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STATE OF TENNESSEE—STATE GEOLOGICAL SURVEY
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IN COOPERATION WITH THE FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE
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PRELIMINARY STUDY OF FOREST CONDITIONS IN TENNESSEE

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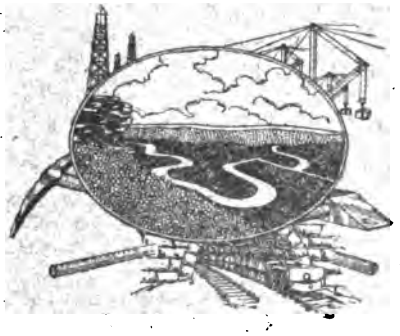
EXTRACT (A) FROM BULLETIN NO. 10, FOREST STUDIES IN TENNESSEE



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The study upon which this report is based was undertaken by the Forest Service in coöperation with the State Geological Survey, the work being done under the direction of the Office of State Coöperation in the Forest Service and under the local instructions of the Director of the Survey. By the terms of the coöperative agreement the State is authorized to publish the findings of the investigation.

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VIRGIN FOREST OF HEMLOCK ON UPPER NORTH SLOPE—SEVIER COUNTY.

Preliminary Study of Forest Conditions in Tennessee

The bill establishing the Tennessee State Geological Survey specifies as one of its duties:

> "An investigation of the forests, . . . with especial reference to their conservation and development for industrial enterprises."

In accordance with this provision, the Geological Survey secured the coöperation of the Forest Service of the United States Department of Agriculture in a preliminary study of forest conditions in the State, the Forest Service paying one-half of the cost. The object of this study was to determine the forest resources and possibilities of the State, the legislation needed to secure protection and preservation of the forests, and the lines along which more detailed forest investigations can most profitably be carried out. In November and December, 1910, typical sections of each forest region were examined by a representative of the Forest Service, and interviews were obtained with public officials, lumbermen, and others familiar with local conditions. Considerable information was also obtained from reports on private tracts previously examined by the Forest Service.

SUMMARY.

The following is a brief statement of the results of the study and the conclusions drawn:

1. It is estimated that about 35 per cent of the total area of the State is in forest.

2. A large part of this land is best suited for growing timber.

3. It is of utmost importance, especially in the Unaka Range and the Cumberland Plateau, to conserve the forests that cover the steep slopes, not only for their timber supply, but also because of their protective value to the soil and their beneficial influence in regulating stream flow.

4. The forest land of the State is losing its capacity to produce valuable timber on account of forest fires and short-sighted, wasteful methods of cutting. Surface fires, which are very common throughout the State, in addition to burning the humus out of the soil and destroying the leaf mulch, kill young growth and injure larger trees at the butt, so that insects and rot can enter the wood and impair its commercial value. The usual methods of cutting are at fault in that too large a proportion of the tree is not utilized, and at the same time no provision is made for securing future crops. Both fire and repeated culling of the better trees result in the replacement of good timber by a comparatively worthless second growth.

5. Better methods of management should be instituted in order to increase the productiveness of forest land and to afford a permanent supply of raw material for the important wood-using industries of the State. By cutting old timber in such a way as to secure the restocking of the land with valuable species, by stimulating the growth of young timber by thinning out the inferior trees, and by other common-sense measures, the annual growth can be greatly increased and the possible lumber production of the future correspondingly augmented.

6. It is to the best interest of the State to promote the practice of forestry by adopting a progressive forest policy, including the employment of a State Forester, the establishment of a fire protective system, and the creation of State Forests. Such a policy has been adopted in whole or in part by twenty States.

7. The State Forester, in addition to administering the fire protective system and the State Forests, should engage in educational and research work, and in every way possible should assist the citizens of the State to make their woodlands more productive. He could do this by publishing simple and instructive pamphlets on various phases of forest management, by public lectures, by demonstration work on State Forests, and by preparing and superintending the execution of working plans for private forest lands upon request of the owners. It is impossible to overestimate the value of such work in bringing about a general use of more profitable methods of handling timber land.

