. Subject to epicormic branching when drastically released, especially on poor sites.
Moderately intolerant.	Sparse; usually singly or in small groups within thickets of ground cover in openings.	No special problem	Rather low value because of tendency to warp, but can be excellent when large enough for quartersawing. Standard and box lumber, ties, and pulpwood. Practically no veneer.	Commonly grows with white oaks, winged elm, and hickory. On poorer sites, ties and cordwood only.

TABLE 4.—*Southern hardwood species and*

Approved [1] common and scientific name	Other common names	Occurrence in bottom lands	Occurrence in uplands	Growth rate
Ogeechee tupelo (*N. ogeche*).	Sour tupelo, sour gum.	Rare and local; limited to blackwater streams and coastal swamps of Southeast.	None	Poor
Swamp tupelo (*N. sylvatica* var. *biflora*).	Swamp blackgum, gum, bastard blackgum.	Nonalluvial muck and coastal swamps from Virginia to Florida. Parishes of southeastern Louisiana. Seepage areas at base of uplands and on edges of secondary and minor bottoms.	Branch heads and swampy areas at spring seepages in coves throughout territory.	Medium
Water tupelo (*N. aquatica*).	Tupelo, tupelo gum, swampgum, olive tree, bay poplar.	Throughout region but almost exclusively in swamps of flood plains of alluvial streams. Otherwise only near live streams in coastal swamps or estuaries where blackgum dominates the gross area.	Branch heads or swamps at spring seepages opening into alluvial bottoms.	Medium
HACKBERRY AND SUGARBERRY (*Celtis occidentalis* and *C. laevigata*).	----------	Widely except in deep swamps. Most common on flats and riverfronts of new alluvium. Very rare on ridges of old alluvium, hammocks, and bottoms of small streams.	Only on some deep, moist soils, especially over limestone—notably in Alabama Black Belt.	Poor to medium. Vast variation with competition.
HICKORIES (*Carya* spp.) Also see pecans.	Hickory	Widely on older alluvial ridges, high flats of oldest alluvium, and terraces. General in well-drained creek bottoms and hammocks.	Widely on all sites except wettest branch heads and cove bottoms.	Generally poor. Fair to good on best sites when dominant.

See footnote at end of table.

chief softwood associates [1]—Continued

Tolerance	Reproduction	Susceptibility to damage	Value and primary uses	Remarks
Intolerant	Plentiful in clear openings on bare mud or in marsh; otherwise sparse.	Fire and growing-season inundation.	Sparse or negligible yield of marginal logs for box factory. Pulpwood.	Usually a small, short, malformed tree. Reproduction should be carefully distinguished from better tupelos.
Moderately intolerant. Will endure intense codominant competition indefinitely but will not tolerate overtopping. Very dense stagnated stands are typical in the muck swamps. Responds to release.	Prolific on open, wet soil. Fills very small openings but sparse to absent under direct shade. May plant well. Stump sprouts usual, but root sprouts scarce. Lack of moist seedbed at time of seedfall or flooding soon after germination causes most regeneration failures.	Fire causes wounds which develop rot. Butts often completely hollowed, but hollow usually extends up into tree only few feet. Storm-damaged tops are common but rot descends slowly. Fire wipes out seedlings and often seed source.	Package and commercial veneer, factory and box lumber, small dimension, crossties, and pulpwood. Essentially similar to water tupelo.	Normally in even-aged, dense stands, often with cypress and sweetbay, sometimes with water tupelo. A major type on lower Coastal Plain from Lake Pontchartrain in eastern Louisiana to Dismal Swamp in Virginia; minor elsewhere.
Intolerant. Behaves similarly to swamp tupelo. Responds well to release.	Same as swamp tupelo.	As in swamp tupelo. Fire hazard somewhat more frequent but site conditions (lack of muck) rather less conducive to total devastation. A small, black ingrown bark fleck occasionally degrades logs, usually in trees with dry or damaged tops.	Exceptionally clear and defect-free, a common substitute for sap sweetgum. Package and commercial veneer, factory and box lumber, small dimension, crossties, pulpwood.	Normally in even-aged, dense stands with or without other tupelos and cypress. Swollen butts of trees in deep swamps develop punky texture unfit for use.
Very tolerant. Endures indefinitely in shade of intolerant species.	Becomes established in understory and develops very slowly. Will come up through ground cover in open and there develop rapidly. Few stands are of sprout origin.	Once tree is wounded at base, rot occurs and advances rapidly; fire very easily wounds but does not often kill the tree. Usual understory origin often causes poor form. Survives grazing as bushes.	Factory lumber. Particularly valued for light-colored furniture. Some commercial and package veneer, slack cooperage, and, recently, pulpwood	Sugarberry is the common species, hackberry occurring only in northern part of region. Best quality and form as well as growth from stands originating in open.
Very tolerant	Prolific. Sprouts readily. Develops regularly in understory, but hampered by ground cover. Will yield opening to intolerant species starting growth at same time.	A borer commonly attacks weakened trees and those on poor sites. Sap suckers.	Striking-tool handles, implement parts, athletic goods, and other specialties cut mostly from bolts but partly from thick lumber. Sparingly used for factory lumber, often with pecan. Some crossties and charcoal.	Only best material commonly used. No distinction made between species except through average quality and texture. *C. cordiformis*, "bitternut," is poorest; usually avoided. High proportion of heartwood and slow growth lower salability for specialty uses.

TABLE 4.—*Southern hardwood species and*

Approved [1] common and scientific name	Other common names	Occurrence in bottom lands	Occurrence in uplands	Growth rate
HOLLY, AMERICAN (*Ilex opaca*)	Holly	Principally in minor stream bottoms but on high ridges of oldest alluvium and in most hammocks.	Scattered widely as an understory tree on all but driest and wettest sites.	Poor
LOCUSTS				
Black locust (*Robinia pseudoacacia*).	Locust	Scattered on highest sites; escapee from plantations.	More abundant than in bottom lands because of widespread planting.	Medium; on best sites good to post size.
Honeylocust (*Gleditsia triacanthos*).	Thorn tree, locust.	Scattered widely in large bottoms on all sites except sloughs and swamps. Most common and at its best on the better ridges of new alluvium. Very scarce or absent in the East.	Rare. Sometimes in old pastures as shrub or on lower slopes and in coves.	Medium, but variable.
Waterlocust (*G. aquatica*).	Swamp locust	Scattered widely in nearly all alluvial swamps, sloughs, and wet flats. Very scarce in the East.	None	Good
MAGNOLIAS AND BAYS				
Cucumbertree (*Magnolia acuminata*).	Cucumber, magnolia.	Rarely on outwashes from uplands and in certain small stream bottoms above lower Coastal Plain.	Scattered throughout territory on moist, deep, well-drained soils; mostly middle and lower slopes.	Medium
Redbay (*Persea borbonia*).	Swamp bay	Uncommon. Borders of swamps and swampy drains in rich, moist, mucky soil of lower Coastal Plain, not on alluvial sites; sometimes with slash or pond pine.	Ordinarily not found. Possibly on some wet branch heads of lower Coastal Plain.	Poor
Southern magnolia (*M. grandiflora*).	Magnolia, bull bay.	Mainly within 100 to 200 miles of coast, on oldest alluvium and outwashes from uplands. Principally in minor or secondary stream bottoms and hammocks.	On middle and lower slopes in deep rich soils and in many branch heads within about 150 miles of coast, scattered widely in groups and groves from Carolina to Texas.	Medium

See footnote at end of table.

chief softwood associates [1]—Continued

Tolerance	Reproduction	Susceptibility to damage	Value and primary uses	Remarks
Very tolerant	Sparse but dependable in groups originating in partial openings.	No special problem	Decorative foliage and fruit. Special cabinet work in trifling amounts—from small dimension cut from short logs and bolts. A very little lumber is mixed in with other light-colored species.	Stems at maturity are usually small, short, and limby.
Intolerant	Good on bare, moist sites. Good sprouter.	Locust borer limits tree to small size on poor sites.	The naturally durable wood is preferred for posts.	Minor species.
Intolerant	Sparse and unpredictable. Common on old pastures. Occurs only in clear openings but does best in thicket or tangle of ground cover and copes well with sod.	No special problem except stem canker. Sensitive to fire but safe from grazing.	Limited value. Local-use lumber, posts, and occasionally factory lumber and ties.	Tendency to ring shake and heart check in large, old trees. Seed pods are excellent mast. Not especially durable.
Intolerant	Erratic but occasionally prolific in openings in shallow swamps. Sprouts vigorously from stumps.	No special problem. Immune to grazing.	Rarely for lumber or ties; practically never used for factory lumber.	Third-rate tree. Poor form and small size. Fair mast producer.
Moderately tolerant	Erratic and scattered; pokes up through small and partial openings, singly and in small groups.	No special problem	Often included with yellow-poplar for factory lumber or veneer use. Otherwise of medium to low value for factory lumber, in mixture with other soft-textured woods. High local-use rating on farms.	
Tolerant	Erratic and scattered in groups amongst swamp tupelo, sweetbay, etc.	Bad butts from fire scarring common. Fire may forestall reproduction.	Low value, no established place in commerce. Box factory uses. Pulpwood.	Scarcity and poor form, due to overstory competition, may be principal detractions.
Tolerant	Erratic and scattered. Requirements for regeneration not well understood. Poor sprouter.	No special problem	Good values for factory lumber, largely as substitute for yellow-poplar. Not commonly veneered.	Good second-rate tree. Often appears rough but cuts out fairly clear lumber anyway. Generally sound.

TABLE 4.—*Southern hardwood species and*

Approved [1] common and scientific name	Other common names	Occurrence in bottom lands	Occurrence in uplands	Growth rate
Sweetbay (*M. virginiana*).	White bay, bay, swamp magnolia.	Largely east of Mississippi River in muck swamps of Coastal Plains.	Only in wet branch heads of lower Coastal Plain.	Poor to medium
MAPLES				
Boxelder (*Acer negundo*).	Ashleaf maple	Generally on riverfronts of major streams and scattered throughout bottom lands, particularly on ridges or high flats of new alluvium.	On moist, loose soil in coves and on lower slopes.	Excellent
Florida maple (*A. barbatum*).	Southern hard maple.	Occurs sparsely on higher, better drained sites in secondary bottoms throughout Coastal Plains; more often in lower Coastal Plain.	None	Medium
Red maple (*A. rubrum*).	Soft maple, swamp maple.	Scattered widely everywhere except on high ridges and in deep swamps. Most common in low situations and on heavy soils, especially on old alluvium.	Coves, lower slopes, branch heads.	Medium to good. Occasionally excellent.
Silver maple (*A. saccharinum*).	Soft maple, river maple.	On riverfronts and streambanks in northern part of Mississippi River Delta, but along other major streams almost to coast.	Occasionally in coves, creek bottoms, and edges of branch heads above the Coastal Plains.	Excellent
Sugar maple (*A. saccharum*).	Hard maple, southern hard maple.	None	Widely scattered on middle and lower slopes in rough terrain and river bluffs of upper Coastal Plains and Piedmont. Down the loessal bluff in Mississippi to Louisiana.	Moderate to good
MULBERRY, RED (*Morus rubra*)	Mulberry	Scattered widely except in swamps, sloughs, and ridges of old alluvium. Most common on heavy, moist, but well-drained soils in first bottoms.	Scattered widely on best, moist soils. Not so common as in bottoms.	Poor in understory

See footnote at end of table.

chief softwood associates [1]—Continued

Tolerance	Reproduction	Susceptibility to damage	Value and primary uses	Remarks
Moderately tolerant. Commonly an understory to blackgum and cypress.	Erratic but occasionally prolific in openings and heavy thinnings. Competes fairly well with ground cover.	No special problem	Package veneer, some box lumber. Becoming an important substitute for sap yellow-poplar as factory lumber. Some commercial veneers. Pulpwood.	Small average size and inaccessible sites have limited its use, especially for standard lumber.
Moderately tolerant	Prolific on bare mineral soil. Will reproduce under partially opened overstory of cottonwood or riverfront type. In small openings in other places. Will race heavy ground cover successfully. Sprouting rarely accounts for stand origin.	No special problem except poor understory form which may be related to site or genetics.	Rarely used. Some lumber, crating, and pulpwood. Lumber included with soft maple or other soft, light-colored utility wood.	Matures when young and small. Very poor form prevalent. Practically a weed tree. Turkey, bird, and squirrel food.
Tolerant	Erratic and scattered, singly and in small groups.	No special problem	Scarcity, small size, and poor form limit it to occasional use for factory and box lumber.	Most likely confused with other maples.
Tolerant	Dependable; normally establishes a sparse understory. Sometimes forms a thicket in openings, especially on wet spots. Competes well with ground cover. Seed dispersal is excellent. Sprouting of little importance, mostly from stumps.	Mineral stain and spot worm prevalent. Poor form due to suppression is most serious detraction.	Factory lumber. Good values and ready market wherever general form warrants use. Special handling of spot worm and stain provided in lumber grades. Some commercial and package veneer. Pulpwood.	Scattered occurrence and poor form have limited its use. Species does better in Southeast. Grade of lumber generally is better than indicated on surface of log.
Intolerant	Prolific on bare mineral soil in openings or new ground.	Spot worm common in South. Form rather poor.	Good values for factory lumber. Substituted for hard maple when texture not too important and if relatively free of spot worm. Pulpwood.	Good second-rate tree.
Tolerant	Scattered, coming in as understory and in small and partial openings. Probably does not cope well with ground cover, but seeds well through sod.	No special problem	Very valuable, but sparsity limits use and average quality only medium. Factory lumber.	Not important in South.
Very tolerant	Seeds readily and sprouts well. Reproduces and grows in the understory.	Stem canker causes considerable mortality and cull.	Because of extreme natural durability and good texture, highly prized for fence posts.	A small understory tree, practically never of sawtimber size.

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TABLE 4.—*Southern hardwood species and*

Approved [1] common and scientific name	Other common names	Occurrence in bottom lands	Occurrence in uplands	Growth rate
OAKS				
Black oak (*Quercus velutina*).	Yellow butt oak, red oak.	Widely scattered on oldest alluvium and on driest sites—mostly to north portion of region.	Most common on spots within areas of better pine sites in broken terrain. Rare or absent in lower Coastal Plains, chiefly in higher areas to north and west thereof.	Medium to good on best sites.
Bur oak (*Q. macrocarpa*).	Mossy cup oak	On better flats and low ridges of older alluvium in Delta and tributary bottoms north of latitude of Memphis. Possibly in extreme northwest of region (see next column).	Probably not in southern hardwood region except sparsely in extreme northwest, i.e., corner of La., Okla., and Ark., where it may be in both uplands and bottoms.	Medium to poor
Cherrybark oak (*Q. falcata* var. *pagodaefolia*).	Swamp red oak, bottomland red oak, red oak.	Widely on best loamy sites on all river-bottom ridges and all better drained creek bottoms and hammocks. Preponderantly on older alluvium. Occasionally on tight, silty clay flats and low ridges, but does poorly there.	Wide. Best development on deep, rich, moist, well-drained soils. Does badly on medium upland sites and does not occur on poor, dry sites.	Good to excellent
Chinkapin oak (*Q. muehlenbergii*).	Chinquapin oak, chestnut oak.	None in Delta. Rare on oldest alluvium in bottoms of secondary streams and creeks. More common towards west.	On middle and upper slopes, usually in rough terrain, across north and in west of region. Sparse and scattered.	Medium
Delta post oak (*Q. stellata* var. *mississippiensis*).	Post oak, yellow oak.	Large bottoms of the lower Mississippi Valley only. Well-drained silty clay and loam sites on older alluvium.	None	Medium
Durand oak (*Q. durandii*).	White oak, bastard white oak, bastard post oak.	Local and usually limited. Most plentiful in some hammocks of South Carolina Coastal Plain and by widely separated groups on older alluvium of Delta in southeastern Arkansas.	The principal white oak throughout the Alabama-Mississippi Black Belt, northeast Texas, and southwest Georgia. Possibly southeast Oklahoma. Predilection for calcareous soils.	Medium

See footnote at end of table.

chief softwood associates [1]—Continued

Tolerance	Reproduction	Susceptibility to damage	Value and primary uses	Remarks
Intolerant	Fair in openings. Needs protection.	Greater than average susceptibility to diseases and insects on poor sites. Prevalent occurrence is on sites that burn frequently.	Factory lumber, ties, and timbers. High value according to grade. Wood texture very good.	Often very poor tree, but best trees on best sites equivalent to cherrybark oak. Freedom from borers and bark scarrers correlated with site. Subject to epicormic branching when drastically released, especially on poor sites.
Moderately intolerant.	Prolific in open areas but often killed by high water during growing season. Mast may be seriously depleted by game and livestock.	No special problem. Most resistant of the oaks to fire.	Ties and timbers, factory lumber, tight cooperage. Generally higher quality than overcup oak because free from insects. Fair to medium values.	Hard, strong, durable wood; excellent farm-use species. Second-rate commercially because of roughness; much upland growth nearly worthless because of short, rough boles.
Intolerant	Easily obtained with full light but seldom prolific. Sprouts fairly efficiently. Copes well with ground cover. Fair promise for planting.	No special problem	High value. Face veneer, factory lumber, cooperage, crossties.	Best red oak.
May be slightly tolerant; generally found singly in competitive situations and never forms stands.	Erratic and sparse	No special hazard apparent.	A white oak equal in utility and value to *Q. alba*.	
Moderately intolerant.	Easily obtained with light, but seldom prolific. Mast may be seriously depleted by animals. Few stands are of sprout origin.	No special problem	See swamp chestnut oak.	Wood has distinct yellow-tan cast requiring separate handling as face veneer. Same as swamp chestnut oak otherwise.
Little evidence. May be slightly tolerant.	Sparse and scattered. Usually in small or partial openings. Seeding may be scant. Few stands are of sprout origin.	No special hazards apparent.	Moderate to high value for standard lumber, tight cooperage, and ties.	Yellow-tan color depreciates utility of the small proportion otherwise suitable for face veneer. This apart, an average good white oak—somewhat rough but free of insects.

TABLE 4.—*Southern hardwood species and*

Approved [1] common and scientific name	Other common names	Occurrence in bottom lands	Occurrence in uplands	Growth rate
Laurel oak (*Q. laurifolia*).	Water oak, spotted oak.	Near coast in wet flats, on margins of swamps, and occasionally on low clay ridges or even low sandy loam ridges of blackwater streams. Leaves the larger bottoms above the lower Coastal Plain and occurs progressively farther back on west into east Texas. Above the Coastal Plain it occurs in the minor stream bottoms on wet flats and low ridges with impervious soils.	Only on wet flats in coastal branch heads and a few wet cove bottoms.	Good to excellent
Northern red oak (*Q. rubra*).	Red oak, eastern red oak, water oak, striped oak.	Occasionally found on terrace ridges of secondary rivers and north end of Delta and in well-drained creek bottoms to north edge of region.	On best moist, deep soils of middle and lower slopes of bluffs and in ravines and coves. Rarely on drier but fair sites and then inferior. Holds to higher lands and north edge of region.	Medium to excellent
Nuttall oak (*Q. nuttallii*).	Swamp red oak, southern pin oak, striped oak, pin oak, swamp black oak, tight bark oak.	Widely on flats, low ridges, shallow sloughs, and margins of swamps in recent alluvial sites. To lesser extent on old alluvium, but there restricted to wet, heavy, but not impervious soils. Strictly limited to bottoms of major streams entering the gulf and their larger tributaries.	None	Good to excellent
Oglethorpe oak (*Q. oglethorpensis*).	----------	Spotty on high bottom sites of western South Carolina and northeastern Georgia.	None	Medium
Overcup oak (*Q. lyrata*).	Swamp post oak, swamp white oak.	Widely on poorly drained, heavy soils of major alluvial bottoms. Scattered on better sites, mainly on newer alluvium. Prevalent in sloughs, on margins of swamps, and in backwater areas. Throughout region in all alluvial bottoms and some low hammocks but principally in lower Mississippi Valley and gulf region.	None	Medium. In deep backwaters poor.

See footnote at end of table.

chief softwood associates [1]—Continued

Tolerance	Reproduction	Susceptibility to damage	Value and primary uses	Remarks
Intolerant	Erratic but plentiful with light. Seeds in like hay on flats under heavy stands but requires release by second growing season. Copes moderately well with ground cover. Often killed by growing-season inundation. Sprouts poorly.	Commonly insect-infested and mineral-stained. Epicormic branching is constant threat.	Low value. Rarely for factory lumber or ties and timbers. Locally in Southeast for pulpwood.	**Tendency to check excessively makes it about worthless for ties and timbers. The poorest of the red oaks but can be high-graded for lumber on its better sites.**
Intolerant	Fairly easy to obtain but never profuse. Animals may deplete mast. Must have clear openings. Only fair in fight with ground cover. May plant fairly well.	No special problem	High value. Face veneer, factory lumber, cooperage, ties and timbers.	Equivalent to cherrybark oak. Wood of excellent texture and working properties. Lumber-grade yield very high.
Intolerant	Prolific but often killed by inundation during growing season. Starts readily in either open or shade but dies soon under shade. Maintains itself fairly well against all ground cover but heavy peppervine. Should plant fairly well. Many large trees are of sprout origin.	Severe drouths or lowered water table will readily kill mature trees on low sites. On impervious soils and in backwater areas, overmature and damaged trees subject to insects and mineral stain.	Highly acceptable for factory lumber, but excessive checking in seasoning inhibits use for ties and timbers. Little or no veneering.	Good second-rate tree—one of the best for its sites. Subject to epicormic branching when drastically released, especially on poor sites.
Moderately intolerant.	Good	Unknown	Same as the better white oaks.	Not recognized as species until 1940.
Moderately intolerant.	Prolific but often killed by inundation during growing season. Starts readily in either shade or opening but soon dies in shade. Persists against all ground cover but heavy peppervine. Sprouting not especially effective.	Often damaged by boring and bark-scarring insects, mineral stain, and heart check.	Utility varies extremely with site and fire damage. At best nearly equivalent to white oak. Frequently worthless for factory lumber because of insects and stain. Checking during seasoning prevents general use for ties and timbers.	Next to post oak, the poorest of the white oaks. Subject to epicormic branching when drastically released, especially on poor sites.

TABLE 4.—*Southern hardwood species and*

Approved [1] common and scientific name	Other common names	Occurrence in bottom lands	Occurrence in uplands	Growth rate
Pin oak (*Q. palustris*).	Swamp Spanish oak, northern pin oak.	Northern Delta and major tributaries. In northern Coastal Plains also. In first bottoms and terraces on wet flats with heavy or impervious soils.	None in this region	Good to excellent
Post oak (*Q. stellata* var. *stellata*).	Iron oak	Occasionally on oldest, poorest terrace sites; usually subject to summer drouth. Never on new alluvium. Not a bottom-land species.	On highest, driest hardwood sites. Sparse or absent on good upland hardwood sites.	Poor
Shumard oak (*Q. shumardii*) (varietal nomenclature still controversial).	Striped oak, red oak.	Restricted to good ridge soils in older alluvium and outwash from uplands and to well-drained creek bottoms and hammocks. Rarely on newer soils. Widely distributed but very scattered.	From better ridge sites to lower slopes on moist rich uplands.	Good to excellent
Southern red oak (*Q. falcata* var. *falcata*).	Red oak, Spanish oak, turkey oak.	Common on oldest terraces and outwashes from uplands. Drier sites. Not primarily a bottom-land species.	Almost universal except in wet places. Best development on deep, rich, well-drained slopes.	Medium on reasonably good sites.
Swamp chestnut oak (*Q. michauxii*).	Cow oak, basket oak, swamp white oak.	Common in large creek bottoms and hammocks on best, well-drained loamy ridges. Occasionally on a wet, silty clay, high flat. Rarely on best, more mature recent alluvium but typically a tree of older alluvium.	In bottoms of coves of best uplands, opening out to true bottoms. Not an upland species.	Medium to good

See footnote at end of table.

chief softwood associates [1]—Continued

Tolerance	Reproduction	Susceptibility to damage	Value and primary uses	Remarks
Intolerant	Prolific in openings. Becomes established in shade but needs prompt release. Dense even-aged patches common. Not very effective against ground cover.	No special problem	Local-use lumber and fuel. Some ties and timbers but tends to check excessively. The worst of the oaks for persistent, small body limbs, and therefore generally worthless for factory lumber. Varies by locality and stocking, though, and is occasionally high-graded for factory lumber.	Grades into and confused with Nuttall oak about latitude of Memphis and above.
Moderately intolerant.	Easily obtained with light. Sprouts freely. Depletion of mast by animals and repeated fires are only controls on typical site.	On poor sites, commonly infested with spot or flag worm and with grubs. Blind twig knots and fire scars common.	Factory lumber is high-graded from best sites. Good tie and timber species.	Third-rate tree. Natural pruning of upper stem is slow, trees generally short. Poorest of the white oaks.
Intolerant	Easily obtained in full light. Persists against ground cover. Sprouts well and shows promise for planting.	Same as cherrybark oak.	High value. Face veneer, factory lumber, cooperage, crossties.	Similar to cherrybark oak in quality and utility but more selective as to site. On unproductive, high, dry sites of lower Piedmont and upper Coastal Plain, especially to west. Almost indistinguishable from the scarlet oak that commonly occurs on such sites.
Moderately intolerant.	Easily obtained with light. Works its way up individually through small openings; occasionally takes over large opening on drier site, but seldom prolific. Small sizes sprout aggressively.	Susceptible to insects and disease when wounded or on poor sites. Fire damage conspicuous on poor sites. Form deteriorates there also.	Ties and timbers. Best trees on good sites produce excellent factory lumber and even veneer logs, comparable to northern red oak.	Second-rate tree on all but best upland sites because of tendency to shortness and roughness and insect and stain damage. Good wood texture for all uses. Dries well.
Moderately intolerant.	Easily obtained in clear openings but sparse because mast is highly palatable to animals, and acorns are especially susceptible to weevil damage. Sprouts well and competes fairly well with ground cover. Promising for planting.	Moderate trouble with bark scarrers and epicormic limbs on poorest sites.	Broad utility and high value. Face veneer, factory lumber, tight cooperage, ties, and timbers. Coarse grain and wide sapwood are slight handicap for face veneer and tight cooperage.	Fastest growing white oak and one of best in quality. Generally equivalent to good *Q. alba.*

TABLE 4.—*Southern hardwood species and*

Approved [1] common and scientific name	Other common names	Occurrence in bottom lands	Occurrence in uplands	Growth rate
Swamp white oak (*Q. bicolor*).	White oak	Extreme northern part of lower Mississippi Valley within this region, mainly in smaller bottoms on sites with pervious soils but not necessarily good surface drainage. Quite rare.	Perhaps in bottoms of coves and drains in extreme northern rim of region. Not an upland species.	Medium
Water oak (*Q. nigra*).	Striped oak, pin oak, orange oak, red oak, spotted oak.	Widely on loam ridges in first bottoms and on any ridge and silty clay flats in second bottoms or terraces.	Widely on all sites but the wettest. Best development on lower slopes. Very poor on high, dry sites.	Good to excellent. Varies with site.
White oak (*Q. alba*).	Forked-leaf white oak.	Widely on well-drained oldest alluvium. Common in better drained creek bottoms above the lower Coastal Plain. Occasional on best hammock sites. Not primarily a bottom-land species.	Widely; but principally on middle and upper slopes in rough terrain with deep soils. Largely absent in lower Coastal Plain. In Coastal Plains, often riddled with insects and useless for any product above ties.	Poor to medium, rarely good.
Willow oak (*Q. phellos*).	Pin oak, water oak, black oak, red oak.	Widely on ridges and high flats of major streams. Less common in creek bottoms. At its worst but most prolific in pure stands on hardpan terrace soils. Congregates on flats of old alluvium and on clay loam ridges of new alluvium, where it is at its best.	Rare except in "pin oak flats" underlain by hardpan.	Generally good to excellent but varies greatly with site. Poor to medium on "pin oak flats" underlain by hardpan.
OSAGE-ORANGE (*Maclura pomifera*).	Bois d'arc, mock orange.	Small bottoms in northwestern Louisiana, northeastern Texas and adjacent parts of south Arkansas, and especially in Oklahoma.	Widely but scattered on all sites; primarily on moist, well-drained creek bottoms.	Poor

See footnote at end of table.

chief softwood associates [1]—Continued

Tolerance	Reproduction	Susceptibility to damage	Value and primary uses	Remarks
Moderately intolerant.	Adequate to sparse. Never prolific and occurs only as scattered groups in small openings.	No special hazard unless from animals eating mast.	A high-class white oak of good value but too scarce to be marketed alone. Face veneer, tight cooperage, factory lumber, and ties, etc.	
Intolerant	Prolific in full light. Sprouts aggressively and fights ground cover very well.	Very susceptible to insects, diseases (including basal heart rot), and mineral stain on both dry and impervious soils.	Factory lumber. Ties and timbers only from high, dry sites. Poor to medium values.	A very good second-rate tree on the best sites. Knotty, grubby, bark-pocketed, and stained on poor sites. May check excessively in drying. Subject to epicormic branching when drastically released, especially on poor sites.
Moderately intolerant.	Adequate in openings wide enough to let in direct sunlight. Only moderately efficient in competition with ground cover. Seed supply often deficient for reproduction, perhaps because animals eat it. Sprouts well.	Fire hazard may be above average.	Prized for both commercial and farm use. Face veneer, tight cooperage, factory lumber, ties, and timbers.	Sometimes subject to excessive epicormic branching on poor sites or when crowded.
Intolerant	Easily obtained in full light. Sprouts efficiently. Competes exceptionally well with ground cover. Mast is normally copious. Should plant fairly well.	On poorer sites especially subject to insect infestation, mineral stain, and epicormic branching. Basal heart rot common in old trees on hardpans.	Factory lumber. Ties and timbers, especially from high terrace and "pin oak flat" stands.	Very important species because of wide distribution in bottom lands, rapid growth and relatively high utility on appropriate sites. Tendency to check excessively detracts from utility. Subject to epicormic branching when drastically released, especially on poor sites.
Tolerant	Erratic. Sprouts well. Commonly in understory or in small or partial openings.	No special problem	Very durable wood, highly prized for fence posts and small poles. Too small for lumber and ties but welcomed for specialties such as insulator pins and archery bows.	Minor local species; widely planted and naturalized in spots. Principal handicap is crookedness.

TABLE 4.—*Southern hardwood species and*

Approved [1] common and scientific name	Other common names	Occurrence in bottom lands	Occurrence in uplands	Growth rate
PECANS				
Pecan (*Carya illinoensis*).	Sweet pecan	Largely restricted to present or recent riverfronts on loamy soils (never on old alluvium) in Mississippi River system. Rare in bottoms of other large rivers of Gulf Coastal Plain.	None	Medium to good
Water hickory (*Carya aquatica*).	Bitter pecan, bitternut, pig nut.	Widely, but common only to flats, sloughs, and margins of swamps of major alluvial streams. Occasionally on low clay ridges. Greatest concentrations on flats of principal backwater basins.	None	Poor
PERSIMMON, COMMON (*Diospyros virginiana*).	Persimmon	Scattered widely on wet flats, shallow sloughs, swamp margins. Rare in creek bottoms. At its best on new alluvium in big bottoms.	On lower sites in coves and as old-field weed on high, dry sites.	Poor
PINES				
Loblolly pine (*Pinus taeda*).	Old field pine, Rosemary pine, black pine.	Mainly on terraces and colluvial outwash of smaller rivers and highest ridges in creek bottoms. Also in high hammocks. Reaches optimum development on such sites but is not primarily a bottom-land species.	Widely but scattered on productive upland hardwood sites; on ridges and upper slopes primarily; i.e., the drier sites.	Fair to good. Seldom excellent except in sapling and small pole stage or when superdominant.
Slash pine (*P. elliottii*).	Swamp pine	In margins or borders and on hummocks in muck swamps. (Common with inferior hardwoods in shallow bays and piney woods ponds of the lower Coastal Plain; not treated herein.)	In branch heads and drains of lower Coastal Plains, mostly. Tends to poorer sites, though, where only poplar is of comparable importance; largely disregarded herein.	Medium to good

See footnote at end of table.

chief softwood associates [1]—Continued

Tolerance	Reproduction	Susceptibility to damage	Value and primary uses	Remarks
Moderately tolerant but less than most hickories.	Rarely prolific in clear opening. Generally adequate in small and partial openings. Persistent and develops well. Sprouts aggressively from stumps. Mast heavily foraged.	Notably free of hazards but suffers from fire and grazing.	Medium value for standard lumber and a little commercial and face veneer. Turns into furniture, flooring and trim, and implement and vehicle parts. Sometimes mixed with hickory but not quite hard and tough enough for most hickory specialties.	Good second-class species—perhaps risk of round-headed borer in flooring and trim is only bar to first-class rating.
Moderately tolerant but less than most hickories.	Prolific in full light. Heavy sprouter. Starts and persists in partial light and very small openings. Seeds heavily and often and mast not much foraged.	No special problem. Leafs out very late, withstands flooding well. Survives grazing. Heart shake serious in some localities.	Accepted with sweet pecan for factory lumber when quality permits. Too brash for hickory specialties.	Extreme tendency to ring shake makes it third-rate tree. When free of ring shake, quite acceptable, but determination impossible until trees are felled and opened up.
Very tolerant	Sparse but dependable. Occurs mostly in the understory. Sprouts well from stumps. Occasional small thickets in partial openings.	One of the most fire-resistant hardwoods. Bird peck and borer damage depreciate utility on poor sites.	Very high values in the log but marketing often difficult due to scattered distribution of trees and localized specialty manufacture. Shuttle blocks, golf club heads from white or cream-colored sapwood. Black heartwood valueless because of excessive checking.	Good, self-pruning tree. Little heartwood develops on favorable sites. On dry old fields, a small ill-formed weed along with sassafras.
Intolerant—very intolerant by hardwood scale.	Reproduction made very difficult by hardwood competition and ground cover. Easily planted on old fields. Prolific in clear openings on well-drained sites.	No special problem	Structural lumber, poles, pulpwood.	A valuable fill-in on heavily depleted areas of appropriate site; also, the best means of rehabilitating worn-out sites, old fields and gullies. Naturally temporary, except as individuals, in most situations but ridgetops.
Intolerant. Must have codominant or better position relative to hardwoods.	Prolific in clear openings with exclusion of fire. Sparse or lacking otherwise. Poor in competition with ground cover and hardwood reproduction.	Stands under 10 feet in height are susceptible to fire.	High values for poles, piling, lumber, pulpwood, and naval stores.	A welcome fill-in for appropriate situations but rarely can reproduce successfully in competition with better hardwoods.

TABLE 4.—*Southern hardwood species and*

Approved [1] common and scientific name	Other common names	Occurrence in bottom lands	Occurrence in uplands	Growth rate
Shortleaf pine (*P. echinata*).	Arkansas pine	Very rare; may occur on high, dry terraces of small streams and outwashes in northern and higher areas of region.	Invades productive hardwood areas of deep but dry soils in northern and higher parts of region, especially old fields, heavy cutovers, and destructive burns. Largely vestigial in good old-growth hardwood stands.	Poor to medium. Occasionally good.
Spruce pine (*P. glabra*).	Cedar pine, white pine.	East of Mississippi River on well-drained, high ridges of first bottoms and better terrace sites of minor streams of lower Coastal Plains and some hammocks. Scattered in small groups and groves.	Only in an occasional large, well-drained branch head in the Coastal Plains.	Good to excellent
SASSAFRAS (*Sassafras albidum*).		Scattered widely on any well-drained site. Best on moist, pervious soils.	On all sites, but best in coves and on lower slopes.	Medium, very variable.
SYCAMORE, AMERICAN (*Platanus occidentalis*).	Plane tree, buttonball-tree.	Widely on fronts of major streams and on banks of minor streams; elsewhere, on bare areas and washes of light moist soils.	In cove bottoms and around branch heads above the lower Coastal Plains.	Good to excellent
WALNUT Black walnut (*Juglans nigra*).	Walnut	Scattered mainly in northern and higher parts of region on best well-drained loamy sites. Not common in major bottoms except Delta of Tennessee and Missouri. Typically a creek-bottom species.	Widely scattered throughout region on deep, moist, well-drained soils. Best in moist coves.	Medium to good
Butternut (*Juglans cinerea*).	White walnut	Rare; only in small creek bottoms to the north and in Piedmont.	Scarce; occurs mainly on middle and lower slopes of ravines and coves to the north and in Piedmont.	Medium to good

See footnote at end of table.

chief softwood associates [1]—Continued

Tolerance	Reproduction	Susceptibility to damage	Value and primary uses	Remarks
Intolerant	Prolific in clear openings with exclusion of fire; sparse or lacking otherwise. Seedlings sprout readily following injury.	Sites subject it to frequent fire hazard.	High values for poles, piling, and structural lumber. Pulpwood.	Same as for loblolly but some severely depleted or degraded oak-hickory sites might well be converted to this species.
Moderately intolerant by hardwood standards. Most tolerant of southern pines.	Reproduction adequate in small openings on proper site; occasionally prolific over small bare areas. Most effective of pines in competition with ground cover and hardwood reproduction.	No special problem but crook from competition with hardwoods and ground cover.	Structural lumber, pulpwood, rarely poles.	Rougher than loblolly pine, sweep precludes production of poles. Seldom if ever makes dense structural stock.
Intolerant	Sparse; erratic except for efficient sprouting. Takes over occasional small opening in spite of ground cover. Often prevalent on ridgetop openings and old fields, where it is a weed.	Considerable mortality during drouths. Very susceptible to fire.	Boat lumber, rarely interior trim (mostly custom work), posts. No established market as standard factory lumber.	Sparse, scattered supply makes it negligible in commerce, though the lumber is light, durable, straight grained, easy to work and bend, and of excellent appearance.
Very intolerant	Prolific on bare mineral soil. Sparse to adequate on wet spots with meager ground cover. Never in shade. Excellent sprouter from stump. Good planting prospects; unrooted cuttings possible.	Becomes shaky after reaching maturity. Especially sensitive to fire, but usually occurs on the safer sites. Small bark-scarrer pockets common on dry sites and in overmature trees.	Commercial and package veneer, occasionally factory lumber. Box lumber. Specialties such as butcher blocks. Fair values.	Clean, clear boles, but very large trees likely to be windshaken. Withstands drouth much better than cottonwood and willow and will grow on higher sites and coarser soils.
Intolerant	Sparse but dependable. Mainly in openings on best, well-drained soils. Copes moderately well with ground cover. Sprouts fairly well from stump.	Mineral stain on poorest sites. Bark flecks, probably insect-caused, depreciate utility, especially in southern part of region.	Most valuable native species for face veneer and factory lumber. Gun stocks and other specialties.	Often bought by the tree, stump and all. Where quality is satisfactory, is sought out truckload by truckload over wide radius. Single trees are sold occasionally. Expert middlemen needed, though.
Intolerant	Poor	Unknown	When sufficient quantities can be accumulated, has medium to high value for factory lumber.	Very minor species.

TABLE 4.—*Southern hardwood species and*

Approved [1] common and scientific name	Other common names	Occurrence in bottom lands	Occurrence in uplands	Growth rate
WILLOWS				
Black willow (*Salix nigra*).	Willow	Margins and batture sloughs of principal rivers of Coastal Plains and Mississippi River system. Also ditch banks, swamp margins, etc. Important only on river-front land and abundant in good quality only on Mississippi River system.	Rare. Only in wet coves, in occasional branch heads, and along ditches and drains as clumps, fringes, and single trees.	Excellent
Sandbar willow (*S. interior*).	Smoothbark willow, gray willow.	Along river margins on new, low, bare bars and towheads.	Probably none	Excellent to small pulpwood size.
YELLOW-POPLAR (*Liriodendron tulipifera*).	Poplar, tulip poplar, tulip tree.	Mainly east of Mississippi River. Only on best well-drained terrace sites and outwashes. Mainly along minor streams. Not primarily a bottomland species. In Delta only at extreme northwest corner. Also on margins of muck swamps and in branch heads.	Widely, except on ridgetops and other driest sites. Best and most plentiful in coves and on lower slopes, and in depressions on upper slopes. Common in branch heads of Coastal Plains to the coast. Also in piney woods seeps and drains on Coastal Plains.	Good to excellent

[1] These species, for one reason or another, attain importance in southern hardwood stands. Approved common names and scientific names are according to E. L. Little, Jr., *Check List of Native and Naturalized Trees of the United States (including Alaska)*. U.S. Dept. Agr., Agr. Handb. 41, 472 pp. Comparative growth rate is average diameter increase in 10 years for dominant and codominant trees on better sites, as follows: Poor—less than 2 inches; medium—2 to 3

chief softwood associates [1]—Continued

Tolerance	Reproduction	Susceptibility to damage	Value and primary uses	Remarks
Along with cottonwood, most intolerant American sawtimber species.	Reproduces profusely but only on bare, wet mineral soil. Sprouts vigorously. Cannot compete with ground cover.	Very susceptible to drouth on high sites or light, loose soils with low water table. Fire always disastrous.	Factory lumber, commercial and package veneer, box lumber, pulpwood. Interior trim from the red heartwood.	Form and size good in battures of lower Mississippi and main tributaries, but poor elsewhere.
Same as black willow or more so. Black willow usually shades it out in dense stands.	Same as black willow. Cannot stand competition of any sort. Whole stands of saplings die of drouth during low river stages.	Very susceptible to drouth; often starts on coarse deposits at high water level and dies when river recedes.	Very low. Normally short-lived; rarely reaches 8 inches in diameter. Pulpwood or revetment matting probably only uses.	Often reproduces and grows with black willow, giving way to it.
Very intolerant	Prolific on bare soils in wide, clear openings. Sparse but often adequate in small openings on good sites. With one season's start, outgrows any ground cover. Sprouts well and is very promising for planting.	Great hazards from fire and livestock. Degraded by small ingrown bark flecks and cankers on poor sites. Probably the most subject of all hardwoods to mortality from flooding.	High value. Factory lumber, commercial and package veneer, box lumber, pulpwood.	A clean, clear species of excellent form and technical properties, highly valued for general utility.

inches; good—3 to 4 inches; excellent—better than 4 inches. Tolerance is a relative assessment. When factory lumber is listed as a primary use, it automatically implies the myriad uses into which hardwood lumber is remanufactured. Cypresses, pines, and cedars are included in this table because they occur on some good hardwood sites and therefore must be considered in management programs.

PRELIMINARY MANAGEMENT

The principles of managing southern hardwoods are not unique. Their application follows a pattern common to placing any forest land under management: normally, the first step is to learn what there is to work with and the second is to plan a course of action.

Management of most forest lands—and southern hardwoods are no exception—begins with some very extensive practices. To apply these practices, only elementary information is essential. Later, as management progresses, more detailed information must be obtained. Since the most likely course of development for most owners is from the extensive to the intensive, this discussion proceeds in the same way.

Although it will be assumed that the total acreage under management is sizable, the same principles apply to small properties as to large ones. In most technical respects, these small properties may be regarded simply as subdivisions of larger ones. The small owner, however, often finds it difficult to justify the expense of hiring a professional forester and purchasing equipment. Often, too, it is difficult to hire this service and equipment. There is a need for a combined forestry, logging, and jobbing service to handle the total forest production (all products) of a community or group of small owners.

Reconnaissance

The first steps in management are to collect relevant information and to make a simple reconnaissance.

The forester must first of all locate, at least approximately, the tract's exterior boundary lines and then begin to get acquainted with the terrain, the forest, and the marketing possibilities. In addition to his field reconnaissance, three sources of information are available. The first is written material such as deeds, surveys, and old timber cruises; the second is maps and photographs of the area; and the third is personal contact with persons who already have some knowledge of the property. Public foresters or consultants working on very small tracts must, of course, look to the owners for information about boundaries and history.

Deeds and surveys are usually on file at the county courthouse. Ordinarily, the only information the forester will need prior to his preliminary reconaissance is a plat showing land subdivisions for areas under the Public Land survey. Bearings and distances are, of course, required for properties surveyed by metes and bounds.

Cutoffs, recessions, and accretions may make it difficult to establish the boundaries of lands lying along major rivers. The forester in charge of such properties should know the basic principles of riparian law; information on this subject is included in the appendix, p. 99.

Maps and aerial photographs are the chief tools of a forester in becoming acquainted with a property. The study of drainage on planimetric maps or drainage and contour lines on topographic sheets usually helps in site delineation. Soil maps are similarly useful. Topographic quadrangles for areas east of the Mississippi River may be ordered from the U.S. Geological Survey, Distribution Section, Washington 25, D.C. Orders for areas west of the Mississippi River should be addressed to the U.S. Geological Survey, Distribution Section, Federal Center, Denver, Colo. Quadrangles for the alluvial valley of the Mississippi River and parts of tributary streams may be obtained from the president of the Mississippi River Commission, at Vicksburg, Miss.

Aerial photographs are unexcelled for orientation and for recognition of general forest types and stand conditions. Foresters with a sound knowledge of ground conditions may be able to identify pure stands of cottonwood, willow, baldcypress, the tupelos, or yellow-poplar where photographs have been taken during the growing season. Separation of other species is almost impossible in mixed hardwoods, but important differences in stand conditions are often obvious. Inexpensive aerial photographs may be purchased from several government agencies; a "Status Map of Aerial Photography" covering all such work is available free through the U.S. Geological Survey, Map Information Office, Washington 25, D.C.

Local residents can be very helpful in locating boundaries, landmarks, and routes of access, and their memories may be the only source of information concerning past fires and logging. The forester should make every effort to meet persons living near the tract on a friendly basis right from the beginning. Good public relations established at the start will reduce problems of fire and trespass later.

The preliminary reconnaissance should provide rough but intelligible information about the essential features of the forest and how they vary from place to place. The collection of detailed information on volume may be postponed until needed for planning the first managed cut, but major concentrations of especially valuable components should be located, as should open or other nonproductive areas. Damage to growing stock by fire, storms, insects, and livestock, together with the relative density of cull or weed trees, should also be considered.

The distribution of stand conditions (see first column of table 5, p. 66) and of major sites or species associations may be noted or sketched on a map or aerial photo. All this, affirmed and qualified by observation and occasional rough plot or point samples in the course of a systematic walk-through inspection, will provide such information on volume as may be needed for broad planning and policy decisions at this early stage. The desirability of a detailed type map is debatable. Generally, the only really useful lines on such maps are those delineating physiography and ownership patterns, severe burns, or large blowdowns. After some years of management, other lines will tend to disappear.

For the stands regarded as operable, a clear picture of logging conditions should be obtained. At what seasons can the stands be worked? The answer will depend upon the drainage, soil conditions, and accessibility. What kind of physiographic obstacles exist? When and how frequently do floods occur; and how long do they last? What kind of logging equipment will be needed? Is it available now? If not, will the need justify its acquisition? What major transportation systems are available—highways, railroads, rivers? Are they suitable for the type of operation anticipated? Are necessary rights-of-way legally open? What, if any, logging will be done by the landowner and what should be contract-logged? If contracting appears desirable, will the opportunities interest experienced operators? What is the kind and quality of the labor supply? The fact that most of this information will be accumulated incidentally to other work does not belie its importance.

Somewhat related to logging conditions is the need for knowledge about markets. This information also may be obtained incidentally to reconnaissance and is usually part of a consultant's stock in trade; without it planned management is impossible. What markets or uses are in prospect? How do they fit in with the timber supply? Can and should new or additional markets and uses be developed? If so, how and when can this be done?

It is important to remember that markets for major products are not localized. Hardwood lumber logs are commonly shipped up to a hundred miles, and mills producing face veneer may reach out several times that distance. Information on companies purchasing in the area can sometimes be obtained from local residents and other foresters, but an informant's lack of knowledge should not be taken as proof that markets are nonexistent. Probably every stand of southern hardwoods is within the reach of more than one veneer or factory-lumber mill. Unless expert advice is available, appropriate trade associations and trade journals (listed on p. 99) are more adequate and dependable sources than local hearsay.

By way of summary: When the preliminary reconnaissance is finished, the forester has, first of all, an invaluable mental picture of the property, including a rough idea of timber volume, location, kind, and salability. In addition, he has maps, aerial photographs, and information on logging conditions, markets, the fire situation, and other general features. All the essential points should be clearly and systematically recorded for future reference.

Boundary Location

After the preliminary reconnaissance is finished, it is time for action—actual management begins.

First of all, the boundaries of the property should be accurately surveyed and plainly marked. In most hardwood territory, untended boundaries are soon overgrown and obliterated. Old corners should be relocated whenever possible. If after diligent search a corner cannot be found, a new one must be established either by agreement with adjoining landowners or by a court decision. Any exchanges or agreements, and, of course, all purchases, should be promptly recorded in accordance with the requirements of State law. Boundary disputes are annoying, time-consuming, and expensive.

Once corners have been firmly established, the lines between them should be run with a staff compass and plainly marked. The most common procedure is to paint heavily over a light bark blaze. Paint applied directly to rough bark soon flakes off and blazes alone are too hard to see, while paint applied to a deep blaze through live tissue is soon overgrown. In areas covered by the Public Land Survey, metal plaques engraved with the familiar General Land Office grid are a quick and suitable means of marking corners. The plaques may also be used at the intersection of boundary lines with roads and trails or other well-defined natural or cultural features.

Installing a Protection System

Once the boundaries have been marked, the next step is to place the property under protection from fire, theft, and other trespass. A protective system for southern hardwoods is not strikingly different from one for pine, but a few features deserve especial mention.

The local people in the bottom lands or most other hardwood areas seldom have a compelling urge to burn the woods. Fires are very largely accidental. A majority are caused by careless trespassers and by the escape of fires set for clearing fields, ditch banks, and rights-of-way. This situation is favorable because fire does not occur so often as in pine and fewer people resent attempts to eradicate it; it is unfavorable because people are unfamiliar with the destructiveness of fire and make little effort to prevent or suppress it.

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Awakening or increasing fire consciousness, therefore, is an important part of the fire protection scheme.

Hardwood lands are especially subject to pressure from hunters. Most fires started by hunters are accidental and are caused by the escape of small fires built for warmth or to smoke game out of den trees.