GENERAL CONDITIONS.

The State of Tennessee presents a great variety of topographic and soil conditions. The eastern portion is mountainous in char-

FLOOD DAMAGE TO RAILWAY ON NOLICHUCKY RIVER, MAY, 1901—UNICOI COUNTY.

acter and extends from the crest of the Appalachian Mountains westward over the western flank and foothill region of the Unakas, or Great Smoky Mountains, the Valley of East Tennessee, and the Cumberland Plateau. The rolling central portion includes the Highland Rim and the Central, or Nashville, Basin. The gently rolling western portion, lying between the narrow western valley of the Tennessee River and the Mississippi bottom lands, is known as the Plateau and Slope of West Tennessee.

The mean annual temperature for the State is about 59 degrees, varying from 57 degrees in the East to 61 degrees in the West. The average absolute annual range of temperature is about 90 degrees. The length of the growing season varies from about 175 days in the East to about 200 days in the West. The average annual precipitation is 50 inches, generally fairly well distributed. Thus climatic conditions are favorable to the growth of trees and other vegetation.

Transportation facilities by water are supplied by three great navigable rivers—the Mississippi, on the western boundary; the Cumberland, in the northern part; and the Tennessee, which crosses the State twice. These furnish about 1,200 miles of navigable waters, while a great many of their tributaries are also suitable for floating timber. In addition, there is a fairly well developed system of railroad transportation, with a mileage of over 3,600 miles.* Few portions of the State, even in the mountainous regions, are more than 25 miles from a railroad, and the greater part of the State is within 15 miles of railroad shipping points.

The larger part of the land in Tennessee is owned by farmers, and for the most part in small tracts, except in the mountainous portions of the State and in the Mississippi bottoms. In these portions larger bodies of land are often held by corporations or individuals, usually either for speculation or exploitation of their forest or mineral wealth. Here surface, timber, and mineral rights are frequently held by different owners. All of the larger bodies of virgin timber are owned by lumber companies. There is still considerable confusion in regard to land titles in the wilder parts of the State.

Taxation of timber lands has had but little influence upon forest management. While the present system is not ideal in principle or method of application, it has not resulted thus far in imposing

* "Statistics of Railways in the United States," Interstate Commerce Commission.

an excessive burden on timber land owners as a class. Consequently there is little or no reason to believe that the cutting of timber has been hastened on account of taxes.

TIMBER INDUSTRIES.

The manufacture of lumber and timber products ranks second among the industries of Tennessee. In 1905 the value of these products amounted to over $21,500,000, while the capital invested was over $16,000,000. This is exclusive of planing-mill products, including sash, doors, and blinds, which in 1905 reached a value of over $4,500,000, with an invested capital of over $3,000,000. Fuel wood and a large amount of hewn and split material cut for local use would not be accounted for in these figures, although they constitute an important additional drain upon the forest. The consumption of firewood within the State is estimated at 4,730,000 cords for the year 1908. The most important products are rough and finished lumber of all kinds, railroad ties, staves and heading, vehicle stock, handles, poles, mine timbers, posts, and tanbark. The principal commercial timbers are oak, yellow poplar, yellow pine, red gum, chestnut, white pine, hickory, and hemlock.

STUMPAGE VALUES.

The value of standing timber depends on a number of different factors, chief among which are (1) the distance of the tract from market, (2) its accessibility for logging, and (3) the quality of the material. Since these are quite variable, any average figures, such as are given here, are of very general application, and are not suitable for valuing particular tracts. The stumpage values given for Middle and East Tennessee are based upon a distance from the railroad of from 8 to 12 miles, a haul which would be made in one day. In West Tennessee, where much of the timber does not command a price high enough to warrant long hauls, the basis of the figures is a two-trip haul.