Posting extensive or remote properties against hunting seldom works. Resentment is aroused and enforcement on scattered holdings is almost impossible. Probably the best plan is to allow hunting by written permission. In this manner, numbers may be restricted and responsiblity fixed, at least to some extent. When the hunters apply for permission the dangers of fire and the damage it causes can be explained. Some landowners have found that lease to a hunting club is a good solution; fire protection can be made a condition of the lease.

Firebreaks plowed annually late in the growing season are highly desirable. They should be at least 8 feet wide. Their spacing depends entirely on the location and frequency of the roads, sloughs, swamps, and drainage systems which they will supplement. A very useful tool is the four-disk fireplow, but any implement heavy enough to insure a clean swath of mineral soil is satisfactory. Close maintenance is essential during seasons of high hazard because dry leaves accumulate on the plowed strips.

As access may be difficult in the bottom lands and rougher uplands, it is likely that the existing network of roads and trails on unmanaged forest land will have to be supplemented for protection purposes. If the supplementary trails are to be used only in fire seasons, they need be built only to dry-weather standards.

A system of fire detection must be established if the State does not assume this responsibility. Towers are feasible on large ownerships in the uplands, but air patrol may be necessary in extensive areas of bottom lands where tall timber on flat terrain obstructs the view. Some supplementary ground patrol will be needed in either case to detect small fires that start before all leaves have fallen and to reduce the danger of fire by holding trespass low. On small tracts, detection will of necessity depend entirely on ground patrol and State cooperation.

Suppression of fires in hardwoods generally follows standard techniques except that building a fireline is unusually difficult. The vegetation is heavy, while the soil, often very hard and caked, is filled with tenacious roots. In the worst seasons, the difficulty of fireline construction puts the heaviest equipment to a severe test. In extended drouths, dead roots and buried debris (and in muck swamps the organic soil itself) will burn, often leading the fire below ground. Underground fires are extremely difficult to suppress and mop up.

The best protection against trespass is a system of plainly marked boundary lines coupled with an occasional inspection to see whether theft or damage has occurred. This, together with the good will and cooperation of the neighbors will generally keep the situation within bounds. In some places, a long course of tactful education, plus firm insistence on rights, may be necessary.

A special type of trespass is the grazing of livestock. Formerly, most of the South was open-range country. The only way of preventing grazing was through fencing, and that was costly and often ineffective. Many States now have fence laws providing for the impoundment of stray animals, but the open-range tradition dies slowly. The exclusion of grazing can still be a difficult proposition, generally best accomplished by negotiation and enlightenment. Public outcry and even incendiary fires may follow abrupt, forceful actions. Some degree of control must be achieved, however, for intensive grazing will prevent the establishment of hardwood reproduction.

Protection of hardwood forests from diseases and insects is so far largely a matter of prevention. Elimination of fire will greatly reduce damage by heart rots, the most costly diseases. Deadening or harvesting of trees that are infested by trunk-boring insects, or whose vigor is so low that attack is likely, will probably be beneficial.

Compartmentation

After a protection system has been installed, but before cutting is started, a property should be divided into compartments to facilitate technical management and general administration. Customarily, compartment boundaries will coincide with natural features such as streams, swamps, roads, and fields. Public Land Survey lines or the boundaries of acquired tracts can be used where natural features are not adequate or where man-made lines are more suitable for such purposes as tax information. It is advantageous to use forest type boundaries only where the type change is abrupt, striking, and apt to be permanently reflected by vegetation differences attributable to site, not merely to variations in past history or treatment.

Since compartments are the units of long-term management, they should be very carefully selected for permanence and with the specific purposes of establishing an adequate but simple system of permanent records. All compartment boundaries should be plainly marked on the ground and on a map.

The size of compartments will vary with the size of the property. Volumes, rate and frequency of cutting, access, and physiographic features are

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FIGURE 24.—Almost all hardwood stands contain malformed and low-grade trees whose removal or deadening will improve the stand. Here, trees marked with paper squares should be removed.

the kind of factors to be considered in establishing management units. Properties smaller than a few hundred acres may not require any subdivision at all, unless the owner plans annual cuts on very small units.

Improving Abused Stands Through Harvest or Deadening

The forester will usually find that through the years fire, high-grading, liquidation cuts, or other destructive influences have created a forest with a high proportion of stems that are undesirable as future growing stock. Low-grade, overripe, overcrowded, damaged, or cull trees (and all classes of trees of undesirable species) will be occupying space that once supported and should again support valuable timber. The goal of the forester is to remove the undesirable components and build up the stocking of desirable trees at the same time that he is wresting some income from the property. Treatments at this stage are for stand improvement and are not in accordance with any classical system of management or regeneration. That is, well-advised selection of individual trees for removal, considering stand relationships as well as the merits of the individual trees, will accomplish the essential opening for reproduction and release (fig. 24).

The preliminary survey or reconnaissance may furnish enough information for planning the first cutting, particularly on small properties. A diagnostic tally or inventory made especially for this purpose will, however, furnish a sounder basis for establishing policies and priorities.

Such an inventory need not be extremely accurate or time consuming. It is possible to get approximate estimates of volume and silvicultural condition with little effort by using point-sampling.[5] A field procedure and a form of tally sheet useful in hardwoods are given on page 83. Although plots or strips are probably less efficient, they can be used to develop the same information.

To be useful in the initial stages of management, the inventory data should be broken down by species group, tree class, and utility class. Species similar in form and utility may be combined. The general utility and grade for planning purposes may be adequately estimated from the characteristics of the butt logs.

The silvicultural part of the inventory is the breakdown into four tree classes: *leave*, *storage*, *cut*, and *cull*. These tree classifications are a form of cutting priority. They serve as a basis for planning harvest and improvement cutting and for developing marking rules following analysis of inventory data.

Leave trees are desirable growing stock and include all trees that, in the judgment of the forester, will grow in volume or increase in value at a satisfactory rate for one cutting cycle or more without unduly obstructing more desirable growing stock. The category includes trees that are expected to attain merchantable size and quality in the future as well as those now merchantable.

Storage trees are not expected to make a generally satisfactory net increase in the value of the stand, yet are unlikely to be lost, to deteriorate, or to damage surrounding trees seriously if left in the forest for another cutting cycle. Good mature trees may comprise the bulk of this class but any trees that are borderline between *leave* and *cut* will also fall into it. They can be safely stored on the stump, with reasonable expectation that they will be available for the next cut and thus may shorten the period required to accumulate another operable volume of non-*leave* trees. They may also be invaluable in meeting special market demands or opportunities; the flexibility provided by this classification will help in budgeting the cut to suit the needs of market or mill, or the landowner's personal wishes.

Cut denotes trees that seem likely to lessen the future value of the stand, either through risk of loss or effect on better trees, if left for another cycle. It includes most fully mature and all overmature trees, those likely to suffer mortality, damage, decay, or degrade, and those seriously competing with better individuals. Trees with exceptionally short stems and trees of very low present or potential value may be cut for the sole purpose of fostering reproduction.

Culls are unmerchantable for standard sawtimber because of species, form, knottiness, or damage from rot or insects. Trees below sawtimber size are culls if they have no prospects of future merchantability. Many so-called sound but limby or malformed culls contain cordwood and even bolt stock that under local conditions may or may not be salable. Most culls, though, cannot be harvested profitably for any use.

All these tree classes except *leave* and *storage* may be conveniently spoken of as "overburden," requiring removal or elimination as soon as practicable.

Successful use of these tree classes will depend largely upon the skill and judgment of the forester, because no one can infallibly predict the future from the past or judge the interior from the exterior of a tree. It may, however, be helpful to discuss the criteria that should be considered in classifying a tree.

Successful hardwood silviculture and management demands recognition of the species-site relationships discussed earlier. Many good species are poorly formed and infested with insects, fungi, and stain when grown off-site. The forester must also remember that growth capacity, form, tolerance, reproductive capacity, quality, or adaptation to an adverse site may justify leaving a tree of a species otherwise held in low esteem. To put it another way, not all yellow-poplars should be saved nor should all water hickories be liquidated.

The mere presence of a few obvious defects (such as very large or punky knots) does not in itself render a hardwood tree unsuitable for high-quality products, while inconspicous faults (such as numerous overgrown small knots or bird peck) may prevent sound straight trees from ever being used for anything but crossties or low-grade structural or box lumber. Where defect-free veneer, lumber, or bolts can be derived from species ordinarily scorned, value may exceed that of poor-quality trees from very desirable species.

A tree's relative vigor determines its growth capacity and is usually correlated with the likelihood of early death. Indicators of vigor may be characteristics such as the relative length and

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[5] Among publications that deal with point-sampling are the following:

Grosenbaugh, L. R. *Better diagnosis and prescription in southern forest management.* U.S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 145, 27 pp., illus. 1955.

Bruce, D. *A new way to look at trees.* Jour. Forestry 53: 163–167, illus. 1955.

shape of the crown; color, luster, and density of foliage; the ratio of young to old branches; presence and prevalence of dead terminal twigs in the upper crown; and epicormic branching. Other indicators are bark characteristics such as color, smoothness, texture, scaliness, fissuring, plating, or ridging (fig. 25). Bark change lags 3–5 years behind physiological change, but is otherwise a very useful clue to vigor. Size alone is not a reliable indicator of vigor.

Overcrowding or overtopping rarely is critical at the time of the first managed cut. Occasionally, however, the reason for marking a tree will be to provide growing space for more desirable individuals in a clump. For example, if a vigorous ash pole is being overtopped by an otherwise desirable soft elm of commercial size, the elm should be cut. Badly surpressed trees in clumps or patches should be salvaged if merchantable. In addition, occasional even-aged stands, especially of cottonwood, willow, sweetgum, the tupelos, baldcypress, and yellow-poplar, will require a general thinning. Here the best stems should be favored by removal of their less promising competitors, generally of inferior crown class. Thinning and stand improvement may still be infeasible in many situations, especially in swamps, if the cut is too light or if silvicultural marking involves mainly trees too small for saw logs. Postponement of thinning in such cases is preferable to premature cutting of the dominant growing stock.

Most initial improvement cuts are composed principally of low-grade, deformed, or damaged trees that either have a dismal future or are interfering with better trees. The merchantability of such cuts, however, is usually maintained at a practical level by high-grade trees that are mature, overmature, or short stemmed. Damaged but otherwise promising trees that appear likely to survive till the next cut without interfering with better trees should be left unless needed for an operable cut or unless the progress of cull or degrade threatens to offset growth gains.

Under management, cuts can only be planned intelligently after information such as that outlined on pages 63–64 is available. The volume and basal areas of each compartment classified by species, tree class, and grade will show the location, kind, and amount of material available for cutting and that suitable for continued growth. The stand classes suggested in table 5 may be helpful in formulating cutting policies and priorities. The classifications may be overly detailed for some purposes, but can readily be condensed. The table is intended to guide notation or sketch of the silvicultural and economic character of stands over a substantial area in a particular locality. Its application is for description and prescription rather than for formal management record.

From a purely silvicultural viewpoint, the best procedure usually would be to remove the *cut*, *storage*, and *cull* trees at once, saving all the *leave* trees for future growth. Practically, one or more difficulties may block such a simple solution:

- The volume per acre in the *cut* and *storage* categories may be too light to support a cut.
- It may be impossible to market a cut composed largely of small, low-grade material or undesirable species.
- Removal of all *cut* and *storage* trees may so reduce growing stock as to make a second cut infeasible for too long a time.
- The required investment in cull-tree elimination may exceed the finances available.
- The total merchantable volume in *cut* and *storage* categories might glut the market for certain use classes or overload the local harvesting and logging facilities.
- The owner may prefer to retain certain *cut* or *storage* trees and gamble on a future price increase.
- On large properties, it may be preferable first to cover the entire property with a light salvage cut rather than to log some areas fully while suffering unsalvaged loss in deferred areas.
- The owner may prefer to spread his income over a considerable period instead of concentrating it in the early years of management, either for direct income purposes or to maintain operation of a plant.

Only through compromise can silviculture be reconciled with economics. Harvests too light to to be operable or too low in quality to be salable may be sweetened by cutting some *leave* trees, but such cutting should be restricted to the absolute minimum. The forester should assure himself that the silvicultural and economic advantages of an immediate operation more than offset the disadvantages of further reducing the density of an already understocked stand. Cuts followed by long years of inoperability are undesirable silviculturally, economically, and psychologically, since they preclude not only intermittent cleaning, thinning, and salvage, but also the periodic revenue that may reassure a skeptical owner.

No cutting at all is usually better than premature harvest of a large component of desirable growing stock. Premature cutting should always be considered only as a last resort, a sort of silvicultural suicide that may indefinitely postpone maximum sustained yield.

If removal of all undesirable material might delay subsequent cuts and revenue too long, the harvesting of all or some of the *storage* trees may be postponed. However, the faster that such trees can be removed, the sooner the property will attain its full growth capacity. In general, the period allotted to removal of the undesirable

TABLE 5.—*Generalized stand classes: their characteristics and place in the first commercial improvement cut* [1]

Stand class	Cutting objectives	Cutting priority	Silvicultural results of the cut
I. *Heavy sawtimber* (8,000 bd. ft. and more per acre):			
(a) Large. 50 percent or more of the volume in trees 23 inches d.b.h. and larger.	Harvest and salvage; regeneration.	Highest priority; large values at risk, highly operable.	Nominal shelterwood. Sparse residual stand, often heavy in thrifty groups.
(b) Small. Less than 50 percent of the volume in trees 23 inches d.b.h. or larger.	Normally stand improvement and release; regeneration incidental.	Medium; high if damaged. This class has best possibility of early sustained-yield management.	Good residual stand for beginning of sustained-yield management except where much timber is damaged.
II. *Medium sawtimber* (3,500–8,000 bd. ft. per acre):			
(a) Large. 50 percent or more of the volume in trees 23 inches d.b.h. and larger:			
1. Adequate supporting stands of saplings and poles.	Harvest, salvage, stand improvement, release, and regeneration. Large trees mostly residual old growth, often obstructing promising second growth.	High; strong salvage considerations and possibility of developing early sustained yield. Highly operable.	Fair to good uneven-aged residual stand, scattered or in groups.
2. Inadequate supporting stands of saplings and poles.	Harvest, salvage, stand improvement, and regeneration. Sawtimber usually in poor condition from same causes that damaged or precluded supporting stand.	High; next after class I–a because of urgency of salvage and desirability of promoting reproduction.	Sparse residual stand in urgent need of regeneration. Dim prospects of early sustained yield.
(b) Small. Less than 50 percent of the volume in trees 23 inches d.b.h. and larger. Supporting stands usually.	Stand improvement, release, occasionally salvage.	Low; relatively low values at stake. Sometimes good deal of bolt stock and pulpwood. Integrated utilization important. Further development will greatly increase operability. Medium priority if damaged.	Good residual young stand unless original stand had heavy early damage or sparse support. If undamaged, fair chance of sustained yield after first cut.
III. *Light sawtimber* (1,500–3,500 bd. ft. per acre):			
(a) Large. 50 percent or more of the volume in trees 23 inches d.b.h. or larger:			
1. Adequate supporting stands of saplings and poles.	Harvest, salvage, stand improvement, release. Use of all sizes urgent.	Low; small values involved, and products hard to market. Medium priority if of maximum volume and seriously damaged.	Good to sparse residual stand, depending on damage and development of supporting stand. Light sustained yields may be in sight.
2. Without supporting stands of saplings and poles.	Harvest and salvage; regeneration; stand improvement incidental. Stands mainly residual old growth. Repeated burning or grazing has prevented regeneration.	Next to lowest sawtimber class. Values small, and reproduction usually comes in without cutting if protection is adequate. Medium priority when salvage is urgent.	Sparse residual stand needing reproduction urgently. No prospect of early sustained yield.
(b) Small. Less than 50 percent of volume in trees 23 inches d.b.h. or larger. Supporting stands may be sparse because of damaging influences.	Stand improvement, release, harvest, salvage, and regeneration. Only the best of such stands are operable for sawtimber. Integrated operation generally imperative.	Lowest of sawtimber stand classes; products hard to market, low values at stake, and saplings and poles usually develop satisfactorily for time being if left alone. Need for salvage or existence of markets raises priority.	Fair residual stand if not too heavily damaged. No prospect of early sustained yield.

IV. *Heavy pole stand* (160 or more trees per acre, 5–13 inches d.b.h.).	Thinning and stand improvement, occasional salvage. Stands are mainly even-aged but often with traces of residual old growth.	If not badly damaged, high cutting priority because of management potentials. Otherwise low because of small values. Products almost entirely pulpwood with some bolts and a few logs.	Excellent young residual stand with great possibilities of formal even-aged management. Salvage and reproduction cutting in damaged stands will create stand classes V or VI.
V. *Light pole stand* (less than 160 but at least 40 trees per acre 5–13 inches d.b.h.):			
(a) With supporting stands of saplings.	Mainly stand improvement and release; occasional salvage.	Low to medium. One of commonest conditions. Products mainly low grade—cordwood, bolts, and posts, occasionally traces of residual sawtimber.	Sparse residual stand, but established reproduction has good future. Uneven-aged.
(b) Without supporting stands of saplings.	Stand improvement, occasional salvage.	Very low. Generally little can be done except to promote regeneration. Products mainly low grade—cordwood, bolt stock, and posts, occasionally traces of residual timber. Very common condition.	Very sparse residual stand. Reproduction badly needed.
VI. *Saplings and seedlings* (at least 250 trees per acre).	Release and stand improvement	Lowest of all. With protection will usually develop satisfactorily for time being. Low-grade cordwood and bolts; some low-grade, local-use logs from residual sawtimber. Usually too light for commercial operation.	Reproduction promising if species composition is even fair.
VII. *Nonstocked* (all potentially productive sites).	----------	----------	

[1] All classes of growing stock and all timber species are included in the stipulated stocking and structure for the various stand classes. Culls and weed species are disregarded, but the necessity of their elimination, incidental to any thorough management, is assumed. Their proportions and the general condition of the growing stock should be noted, especially where lack of supporting subordinate size classes is a reflection of space occupied by culls and weeds.

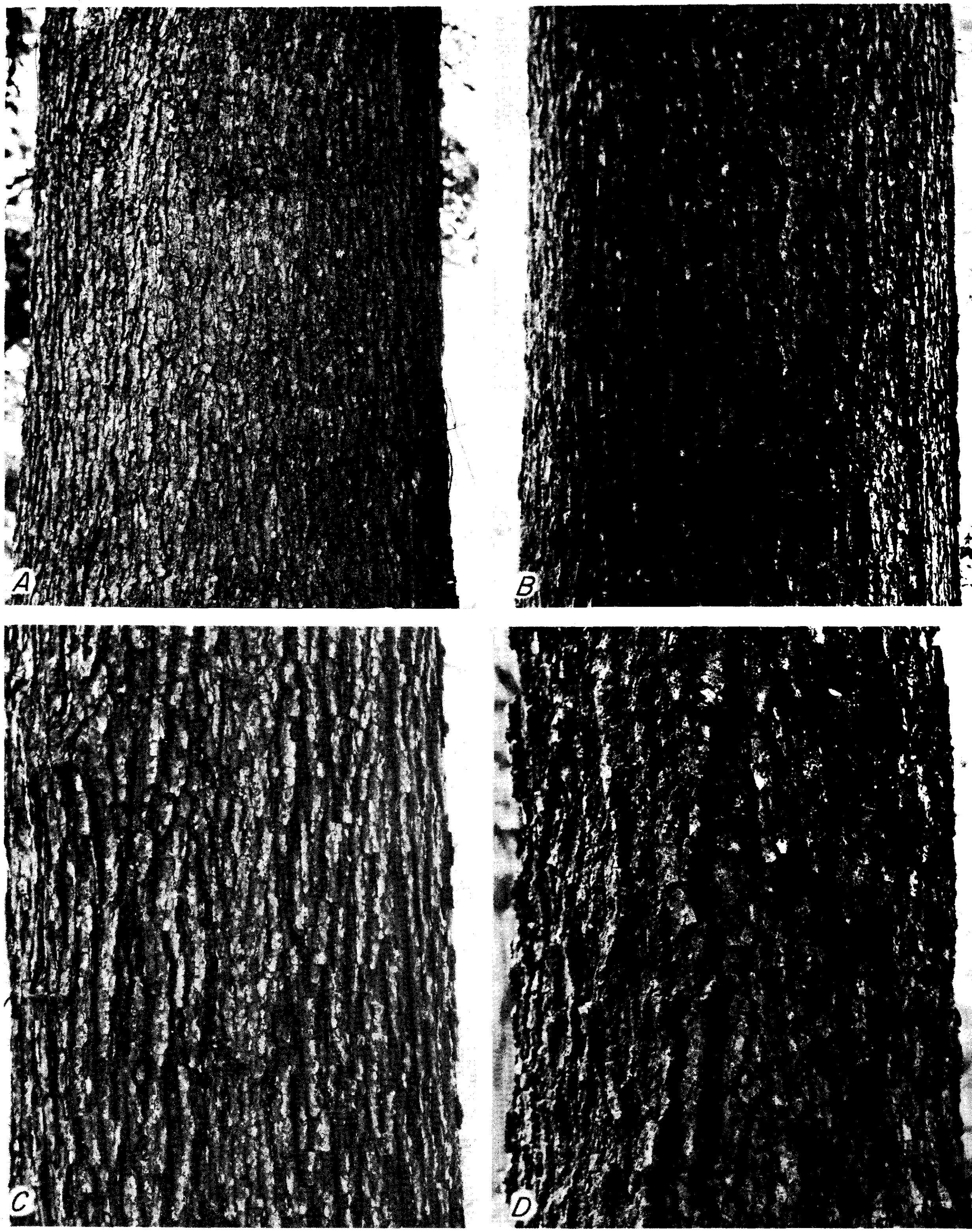

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FIGURE 25.—Appraisal of tree vigor is often aided by bark characteristics. The bark patterns shown here signify high vigor (*A*), medium vigor (*B*), low vigor (*C*), and decadence (*D*) in cherrybark oak.

components should not be more than 10 years. If such a schedule would liquidate stands more rapidly than the owner desires or than the cuts can be handled, it may be stretched out, but the cost of the delay in terms of unsalvaged mortality or deferred reproduction must be acceptable. A partial alternative is a stop-loss policy of cutting only poor-risk trees during the first cycle.

Before expenditures for cull-tree elimination are budgeted, all possible markets should be explored. This undertaking may challenge the ingenuity of the forester, but there is no excuse for thoughtlessly destroying merchantable trees. Markets for hardwood pulpwood are expanding rapidly. Small and very knotty or deformed trees of most sawtimber species and some nonsawtimber species may become merchantable. In addition, substandard lengths of saw stock may become usable through integrated operation. Of course, the prospects of these culls must be weighed against the value of the growing space they occupy and the reproduction they prevent.

Where the principal effects of the stand improvement measures are thinning and release, the dangers of opening the canopy too much must be carefully considered. Such dangers include establishment of a heavy ground cover of vines and understory of weed species in advance of reproduction, and the encouragement of epicormic branching. Research has not yet determined the lower limits of density that will guard against these dangers. Occasionally, therefore, a shift of objective to regeneration, or a delay in all cutting, may be appropriate.

When stand improvement cutting is aimed at obtaining reproduction, openings should be made boldly and of size sufficient to obtain the objective. Most of the trees that would be likely to whisker will thus be harvested, and prompt reproduction will usually forestall the ground cover.

Sometimes, trees otherwise worthless must be kept for their seed. As certain elements of form or defect are heritable, culls should not be left for seed unless the cause of deformation or defect is environmental. It is probably safe to leave rotten culls when it is obvious that the decay entered through an old fire scar or mechanical injury.

The First Cut

Once the annual allowable cut for an entire ownership has been set and decisions have been made on cull-tree elimination, the question of scheduling cut or treatment by compartments and years arises. This cut will be exclusively for stand improvement. In planning it, the compartments with the heaviest volumes in undesirable growing-stock trees should be given the highest cutting priority. It may be necessary, especially at first, to forego a complete job on any one compartment; isolated stands of overmature or severely damaged timber may require immediate salvage. Liquidation of the least overmature or damaged trees may be postponed till more pressing salvage in other compartments can be accomplished.

The cutting plan should be flexible enough to conform to variations in the market. The demand for many hardwood products fluctuates violently. At times, sap gum lumber may be moving readily when demand for flooring oak is weak. The converse may also be true. The markets for the best veneer logs are almost on a custom basis. Marketing opportunities for the odd species such as the pecans and elms are especially spotty. Thus, the forester can increase the returns from the first improvement cut by operating in the compartment that has more of the species and qualities in demand at the time. Periods of generally strong demand should be utilized to move trees of poor species or quality. When the market weakens, the preferred species and grades can still be sold.

Management and regulation of cut for small ownerships should be essentially the same as for one or two compartments. Although the entire cut for a cycle will usually be made in 1 to 3 years, it is all the more important that the marketing be done carefully and intelligently. Ill-considered, hasty action is never necessary and usually results in loss, waste, or damage to the residual stand.

Marking.—Marking a stand for the first managed cut is the implementation of the general policies decided upon after the preliminary reconnaissance and inventory. The kind, approximate amount, and source of material to be removed have been fixed; the job now is to select and designate the individual trees that are to be cut. This task is the responsibility of the forester and should be under his control. No cutting should ever be done unless the stands are first marked, except in the rare situations where low-grade or mature stands are to be completely liquidated and the area planted.