White and red* oaks are about equal in value if the red oak is of the best quality. In many cases, however, the red oaks consist of inferior species which have a lower stumpage value. The largest amounts of white oak are produced in the Cumberlands, where it is worth about $5 a thousand feet on the stump. Similar timber in the Highland Rim, which also produces considerable white oak,

* All merchantable black oaks are usually termed "red oak."

is worth about $6 a thousand. The stumpage value of average quality red oak in Middle and East Tennessee is about $3.

Yellow poplar is obtained from nearly every part of the State and brings from $3 to $5 more than white oak.

White pine is produced mostly in the eastern part of the Cumberland Plateau region, in the Valley of East Tennessee, and along the western borders of the Appalachian Mountains. It is usually worth about $2 or $3 a thousand on the stump.

Hemlock, which is obtained from the Cumberlands and Appalachian Mountains, is worth about $1.50 or $2 a thousand, including the bark, while white pine with a somewhat similar commercial distribution brings from $3 to $4 a thousand.

Chestnut is of commercial importance throughout Middle and East Tennessee, and usually is worth on the stump from $1 to $2 a thousand.

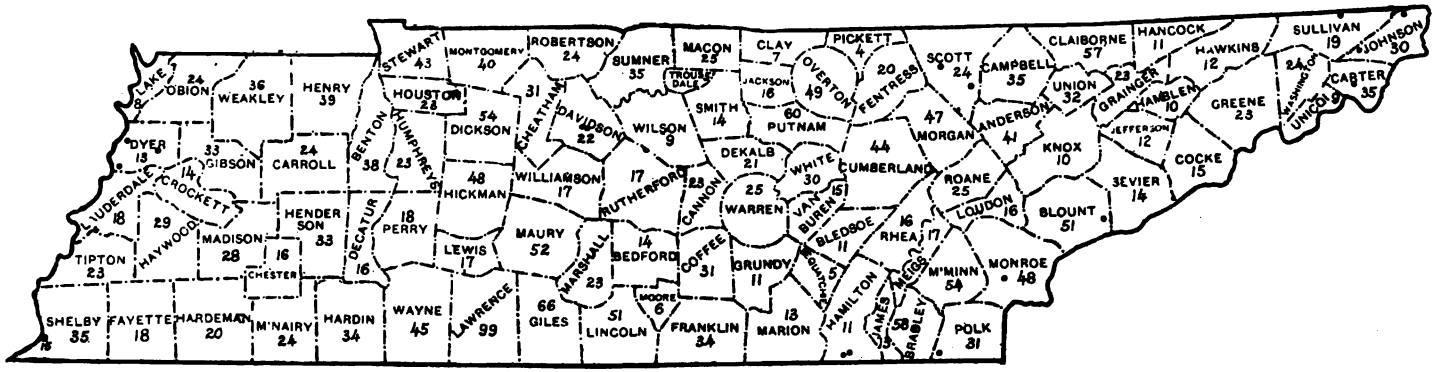
The value of hickory is especially uncertain, owing to its great variation in quality and to the fact that a special market and special methods of logging are required. In one large lumbering operation in the Cumberlands the hickory is left standing because of the difficulty of finding a suitable market. In general, it is worth from $2 to $5 on the stump. In West Tennessee, where the quality is as a rule not very good, it brings only about $3, based on a haul of two trips a day.

The West Tennessee "soft woods," such as gum, ash, and cottonwood, are worth from $2 to $4 a thousand on the stump. When sold separately, ash and cottonwood are valued somewhat higher than gum. Here there is little true white oak, and all the oaks are usually classed together as to stumpage value, which is about $6 or $7. There is little market for beech, and it is of no value unless located directly on the railroad, when it sometimes brings from $1 to $2 a thousand.

SAW TIMBER.

In 1909 there were over 2,500 active sawmills in Tennessee. Most of them were of small capacity and operated intermittently, with an average cut of only about 490,000 board feet. Only 33 mills cut over 5,000,000 board feet, and nearly half of these were located in or near Memphis and received a great deal of raw material from other States. The number of small mills is increasing as the larger bodies of timber are cut over and it becomes necessary to lumber small and scattered tracts. There is a great deal

MAP 1—TENNESSEE



SAWMILL STATISTICS, 1909.