Each tree should be examined from all sides; otherwise, catfaces or other injuries on the back side may be missed and competitive conditions may not be properly evaluated (fig. 26). A practical procedure is for the marker to look back over his shoulder frequently to check on the trees that he has already examined. Tops should be sized up from a distance and checked by a view from the side.

Butt rot should be suspected whenever there are old seams or abrupt changes in taper or bark pattern near the base of the tree. Superficial indications of rot—e.g., catfaces showing only rotten sapwood, rotten limb stubs, and even broken tops and hollow knots on upper stems—should be discounted unless supported by other evidence. All questionable trees should be sounded with a

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FIGURE 26.—From one side, this sweetgum appears sound, but the view of the other side emphasizes the need for a marker or cruiser to look all around each hardwood.

belt ax, machete, or heavy Biltmore stick. Detection of rot or hollows by sounding requires some skill. Sounding the tree in more than one spot or sounding an adjacent good tree and listening for differences in tone will often be helpful. Pounding on trees with thick, corky, or loose bark is not usually successful; it is better to chuck the corner of an ax bit into the wood.

An efficient crew for marking hardwoods consists of three men: two markers and a compassman. The compassman runs a straight line through the woods, helps orient the markers, and carries a supply of extra paint. One marker works on each side of the compass line, zigzagging back and forth across his half of the strip. At the end of each strip, the markers change sides for the return trip so that the inside man is always working up to his previous marks. Care should be taken to keep the marks at right angles to the line and on the side facing the body of unmarked timber.

In upland hardwoods, particularly in the bluffs where the terrain is steep, it is usually inadvisable to carry uniform strips straight across country. Instead, each cove is treated as a unit and marked out completely before the job proceeds.

Climbing can be reduced if the markers work on the contour.

When the trees are bare, a 3-man crew on favorable terrain can mark and tally approximately 80 acres of sawtimber per day. Where underbrush is thick, the same crew in summer will mark less than 40 acres.

While visibility is good and travel through the woods is fairly easy in winter, some indications of vigor—notably the color, luster, and density of foliage—are absent. Judgment of vigor must therefore depend on bark and limb characteristics. Abrupt changes in vigor are not immediately reflected by bark and limbs, and vigilance is especially necessary during severe droughts. To avoid overlooking recent mortality at such times, it may be necessary to mark while the leaves are on the tree. In all marking, it is well to remember that there may be a lag of 4 to 5 years before the bark reflects either improvement or decline in vigor and growth rate. Occasional checking with an increment borer is advisable.

Poor visibility, heat, humidity, and insects make summer marking slow and unpleasant. Low brush and vines may hide defects at the base of a tree, and it is difficult for a marker to keep himself oriented. Whole clumps of trees may be missed. A satisfactory job can be done during the summer, but only if the marker works a narrow strip and takes great pains to examine every tree.

During seasons when foliage is notably sparse or absent, marking may be complicated by difficulty in distinguishing recently dead trees and in evaluating the dying ones. Likewise, the status of trees of certain species that defoliate early or leaf out late may be confusing. In marking during the early fall, the tendency is to penalize red maple, silver maple, soft elm, and other species that drop their leaves early. A bias against overcup oak and water hickory (species that leaf out later than their associates) may develop in the early spring. Here, however, the species penalized are relatively undesirable and the phenomenon is obvious and easily detected.

If the material from the first cut is to be sold for a lump sum, an accurate inventory by species, grade, and size will usually be necessary. In sales involving less than 500 M feet, a 100-percent inventory is generally advisable. In larger sales, considerable time and effort may be saved by measuring sample trees (as described on p. 84). If the timber is to be sold by log scale or lumber tally, measurement of marked trees may be superfluous, although some approximate figures may still be needed for planning sales and logging. If an inventory is to be made during marking, the compassman also acts as tally man.

In marking for a sale, the forester should be especially careful in his handling of low-grade and cull trees. Nothing repels prospective buyers as fast as an abundance of marked trees too small, too low in quality, or too unsound to be usable. Trees that need to be removed but are of questionable merchantability should be marked with an X. The buyer should be told that such trees have been excluded from the volume estimates and that he can cut or leave them at his own discretion. The marking of culls should be treated as a separate job, after the merchantable volume has been removed. This will minimize confusion in the case of inexperienced buyers or loggers. Moreover, a better job of cull marking can be done with the results of the commercial cut in view. Uncut X'd trees can be deadened with the other culls.

Supervising the logging.—The forester has three important purposes in supervising a lump-sum sale: first, to see that the logger cuts all marked trees and no unmarked trees; second, to minimize damage to the residual stand and to installations such as roads, bridges, and fences; and third, to direct salvage of unmarked trees unavoidably damaged.

If the forester is manufacturing the timber or selling logs, he has two additional objectives. The first is to get every tree cut and bucked so that it will yield the maximum volume of the highest grade logs with a minimum of cull and waste. The other is to assure due care in finding and hauling all merchantable logs. On sizable operations, these objectives alone are well worth the time of a good man.

Ordinarily, no serious difficulty will arise if the forester deals with a reputable logger who is experienced in cutting marked timber or one who is sincerely willing to learn. It is usually better not to attempt an operation than to depend upon an inexperienced, poorly equipped, or otherwise unreliable man. Operation of small properties is especially handicapped by dealings with irresponsible puchasers or unreliable loggers.

During the whole logging operation, the forester should make inspections frequently, to avoid backtracking; oversights and violations should be corrected as they occur. The forester can use his knowledge of the tract to point out the location of trails and bridges, the lay of the land, and scattered groups of marked trees. Such helpfulness will usually be repaid by the good will and cooperation of the logger.

The goal should always be to achieve cooperation rather than to demand compliance through threats, but whenever stumpage payments are involved the forester should encourage the landowner to protect himself with an appropriate timber sale contract or agreement, guaranteed by a cash deposit. Provisions should be made for penalties when unmarked trees are cut or when unnecessary damage is done. A date should always be set for the termination of cutting, but it

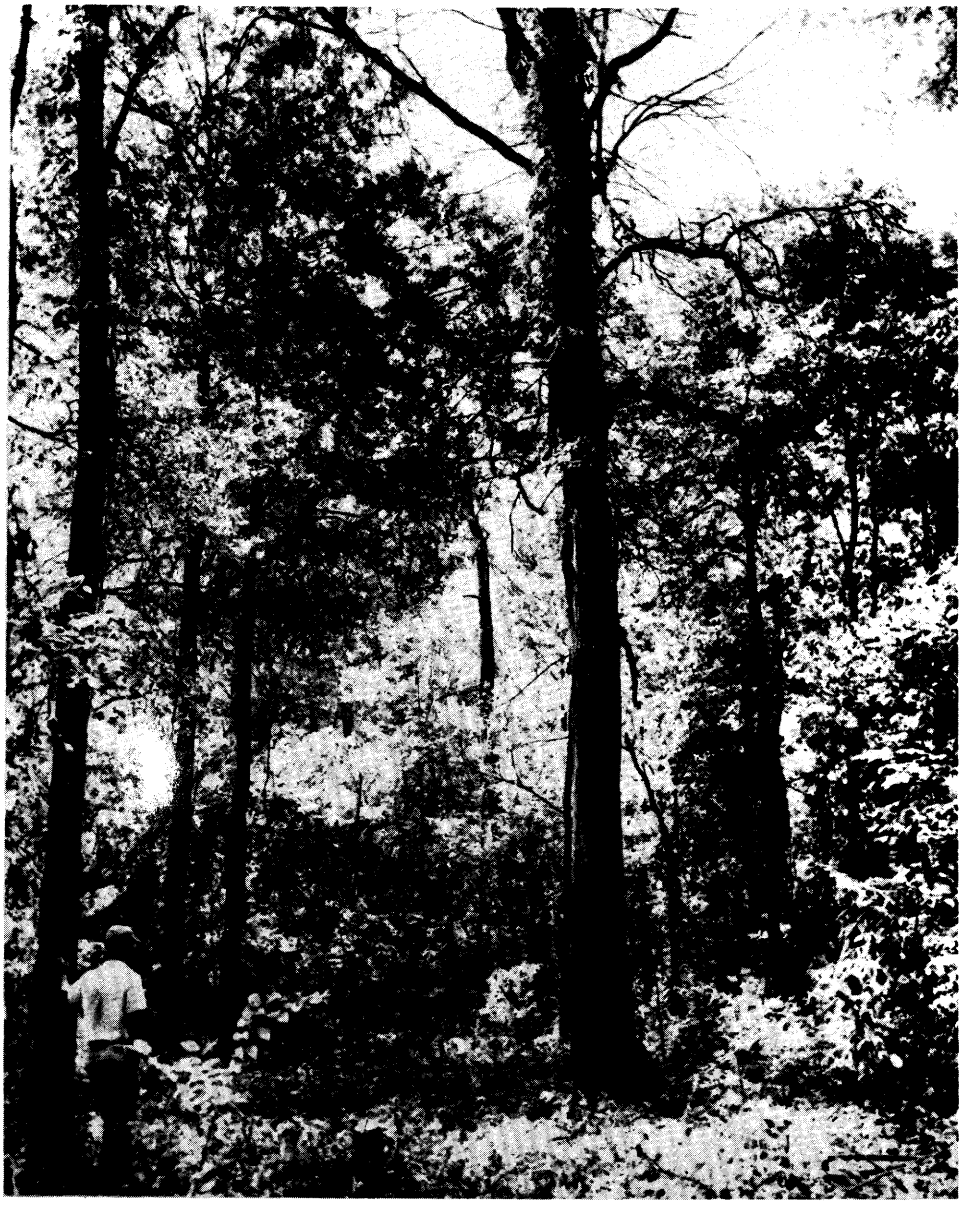

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FIGURE 27.—This cedar elm cull was deadened to provide growing space for pole-size green ash and willow oak.

should take into account the fact that weather usually prevents year-round operation. A period long enough to include two or three normal dry seasons is customary for all but the smallest transactions.

Occasionally, cases of outright fraud may arise. Large, valuable trees that are not marked may be cut and a paint mark placed on the stump. Such deceptions can be detected and proved if the forester has taken the precaution of adding to his paint an unusual chemical or tagged ingredient that can be identified by chemical analysis. Commercial laboratories can furnish such ingredients and perform the analyses.

Culls

Ordinarily it will be best for cull elimination to follow the commercial improvement cut, for then it is easier to identify the trees that should be deadened. Trees ruined in logging can be removed, and advantage may be taken of logging roads and skid trails for access. Not more than a year should elapse between the improvement cut and the deadening operation; otherwise the trails and openings will be grown up in briars, weeds, and brush. In unusual circumstances, as when the commercial cut is heavy and culls are scarce or ground conditions difficult, it is advantageous to have deadening done in advance of or at the same time as commercial harvest.

The cost of girdling or frilling is roughly proportional to tree diameter, but the space occupied by a tree tends to be proportional to its basal area. Thus, it costs about as much to kill two 6-inch culls as it does to deaden one 12-inch tree, but the two smaller trees combined take up only half as much space as the single large tree.

The greatest returns per dollar spent will be obtained by concentrating on large dominant culls (fig. 27) with deadening of small trees restricted to occasional individuals and clumps whose demise will improve or expand the openings made by removal of large trees. Seed-bearing weed trees of all size classes should be deadened, of course.

Trees to be killed should be marked by a well-trained forester or woodsman; the complexity of silviculture and utilization usually makes it impractical to issue general instructions to a labor crew.

Conventional girdles kill tree crowns very satisfactorily, but do not prevent young trees from sprouting. The most popular way of killing culls and inhibiting sprouts is to apply 2,4,5–T in oil or water to a single-hack frill. Oil is recommended because it gives faster, more reliable kills. It has to be transported through the woods, however, while water is often convenient in streams and sloughs. Trees treated in spring seem to die quicker and sprout less than those dosed at other seasons. Whatever method is used, it is vital that frills or girdles be complete enough to sever all cambium. Narrow girdles not treated with chemicals will often bridge over even though the cambium has been completely severed.

The recommended concentration of chemical is the same for water or oil. Commercial preparations of 2,4,5–T low-volatile ester usually contain four pounds of 2,4,5–T acid equivalent per gallon of concentrate. For pouring into the cut surface of a girdle or frill, one part by volume of the concentrate should be mixed with 25 parts of oil or water. An open-topped 5-gallon can with a mark scratched on the inside at the 4-gallon level makes a good mixing vessel. The desired concentration can be obtained by mixing 20 ounces of the concentrate with enough water or oil to bring the liquid up to the 4-gallon level.

Limiting cull-tree control to the larger trees will not improve areas covered with thickets of small weed trees. Some blanket treatment is needed here, but research is required before recommendations can be made. Bulldozing and other means of land clearing with heavy machinery are very expensive, as are basal or foliage sprays. Sprouting from rootstocks is a serious problem, the more so because prompt reproduction of desirable trees cannot always be relied on. Many brushy areas are not so bad as they first seem.

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FIGURE 28.—When he frilled and poisoned this willow oak, the axman failed to chop through the folds of bark at the catface. Three years later, the tree is still flourishing. On good sites a much narrower skip will enable a tree to survive.

Close inspection often reveals desirable saplings, and if there is one free to grow every 12 to 15 feet, the area will be fully stocked by the time the trees reach pulpwood size. Before blanket treatments for such thickets and "brush patches" are employed, their need, effectiveness, cost, and impact on game populations should be appraised.

The 3-man crew suggested for marking the first improvement cut will also be suitable for marking culls. The rate of work will be slower—from 40 to 60 acres per day in winter—because a great many small trees must be examined.

On sizable jobs, six axmen and a supervisor comprise an efficient crew for frilling and applying chemicals. Each axman should be equipped with fibre or metal guards to protect his feet and legs, for this work is more hazardous than timber cutting, and the crews are generally less experienced. To improve the likelihood that all frills will receive chemical, and to minimize lost motion, it is usually best to have each axman carry a can of herbicide and dose each frill as he completes it. If frilling and chemical treatment are done by different men, dye can be added to the solution as a check.

The supervisor should mix the chemical and see that the axmen leave no uncut cambium in the frills and do not miss marked trees. The frill must be continuous, even though a herbicide is used. The tree may live if only a narrow strip of inner bark is left uncut (fig. 28).

Power girdlers, tree injectors, and other new developments are being used for deadening trees. Since responses of individual species may vary with weather and site, local trials should be made before adopting any particular method.

ADVANCED MANAGEMENT

During the early stages of management, accumulations of undesirable growing stock and culls must be removed, and balancing harvest against growth may be neither necessary nor desirable. But once the initial improvement cuts have been made, and before a cycle of cutting based on increment is begun, it is time to calculate a periodic allowable cut somewhat less than or equal to periodic growth. A silvicultural policy must be adopted that will insure good development of immature trees and bring about reproduction when needed.

Some hardwood species, chiefly cottonwood, willow, sweetgum, baldcypress, yellow-poplar, and the tupelos, occur in extensive even-aged stands and may be managed as such. The silvicultural system will usually be seed-tree—perhaps a reserve cutting in which especially desirable individuals are retained not only for seed but to make some valuable growth. (The reserve stand of seed trees should not be so dense as to encourage the development of undesirable tolerant species.) Cottonwood and willow cannot practicably be regenerated naturally by this or any other system, but the riverfront hardwoods that succeed them are usually acceptable.

For most of the remainder of the hardwood forest, some modified system of partial cutting (selection), with limitation of the cut by volume rather than by area, is recommended. The forests at present are primarily many-aged. Conversion to even-aged stands would require uneconomic harvesting of a great deal of immature timber and cutting or deadening of much small but promising growing stock. This stock, if left, would develop into needed sawtimber sizes in a much shorter time than regeneration that might supplant it after cutting. Furthermore, it is doubtful that even-aged stand structure could be either attained or maintained in most hardwood types. The prompt and uniform regeneration of hardwoods of desirable species over sizable operating area is uncommon. Heavy harvest cuts over wide areas under unfavorable conditions can bring about a jungle of vines and trees worthless because of poor form or species. Even if extensive even-aged stands could be established, their maintenance would be almost impossible. Variations in species growth rates, the vigor of individual trees, and the microsite inevitably cause tremendous variations in tree size and economic maturity.

These many-aged forests are composed of small groves of intolerant trees and are actually a mosaic of small, even-aged stands of various ages. Trees or groups should be marked or left on their individual merits. Cleaning, thinning, release, and harvest will be based on consideration of the quality and needs of the individual tree in comparison with those of its neighbors; these considerations may vary even in closely adjoining stands. This application of the so-called principle of "unit-area control" of small patches bears only superficial resemblance to true even-aged management, however, because such areas are not permanent and cannot be used in recordkeeping or for limiting or allocating the harvest.

The principle of regulation appropriate for any system of repeated partial cutting is volume control. The allowable cut for the cutting cycle is determined in units of volume and allocated to classes of trees or areas in need of cutting. Usually, treatments should be scheduled and carried out for entire compartments on the basis of the prevalent tree classes or stand conditions disclosed by on-the-ground examination.

This does not mean that a uniform treatment will be blindly applied to the whole compartment. The type of cutting at any given location will depend only on the class of trees found on that small area. Thus, though stand improvement cuttings might form the major portion of the cut for a compartment as a whole, the treatment on one "unit area" within the compartment may be the harvesting of a very large mature tree with expectation of securing reproduction in the open-

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Figure 29.—Under advanced management, partial cutting and deadening of culls will leave young mixed hardwoods in excellent growing condition. This stand, on the Obion River in western Tennessee, contains chiefly cherrybark oak and sweetgum.

ing that results. On another small area in the same compartment it may be primarily thinning; on still another, principally salvage.

In contrast, cutting in species that form extensive even-aged stands will normally consist of a uniform thinning or harvest over a relatively large area (fig. 29); any other treatment will be secondary. But the trees will still be selected for cutting primarily on their individual characteristics, although judgment will be influenced by spacing. Naturally, any such extensive areas that are distinct in fundamental respects may be taken into account in mapping and recordkeeping.

The terminology of traditional silvicultural systems is difficult to apply to the realities of southern hardwood management. "Selection" and "group selection" are localized "clearcutting" of small "units of area" for purposes of thinning, stand improvement, harvest, or salvage. Literal "clear cutting" harvests are seldom either appropriate or feasible. A common result of applying the most appropriate silvicultural measures to either all-aged or even-aged stands in need of harvest or salvage is to leave a stand that resembles a "shelterwood," but shelter is not desired once regeneration is secured.

The backbone of regulation is the cutting budget, a schedule of areas to be cut and volumes to be removed. The cutting budget should not be a rigid, inflexible plan of action. Silvicultural requirements such as need for salvage, and economic considerations such as market conditions, will invariably necessitate some deviations, as will unusual weather and logging conditions. At the same time, the uncertainty of future events should never be used as an excuse for unplanned, haphazard cutting. A schedule of cutting should lead toward better stocking and stand structure even though unforeseen circumstances may cause detours and temporary setbacks.

Before a cutting budget can be set up, answers are required to the following questions:

1. What is the present stand density, diameter distribution, species composition, merchantability, and distribution of the stands by compartments?
2. What is the present total growth?
3. What is the desired level of stand density, the desired diameter distribution, and the desired species composition?
4. How much of the total growth or increment can be accumulated for the buildup toward stocking goals?

As will be indicated, accurate answers can be obtained for the first two questions, and technical knowledge has progressed far enough so that guiding principles and tentative goals can be offered for the third.

The answer to the fourth question depends largely upon the enlightened policy of the forest owner. The volume left after the original improvement cut will be much less than necessary for optimum sustained yield. A forester naturally will like to retain as much of the growth in standing timber as possible, while owners in need of funds or those with more desirable investment opportunities will insist on cutting a large part of it. Frequently, the tax position of the owner or his wish to defer capital gains and build up an estate makes him amenable to the same policy that pure silviculture would dictate. In any case, owner and forester must firmly establish a policy that will put the stands on the road to satisfactory stocking at some reasonable pace.[6]

Present Stocking

Present stocking and diameter distribution (or stand structure) may be determined from a management inventory made according to procedures described on pages 83–84. However obtained, the inventory data for each compartment should include number of trees and volumes segregated by species group, diameter group, tree class, use class, and sometimes grade within a use class.

The most important information for the regulation of the property as a whole is a stand table showing numbers of desirable growing-stock trees per acre and their volumes per acre by species and diameter class. This table will be compared with those from succeeding inventories as a check on progress toward desired stocking and stand structure; hence, volume estimates must employ comparable procedures and be reasonably precise for the property as a whole. The breakdowns of data by compartments need only be approximate, but will be extremely useful to the forester in planning the details of his cutting operations—where to cut, what to cut, and how to market the material. More exact estimates of volume to be cut may be made by sample-tree measurement at the time compartments are marked for cutting.

Growth

The first step toward obtaining adequate information on growth and stand development should be taken promptly after the initial improvement cut. This would be the establishment of carefully measured permanent observation points or plots throughout the property. Remeasurement of these permanent points before the succeeding cuts will accurately indicate progress toward size, volume, utility, and quality objectives. A method for establishing and using such points is suggested on page 87.

If no advance provision has been made for this procedure (as will necessarily be the case with small tracts), rough estimates to guide the first regulated cut may be obtained by stand-table projection, with the aid of increment-core data collected for this purpose. The great weakness of such projection is ignorance of probable mortality, and of the impact of future salvage and improvement cutting or the lack of it upon growth rate. Until the cutting policy is at least tentatively established, there is also the difficult question of which trees or classes of trees to sample and tally for growth studies. It should be remembered that actual growth may be less than predicted growth if part of the projected growing stock is removed during the period covered by the estimate. It will be greater than indicated past growth if potential mortality can be salvaged.

Since assumptions must be made at this early stage of development, projection of volume by using growth percents (simple interest) usually is the simplest technique and as accurate as any other.[7] If growth percents from comparable stands are available, they can be used to approximate short-term growth. Much general information on growth percents can be gathered from publications of the Forest Survey of the U.S. Forest Service.

Total growth, even if closely estimated, tells nothing about size, utility, or quality of its various components on any given tract, but only a very rough figure is necessary at this stage. It should conservatively represent the probable growth on the desirable growing stock during the expected cutting cycle and serve simply to warn and guide against cutting too heavily into such

[6] A method of reaching a decision is described in: Duerr, W. A., Fedkiw, J., and Guttenberg, S. *Financial maturity: a guide to profitable timber growing.* U.S. Dept. Agr. Tech. Bull. 1146, 74 pp., illus. 1956.

[7] A discussion of the use of simple annual growth percents to calculate allowable cut may be found in: Grosenbaugh, L. R. *Allowable cut as a new function of growth and diagnostic tallies.* Jour. Forestry 56: 727–730. 1958.

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FIGURE 30.—Most managed stands of southern hardwoods will contain trees, either singly or in groups, that vary in size from seedlings to large sawtimber. This stand is on a first-bottom flat of the Mississippi Delta.

growth. Since a major proportion of growth must be left for buildup at this stage, any reasonable estimate of growth will suffice. Before management can progress very far, though, these arbitrary predictions must be replaced by repeated measurements of growth at permanent locations.

Ordinarily, the allowable cut will be computed for the tract as a whole. It will rarely be possible or desirable to operate individual compartments as sustained-yield units—not, at least, until a long course of management has put the stands in near-optimum condition.

After the initial cut, very small ownerships should aim at keeping cut well below growth for the property as a whole, even though regular equal harvests at short intervals may not be possible until good management has been in effect for many years. If permanent growth samples are deemed impractical, an intensive inventory should be made immediately following the initial cut and repeated at long intervals as a check upon the crude interim estimates that have been suggested.

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Stocking and Stand-Structure Goals

Uneven-aged management.—Table 6 is a recommendation, based partly upon experience and judgment, as to desirable stocking and diameter distribution of uneven-aged southern hardwoods on reasonably good sites (fig. 30). Future research may indicate modifications and local adaptations, but meanwhile the table offers a reasonable goal for management.

The distribution indicated cannot, of course, be expected on each acre. Rather it is the aggregate of many different acres or the multitude of "unit areas" within a fairly sizable area. Inevitably some of the area in the aggregate will have only seedlings on it, or will even be unoccupied, awaiting regeneration. Thus, the basal area indicated by the table occupies only a part of the total area, and densities on the occupied part will be greater than the overall average. Finally, it should be apparent that, under this system, there is no fixed rotation age for harvesting stands or trees. The prospective growth rate and the relative value in-

TABLE 6.—*Hypothetical stocking and diameter distribution, with estimated development and yield per acre, for well-managed uneven-aged southern hardwoods on average or better sites* [1, 2]

D.b.h. (inches)	After cutting; beginning of new cycle			Midway of cycle; or average stand			End of cycle; ready for cutting			Cut		
	Trees	Basal area	Volume [3]	Trees	Basal area	Volume [3]	Trees	Basal area	Volume [3]	Trees	Basal area	Volume [3]
	No.	*Sq. ft.*	*Cords*	*No.*	*Sq. ft.*	*Cords*	*No.*	*Sq. ft.*	*Cords*	*No.*	*Sq. ft.*	*Cords*
2	26. 0	0. 58	(4)	36. 0	0. 79	(4)	48. 0	1. 06	(4)	22. 0	0. 48	(4)
4	17. 2	1. 50	0. 2	20. 0	1. 74	0. 3	30. 0	2. 61	0. 4	12. 8	1. 11	0. 2
6	10. 5	2. 07	. 4	13. 0	2. 55	. 5	15. 8	3. 10	. 6	5. 3	1. 03	. 2
8	8. 2	2. 86	. 6	9. 7	3. 39	. 7	12. 2	4. 27	. 9	4. 0	1. 41	. 3
10	7. 0	3. 82	. 8	7. 6	4. 14	1. 0	9. 0	4. 92	1. 2	2. 0	1. 10	. 4
12	6. 5	5. 10	1. 3	6. 8	5. 34	1. 2	6. 6	5. 18	1. 3	. 1	. 08	(4)
Total	75. 4	15. 93	3. 3	93. 1	17. 95	3. 7	121. 6	21. 14	4. 4	46. 2	5. 21	1. 1
			Bd. ft. [5]			*Bd. ft.* [5]			*Bd. ft.* [5]			*Bd. ft.* [5]
14	6. 0	6. 41	312	6. 2	6. 63	322	6. 0	6. 41	312	. 00	-------	0
16	5. 3	7. 40	503	5. 6	7. 82	532	5. 7	7. 96	541	. 40	. 56	38
18	4. 3	7. 60	632	5. 3	9. 37	779	5. 6	9. 90	823	1. 30	2. 30	191
20	3. 2	6. 98	688	4. 3	9. 38	925	5. 3	11. 56	1, 139	2. 10	4. 58	451
22	2. 3	6. 07	678	3. 2	8. 45	944	4. 3	11. 35	1. 268	2. 00	5. 28	590
24	1. 6	5. 03	524	2. 3	7. 23	897	3. 2	10. 06	1, 248	1. 60	5. 03	724
26	1. 1	4. 06	561	1. 6	5. 90	816	2. 3	8. 48	1, 170	1. 20	4. 42	609
28	. 8	3. 42	524	1. 1	4. 70	721	1. 6	6. 84	1, 048	. 80	3. 42	524
30	. 45	2. 21	369	. 80	3. 93	656	1. 1	5. 40	902	. 65	3. 19	533
32	. 27	1. 51	272	. 45	2. 51	452	. 8	4. 47	804	. 53	2. 96	532
34	. 11	. 69	139	. 27	1. 70	329	. 45	2. 83	547	. 34	2. 14	408
36	. 04	. 28	57	. 11	. 78	165	. 27	1. 91	392	. 23	1. 63	335
38	. 02	. 16	28	. 04	. 32	64	. 11	. 95	191	. 10	. 79	163
40	-------	-------	-------	. 02	. 17	34	. 04	. 35	76	. 04	. 35	76
42	-------	-------	-------	-------	-------	-------	. 02	. 19	37	. 02	. 19	37
Total	25. 49	51. 82	5, 287	31. 29	68. 89	7, 636	36. 80	88. 66	10, 498	11. 31	36. 84	5, 211
All trees	100. 89	67. 75	-------	124. 39	86. 84	-------	158. 40	109. 80	-------	57. 51	42. 05	-------

1 Revised from a table appearing in: Putnam, J. A. *Management of Bottomland Hardwoods.* U.S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 116, 60 pp. 1951.

2 The cycle of development illustrated by this table will usually be completed in about 10 years, but may require 8 to 15 years, depending upon site quality.

3 Saw-log volume includes all sound, reasonably straight stems to a 10-inch minimum top diameter, inside bark, at least 12 feet above the stump. Poletimber and topwood are measured in cords of 128 cubic feet of wood, bark, and air. A conversion factor of 80 cubic feet of wood per cord has been assumed. Additional cordwood volume in tops of saw-log trees, not shown, is equivalent to about one cord per thousand board feet log scale or 40 percent of the total cubic volume of such trees.

4 Negligible.

5 Doyle rule.

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FIGURE 31.—This even-aged stand of water and swamp tupelos has reached the stage where a light thinning is necessary to maintain growth. It is on a creek bottom in central Mississippi.

crease of individual trees determine their maturity.

Above all, stand development should be directed towards concentrating growth on large, vigorous, high-grade trees. The aim is to have as many trees of the larger sizes and as few of the smaller sizes as possible—enough, but only enough, of the small ones to furnish replacements for the large ones as they are harvested. In fully developed, intensively managed stands, trees 28 to 32 inches d.b.h. will be the usual mature sizes on reasonably good sites, but some exceptionally good 36-inch or larger trees may be grown another cycle or two for special products like face veneer.

Even-aged management.—The stocking of individual even-aged stands of mixed hardwoods may be judged by table 7. It should be understood that the terminal stocking indicated in the table by even diameter classes is not the conventional maximum implicit in "normal" yield tables. Rather it is the heaviest stocking in which individual well-situated trees can maintain good diameter growth under intensive management. Such stocking is comparable with that of the all-aged table.

Table 7 is thought to be appropriate for most species of normal form in ordinary mixtures and on all but the poorer sites. For cottonwood and willow, which are quite intolerant, basal areas and

TABLE 7.—*Hypothetical stocking and estimated development and yields per acre, for well-managed*

Average d.b.h.			Average basal area			Average number of trees		
All trees	*Leave* trees	*Cut* trees	All trees	*Leave* trees	*Cut* trees	Total	*Leave* trees	*Cut* trees
Inches	*Inches*	*Inches*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*No.*	*No.*	*No.*
2	2.30	1.90	46.2	13.8	32.4	2,120	475	1,645
6	6.55	5.55	93.2	47.3	45.9	475	202	273
10	10.75	8.95	110.2	70.8	39.4	202	112	90
14	14.80	12.45	119.7	85.1	34.6	112	71	41
18	18.85	15.95	125.5	95.0	30.5	71	49	22
22	22.85	19.55	129.4	102.3	27.1	49	36	13
26	26.80	23.50	132.7	105.6	27.1	36	27	9
30	30.70	27.35	132.5	108.0	24.5	27	21	6
34	34.60	31.60	132.4	107.9	24.5	21	16.5	4.5
38	38.50	36.30	130.0	103.1	26.9	16.5	12.75	3.75
42	------------	42.00	122.6	------------	122.6	12.75	------------	12.75

[1] Revised from table appearing in: Putnam, J. A. *Cutting schedule for even-aged bottomland hardwoods.* Jour. Forestry 50: 866–867. 1952.
[2] Duration of each growth period will vary with size of residual growing stock (*leave* trees), site, species composition, and, for first cycle, on time lapse pending reproduction. End of each period is signaled by attainment of specified average size.
[3] Saw-log volume includes all sound, reasonably straight stems to a 10-inch minimum top diameter, inside bark, at least 12 feet above the stump. Pole-

numbers of trees should be reduced 15 to 20 percent. The reduced number of trees of these two species nevertheless will still have about the same tabular volumes, because of their above-average height and form. Sweetgum and yellow-poplar should probably exceed the table by 5 to 10 percent in basal area and number of trees, and even more in volume, because of their better form.

Table 8 is intended specifically for the tupelos but may be roughly adjusted for baldcypress. These species require separate consideration because of their radically different form class, their normally heavier stocking, and their greater average stem length (fig. 31). To approximate baldcypress, the numbers of trees and basal areas for tupelo may be increased by about 10 percent and the volumes by about 15 percent. D.b.n. (diameter above bottleneck) is taken 2 to 2½ feet above the shoulder of the butt swell or flare for these species, and is used in place of the more familiar d.b.h.

Expected yields.—The last columns of tables 6, 7, and 8 may be used to estimate yields from well-stocked stands, provided that some informa-

TABLE 8.—*Hypothetical stocking and estimated development and yields per acre, for well-managed*

Average diameter above bottleneck			Average basal area			Average number of trees		
All trees	*Leave* trees	*Cut* trees	All trees	*Leave* trees	*Cut* trees	Total	*Leave* trees	*Cut* trees
Inches	*Inches*	*Inches*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*No.*	*No.*	*No.*
2	2.30	1.90	56.6	13.3	43.3	2,570	605	1,965
6	6.55	5.55	118.6	50.8	67.8	605	259	346
10	10.75	8.95	141.3	79.5	61.8	259	146	113
14	14.80	12.45	155.8	101.6	54.2	146	95	51
18	18.85	15.95	167.9	118.4	49.5	95	67	28
22	22.85	19.55	176.8	131.1	45.7	67	50	17
26	26.80	23.50	183.3	139.5	43.8	50	38	12
30	30.70	27.35	185.5	143.2	42.3	38	29	9
34	34.60	31.60	183.7	142.9	40.8	29	23	6
38	38.50	36.30	178.7	136.2	42.5	23	17	5
42	------------	42.00	166.2	------------	166.2	17	------------	17

[1] Duration of each growth period will vary with size of residual growing stock (*leave* trees), site, species composition, and, for first cycle, on time lapse pending reproduction. End of each period is signaled by attainment of specified average size.

even-aged southern hardwood stands at end of successive growth periods on average or better sites [1, 2]

Average volumes [3]						Cumulative yields [3]		
Total		*Leave* trees		*Cut* trees		Sawtimber	Poletimber	Topwood
Sawtimber	Poletimber	Sawtimber	Poletimber	Sawtimber	Poletimber			
Bd. ft.[4]	*Cords*	*Bd. ft.*[4]	*Cords*	*Bd. ft.*[4]	*Cords*	*Bd. ft.*[4]	*Cords*	*Cords*
-	16. 1	-	10. 8	-	5. 3	-	16. 1	-
-	23. 5	-	17. 0	-	6. 5	-	28. 8	-
5, 196	7. 0	5, 196	-	-	7. 0	5, 196	18. 8	6. 8
10, 623	-	8, 918	-	1, 705	-	10, 623	18. 8	12. 7
14, 699	-	12, 528	-	2, 171	-	16, 404	18. 8	18. 2
18, 243	-	15, 417	-	2, 826	-	22, 099	18. 8	23. 2
21, 570	-	18, 438	-	3, 132	-	28, 272	18. 8	28. 3
24, 963	-	21, 120	-	3, 843	-	34, 797	18. 8	33. 0
28, 000	-	22, 950	-	5, 050	-	41, 677	18. 8	37. 0
29, 500	-	-	-	29, 500	-	48, 227	18. 8	41. 0

timber and topwood are measured in cords of 128 cubic feet of wood, bark, and air. A conversion factor of 80 cubic feet of wood per cord has been assumed. Aggregate volume of topwood is shown only in last column (no topwood is credited to saw-log-size trees elsewhere in the table).
[4] Doyle rule.

tion is available as to diameter growth rates.

On most sites, the sawtimber portion of all-aged stands will require about 10 years to grow the 4 inches needed to complete a cycle as envisaged in table 6. Differences in average growth capacities of various diameter classes will affect the projection of the diameter distribution, but an approximately constant growth rate in the sawtimber sizes can be maintained by leaving only the most vigorous large trees. Growth rates are seldom such that cycles shorter than 8 years can be sustained indefinitely. Need for cycles longer than 15 years would reflect site and management conditions so unfavorable that the table would not be applicable; a shorter range of diameters and probably lighter stocking would have to be assumed.

In even-aged management, use of the tables would involve variation in cutting-cycle lengths because of the differences in growth rates by diameter classes. Under intensive management, this variation would not be great and will be ignored for convenience. At the same time, about the same range in cycle length relative to site may be

even-aged tupelos at end of successive growth periods on average or better sites [1]

Average volumes [2]						Cumulative yields [2]		
Total		*Leave trees*		*Cut* trees		Sawtimber	Poletimber	Topwood
Sawtimber	Poletimber	Sawtimber	Poletimber	Sawtimber	Poletimber			
Bd. ft.[3]	*Cords*	*Bd. ft.*[3]	*Cords*	*Bd. ft.*[3]	*Cords*	*Bd. ft.*[3]	*Cords*	*Cords*
-	14. 6	-	9. 0	-	5. 6	-	14. 6	-
-	25. 9	-	18. 8	-	7. 1	-	31. 5	-
3, 335	18. 4	3, 335	-	-	18. 4	3, 335	31. 1	4. 3
8, 970	-	7, 935	-	1, 035	-	8, 970	31. 1	10. 8
13, 800	-	11, 615	-	2, 185	-	14, 835	31. 1	16. 3
17, 796	-	15, 042	-	2, 754	-	21, 016	31. 1	22. 1
21, 246	-	17, 940	-	3, 306	-	27, 220	31. 1	27. 2
24, 587	-	21, 016	-	3, 571	-	33, 867	31. 1	32. 2
27, 945	-	23, 794	-	4, 151	-	40, 796	31. 1	36. 0
31, 280	-	-	-	31, 280	-	48, 282	31. 1	38. 4

[2] Saw-log volume includes all sound, reasonably straight stems to a 10-inch minimum top diameter, inside bark, at least 12 feet above the stump. Poletimber and topwood are measured in cords of 128 cubic feet of wood, bark, and air. A conversion factor of 80 cubic feet of wood per cord has been assumed. Aggregate volume of topwood is shown only in last column (no topwood is credited to saw-log-size trees elsewhere in the table).
[3] Doyle rule.

assumed as in all-aged stands, i.e., 8 to 15 years. For cottonwood and willow, however, a cycle of 5 years is considered appropriate.

Futhermore, the time required for regeneration and growth to the 2-inch class will vary radically from place to place and time to time. It may range from 8 to 12 or even 15 years but may be assumed to average 10 years. Hardly half as long will be needed ordinarily for cottonwood and willow.

Estimates of yield from the even-aged tables should also recognize that cutting the weakest, poorest, and smallest trees at the end of each cycle leaves a stand of increased average diameter, and thus represents progress toward the desired terminal diameter. In all-aged stands, this effect is less important, as *cut* and *leave* are shown by specific 2-inch diameter classes rather than by a single average for the entire stand.

In all three tables, the cuts indicated at the end of each cycle leave only enough growing stock to form the next stand without allowance for any mortality. Under the assumed highly skilled and very intensive management, mortality, barring catastrophes, should be small and largely salvaged.

As an aid in using the tables to predict yield, table 9 lists diameter-growth rates that might be expected from unmanaged woods-run hardwoods in favorable competitive positions on average bottom-land sites. The table was derived from original data gathered by the Forest Survey from thousands of sample trees randomly selected from unmanaged, generally abused bottom-land forest.

Under the best intensive management on good sites, the growth rates for the individual species shown in table 9 might eventually be increased 30 percent. The increase for entire stands might be close to 40 percent, because management would improve the species composition. Thus it would not be unreasonable to expect average 10-year diameter growth rates of about 3.5 inches for 6- to 12-inch trees, 4.0 inches for 14- to 18-inch trees, 4.5 inches for 20- to 28-inch trees, and 4.0 inches for trees 30 inches d.b.h. and larger.

TABLE 9.—*Ten-year average diameter growth rates for trees free to grow in unmanaged stands on average bottom-land sites*

Species	Diameter class			
	6–12 inches	14–18 inches	20–28 inches	30+ inches
	Inches	*Inches*	*Inches*	*Inches*
Sweetgum	2.80	2.85	3.05	2.30
Red oaks	3.60	4.30	4.45	3.25
White oaks	2.40	2.50	2.90	2.70
Ashes	2.05	2.30	2.85	2.65
Tupelos	2.85	3.15	3.25	3.00
Pecan	2.60	3.55	3.60	3.10
Cottonwood	6.30	5.85	6.30	4.65
Willow	3.80	5.45	5.50	4.20
Overcup oak	2.05	2.20	2.10	2.15
Water hickory	1.95	2.00	2.30	2.55
Baldcypress (second-growth)	2.30	2.60	3.20	2.70
Miscellaneous rapid growers [1]	3.20	3.30	3.80	3.70
Miscellaneous slow growers [2]	2.00	2.10	2.50	2.30
Average	2.55	2.80	3.00	2.80

[1] American elm, maples, American sycamore, honeylocust, waterlocust.
[2] Cedar elm, winged elm, black tupelo, hickories, sugarberry.

INVENTORY

In the past, most cruises of hardwood land were made in connection with sales, purchases, tax valuation, or accounting. The information gathered was commonly limited to volume by species and area subdivisions, with occasional comments on timber quality and tree size. Strip cruises covering 10 to 20 percent of the property were common, and volumes were often recorded directly in the field, log-by-log or tree-by-tree. Most cruisers memorized the Doyle rule and estimated scaling diameters by assuming an average upper-log taper of 2 inches in 16 feet. Some extremely accurate volume estimates have been and are still being made in this manner, but such cruises do not provide information on basal area, tree size, alternative products, cull trees, or silvicultural considerations.

At present, a common procedure involves a tally of trees on 1/4- or 1/5-acre plots by species, d.b.h., and log length, and conversion of this tally to volume, basal area, and other information by the use of tabled volumes and basal areas. Satisfactory estimates of volume can be obtained in this manner, and stand tables, basal areas, and other useful information can also be obtained in as much detail as desired.

Recently, the popularity of plot cruises has been challenged by a new technique—point-sampling with an angle gage.[8] In the inventory procedures to be described, point-sampling is employed exclusively. Plot techniques are omitted because they are too well known to require description.

As management of a forest progresses, several types of inventories will be required. The sections that follow describe a simple inventory useful for reconnaissance, a method of sampling trees marked for sale, and three systems of periodic inventories for estimating growth and stand development. The first periodic inventory to be described employs only temporary sample points.

[8] Grosenbaugh, L. R. *Point-sampling and line-sampling: probability theory, geometric implications, synthesis.* U.S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 160, 34 pp., illus. 1958.

The other two are based on a combination of temporary and permanent points, but one provides for relocation of individual trees and the other does not.

Simple Inventory for Beginning Management

The reconnaissance preceding the first managed cut should ordinarily be an inexpensive affair. An inspection and sight estimate (with supporting notes, as previously discussed) may suffice for experienced men, though a more formal approach will be necessary for most foresters. The point-sampling technique makes it possible to get approximate estimates of volume with very little effort. If a prism or angle gage with a basal area factor of 10 is employed to select sample trees, 25 sample points distributed systematically over a management unit will usually give a sampling error for board-foot volume of less than 23 percent. The aggregate volume on four management units will ordinarily be estimated within 12 percent two-thirds of the time. The goal is not extreme accuracy but rather rough estimates obtained as quickly and cheaply as possible.

If a more intensive survey is needed, the following tabulation may be used to obtain approximate and usually conservative sampling errors as a percent of total volume:

Points (number)	*Error (percent)*
25	23
50	17
100	12
200	8
400	6
1,600	3

For cruises of the specified intensity, differences between sample volume and volume by 100-percent tally will be exceeded, on the average, in only one cruise in three. Five percent of the time, the difference might be twice the chosen limit, but 50 percent of the time the difference will be less than 68 percent of the tabulated error.

This means, for example, that a cruiser choosing 12 percent as his limit of sampling error may be wrong by more than this amount on one cruise out of three. In fact, one time in twenty his actual error may be more than 24 percent, but half the time his error will be less than 8 percent. In the rare cases where a sample of low intensity might deviate from the true mean considerably, an experienced cruiser will suspect the lack of representativeness and intensify the sampling accordingly.

Whether sample points are located systematically or at random, the area of the tract has little effect on the number of points required for a given sampling error. The important thing is the variability among the aggregate volumes sampled at various points. The tabulation is based on average variation over a large portion of an entire southern State. Errors may be larger in extremely irregular stands and smaller where stands are relatively uniform.

A suggested tally sheet for this simple inventory is shown in figure 32. A single tally sheet is employed for each compartment or other management unit. In the field, the number of 16-foot saw logs in each qualifying sawtimber tree is tallied to the nearest half log under the proper tree class and butt-log grade. A very approximate and usually generous deduction for butt cull from any cause may be made by reducing the merchantable height by twice the length of the cull section. The number of 16-foot pulpwood sticks in each qualifying pulpwood tree is similarly tallied to the nearest half stick in the appropriate space on the form. Cull trees are recorded by dot tally.

Suggested butt-log grades or classes are *prime*, *lumber*, and *minimum*. Prime logs are those that are larger than 17 inches in d.i.b. at the small end and that are grade 1 on all four faces according to the specifications for hardwood log grades for standard lumber. Lumber logs are grade 2 logs (or better) that do not meet the requirements for prime. The minimum class includes all grade 3 factory lumber and all structural logs that cannot meet the requirements for grade 2 or better factory-lumber logs. These grade breakdowns can, of course, be modified. Separating grade 3 factory-lumber logs from structural material may be of more interest to some than the suggested break between prime and lumber.

COMPARTMENT ____________ DATE ______

USE	SPECIES GROUP				
CUT					
PRIME					
LUMBER					
MINIMUM					
PULPWOOD					
CULL					
LEAVE					
PRIME					
LUMBER					
MINIMUM					
PULPWOOD					
STORAGE					
PRIME					
LUMBER					
MINIMUM					
PULPWOOD					

FIGURE 32.—Tally sheet for preliminary survey.

Volumes and basal areas, all on an acre basis, are obtained directly from the field tally as follows:

Volume

1. Sum the logs in each breakdown.
2. Sawtimber (board feet): multiply each sum of logs by 60 times the instrument factor and divide by the number of sample points.
3. Pulpwood (rough cords): multiply each sum of logs by 0.07 times the instrument factor and divide by the number of sample points.

Basal area

1. Count the trees in each breakdown.
2. Multiply the number of trees by the instrument factor and divide by the number of sample points.

Pulpwood volumes are in rough cords and sawtimber volumes are by the International 1/4-inch rule. Doyle volumes can be obtained by first estimating the average tree size and then multiplying it by the corresponding ratio from the following list:

Average d.b.h. (inches)	*Ratio:* $\frac{\textit{Doyle}}{\textit{International}}$
16	0.62
18	.68
20	.74
22	.78
24	.81
26	.83
28	.86
30	.89

The value of this simple inventory can be further enhanced if supplementary observations are made during the field work. Notes or a sample tally might be made on the distribution of trees by diameter classes, the proportion of individual species within the species groups, and any other factors of interest or importance.

Inventory of Trees Marked for Sale

If the material from the first cut is to be sold for a lump sum, an accurate inventory by species and grade is usually advisable. In sales involving less than 500,000 feet, each marked tree should be tallied by diameter and height. In large sales, considerable time and effort is saved by sampling diameter and height (or volume) within broad diameter classes.

A suggested field procedure is outlined here:

1. Estimate and tally the d.b.h. of each marked tree by 4-inch classes.
2. Select sample trees from each broad d.b.h. class and record their d.b.h. to the nearest inch and their merchantable length to the nearest half log.

The average volume per tree for a given 4-inch class is then computed from the appropriate sample trees. Total volume in a class is obtained by multiplying average sample-tree volume by the total number of trees marked and tallied in the broad diameter class.

For a sawtimber sampling error of approximately 3 percent when all marked trees are stratified into 4-inch classes, 200 sawtimber-size sample trees should be measured. The sampling interval for a given tract may be obtained by estimating the total number of sawtimber trees to be marked and dividing by 200. Thus, if it is estimated that 2,000 trees are to be marked, every tenth tree should be taken as a sample tree. To ensure that at least 200 sample trees will be obtained, the estimate of the total number of trees to be marked should be conservative.

Using a single sampling interval for all size classes is not recommended. More reliable results will be obtained with the same number of trees if the larger size classes are sampled more intensively than the smaller ones. Optimum allocation of sample trees by d.b.h. classes can be approximated from the equation

$$F=\left(\frac{\overline{D}-2}{D-2}\right)^2 \times \overline{F}$$

Here, F is the desirable sampling interval for a given diameter class, $\overline{F}$ is the average sampling interval for all trees, estimated in the manner previously described, $\overline{D}$ is estimated average d.b.h. of all trees to be marked, and D is midpoint of the given d.b.h. class.

Thus, an average sample interval of 1 in 10 for a sale with an estimated average tree d.b.h. of 24 inches would be modified as follows:

13- to 17-inch class (upper and lower class limits shown) $F=\left(\frac{24-2}{15-2}\right)^2 \times 10=28$

17- to 21-inch class (upper and lower class limits shown) $F=\left(\frac{24-2}{19-2}\right)^2 \times 10=16$

29- to 33-inch class (upper and lower class limits shown) $F=\left(\frac{24-2}{31-2}\right)^2 \times 10=5$

Every twenty-eighth tree would be taken as a sample tree in the 15-inch class, every sixteenth tree in the 19-inch class, and every fifth tree in the 31-inch class. All sampling intervals should be rounded downwards to the nearest whole tree. Ordinarily, all trees larger than 33 inches should be measured as sample trees.