Figures show number of active mills within the county.

Dots show the approximate location of mills that sawed over 5,000,000 board feet in 1909.

TABLE 1.—PRODUCTION OF LUMBER, LATH, AND SHINGLES, 1909.
(*Tennessee.*)

LUMBER.	THOUSAND BOARD FEET.	PER CENT.
Oak	546,500	44.6
Yellow poplar	164,826	13.5
Yellow pine	117,135	9.6
Red gum	75,565	6.2
Chestnut	71,962	5.9
Hickory	58,477	4.8
White pine	35,553	2.9
Hemlock	35,593	2.9
Ash	18,709	1.5
Beech	18,341	1.5
Cottonwood	12,380	1.0
Basswood	11,463	.9
Elm	10,688	.9
Cedar	8,927	.7
Cypress	8,709	.7
Maple	8,610	.7
Walnut	4,068	.3
Sycamore	3,512	.3
Tupelo	3,180	.3
Balsam fir	1,489	.1
Birch	1,274	.1
Cherry	874	.1
Spruce	720	.1
All other	5,294	.4
Total	1,223,849	100.0
Lath, M pieces	31,179	
Shingles, M pieces	35,692	

of waste connected with small mills owing to rough methods, wide saw kerf, lack of alignment in the machinery, and unskillful sawyers. However, they are at a great advantage in being able to move at small cost from one wood lot to another, thus saving the expense of hauling the logs. Where timber is so far from the railroad that only select logs could bear the cost of hauling in that form, a portable mill can move in and saw the inferior timber into lumber which can obviously be hauled to market at a much lower cost than in the log. Furthermore, the small mills can dispose of a certain amount of inferior lumber locally that could not be sold in the general market. This kind of lumbering will in time entirely supersede the larger operations. Some of the big sawmills claim a supply sufficient to keep them running for thirty or forty years, but these are very few in number.

Map 1 shows the approximate number of sawmills in each county and the location of the large mills for the year 1909. This map indicates very plainly the widespread character of the industry.

The amount of timber sawed in 1909 is shown by species in Table 1.* The woods classified as "all other" are chiefly buckeye, dogwood, and persimmon.

Waste in the manufacture of lumber is likely to occur both in the woods and in the sawmill. Very often timber is wasted in the woods by leaving high stumps, by cutting logs into such lengths as to leave merchantable timber in the tops, and by leaving trees uncut which ought to be removed. It would sometimes be possible to secure closer utilization by working the tops into ties, slack staves, or other small products for which there may be a market. Of course, in the more inaccessible districts where most of the large operations are carried on, it is usually impossible to handle anything but saw logs at a profit.

There is also great possibility for waste at the mill because of unskillful sawing, or lack of means for using slabs. Lath mills are often run in connection with the larger sawmills, thus utilizing material which would otherwise be wasted. The small mills are at a disadvantage in this respect, since they cannot afford to install the necessary machinery for making such by-products. Mills located in cities can usually dispose of scraps for kindling wood. A great deal of timber would be saved if boards were cut in odd as well as in even lengths.

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* Compiled by the Bureau of the Census in coöperation with the Department of Agriculture, Forest Service.

FIG. A.—HEWING RAILROAD TIES—DECATUR COUNTY.

FIG. B.—WHITE OAK BUTT CUT FOR STAVE BOLTS, SHOWING THE MANNER IN WHICH THE SAP BOLTS AND HEART BOLTS WERE SPLIT OUT WITH WEDGES—GILES COUNTY.

RAILROAD TIES.

An important forest industry of Tennessee is the production of cross-ties. This furnishes a large market for timber which is too small and knotty for saw logs. Owing to the abundance of tie timber, there is at present little demand for other woods than white and post oaks, which are best suited for the purpose on account of their hardness and durability in contact with the ground. The best grades of these ties, delivered at the railroad, usually bring from 40 to 50 cents. In West Tennessee "soft woods," such as gum, ash, sycamore, elm, and maple, are bought to a limited extent at about 25 cents a tie. Red oak, beech, and cypress ties usually bring a few cents more. Of course ties of these species, with the exception of cypress, are treated with preservatives before using.