A variable sampling interval complicates the field work to some extent, but is feasible where a tallyman records for two or more markers on a tally sheet of the form illustrated in figure 33. Space is provided on the left for a dot tally by broad diameter classes, but the tally should employ units corresponding to the sampling interval for the d.b.h. class rather than the usual square of 10 trees. Thus, to continue the previous ex-

SPECIES ______________ DATE ______________

POLE SAMPLE TREES

CLASS LIMITS (Inches)	DOT TALLY	D. B. H.	HEIGHT	VOLUME	D. B. H.	HEIGHT	VOLUME	D. B. H.	HEIGHT	VOLUME
5–9										
9–13										

SAWTIMBER SAMPLE TREES

CLASS LIMITS (Inches)	DOT TALLY	D. B. H.	CULL		PRIME		LUMBER		MINIMUM	
			HEIGHT	VOLUME	HEIGHT	VOLUME	HEIGHT	VOLUME	HEIGHT	VOLUME
13–17										
17–21										

Figure 33.—Tally sheet for trees marked for sale.

ample, the tally unit would be 10 trees for the 21- to 25-inch class and 7 trees for the 25- to 29-inch class. A specimen of the line and dot pattern made by a tally unit for each class should be entered on the tally sheet in ink or colored pencil to aid recognition of sample-tree occurrence. Whenever spaces for sample trees in one diameter class are exhausted, it is advisable to start a new tally sheet for *all* classes to avoid having to manipulate several tally sheets.

The selection of sample trees by a crew in the field is simple. The tallyman dot-tallies the trees as the markers call the diameters by 4-inch classes. When a tally unit is completed, the tallyman calls "sample" and the sample-tree data are recorded. The markers should not know whether a tree is a sample until after they have marked it. The procedure just described will accomplish this purpose when one man tallies for several markers. When a single marker works alone, some device must be used that will select sample trees at random.

For a pulpwood sample tree, the diameter to the nearest inch and the merchantable height are entered in the squares provided. For sawtimber trees, diameters are also tallied to the nearest inch, but the tally of merchantable height may require height estimates to as many as four different points: height of butt cull, height to a prime log top, height to a lumber log top, and height to top of a minimum log. The estimated height to a prime log top should include the length of cull butt; the height to a lumber log top should include butt cull and prime; and the height to the top of the minimum grade log should include cull, prime, and lumber. Thus, for a tree with 8 feet to top of butt cull and with 20 feet (accumulative) to top of lumber log, the 8 feet should be repeated in the prime column, even though the tree has no prime material in it. Also, the 20 should be repeated in the minimum column, even though the tree contains no minimum material. Similarly, for a sample tree with prime, no lumber, but some minimum material, the prime height should be repeated in the lumber columns. The reason is that volumes will be calculated by subtraction, and for $V_1 - V_2$ to equal zero, V_2 must be the same as V_1.

The units in which heights are tallied should, of course, correspond to those of the volume table to be used.[9] International ¼-inch and cubic volumes for height intervals of 1 foot or more may be obtained from Grosenbaugh's giant-tree table.[10] A similar table for the Doyle rule is given in the appendix. The giant-tree tables are based on a constant upper-log taper of ⅛ inch per foot. Conventional volume tables employing variable upper-log tapers are not appropriate when total volume is partitioned into portions appropriate to different segments of the tree.

Occasional difficulty will be experienced with grade inversions. For example, consider a three-log tree with a butt log of lumber quality, a second log of prime, and a third of minimum grade. The tree should be tallied as two logs to a prime top and three logs to a minimum log top or as two logs to a lumber top and three logs to minimum log top. The lower logs can be considered either as both prime or both lumber, as the interests of the owner dictate. This procedure is far from ideal, but alternative methods are more complicated. Fortunately, grade inversions are so infrequent in hardwoods that the distribution of volume by grade will not be seriously disturbed.

A similar difficulty arises when upper-log cull lies between merchantable volumes. The recommended procedure here is to subtract 1½ times the length of such cull sections from the merchantable heights. The procedure is not exact, but again complicated alternatives do not appear worth while. Most cull in southern hardwoods is caused by fire and occurs at the base of the tree.

Once the field work is completed, the first step in the office computations is to look up the volume or volumes for each sample tree, and enter them in the squares provided on the field sheets. The computation of total volume by grade for a given species-diameter class is then:

1. Add the sample-tree pulp volumes.
2. Divide by the number of sample trees.
3. Multiply by the number of trees tallied in the class.
4. Repeat for butt cull, prime, lumber, and minimum.

The volumes obtained are total butt cull, gross prime, gross lumber and better, gross minimum and better, and gross pulp. Net sawtimber volumes by use-class may be obtained by subtraction:

Net prime = gross prime less cull.

Net lumber = gross lumber and better less gross prime.

Net minimum = gross minimum and better less gross lumber and better.

Another method of handling butt cull in the field for sawtimber trees is to reduce sawtimber lengths of stem by the length of cull and then reduce the d.b.h. measurement by 1 inch for each 6 feet of cull. When necessary, the d.b.h. should also be corrected for abnormal or exceptional butt swell that often accompanies rot. This rule is accurate enough for practical use with all species. In principle, however, a smaller reduction in d.b.h. is in order for a form class higher than 75, and vice versa. The computation of volume by grade proceeds as before, except that cull volumes do not enter. This alternative procedure may be preferable where accurate d.b.h. stand tables or basal areas are not desired.

The sampling error of 3 percent applies only to the grand total volume of net minimum and better[11] for all trees marked. The error applicable to a given species-diameter (4-inch classes) breakdown for net minimum and better can be approximated from the equation:

$$\text{Percent error} = 40\sqrt{\frac{N-n}{Nn}}$$

where N is total number of trees tallied in the class and n is number of sample trees in the class.

Periodic Inventories With Temporary Sampling Points

Once intensive management has begun, the importance of periodic inventories can hardly be overemphasized. Timber growing is an enterprise in which the product and the productive machinery are one and the same. With accurate and detailed inventory data, the forest manager can balance cut with growth. Changes in the structure of the forest become apparent, and policies can be formulated against a background of facts instead of opinions and guesses.

The system of periodic inventory to be described uses temporary sampling points with sample

[9] Suitable tables for estimating a single total cubic volume for a tree will be found in: Mesavage, C. *Tables for estimating cubic-foot volume of timber.* U.S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 111, 71 pp. 1947.

[10] Grosenbaugh, L. R. *New tree-measurement concepts: height accumulation, giant tree, taper and shape.* U.S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 134, 32 pp. 1954.

[11] The sampling errors appropriate to various portions of volume in each grade will be larger than those computed for the total minimum and better volume. The errors could be computed from the field data, but a description of the technique is beyond the scope of this publication.

trees measured for volume and grade. It is simple and inexpensive, but it does not obtain reliable information on growth over short intervals as efficiently as do the more complicated systems discussed later.

The tally sheet in figure 33 is suitable. Three sheets will be necessary for each species group—one for *cut* trees, one for *storage*, and one for *leave*.

The field procedure is very similar to that for the inventory of marked trees. Trees qualifying according to the prism are dot-tallied by 4-inch diameter classes on the proper species-tree class sheet. Cull trees may be dot-tallied in the spaces around the diameter-class legends for the *cut* class. Every fifth tree in each diameter class is selected in some unbiased manner as a sample tree and the sample-tree data are recorded exactly as described previously. A sampling interval varying by diameter class is unnecessary here, because trees tallied with an angle gage are already selected with frequency proportional to basal area.

A prism with a basal area factor of 10 is recommended. Careful work is required for good results. Doubtful trees must be checked by measuring tree diameter and the distance from the sampling point to the heart center of the tree. If the ratio of distance in feet and tenths to diameter in inches is less than 2.75, the tree should be tallied.

After the field work is completed, the first step in computing total volume for species-diameter-tree class groups is to obtain $\frac{\text{volume}}{\text{basal area}}$ ratios for the sample trees. Time will be saved if the volume tables to be used are converted to $\frac{\text{volume}}{\text{basal area}}$ ratio tables by dividing each tabulated volume by the appropriate basal area. The ratios for each sample tree can then be taken from the tables and entered on the tally sheets in the columns headed *volume*. Next, the sum of the ratios of volume to basal area for each diameter class is computed for cull, gross prime, gross lumber and better, gross minimum and better, and gross pulpwood. Finally, the ratio of the total number of trees tallied in the group to the number of trees measured for volume is used to convert the sum of ratios to volume per acre, thus:

$$V=\left(\frac{N}{n}\right)\left(\frac{F}{E}\right)R$$

where V=volume per acre
R=sum of ratios of volume to basal area for the species-diameter-tree class group
N=total number of trees tallied in the group (including those sampled for volume and those merely tallied)
n=number of sample trees measured for volume in the group
E=number of temporary sampling points
F=basal area factor

For example suppose that 16 red oaks are tallied as *leave* trees in the 29- to 33-inch diameter group and that three of them are sample trees with the following ratios of Doyle volume to basal area for gross minimum and better:

$$\text{Tree No. 1: } \frac{752 \text{ bd. ft.}}{4.91 \text{ sq. ft.}}=153.2$$

$$\text{Tree No. 2: } \frac{818 \text{ bd. ft.}}{5.24 \text{ sq. ft.}}=156.1$$

$$\text{Tree No. 3: } \frac{1{,}023 \text{ bd. ft.}}{5.58 \text{ sq. ft.}}=183.3$$

$$492.6$$

If 100 sample points were occupied, and the basal area factor of the prism was 10, the estimate of the average volume of minimum and better for the group would take the form:

$$V=\left(\frac{16}{3}\right)\left(\frac{10}{100}\right)492.6=262.7 \text{ bd. ft. per acre}$$

The computations are repeated for cull, gross prime, and gross lumber and better. Net volumes by grade are obtained by subtraction.

No flat recommendation can be given as to the number of sampling points. The tabulation on page 83 may be used to obtain approximate sampling errors in percent of total volume for numbers of sample points varying from 25 to 1,600.

If the difference between two consecutive independent inventories is to be used to estimate net growth, the sampling error for growth will be approximately 1.4 times as large as the error for the original volume estimate *where both errors are in units of volume*. For example, if a cruise of a tract shows 5,000 board feet per acre with a standard error of 5 percent, the error applicable to growth as estimated from two cruises would be 1.4×0.05×5,000 or 350 board feet per acre for the whole period.

Periodic Inventories With Temporary and Permanent Sampling Points

The system just described can readily be adapted to a combination of permanent and temporary points. It will then supply a good estimate of present volume at a reasonable cost. Remeasurement of the permanent points will furnish a sensitive and reliable estimate of growth and of stand and tree development at reasonably short intervals.

Two changes are required:

1. Every fifth point is monumented as a permanent sampling point. Monuments should be as inconspicuous as is compatible with reasonably certain relocation.

2. All trees tallied at the permanent points are taken as sample trees but no volumes are taken at the temporary points (i.e., dot-tally only, by species, tree class, and diameter class).

After the field work is completed, two quantities must be calculated: Class sample volumes per acre, computed from the permanent points alone; and adjusted class volumes per acre, based on both temporary and permanent plots. The class sample volumes per acre are computed as follows:

$$\text{Class sample volume per acre } (S) = \frac{FR}{P}$$

where R is the sum of the $\frac{\text{volume}}{\text{basal area}}$ ratios for a given grade in a given species-tree class-diameter group, P is the number of permanent sampling points, and F is the basal area factor of the prism or angle gage employed.

Adjusted volumes are obtained by multiplying the class sample volumes by the appropriate factor $\left(\frac{N+n}{n}\right)\left(\frac{P}{P+E}\right)$, where N is the total number of trees tallied at temporary points, E is the total number of temporary points, n is the number of trees tallied at permanent points, and P is the number of permanent points. Two or more classes must be combined when there are no sample trees in one of them. The adjusted class volume computations may be illustrated by means of the red oak trees from page 87. If 20 of the 100 sample points were monumented as permanent points, the class sample volume per acre (based on 3 tallied trees) would be

$$\frac{10}{20} \times 492.6 \text{ or } 246.3 \text{ bd. ft.}$$

and the corresponding adjusted class volume per acre would be

$$\left(\frac{13+3}{3}\right)\left(\frac{20}{20+80}\right)246.3 \text{ or } 262.7 \text{ bd. ft.}$$

The suggested minimum interval for remeasurement of the permanent points is 5 to 7 years. The field procedure for remeasurement is the same as that followed at the time of installation, except that cull lengths are not tallied and only one height (to a minimum-log top) needs to be estimated for sawtimber trees. Changes in cull percent and grade of individual trees will ordinarily be too small to detect until several remeasurements have been made.

After each re-inventory, the formula $S=\frac{FR}{P}$ is used to compute new sample gross class volumes per acre for pulpwood and minimum and better classes of trees. Adjusted current gross class volumes per acre are then calculated by multiplying each new sample gross volume by the same $\left(\frac{N+n}{n}\right)\left(\frac{P}{P+E}\right)$ used in the initial inventory. New net volumes are computed by applying cull percentages from the initial inventory. Net change (or survivor growth plus ingrowth less mortality less harvest) may then be obtained as the difference between original volume and current volume.

After the permanent sample points have been remeasured three to five times, a completely new set of temporary and permanent plots should be established by the same field and office procedure as in the initial installation. The purpose here is twofold: First, to obtain new adjustment factors; second, to obtain a complete new sample more closely correlated with the existing stand.

Periodic Inventories With Relocation of Sample Trees

If the individual sample trees at the permanent points are mapped or numbered so that they can be identified at subsequent remeasurements, growth data can be collected in great detail. Net growth can be separated into its components—survivor growth, ingrowth, mortality, and harvest. Computation of growth by tree class—*cut*, *leave*, and *storage*—also becomes feasible, as does calculation of survivor growth by diameter classes. In addition, growth rates and changes in grade and tree class can be followed for individual trees.

The computations, while not complex, are so voluminous that the data had best be processed on punchcards in modern business machines.

Field Procedure

The field procedure is similar to that described for use where sample trees are not relocated. Point-sampling with the same angle gage is employed, with every fifth point monumented for relocation. All trees tallied at the permanent points are taken as permanent sample trees and all qualifying permanent sample trees should be tallied, even those as small as one-tenth inch in d.b.h.

A map is prepared for each permanent point to show the approximate location of the sample trees. The mapping may be done by eye, as great precision is not required except where similar trees are close neighbors. No more than 10 trees will be tallied at most points, and the variety of species and range of diameters and other characteristics common in hardwoods will aid identification in doubtful cases.

Mapping rather than numbering with tags or paint is recommended for two reasons. First, the field work is simplified; there are no tags to keep

COMPARTMENT__________ PLOT__________ DATE __________

TREE NO.	CLASS	SPECIES	D.B.H.	FORM	CULL	PRIME	LUMBER	MINIMUM	PULPWOOD	USE

Figure 34.—Tally sheet for mapped permanent points.

in order and no painting paraphernalia to be carried. Second, the sample trees are much less conspicuous; this greatly reduces the possibility of vandalism and makes bias in the growth figures caused by cutting the plots differently from the rest of the tract unlikely.

A tally sheet for the mapped permanent points is illustrated in figure 34. One tally sheet is used for each plot, one line for each tree. The entries to be made under each heading will be described in detail.

Tree Number.—The first tree tallied at each point is numbered 1, starting from north and proceeding clockwise. The number on the tally sheet also identifies the tree on the map of the permanent point.

Tree Class.—Each tree larger than 5 inches is classified as *cull*, *cut*, *storage*, or *leave*. Key punching will be simplified if coded entries are made in the field, possibly

Cull	0
Cut	1
Storage	2
Leave	3

Species.—Again the office work can be simplified by coded entries in the field.

D.b.h.—All diameters are measured and rounded downwards to the first integral tenth inch below the actual measurement. Thus, if a d.b.h. were 10.39, it would be recorded as 10.3, as would a d.b.h. of 10.31. Such rounding permits combining tenth-inch classes into larger classes having nominal midpoints at whole inches. Thus the 10-inch class will be composed of all trees in classes 9.5 to 10.4 inches, and the class limits will be 9.5 to 10.5 inches.

The diameters of all trees should be measured at exactly breast height, regardless of swollen butts or other abnormalities, because point-sampled growth estimates may be seriously in error unless diameter values are at breast height and strictly comparable from remeasurement to remeasurement. The lessened accuracy of the volume estimates caused by use of an arbitrary d.b.h. rather than d.b.n. (diameter above bottleneck) for swell-butted species must be accepted. The type of inventory described here is designed to obtain much information useful in management, but is not intended to furnish precise estimates of volume for sales or purchases.

Each stem of a tree forked below breast height is tallied as a separate tree. The stems of trees forked between 4.5 and 12 feet are also tallied as separate trees, but the diameter of the tree at breast height is recorded for each. Trees forked above 12 feet are tallied as single trees (fig. 35).

Form.—An average Girard form class (the d.i.b. at the top of the first 16-foot log as a percentage of d.o.b. at breast height) may be assigned for each species, except baldcypress and tupelo. For these two species, form class should be estimated tree by tree.

Individual estimates should also be made for forked trees and for trees with abnormal swell. A form class is estimated for each stem of a tree forked below 12 feet, but the top of the first log is taken as 16 feet above the fork. Thus, the form class for such stems is the d.i.b. 16 feet above the fork expressed as a percentage of d.o.b. at breast height.

The tree-by-tree estimates of form class required for baldcypress, tupelos, or other swell-butted trees, or for forked trees, are best obtained by working back from an estimate of d.i.b. at the top of the first log (fig. 36). Direct estimation of form class is difficult for these odd-shaped trees.

Cull.—Length of butt cull is estimated to the nearest even foot. The punky butts of baldcypress and tupelo normally left in the woods are tallied as cull.

Prime, Lumber, Minimum, Pulpwood.—Usable length of the tree is recorded to the nearest even foot for all classes of trees. The lengths of cull

F—486585, 486588, 486587

FIGURE 35.—Forked trees require special handling in tallies.

butts and other cull sections are deducted before the lengths are entered on the tally sheets.

Use.—For each tree, a notation should be made as to the most important class of usable material it contains:

None	0
Pulpwood	1
Bolts or staves	2
Sawtimber	3

The above discussion applies only to the trees sampled at permanent points. At the temporary points, qualifying trees larger than 5 inches are dot-tallied by species and tree class in 4-inch diameter classes. A suitable tally sheet is shown in figure 37. A single tally sheet is used for each compartment. Culls and weeds may also be tallied at the temporary points if so desired.

F-486586

FIGURE 36.—Form class is estimated tree by tree for swell-butted species like baldcypress.

Working Up the Data

The procedures to be described rely almost entirely on punchcard, data-processing machines. Relatively simple equipment such as key punch, sorter, reproducer, and multiplying punch is utilized. Nevertheless, any organization using the system should have at least one forester familiar with the capabilities and operational features of such equipment, even though machine work is ordinarily contracted.

The first step in organizing the data is to keypunch the information from the permanent-point tally sheets onto cards—a separate card for each tree. All information except diameter is punched as recorded in the field. As the diameter tallied for each tree is the lower limit of the tenth-inch class in which the tree falls, 0.05 must be added to bring this lower limit to the midpoint of the class. The addition is performed by expanding the three-column d.b.h. code to four columns and gang-punching a 5 into the additional column.

A diameter-group code for the sample trees at permanent points may also be entered at this time by sorting on the first two d.b.h. columns and punching:

Code	*Lower limits of diameter-class groups (inches)*
0	less than 05
1	05, 06, 07, 08
2	09, 10, 11, 12
3	13, 14, 15, 16
4	17, 18, 19, 20
5	21, 22, 23, 24
6	25, 26, 27, 28
7	29, 30, 31, 32
8	33, 34, 35, 36
9	37, 38, 39, 40+

Basal area is obtained after sorting by compartment and gang-punching compartment acreage (A), number of permanent sampling points in a compartment (P), and number of temporary sampling points in a compartment (E). Cards are next sorted for trees at permanent points within a compartment by species, tree class, and diameter group and punched with the number of trees (n_i) tallied in each breakdown. Then the numbers of trees (N_i) tallied in corresponding strata on the tally sheets for the temporary points are summarized. Finally, (n_i) and (n_i+N_i) are punched on each sample-tree card in the i^{th} stratum. The basal area B represented by each permanent sample tree is computed from the formula:

$$B=\left(\frac{N_i+n_i}{n_i}\right)\left(\frac{A}{P+E}\right)F \text{ for trees larger than 5 inches}$$

$$B=\left(\frac{A}{P}\right)F \text{ for trees smaller than 5 inches,}$$

where F is the basal area factor for the angle gage employed.

For example, the basal area represented by a 30-inch red oak *leave* tree in a 1,500-acre compartment with 80 temporary points and 20 permanent points would be

$$\left(\frac{13+3}{3}\right)\left(\frac{1{,}500}{20+80}\right)10=800 \text{ sq. ft.}$$

if 13 such trees were tallied at the temporary points and 3 were measured at the permanent points. The basal area represented by a tree less than 5 inches in d.b.h. tallied at a permanent point in the same compartment would be

$$\left(\frac{1{,}500}{20}\right)10=750 \text{ sq. ft.}$$

COMPARTMENT____________ DATE____

CLASS LIMITS (Inches)	SPECIES							
	CUT	LEAVE	STORAGE	CUT	LEAVE	STORAGE	CUT	L
5—9								
9—13								
13—17								
17—21								
21—25								
25—29								

Figure 37.—Tally sheet for temporary sampling points.

Number of trees (M) represented by each sample tree is computed from the formula

$$M=\frac{183.3\ B}{(\text{d.b.h.})^2}$$

The number of trees represented by the 30-inch red oak in the preceding paragraph would be $\frac{183.3\times 800}{900}$ or 162.9 trees.

The procedure suggested for computing volumes per tree involves calculating first-log diameter as a function of d.b.h., length of butt cull, and form class. First the cards are sorted by use, and the unusable trees are removed. Then the following operation is performed on a calculating punch or similar machine:

$$D=16\ Q\ (\text{d.b.h.})-2\ C$$

where Q is Girard form class $\frac{\text{d.i.b. at 17 ft.}}{\text{d.b.h. (o.b.)}}$ and C is length of butt cull.

Pulpwood volumes are approximated from the formula:

$$V_P=\frac{(D+28-L)^2\ LM}{46{,}937}$$

where V_P is volume per tree in cubic feet inside bark, L is usable length in feet to a pulpwood top, and M is number of trees. The volume computations for 10.5-inch tree with a form class of 0.75, 4 feet of butt cull, and 32 feet of usable length, would be

$$D=(16\times 0.75)\ (10.5)-(2\times 4)=118$$

and

$$V_P=\frac{(118+28-32)^2\ 32}{46{,}937}=8.86 \text{ cu. ft.}$$

Results, coded as necessary are rounded and punched into four columns.

Board-foot volumes per tree can be computed according to Doyle or International 1/4-inch rule by using one of the following formulae:

$$V_D = \frac{(D-48-L)^2 LM}{4{,}096}$$

$$V_I = \frac{(D-L)^2 LM}{5{,}120}$$

where V_D is board-foot volume by the Doyle rule, and V_I by the International 1/4-inch rule. L again is usable length, but to a prime, lumber, and minimum-log top in turn. Volumes are computed for each grade, coded, and punched into four columns. The volumes are cumulative and must be differenced to show volume in each category.

The computations are now complete, and volume, basal area, and number of trees may be tabulated as desired. When uncoded, results will be totals for the tract or compartment.

Remeasurement of Permanent Points

It is suggested that the permanent points be reinventoried at intervals of 3 to 5 years. No new trees are tallied during these remeasurements. All information on growth is obtained from trees measured when the points were established.

Before the field work is begun, the following information from the original tree cards is listed on business-machine paper in compartment, plot, and tree order:

Compartment number
Plot number
Tree number
Species
D.b.h.
Tree class
Use

Each plot can be regarded as a separate list of trees, and each such list can be used as a plot tally sheet. Some additional headings will be required on these tally sheets:

Growth component
Current tree class
Current d.b.h.
Current form class
Current cull
Current usable length to a prime top
Current usable length to a lumber top
Current usable length to a tie or timber top
Current usable length to a pulpwood top
Current use class

Under "Growth component," all trees are classified into 6 categories:

Dead	0
Harvested	1
Pulpwood ingrowth	2
Pulpwood survivor	3
Sawtimber ingrowth	4
Sawtimber survivor	5

No data are needed for dead and harvested trees except identification and notation (by appropriate original tree number) as to growth component. Current tree class and current d.b.h. are recorded for all surviving trees. Cull is estimated for those trees that have developed it since the first inventory, and appropriate usable lengths are recorded for trees that have reached pulpwood size or grown from pulpwood into sawtimber. Current values of cull for trees with cull at the first inventory and present usable lengths for trees whose use class remains unchanged will be obtained by projecting old values. Field estimates of stem length and cull are not sufficiently precise to measure change over a short time. Current form class is not needed.

After the completion of the field work, a second set of tree cards is prepared. The following data are punched from the old tree cards into the new:

Compartment number
Plot number
Species
Old tree class
Old d.b.h.
Old form class
Old cull
Old usable lengths to pulpwood, minimum-log, lumber, and veneer tops
Old use class
Old d.b.h. group code
Old number of trees

Information from the re-inventory tally sheets is added to the new cards by key-punching. Current cull and current usable lengths are left unpunched where not tallied in the field. Current d.b.h. is key-punched for all trees as three columns (inches and tenths), with a fourth column gang-punched with the digit five as previously described (to denote the nominal midpoint of the tenth-inch class). Old form class is reproduced as current form class for surviving trees.

Current cull will have been key-punched for originally sampled submerchantable trees which have become merchantable subsequent to previous tally, and also for survivors that were sound at the original inventory but now have cull. For survivors that still are free of cull, current cull is gang-punched as zero.