The railroads charge the same freight rate for ties as for lumber; and it is, therefore, usually impossible to sell them at a profit except to the railroad that serves the particular locality in which the timber is located, or to the tie company that buys for that railroad. This has a tendency to keep the price down. Where transportation by water is possible, as in the neighborhood of the Tennessee and Cumberland Rivers, higher prices can usually be obtained. As a general rule, the stumpage value of ties is not more than from 5 to 10 cents each, even for white oak, and a great many are cut and delivered for a return that will scarcely pay wages. In such cases the owners are willing practically to give the timber away in order to get work for themselves or their men at seasons when there is nothing else to do.

There are two principal sources of waste in tie making as commonly carried on: (1) Many trees are cut just at the time when they are putting on the maximum amount of valuable wood. Straight, thrifty trees large enough to make several ties are very easy to work up, and are, therefore, usually cut, although it is much more profitable to allow them to reach larger size before cutting. On the other hand, small trees of poor form, which could often be thinned from overcrowded stands to advantage, are not so easy to work up and are likely to be left by the woodsman. (2) A great deal of wood is wasted in hewing ties, especially if the timber is knotty. Most timber will yield about one-third more ties if they are sawed rather than hewed. Nevertheless, nearly 90 per cent of the ties produced in Tennessee are hewed, since conditions usually make this method the more practicable. Hewed ties are preferred by most of the railroads; and even though no difference in price is made, inspection is likely to be much less rigid, so that a slightly

undersized or defective tie will be accepted if hewed when it would be rejected if sawed. Also it is somewhat less expensive to make and deliver a hewed tie, if the amount of timber wasted is not considered. Sometimes mine props and cordwood can be made from the tops of tie trees, thus saving wood which would otherwise be wasted.

MINE TIMBERS.

One of the principal uses for second-growth timber within the Cumberland Plateau is in connection with the coal mining industry, which is of great importance in that region. Timber of low grade and small size is suitable for props, caps, and mine ties, which are usually either round or split. Red oak and chestnut are the chief woods used for these purposes. Considerable saw timber is also used inside the mines for brattice, rails, and other purposes, and outside for the construction and repair of trestles and tipples. The number of props required varies greatly with the character of the rock covering which forms the roof of the coal seam. An investigation of the amount of timber used by coal mines in Eastern Kentucky showed an average consumption of about 4½ board feet per ton of coal mined. On this basis the amount of timber used in mining coal in Tennessee for the year 1909 would be 27,930,000 board feet. Of course a large part of this timber consists of material too small to make lumber.

OTHER PRODUCTS.

The manufacture of tight cooperage stock, for which white oak is the chief wood required, reaches its greatest importance in the Cumberland Plateau region. Elm and hickory are commonly used for hoops. A high grade of timber is consumed in making tight staves, and a great deal of the tree is wasted, especially if the staves are split out in the woods. In the manufacture of slack staves, on the other hand, close utilization is the rule. Oak, gum, and cottonwood are the chief woods used, and are taken largely from the bottom lands of West Tennessee. Table 2 shows the production of cooperage stock in 1909.*

Boxes and box veneers are also produced in considerable amount. In East Tennessee yellow poplar is used for this purpose, especially

* Compiled by the Bureau of the Census in coöperation with the Department of Agriculture, Forest Service.

TABLE 2.—COOPERAGE STOCK.

Production of Slack Cooperage Stock in Tennessee, 1909.

PRODUCT	TOTAL	Oaks	Red Gum	Cotton-wood	Yellow Poplar	Elm	Ash	Syca-more	Cedar	Bass-wood	Maple	Tupelo	Chest-nut
STAVES (thousands)	67,127	20,906	18,869	15,975	4,685	2,803	1,607	1,249	643	300	90	.....	.....
HEADING (thousand sets)	3,145	508	431	525	865	247	.....	10	1	.....	.....	438	120
HOOPS (thousands)	13,180	15	50	.....	.....	13,060	.....	.....	5	.....	.....	.....	.....

Production of Tight Cooperage Stock in Tennessee, 1909.

PRODUCT	TOTAL	Sawed	Bucked and Split	Hewed	Beer and Ale
STAVES (thousands)	35,744	34,345	278	4	1,117
HEADING (sets)	3,694,582	3,615,557	.....	.....	78,975

in making cigar boxes. In West Tennessee gum and cottonwood are extensively used for veneer boxes, while considerable elm is shipped to New Albany for manufacture into baskets. Close utilization is also the rule in this industry.

The production of tannic acid centers in the Valley of East Tennessee, although the neighboring regions are drawn upon for raw material. Hemlock and chestnut oak bark and chestnut wood are the chief native sources. Oak bark is worth about $9 a cord delivered on the cars, and hemlock bark about $8. Chestnut wood is bought at from $3 to $4 a cord of 5-foot wood delivered on the cars. This industry is beneficial to conservative forest management, since it affords a market for chestnut timber which is too old and defective for lumber and which should be removed for the good of the forest. The bark is also a profitable by-product in the manufacture of chestnut oak and hemlock lumber.

Vehicle stock of all kinds is manufactured extensively from oak and hickory, especially in Middle and West Tennessee. Spokes constitute the most important product of this class. For heavy wagons, white oak is used, while for light wagons and buggies hickory is preferred. Red (willow) oak is also cut in West Tennessee for cane-cart spokes. As a rule, timber from 14 to 22 inches in diameter is preferred for these purposes. The billets from which the spokes are turned are either split in the woods or sawed from bolts at the mill. While the split billets make a better grade of spokes, there is more waste in making them, since fewer cuts are taken from the tree. Even at best there is a great deal of waste in the use of hickory owing to the discrimination against heartwood and bird-peck wood.

Another special use for hickory is the manufacture of tool handles, which constitute an important product in many parts of Middle and West Tennessee. Among other minor products made from hickory are skewers, picker sticks, and weaver frames.

The production of red cedar for pencil wood, piling, and posts centers in the Central Basin, more particularly in Wilson and Rutherford Counties. Other important red-cedar counties are Marshall, Giles, Bedford, and, in part, Maury and Fentress. Red-cedar lumber of average quality is worth about $35 a thousand feet at the railroad, while the best grades run as high as $50. The average stumpage value is about $20 for saw logs. Pencil factories are located at Murfreesboro, Lebanon, and Nashville. The supply of wood suitable for this purpose is so scarce that these factories buy

logs from old cedar barns and fence rails, in some cases paying as high as 10 cents a rail in addition to putting up a new wire fence. Piling and posts of different sizes are also produced in large numbers. About 20 cents is paid for a 7-foot post 3 to 5 inches in diameter at the top. Black locust is also cut for fence posts in many parts of the State.

The strong demand for chestnut poles makes a wide market for straight second-growth timber of this species, which is valuable for the purpose on account of its light weight and durability. The poles are probably produced in greatest quantity on the western side of the Cumberland Plateau. Prices vary greatly with the size.