For trees with cull at the first inventory, the procedure is to sort for cards that are not 00 in the old cull columns and apply the equation where

$$C' = C + 0.13Y$$

C' is length of current cull in feet, C is length of old cull in feet, and Y is the number of years since original measurement. The value of 0.13 is an average yearly rate of cull increase in feet for southern hardwoods.

Current usable lengths not already entered by key-punching are obtained by projecting old usable lengths parallel with length-over-diameter curves prepared from the data taken in the first inventory. Separate curves should be made for pulpwood, prime, lumber, and minimum-class logs, but all species may be combined. As the curves will be used only to obtain the increase in usable length from one diameter to another, their general level is not important and differences in slope and curvature between species are usually minor.

Preparation of the curves can be facilitated by first sorting the old tree cards into 2-inch diameter classes and tabulating the usable lengths on a business machine. Average lengths are then computed by hand for each class. Curves are fitted to the data, either by least squares or by the method of selected points, with equations of the form

$$L=b_0+b_1\ (\text{d.b.h.})+b_2\ (\text{d.b.h.})^2$$

where L is in turn usable length to a pulpwood, prime, lumber, and minimum-log top; d.b.h. is old diameter at breast height and the b's are coefficients determined from the data. The actual projections are accomplished on the computer by use of the modified formula:

$$\text{Current } L=\text{Old } L + \text{Old } C - \text{Current } C + b_1\ (\text{D.B.H.-d.b.h.}) + b_2\ [(\text{D.B.H.})^2 - (\text{d.b.h.})^2]$$

where d.b.h. is old diameter and D.B.H. is current diameter. Since the coefficient b_0 is not used in projecting lengths, only b_1 and b_2 need be computed in fitting the original curve.

The number of trees (M) represented by each sample tree remains unchanged from the first inventory.

Current basal area represented by each surviving sample tree is computed from the formula:

$$B=0.005454\ M\ (\text{D.B.H.})^2$$

where B is the basal area represented by each sample tree
and M is old (and current) number of trees.

Current first-log diameters and volumes are computed for all surviving trees by use of the same formulae employed in the first inventory. The values inserted are, of course, present values of D.B.H., cull, and usable length.

Subsequent Inventories

After the permanent sample points have been remeasured 3 to 5 times (10 to 20 years after the initial establishment), a new set of temporary plots should be installed and the original permanent points should be completely re-inventoried by the same field and office procedure as in the original installation. The main objects will be to get a more precise estimate of current volume and stand structure and to obtain a new base for future estimates of growth. An additional reason for a fresh start at intervals is to include a component of growth neglected in remeasuring only the old sample trees. After 10 years or more, an appreciable number of trees that were less than 4.5 feet tall at the time of the first inventory will have grown into pulpwood size; such trees are not represented among the old sample trees.

SELECTED BIBLIOGRAPHY

ANONYMOUS.
1943. GERMINATION OF SEEDS: FIELD GERMINATION OF VARIOUS HARDWOODS. Amer. Nurseryman 77(6): 32.

ABELL, C. A.
1935. RESULTS OF 1924 CLEANINGS OF COVE HARDWOODS, PISGAH NATIONAL FOREST. Jour. Forestry 33: 626–627.

ARBOGAST, C. F.
1947. YOUNG HARDWOOD CROP TREES CAN BE SELECTED. U.S. Forest Serv. Lake States Forest Expt. Sta. Tech. Notes 281, 1 p. [Processed.]

AIKMAN, J. M.
1934. THE EFFECT OF LOW TEMPERATURE ON THE GERMINATION AND SURVIVAL OF NATIVE OAKS. Iowa Acad. Sci. Proc. 41: 89–93, illus.

ALLEN, R. M., and MCCOMB, A. L.
1956. ROOTING OF COTTONWOOD CUTTINGS. U.S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 151, 10 pp., illus. [Processed.]

AUTEN, J. T.
1937. SITE REQUIREMENTS OF YELLOW POPLAR. U.S. Forest Serv. Central States Forest Expt. Sta., Sta. Note 32, 13 pp. [Processed.]

BAKER, F. S.
1921. BLACK WALNUT: ITS GROWTH AND MANAGEMENT. U.S. Dept. Agr. Bul. 933, 43 pp., illus.

BARRETT, L. I., and BUELL, J. H.
1941. OAK TOPWOOD VOLUME TABLES. U.S. Forest Serv. Appalachian Forest Expt. Sta. Tech. Note 48, 3 pp. [Processed.]

BEAUFAIT, W. R.
1955. SOIL PROFILE OBSERVATIONS RELATING TO DROUTH DAMAGE IN BLACK WILLOW STANDS. Jour. Forestry 53: 517.

———
1956. INFLUENCE OF SOIL AND TOPOGRAPHY ON WILLOW OAK SITES. U.S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 148, 12 pp., illus. [Processed.]

——— and JOHNSON, R. L.
1956. 15-YEAR RESULTS OF IMPROVEMENT CUTTING IN BOTTOMLAND HARDWOODS. Miss. Agr. Expt. Sta. Inform. Sheet 547, 2 pp., illus.

——— and NELSON, T. C.
1957. RING COUNTS IN SECOND-GROWTH BALDCYPRESS. Jour. Forestry 55: 588, illus.

BESLEY, L.
1941. PRACTICAL FOREST MANAGEMENT FOR THE CUT-OVER HARDWOOD LANDS IN SOUTHERN WEST VIRGINIA. W. Va. Agr. Expt. Sta. Bul. 300, 56 pp.

BETTS, H. S.
1945. AMERICAN WOODS SERIES. U.S. Dept. Agr., Forest Serv. Rev. 1954.

BISHOP, G. N., and NELSON, T. C.
1955. A WINTER KEY TO THE HICKORIES OF GEORGIA. U.S. Forest Serv. Southeast. Forest Expt. Sta. Res. Note 89, 2 pp. [Processed.]

BROADFOOT, W. M.
1951. FOREST PLANTING SITES IN NORTH MISSISSIPPI AND WEST TENNESSEE. U.S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 120, 15 pp., illus. [Processed.]

———
1958. STUDY EFFECTS OF IMPOUNDED WATER ON TREES. Miss. Farm Res. 21(6): 1–2, illus.

——— and KRINARD, R. M.
1959. GUIDE FOR EVALUATING SWEETGUM SITES. U.S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 176, 8 pp., illus. [Processed.]

——— and TOOLE, E. R.
1956. SOIL FACTORS MAY CAUSE GUM BLIGHT. U.S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 106. [Processed.]

——— and TOOLE, E. R.
1958. WHAT'S CAUSING THE MORTALITY IN HARDWOODS? Jour. Soil and Water Conserv. 13: 276–277, illus.

——— and TOOLE, E. R.
1959. HARDWOODS RECOVERING FROM DROUGHT. U.S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 119. [Processed.]

BROWN, C. A.
1943. VEGETATION AND LAKE LEVEL CORRELATIONS AT CATAHOULA LAKE, LOUISIANA. Georg. Rev. 33: 435–445, illus.

BROWN, J. W.
1939. RESPIRATION OF ACORNS AS RELATED TO TEMPERATURE AND AFTER-RIPENING. Plant Physiol. 14: 621–645, illus.

BUELL, J. H.
1940. EFFECT OF SEASON OF CUTTING ON SPROUTING OF DOGWOOD. Jour. Forestry 38: 649–650, illus.

BULL, H.
1945. DIAMETER GROWTH OF SOUTHERN BOTTOMLAND HARDWOODS. Jour. Forestry 43: 326–327.

———
1949. CYPRESS PLANTING IN SOUTHERN LOUISIANA. South. Lumberman 179(2249): 227–230, illus.

BURKE, H. D.
1956. GAME HABITAT AND THE MULTIPLE USE OF SOUTHERN FOREST RANGES. Jour. Range Mangt. 9: 164–166.

CAMPBELL, R. S., and SHEPHERD, W. O.
1952. FOREST GRAZING IN THE SOUTHEASTERN UNITED STATES. Sixth Internatl. Grassland Cong. Proc. 1952: 1550–1555.

CAMPBELL, W. A.
1955. A STUDY IN UTILIZATION: PIEDMONT HARDWOODS. Forest Farmer 15(1): 10, 28–29, illus.

——— and VERRALL, A. F.
1956. FUNGUS ENEMIES OF HICKORY. U.S. Forest Serv. Southeast. Forest Expt. Sta. Hickory Task Force Rpt. 3, 8 pp., illus. [Processed.]

CRUIKSHANK, J. W.
1952. 10-YEAR DIAMETER GROWTH OF SELECTED TREE SPECIES IN SOUTH GEORGIA. U.S. Forest Serv. Southeast. Forest Expt. Sta. Res. Notes 20, 1 p. [Processed.]

DAVIDSON, R. W., CAMPBELL, W. A., and LORENZ, R. C.
1941. ASSOCIATION OF STEREUM MURRAYI WITH HEART ROT AND CANKERS OF LIVING HARDWOODS. Phytopath. 31: 82–87, illus.

DAVIS, E. M.
1942. MACHINING AND RELATED CHARACTERISTICS OF SOUTHERN HARDWOODS. U.S. Dept. Agr. Tech. Bul. 824, 42 pp., illus.

DAVIS, V. B.
1935. RATE OF GROWTH IN A SELECTIVELY LOGGED STAND IN THE BOTTOMLAND HARDWOODS. U.S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 41, 9 pp. [Processed.]

DEMAREE, D.
1932. SUBMERGING EXPERIMENTS WITH TAXODIUM. Ecol. 13: 258–262.

DENUYL, D., DILLER, O. D., and DAY, R. K.
1938. THE DEVELOPMENT OF NATURAL REPRODUCTION IN PREVIOUSLY GRAZED FARMWOODS. Purdue Univ. Agr. Expt. Sta. Bul. 431, 28 pp.

DETWILER, S. B.
1943. BETTER ACORNS FROM A HEAVILY FERTILIZED WHITE OAK TREE. Jour. Forestry 41: 915–916.

DOOLITTLE, W. T.
1956. PRUNING SYCAMORE. South. Lumberman 193 (2417): 222–223, illus.

———
1953. GROWTH AND SURVIVAL OF HYBRID POPLARS. South. Lumberman 187(2345): 178–179, illus.

DOWNS, A. A.
1946. RESPONSE TO RELEASE OF SUGAR MAPLE, WHITE OAK, AND YELLOW-POPLAR. Jour. Forestry 44: 22–27.

———
1949. LOW FORKING IN WHITE OAK SPROUTS MAY BE HEREDITARY. Jour. Forestry 47: 736.

DUERR, W. A., FEDKIW, J., and GUTTENBERG, S.
1956. FINANCIAL MATURITY: A GUIDE TO PROFITABLE TIMBER GROWING. U.S. Dept. Agr. Tech. Bul. 1146, 74 pp., illus.

ENGLERTH, G. H., BOYCE, J. S., JR., and ROTH, E. R.
1956. LONGEVITY OF THE OAK WILT FUNGUS IN RED OAK LUMBER. Forest Sci. 2: 2–6, illus.

EYRE, F. H.
1939. SILVICULTURAL MANAGEMENT OF NORTHERN HARDWOODS. Jour. Forestry 37: 719–721.

FLETCHER, W. F.
1942. THE NATIVE PERSIMMON. U.S. Dept. Agr. Farmers' Bul. 685, rev., 22 pp., illus.

FREESE, F.
1952. YELLOW-POPLAR UNDERPLANTING. U.S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 77. [Processed.]

FROTHINGHAM, E. H.
1922. FOREST PROBLEMS OF GEORGIA'S HARDWOOD REGION. Amer. Forests and Wildlife 28: 673–677, illus.

FURNIVAL, G. M.
1954. DEADENING CULLS IN BOTTOMLAND HARDWOOD STANDS. South. Lumberman 189(2369): 123–124, illus.

GAMMAGE, J. L., and FURNIVAL, G. M.
1957. CHEMICAL DEBARKING IN BOTTOMLAND HARDWOODS. South. Pulp and Paper Mfr. 10(9): 78, 80, illus.

GIRARD, J. W.
1933. VOLUME TABLES FOR MISSISSIPPI BOTTOMLAND HARDWOODS AND SOUTHERN PINES. Jour. Forestry 31: 34–41, illus.

GOOCH, F. S.
1953. NURSERY CULTURE OF CYPRESS. South. Lumberman 186(2324): 37–38, illus.

GRANO, C. X.
1957. PRUNING-WOUND CLOSURE ON SOUTHERN RED OAK. Jour. Forestry 55: 669.

GUENTHER, K. W.
1951. AN INVESTIGATION OF THE TOLERANCE OF WHITE ASH REPRODUCTION. Jour. Forestry 49: 576–577.

GUTTENBERG, S.
1952. SWEETGUM SEED IS OVERRATED FLIER. Jour. Forestry 50: 844.

HADLEY, E. W.
1926. A PRELIMINARY STUDY OF THE GROWTH AND YIELD OF SECOND-GROWTH TUPELO GUM IN THE ATCHAFALAYA BASIN OF SOUTHERN LOUISIANA. Lumber Trade Jour. 90(10): 17–18, illus.

Hadley, E. W.
1926. Notes on butt taper of tupelo gum (Nyssa aquatica). Jour. Forestry 24: 202–203, illus.
Hall, T. F., and Smith, G. E.
1955. Effects of flooding on woody plants, West Sandy dewatering project, Kentucky reservoir. Jour. Forestry 53: 281–285, illus.
Harley, J. L.
1949. Soil conditions and the growth of beech seedlings. Jour. Ecol. 37: 28–37, illus.
Harrar, E. S.
1954. Defects in hardwood veneer logs: their frequency and importance. U.S. Forest Serv. Southeast. Forest Expt. Sta. Paper 39, 45 pp., illus. [Processed.]
Henry, B. W.
1951. Oak leaf blister severe in south Mississippi. Plant Dis. Rptr. 35: 384. [Processed.]
Hepting, G. H.
1935. Decay following fire in young Mississippi Delta hardwoods. U.S. Dept. Agr. Tech. Bul. 494, 32 pp., illus.
———
1955. The current status of oak wilt in the United States. Forest Sci. 1: 95–103, illus.
Hoffmann, C. H.
1942. Annotated list of elm insects in the United States. U.S. Dept. Agr. Misc. Pub. 466, 20 pp.
Holsoe, T.
1947. The relation of tree development to the timing of the first thinning in even-aged hardwood stands. Harvard Forest Papers 1(2): 20–25, illus.
———
1948. Crown development and basal area growth of red oak and white ash. Harvard Forest Papers 1(3): 28–33, illus.
Huckenpahler, B. J.
1955. Auxins fail to stimulate rooting of yellow-poplar cuttings. Bot. Gaz. 117: 73–75.
Jemison, G. M., and Schumacher, F. X.
1948. Epicormic branching in old-growth Appalachian hardwoods. Jour. Forestry 46: 252–255, illus.
Johnson, J. W.
1950. Cottonwoods respond to selection cuts. U.S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 66. [Processed.]
———
1950. Release speeds growth of bottomland hardwoods. South. Lumberman 181(2262): 41–42, illus.
———
1955. The pulp industry looks at hardwood. Forest Farmer 15(1): 5, 20, illus.
Johnson, R. L.
1958. Bluff hills—ideal for hardwood timber production. South. Lumberman 197(2465): 126–128, illus.
———
1958. Clip or deep-plant cypress? U.S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 116. [Processed.]
———
1959. Frills must be complete. U.S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 119. [Processed.]
———
1959. Pruning cottonwood. South. Lumberman 198 (2473): 28–29, illus.
Johnston, H. R., Smith, R. H., and St. George, R. A.
1955. Prevention and control of Lyctus powder-post bettles. South. Lumberman 190 (2375): 72, 74, illus.
Koehler, A.
1926. The identification of furniture woods. U.S. Dept. Agr. Misc. Cir. 66, 76 pp., illus.
Korstian, C. F.
1927. Factors controlling germination and early survival in oaks. Yale School Forestry Bul. 19, 115 pp., illus.
———
1930. Acorn storage in the southern states. Jour. Forestry 28: 858–863.
Kowal, R. J.
1949. Control of wood-boring insects in green logs and lumber. Forest Products Res. Soc. Preprint 81, 10 pp.
Lamb, G. N.
1915. Willows: their growth, use, and importance. U.S. Dept. Agr. Bul. 316, 52 pp., illus.
Lindenmuth, A. W., Jr., and Keetch, J. J.
1949. Open method for measuring fire danger in hardwood forests. U.S. Forest Serv. Southeast. Forest Expt. Sta. Tech. Note 71, 11 pp. [Processed.]
Lockard, C. R., Putnam, J. A., and Carpenter, R. D.
1950. Log defects in southern hardwoods. U.S. Dept. Agr., Agr. Handb. 4, 37 pp., illus.
Lotti, T.
1955. Yellow-poplar height growth affected by seed source. U.S. Forest Serv. Tree Planters' Notes 22, p. 3. [Processed.]
Lunt, H. A.
1933. Effect of weathering upon composition of hardwood leaves. Jour. Forestry 31: 943–945.
Lutz, J. F.
1955. Hickory for veneer and plywood. U.S. Forest Serv. Southeast. Forest Expt. Sta. Hickory Task Force Rpt. 1, 12 pp., illus. [Processed.]
McCarthy, E. F.
1933. Yellow poplar characteristics, growth, and management. U.S. Dept. Agr. Tech. Bul. 356, 58 pp., illus.
McCormack, J. F.
1955. An allowance for bark increment in computing tree diameter growth for southeastern species. U.S. Forest Serv. Southeast. Forest Expt. Sta., Sta. Paper 60, 6 pp. illus. [Processed.]
McKnight, J. S.
1950. Forest management by Old Man River. South. Lumberman 181 (2273): 233–235, illus.
———
1956. Thinning our young gum. Forests and People 6(3): 28–29, illus.
———
1957. Black willow . . . hints for management. Forests and People 7(3): 30–31, 50, illus.
———
1958. Thinning stands of water oaks. La. State Univ. School of Forestry, Seventh Ann. Forestry Symposium Proc., pp. 46–50. [Processed.]
——— and Johnson, J. W.
1953. Fence posts from Delta hardwoods give good service. Miss. State Col. Serv. Sheet 426, 2 pp.
——— and McWilliams, J. S.
1957. Improving southern hardwood stands through commercial harvest and cull-tree control. Soc. Amer. Foresters Proc. 1956: 71–72.
——— and Putnam, J. A.
1952. Logging cut-over stands of bottomland hardwoods. South. Lumberman 185(2321): 184–186, illus.

MAISENHELDER, L. C.
1951. PLANTING AND GROWING COTTONWOOD ON BOTTOMLANDS. Miss Agr. Expt. Sta. Bul. 485, 23 pp., illus.

——— 1951. PROBABLE RETURNS FROM COTTONWOOD PLANTATIONS. U.S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 74. [Processed.]

——— 1957. PROPAGATION OF SOME DELTA HARDWOODS BY ROOTING. Soc. Amer. Foresters Proc. 1956: 55–58.

——— 1957. TIPS FOR PLANTING SOUTHERN HARDWOODS. South. Lumberman 195(2441): 93–94, illus.

——— 1958. NATURAL REGENERATION FOLLOWING SELECTION CUTTING IN BOTTOMLAND HARDWOODS. La. State Univ. School of Forestry, Seventh Ann. Forestry Symposium Proc., pp. 21–26. [Processed.]

——— 1958. UNDERSTORY PLANTS OF BOTTOMLAND FORESTS. U.S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 165, 40 pp., illus.

——— and HEAVRIN, C. A.
1957. SILVICS AND SILVICULTURE OF THE PIONEER HARDWOODS—COTTONWOOD AND WILLOW. Soc. Amer. Foresters Proc. 1956: 73–75.

MATTOON, W. R.
1915. THE SOUTHERN CYPRESS. U.S. Dept. Agr. Bul. 272, 74 pp., illus.

——— 1932. PLANTING BLACK WALNUT. U.S. Dept. Agr. Leaflet 84, 8 pp., illus.

MERZ, R.
1951. COMPARATIVE SURVIVALS AND COSTS OF PLANTATIONS BY DIFFERENT METHODS OF GROUND PREPARATION AND PLANTING. U.S. Forest Serv. Cent. States Forest Expt. Sta., Sta. Notes 64, 2 pp. [Processed.]

——— and BOYCE, S. G.
1956. AGE OF OAK "SEEDLINGS". Jour. Forestry 54: 774–775, illus.

MIGNERY, A. L.
1956. BASAL SPRAY CONTROLS IRONWOOD AND HAWTHORN. Texas Forest News 35(4): 10.

MINCKLER, L. S.
1958. BOTTOMLAND HARDWOODS RESPOND TO CUTTING. U.S. Forest Serv. Cent. States Forest Expt. Sta. Tech. Paper 154, 10 pp., illus. [Processed.]

——— and LAMENDOLA, P. E.
1953. GROWTH OF WELL-STOCKED COTTONWOOD STAND. U.S. Forest Serv. Cent. States Forest Expt. Sta., Sta. Notes 75, 2 pp. [Processed.]

MOORE, B.
1928. GERMINATION AND EARLY SURVIVAL IN OAKS. Ecol. 9: 104–106.

MORRIS, R. C.
1955. INSECT PROBLEMS IN SOUTHERN HARDWOOD FORESTS. South. Lumberman 191(2392): 136–139, illus.

——— 1957. LUMBER DEFECT—WHAT IS THE INSECTS' SHARE? South. Lumberman 195(2431): 26–27, illus.

——— 1958. INSECT PESTS OF COTTONWOOD. Miss. Farm Res. 21(5): 8, illus.

NELSON, I. L.
1958. REFERENCES ON THE MANAGEMENT OF BOTTOMLAND HARDWOODS AND BALDCYPRESS. U.S. Forest Serv. South. Forest Expt. Sta., 11 pp. [Processed.]

NELSON, R. M.
1940. VIGOROUS YOUNG YELLOW POPLAR TREES CAN RECOVER FROM INJURY BY NECTRIA CANKERS. Jour. Forestry 38: 587–588.

NELSON, T. C.
1957. ROOTING AND AIR-LAYERING SOME SOUTHERN HARDWOODS. Fourth South. Conf. on Forest Tree Improvement Proc., pp. 51–54.

——— 1957. SURVIVAL AND EARLY GROWTH OF AN EASTERN COTTONWOOD PLANTATION ON THE PIEDMONT. U.S. Forest Serv. Tree Planters' Notes 28, p. 9. [Processed.]

——— and BEAUFAIT, W. R.
1957. STUDIES IN SITE EVALUATION FOR SOUTHERN HARDWOODS. Soc. Amer. Foresters Proc. 1956: 67–70.

——— and JACKSON, L. W. R.
1956. YELLOW POPLAR PLANTATIONS. Forest Farmer 15(10): 11, illus.

——— ROSS, R. D., and WALKER, G. D.
1957. THE EXTENT OF MOIST SITES IN THE GEORGIA PIEDMONT AND THEIR FOREST ASSOCIATIONS. U.S. Forest Serv. Southeast. Forest Expt. Sta. Res. Note 102, 2 pp. [Processed.]

OSTRANDER, M. D., and ENGLERTH, G. H.
1953. HARDWOOD LOG GRADING STICK IMPROVED. U.S. Forest Serv. Northeast. Forest Expt. Sta. Res. Notes 24. [Processed.]

PUTNAM, J. A.
1928. BUTT SWELL IN SOUTHERN SWAMP HARDWOODS. South. Lumberman 133(1734): 213–215, illus.

——— 1928. THE OCCURRENCE OF HEARTWOOD AND FIGURE IN RED GUM. South. Lumberman 133(1734): 204–206, illus.

——— 1951. MANAGEMENT OF BOTTOMLAND HARDWOODS. U.S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 116, 60 pp. [Processed.]

——— 1953. MANAGEMENT POSSIBILITIES IN UPLAND HARDWOODS, IF ANY. La. State Univ. School Forestry, Second Ann. Forestry Symposium Proc., pp. 63–67. [Processed.]

——— 1955. GROWING HARDWOOD TREES AS A CROP. Forest Farmer 15(1): 6–7, 30–31, illus.

——— 1957. OPPORTUNITIES AND PROBLEMS IN THE SILVICULTURE OF SOUTHERN HARDWOODS. Soc. Amer. Foresters Proc. 1956: 62–64.

——— 1959. MANAGEMENT OF SOUTHERN HARDWOOD FORESTS RELATIVE TO THE SUPPLY OF RAILROAD STOCK. Cross Tie Bul. 40(2): 18–19, 22, 24–27.

——— and BULL, H.
1932. THE TREES OF THE BOTTOMLANDS OF THE MISSISSIPPI RIVER DELTA REGION. U.S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 27, 207 pp., illus. [Processed.]

——— and MCKNIGHT, J. S.
1949. DEPLETED BOTTOM-LAND HARDWOODS MAKE QUICK COME-BACK. South. Lumberman 179(2249): 143–146, illus.

ROTH, E. R.
1948. HEALING AND DEFECTS FOLLOWING OAK PRUNING. Jour. Forestry 46: 500–504, illus.

——— 1950. CANKERS AND DECAY OF OAK ASSOCIATED WITH IRPEX MOLLIS. U.S. Bur. Plant Indus. Plant Dis. Rptr. 34: 347–348, illus. [Processed.]

——— 1950. DISCOLORATIONS IN LIVING YELLOW-POPLAR TREES. Jour. Forestry 48: 184–185, illus.

——— 1956. DECAY FOLLOWING THINNING OF SPROUT OAK CLUMPS. Jour. Forestry 54: 26–30, illus.

ROTH, E. R., and HEPTING, G. H.
1943. ORIGIN AND DEVELOPMENT OF OAK STUMP SPROUTS AS AFFECTING THEIR LIKELIHOOD TO DECAY. Jour. Forestry 41: 27–36, illus.
——— and HEPTING, G. H.
1943. WOUNDS AND DECAY CAUSED BY REMOVING LARGE COMPANION SPROUTS OF OAKS. Jour. Forestry 41: 190–195, illus.
SCHOMAKER, C. E.
1958. TWO-YEAR RESULTS OF PLANTING YELLOW-POPLAR IN NORTH ALABAMA. Jour. Forestry 56: 37–38, illus.
SHUNK, I. V.
1939. OXYGEN REQUIREMENTS FOR GERMINATION OF SEEDS OF NYSSA AQUATICA—TUPELO GUM. Sci. 90: 565–566.
SILKER, T. H.
1948. PLANTING OF WATER-TOLERANT TREES ALONG MARGINS OF FLUCTUATING-LEVEL RESERVOIRS. Iowa State Col. Jour. Sci. 22: 431–447.
SMITH, R. H.
1954. A LEAF-CHEWING BEETLE CAUSES CYPRESS FOLIAGE TO DISCOLOR IN MID-SUMMER. U.S. Forest Serv. Southeast. Forest Expt. Sta. Res. Note 70, 2 pp. [Processed.]
SMITH, W. R.
1955. THE SOURCE OF LUMBER FOR FURNITURE PLANTS IN NORTH CAROLINA. N.C. Forestry Assoc. Furniture, Plywood, and Veneer Council, 5 pp.
———
1956. SPECIALTY PRODUCTS FROM HARDWOOD AND PINE IN THE SOUTH. Jour. Forestry 54: 646–649, illus.
SOUTHERN FOREST EXPERIMENT STATION ET AL.
1949. PREVENTION OF DETERIORATION IN STORED HARDWOOD LOGS. U.S. Forest Serv. South. Forest Expt. Sta., 6 pp. [Processed.]
STERNITZKE, H. S., and PUTNAM, J. A.
1956. FORESTS OF THE MISSISSIPPI DELTA. U.S. Forest Serv. South. Forest Expt. Sta. Forest Survey Release 78, 42 pp., illus. [Processed.]
STERRETT, W. D.
1915. THE ASHES: THEIR CHARACTERISTICS AND MANAGEMENT. U.S. Dept. Agr. Bul. 299, 88 pp., illus.
———
1921. A GENERALIZED YIELD TABLE FOR EVEN-AGED, WELL-STOCKED STANDS OF SOUTHERN UPLAND HARDWOODS. Jour. Forestry 19: 382–389.
SWENNING, K. A.
1924. MANAGEMENT STUDIES ON COTTONWOOD AND SILVER MAPLE. Jour. Forestry 22: 178–183.
SWITZER, H. D.
1948. THE MANAGEMENT OF COTTONWOOD IN THE BOTTOMLANDS OF SOUTHERN ILLINOIS. South. Lumberman 177(2225): 153–157, illus.
TILLOTSON, C. R.
1921. GROWING AND PLANTING HARDWOOD SEEDLINGS ON THE FARM. U.S. Dept. Agr. Farmers' Bul. 1123, 28 pp., illus.
———
1927. TIMBER GROWING AND LOGGING PRACTICE IN THE CENTRAL HARDWOOD REGION. U.S. Dept. Agr. Bul. 1491, 39 pp., illus.
TOOLE, E. R.
1954. DISEASE PROBLEMS IN HARDWOOD FORESTS OF THE LOWER MISSISSIPPI VALLEY. South. Lumberman 189(2369): 179–181, illus.
———
1954. SWEETGUM BLIGHT—A PROBLEM IN FOREST MANAGEMENT. South. Lumberman 189(2362): 35, illus.
———
1955. RED STAIN OF BOXELDER. U.S. Agr. Res. Serv. Plant Dis. Rptr. 39: 66–67. [Processed.]
———
1956. HISPIDUS CANKER. Forest Farmer 16(1): 7, illus.
TOOLE, E. R.
1958. DECAY AFTER FIRE INJURY TO SOUTHERN BOTTOMLAND HARDWOODS. U.S. Dept. Agr. Tech. Bul. 1189, 25 pp., illus.
———
1959. CANKER-ROTS IN SOUTHERN HARDWOODS. U.S. Dept. Agr. Forest Pest Leaflet 33, 4 pp., illus.
———
1959. SWEETGUM BLIGHT. U.S. Dept. Agr. Forest Pest Leaflet 37, 4 pp., illus.
——— and BOYCE, J. S., JR.
1952. FOMES ANNOSUS ON ATLANTIC WHITE CEDAR. U.S. Bur. Plant Indus. Plant Dis. Rptr. 36: 330. [Processed.]
——— and BROADFOOT, W. M.
1959. IRRIGATION LESSENS SWEETGUM BLIGHT. U.S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 120. [Processed.]
——— and BROADFOOT, W. M.
1959. SWEETGUM BLIGHT AS RELATED TO ALLUVIAL SOILS OF THE MISSISSIPPI RIVER FLOODPLAIN. Forest Sci. 5: 2–9, illus.
——— and MCKNIGHT, J. S.
1956. FIRE EFFECTS IN SOUTHERN HARDWOODS. U.S. Forest Serv. Fire Control Notes 17(3): 1–4, illus.
U.S. ARMY CORPS OF ENGINEERS.
1955. TIMBER PROTECTION IN RESERVOIRS. Project CW-515, New Orleans District, 46 pp., illus. [Processed.]
U.S. FOREST PRODUCTS LABORATORY.
1949. HARDWOOD LOG GRADES FOR STANDARD LUMBER AND HOW TO APPLY THEM. U.S. Forest Serv. Forest Products Lab. D1737–A, 16 pp., illus. [Processed.]
———
1953. HARDWOOD LOG GRADES FOR STANDARD LUMBER: PROPOSALS AND RESULTS. U.S. Forest Serv. Forest Products Lab. D1737, 64 pp., illus. [Processed.]
———
1955. WOOD HANDBOOK. U.S. Dept. Agr., Agr. Handb. 72, 528 pp., illus.
———
1956. WOOD: COLORS AND KINDS. U.S. Dept. Agr., Agr. Handb. 101, 36 pp., illus.
U.S. FOREST SERVICE.
1948. WOODY-PLANT SEED MANUAL. U.S. Dept. Agr. Misc. Pub. 654, 416 pp., illus.
WAHLENBERG, W. G.
1949. FOREST SUCCESSION IN THE SOUTHERN PIEDMONT REGION. Jour. Forestry 47: 713–715, illus.
———
1950. EPICORMIC BRANCHING OF YOUNG YELLOW-POPLAR. Jour. Forestry 48: 417–419, illus.
———
1952. THINNING YELLOW-POPLAR IN SECOND-GROWTH UPLAND HARDWOOD STANDS. Jour. Forestry 50: 671–676, illus.
———
1953. THREE METHODS OF REHABILITATION FOR DEPLETED APPALACHIAN HARDWOOD STANDS. Jour. Forestry 51: 874–880, illus.
WENGER, K. F.
1952. EFFECT OF MOISTURE SUPPLY AND SOIL TEXTURE ON THE GROWTH OF SWEETGUM AND PINE SEEDLINGS. Jour. Forestry 50: 862–864.
———
1953. THE SPROUTING OF SWEETGUM IN RELATION TO SEASON OF CUTTING AND CARBOHYDRATE CONTENT. Plant Physiol. 28: 35–49, illus.
WHEELER, P. R.
1958. THE BOTTOMLAND HARDWOOD FOREST RESOURCE. La. State Univ. School of Forestry, Seventh Ann. Forestry Symposium Proc., pp. 1–4. [Processed.]

WILLIAMSON, A. W.
1913. COTTONWOOD IN THE MISSISSIPPI VALLEY. U.S. Dept. Agr. Bul. 24, 62 pp., illus.
WILLISTON, H. L., and HUCKENPAHLER, B. J.
1957. HARDWOOD UNDERPLANTING IN NORTH MISSISSIPPI. Jour. Forestry 55: 287–290.
WINTERS, R. K., and OSBORNE, J. G.
1935. GROWTH AND YIELD OF SECOND-GROWTH RED GUM IN FULLY STOCKED STANDS ON ALLUVIAL LANDS IN THE SOUTH. U.S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 54, 12 pp., illus. [Processed.]
YEAGER, L. E.
1949. EFFECTS OF PERMANENT FLOODING IN A RIVER-BOTTOM TIMBER AREA. Bul Ill. Nat. Hist. Surv. 25(2): 33–65, illus.

APPENDIX

Hardwood Trade Associations

American Veneer Package Association
1225½ N. Orange Avenue, Orlando, Fla.
American Walnut Manufacturers Association
666 North Lake Shore Drive, Chicago 11, Ill.
Appalachian Hardwood Manufacturers, Inc.
414 Walnut Street, Cincinnati, Ohio
Associated Cooperage Industries of America, Inc.
408 Olive Street, St. Louis 2, Mo.
Fine Hardwoods Association
666 North Lake Shore Drive, Chicago 11, Ill.
Hardwood Dimension Manufacturers Association, Inc.
218 Broadway National Bank Building, Nashville 3, Tenn.
Hardwood Plywood Institute
600 S. Michigan, Chicago, Ill.
Hickory Handle Association
Jonesboro, Ark.
National Hardwood Lumber Association
59 East Van Buren Street, Chicago 5, Ill.
National Wooden Box Association
Barr Building, Washington 6, D.C.
Railway Tie Association
1221 Locust Street, St. Louis 3, Mo.
Southern Hardwood Producers, Inc.
805 Sterick Building, Memphis, Tenn.
Wirebound Box Manufacturers Association
327 LaSalle Street, Chicago 4, Ill.

Some Trade Papers Particularly Interested in Southern Hardwoods

National Hardwood Magazine
2065 Union Avenue, Memphis, Tenn.
Southern Lumber Journal
P.O. Box 440, Jacksonville, Fla.
Southern Lumberman
2916 Sidco Drive, Nashville 4, Tenn.
Wood and Wood Products
139 N. Clark Street, Chicago 2, Ill.

Examples of Problems in the Law of Waters

Any forester or landowner involved with bottom lands should acquaint himself with the laws of riparian rights that apply to his property. Innumerable court decisions and articles have shown the complexity of the law of waters affecting accretions, relictions, avulsions, boundaries, apportionment, and titles generally. Each State has its own laws by statutes and court decisions. In Tennessee, the riparian owner's title on a navigable stream stops at low water (*Cunningham* v. *Prevow*, 28 Tenn. App. 643; 192 S.W. 2d 338 (1948)). In Arkansas, the riparian owner's title on a navigable stream stops at the high-water mark (*Wallace* v. *Driver*, 61 Ark. 429; 33 S.W. 641 (1896)).

It is generally recognized that the riparian owner takes to the middle or "thread" of a non-navigable stream or lake (Tiffany, *Real Property*, Ed. 3 § 663). However, such ownership should not be assumed without a check of the laws of the State in which land is owned.

In Arkansas, one of the leading and basic cases on the law of riparian ownership is *Wallace* v. *Driver*, *supra*. In this case, the court made the following remarks (33 S.W. 642, 643):

"The water boundaries of land on running streams, whatever they may be in the beginning, whether the thread of the stream, the water's edge, ordinary high or low water mark, *always remain the same when they change gradually*, as by the process of accretion or attrition. They gradually shift as the water recedes or encroaches, and the area of the riparian owner's possession varies as they change by this process. Whatever constituted them at first still constitutes them so long as it remains permanent or *shifts gradually and imperceptibly*. Hence lands formed by alluvion, or the gradual and imperceptible accretion from the water, and land gained by reliction, or the gradual and imperceptible recession of the water, belongs to the owner of the contiguous land to which the addition is made." [Italics supplied.]

* * * * *

"The reverse of what has been said of accretions and erosions is true of *avulsions*. Where a stream which forms a boundary line of lands from any cause *suddenly* abandons its old, and seeks a new, bed, or *suddenly* and *perceptibly* washes away its banks, such change of channel or banks (if its limits can be determined) *works no change of boundary*. The owner still holds his title to the submerged land. If an island or dry land afterwards forms upon it, the same belongs to him." [Italics supplied.]

TABLE 10.—*Giant-tree table for Doyle log rule*[1]

D.i.b. (inches)	Length	Volume	D.i.b. (inches)	Length	Volume	D.i.b. (inches)	Length	Volume	D.i.b. (inches)	Length	Volume	D.i.b. (inches)	Length	Volume
	Feet	*Board feet*		*Feet*	*Board feet*		*Feet*	*Board feet*		*Feet*	*Board feet*		*Feet*	*Board feet*
4	368	15, 180	14	288	15, 060	24	208	14, 040	34	128	11, 120	44	48	5, 300
1/8	367	15, 180	1/8	287	15, 055	1/8	207	14, 017	1/8	127	11, 067	1/8	47	5, 205
2/8	366	15, 180	2/8	286	15, 050	2/8	206	13, 994	2/8	126	11, 014	2/8	46	5, 109
3/8	365	15, 180	3/8	285	15, 044	3/8	205	13, 971	3/8	125	10, 960	3/8	45	5, 012
4/8	364	15, 180	4/8	284	15, 039	4/8	204	13, 947	4/8	124	10, 906	4/8	44	4, 915
5/8	363	15, 180	5/8	283	15, 033	5/8	203	13, 924	5/8	123	10, 852	5/8	43	4, 817
6/8	362	15, 180	6/8	282	15, 027	6/8	202	13, 899	6/8	122	10, 797	6/8	42	4, 719
7/8	361	15, 180	7/8	281	15, 021	7/8	201	13, 875	7/8	121	10, 741	7/8	41	4, 620
5	360	15, 180	15	280	15, 015	25	200	13, 850	35	120	10, 685	45	40	4, 520
1/8	359	15, 180	1/8	279	15, 009	1/8	199	13, 825	1/8	119	10, 629	1/8	39	4, 420
2/8	358	15, 180	2/8	278	15, 002	2/8	198	13, 799	2/8	118	10, 572	2/8	38	4, 319
3/8	357	15, 180	3/8	277	14, 996	3/8	197	13, 774	3/8	117	10, 514	3/8	37	4, 217
4/8	356	15, 180	4/8	276	14, 989	4/8	196	13, 748	4/8	116	10, 456	4/8	36	4, 115
5/8	355	15, 180	5/8	275	14, 982	5/8	195	13, 721	5/8	115	10, 398	5/8	35	4, 012
6/8	354	15, 180	6/8	274	14, 975	6/8	194	13, 694	6/8	114	10, 339	6/8	34	3, 909
7/8	353	15, 180	7/8	273	14, 967	7/8	193	13, 667	7/8	113	10, 280	7/8	33	3, 805
6	352	15, 180	16	272	14, 960	26	192	13, 640	36	112	10, 220	46	32	3, 700
1/8	351	15, 180	1/8	271	14, 952	1/8	191	13, 612	1/8	111	10, 160	1/8	31	3, 595
2/8	350	15, 180	2/8	270	14, 945	2/8	190	13, 584	2/8	110	10, 099	2/8	30	3, 489
3/8	349	15, 180	3/8	269	14, 937	3/8	189	13, 556	3/8	109	10, 038	3/8	29	3, 382
4/8	348	15, 180	4/8	268	14, 928	4/8	188	13, 527	4/8	108	9, 976	4/8	28	3, 275
5/8	347	15, 180	5/8	267	14, 920	5/8	187	13, 498	5/8	107	9, 914	5/8	27	3, 167
6/8	346	15, 179	6/8	266	14, 912	6/8	186	13, 469	6/8	106	9, 851	6/8	26	3, 058
7/8	345	15, 179	7/8	265	14, 903	7/8	185	13, 439	7/8	105	9, 788	7/8	25	2, 949
7	344	15, 179	17	264	14, 894	27	184	13, 409	37	104	9, 724	47	24	2, 839
1/8	343	15, 179	1/8	263	14, 885	1/8	183	13, 379	1/8	103	9, 660	1/8	23	2, 728
2/8	342	15, 178	2/8	262	14, 876	2/8	182	13, 348	2/8	102	9, 595	2/8	22	2, 617
3/8	341	15, 178	3/8	261	14, 866	3/8	181	13, 317	3/8	101	9, 530	3/8	21	2, 505
4/8	340	15, 178	4/8	260	14, 857	4/8	180	13, 285	4/8	100	9, 464	4/8	20	2, 393
5/8	339	15, 177	5/8	259	14, 847	5/8	179	13, 254	5/8	99	9, 398	5/8	19	2, 280
6/8	338	15, 177	6/8	258	14, 837	6/8	178	13, 221	6/8	98	9, 331	6/8	18	2, 166
7/8	337	15, 177	7/8	257	14, 826	7/8	177	13, 189	7/8	97	9, 264	7/8	17	2, 051
8	336	15, 176	18	256	14, 816	28	176	13, 156	38	96	9, 196	48	16	1, 936
1/8	335	15, 175	1/8	255	14, 805	1/8	175	13, 123	1/8	95	9, 128	1/8	15	1, 820
2/8	334	15, 175	2/8	254	14, 795	2/8	174	13, 089	2/8	94	9, 059	2/8	14	1, 704
3/8	333	15, 174	3/8	253	14, 783	3/8	173	13, 055	3/8	93	8, 990	3/8	13	1, 586
4/8	332	15, 173	4/8	252	14, 772	4/8	172	13, 021	4/8	92	8, 920	4/8	12	1, 468
5/8	331	15, 173	5/8	251	14, 761	5/8	171	12, 986	5/8	91	8, 849	5/8	11	1, 350
6/8	330	15, 172	6/8	250	14, 749	6/8	170	12, 951	6/8	90	8, 778	6/8	10	1, 231
7/8	329	15, 171	7/8	249	14, 737	7/8	169	12, 916	7/8	89	8, 707	7/8	9	1, 111
9	328	15, 170	19	248	14, 725	29	168	12, 880	39	88	8, 635	49	8	990
1/8	327	15, 169	1/8	247	14, 713	1/8	167	12, 844	1/8	87	8, 563	1/8	7	869
2/8	326	15, 168	2/8	246	14, 700	2/8	166	12, 807	2/8	86	8, 489	2/8	6	747
3/8	325	15, 167	3/8	245	14, 687	3/8	165	12, 770	3/8	85	8, 416	3/8	5	624
4/8	324	15, 166	4/8	244	14, 674	4/8	164	12, 733	4/8	84	8, 342	4/8	4	501
5/8	323	15, 164	5/8	243	14, 661	5/8	163	12, 695	5/8	83	8, 267	5/8	3	376
6/8	322	15, 163	6/8	242	14, 648	6/8	162	12, 657	6/8	82	8, 192	6/8	2	252
7/8	321	15, 162	7/8	241	14, 634	7/8	161	12, 619	7/8	81	8, 116	7/8	1	126

10		320	15, 160	20		240	14, 620	30		160	12, 580	40		80	8, 040	50	0	0
	1/8	319	15, 158		1/8	239	14, 606		1/8	159	12, 541		1/8	79	7, 963			
	2/8	318	15, 157		2/8	238	14, 591		2/8	158	12, 501		2/8	78	7, 886			
	3/8	317	15, 155		3/8	237	14, 577		3/8	157	12, 461		3/8	77	7, 808			
	4/8	316	15, 153		4/8	236	14, 562		4/8	156	12, 421		4/8	76	7, 729			
	5/8	315	15, 151		5/8	235	14, 547		5/8	155	12, 380		5/8	75	7, 650			
	6/8	314	15, 149		6/8	234	14, 531		6/8	154	12, 339		6/8	74	7, 571			
	7/8	313	15, 147		7/8	233	14, 516		7/8	153	12, 297		7/8	73	7, 491			
11		312	15, 145	21		232	14, 500	31		152	12, 255	41		72	7, 410			
	1/8	311	15, 143		1/8	231	14, 484		1/8	151	12, 213		1/8	71	7, 329			
	2/8	310	15, 140		2/8	230	14, 468		2/8	150	12, 170		2/8	70	7, 247			
	3/8	309	15, 138		3/8	229	14, 451		3/8	149	12, 126		3/8	69	7, 165			
	4/8	308	15, 135		4/8	228	14, 434		4/8	148	12, 083		4/8	68	7, 082			
	5/8	307	15, 133		5/8	227	14, 417		5/8	147	12, 039		5/8	67	6, 998			
	6/8	306	15, 130		6/8	226	14, 400		6/8	146	11, 994		6/8	66	6, 914			
	7/8	305	15, 127		7/8	225	14, 382		7/8	145	11, 949		7/8	65	6, 829			
12		304	15, 124	22		224	14, 364	32		144	11, 904	42		64	6, 744			
	1/8	303	15, 121		1/8	223	14, 346		1/8	143	11, 858		1/8	63	6, 658			
	2/8	302	15, 118		2/8	222	14, 327		2/8	142	11, 812		2/8	62	6, 572			
	3/8	301	15, 114		3/8	221	14, 309		3/8	141	11, 765		3/8	61	6, 485			
	4/8	300	15, 111		4/8	220	14, 290		4/8	140	11, 718		4/8	60	6, 397			
	5/8	299	15, 107		5/8	219	14, 270		5/8	139	11, 671		5/8	59	6, 309			
	6/8	298	15, 104		6/8	218	14, 251		6/8	138	11, 623		6/8	58	6, 220			
	7/8	297	15, 100		7/8	217	14, 231		7/8	137	11, 575		7/8	57	6, 131			
13		296	15, 096	23		216	14, 211	33		136	11, 526	43		56	6, 041			
	1/8	295	15, 092		1/8	215	14, 191		1/8	135	11, 477		1/8	55	5, 950			
	2/8	294	15, 088		2/8	214	14, 170		2/8	134	11, 427		2/8	54	5, 859			
	3/8	293	15, 083		3/8	213	14, 149		3/8	133	11, 377		3/8	53	5, 768			
	4/8	292	15, 079		4/8	212	14, 128		4/8	132	11, 327		4/8	52	5, 675			
	5/8	291	15, 075		5/8	211	14, 106		5/8	131	11, 276		5/8	51	5, 582			
	6/8	290	15, 070		6/8	210	14, 084		6/8	130	11, 224		6/8	50	5, 489			
	7/8	289	15, 065		7/8	209	14, 062		7/8	129	11, 172		7/8	49	5, 395			

[1] Table computed from the formula $V=ND^2+2N(N-1)D+2/3N(N-1)(2N-1)$. V is cumulative Doyle volume. D is diameter inside bark less 4, and N is length divided by 16.

The foregoing general principles are clearly stated as being the law even when the boundary line between States is involved, as in *Arkansas* v. *Tennessee*, 246 U.S. 158 (1917).

Those who desire more information should refer to *American Jurisprudence*, volume 56, under the subject of "Waters." Subdivision X, §§ 273 to 290, deals with "Riparian and Littoral Proprietorship and Rights." Subdivision XIX, §§ 448 to 498, deals with "Beds, Banks, and Shores." Subdivision XX, §§ 504 to 507, relates to "Islands."

Giant-Tree Table for Doyle Rule

The giant-tree table given here for the Doyle log rule is modeled after one prepared by L. R. Grosenbaugh for cubic-foot volumes and the International ¼-inch rule.[12]

A giant-tree table is helpful in sampling cull percents or the proportion of the volume of individual trees that falls into various grades of product classes of varying lengths. It is also convenient as a sort of universal volume table, entered with a single d.i.b. at any specified height above the worst of the butt swell; it then assumes a taper of one-eighth inch per foot of length in either direction. The easiest way to visualize it is as a giant tree whose cumulatively increasing height and volume can be read at each d.i.b. in a diameter series diminishing upward in steps of one-eighth inch for each foot of length.

The table is used by entering at the desired small-end d.i.b., noting the volume found opposite this diameter, then moving down the "length" column a distance equal to the desired log length, marking the volume found there, and subtracting the two values. The volumes of a 20-inch log 16 feet long would be determined as follows:

	Board feet
Read the volume opposite 20 inches	14, 620
Length at this point is 240 feet; move down the length column to 224 feet and read the volume	14, 364
Subtract the two volumes	256

For 16-foot logs, the values from the table will exactly correspond to those computed from the formula $(D-4)^2$. Because the Doyle rule does not allow for taper except when long lengths are scaled as more than one log, the table assumes that all logs will be cut 16 feet long and that there will be 2 inches of taper per 16 feet. Actual log scale will be somewhat greater than tabular values for logs shorter than 16 feet, and somewhat less for longer logs. The table is internally consistent, however, and has many advantages over erratic use of the raw Doyle rule.

[12] Grosenbaugh, L. R. *New tree-measurement concepts: height accumulation, giant tree, taper and shape.* U.S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 134, 32 pp. 1954. [Processed.]

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