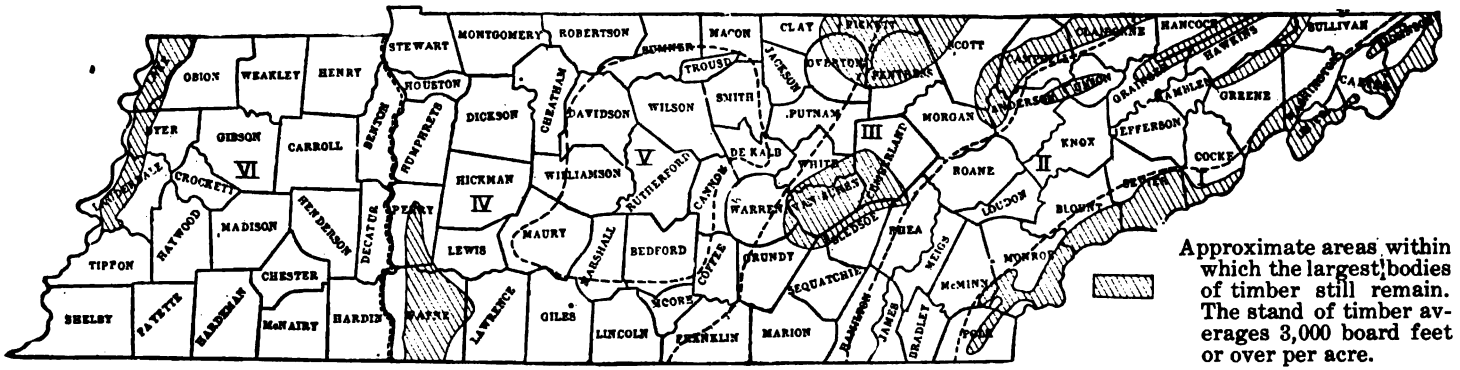
Pulp wood is a minor product of East Tennessee. Hemlock wood is worth about $4 a cord delivered on the cars, and is shipped to Canton, N. C. Poplar, basswood, and cucumber tree are worth about $5.50 a cord for pulp wood, and ash, black gum, and soft maple about $1 less, all delivered on the cars. These woods go to Bristol for manufacture.

There is also a general market for dogwood and persimmon for shuttle blocks. The price paid for dogwood delivered at the railroad is from $7 to $8 a cord of 5-foot wood 5 inches and up in diameter, and for persimmon, which usually comes in larger sticks, from $5.50 to $7 a cord.

FOREST REGIONS.

The character of the forest growth and the distribution of woodland depend chiefly on topography, soil, and other physiographic influences. Accordingly, the State may be divided into forest regions based on physiographic divisions. These divisions are the Unaka Range, or Great Smoky Mountain Belt, the Valley of East Tennessee, the Cumberland Plateau, the Highland Rim, the Central Basin, and the West Tennessee Plateau and Bottom Lands. The accompanying map shows the approximate location of the forest regions, and also of the areas within which the largest bodies of timber occur. The following descriptions are based on information in the files of the Forest Service, supplemented by brief studies made during the present examination in typical portions of each region. They are, therefore, lacking in many details which would be brought out by a longer and more thorough investigation.

MAP 2—TENNESSEE



Approximate areas within which the largest bodies of timber still remain. The stand of timber averages 3,000 board feet or over per acre.

FOREST REGIONS.

I. Unaka Range.
II. Valley of East Tennessee.
III. Cumberland Plateau.
IV. Highland Rim.
V. Central Basin.
VI. West Tennessee Plateau and Bottom Lands.

UNAKA RANGE.

The Unakas constitute a region about 2,000 square miles in extent in the form of a belt averaging 13 miles wide, which extends northeast and southwest and forms the eastern border of the State. The general elevation varies from 1,500 to 5,000 feet, but some of the higher peaks reach over 6,000 feet above sea level. The country is drained westerly by swift mountain streams tributary to the Tennessee River, some of the larger of which rise in North Carolina and cut through the range in deep and narrow valleys. There is very little level land and practically no swamps. Small farms are found along the streams and in the broader coves, mostly in the western part of the region, but the greater part of the land is too steep for cultivation.

This region is crossed at four points by railroad lines, which connect with the north and south trunk lines extending through the Valley of East Tennessee. It is also penetrated by several logging railroads. There are, however, portions of the high ridge along the North Carolina line which are still very inaccessible. Such portions are usually covered with virgin timber, although sometimes the best of the poplar and walnut has been cut and floated out at flood seasons. A considerable proportion of the land is held in large bodies, principally by lumber companies. The smaller holdings are confined chiefly to the foothills and valleys which are most accessible and best adapted for farming.

The chief industry throughout the region is lumbering, although copper mining is of local importance in the southeastern corner (Polk County). In addition to the small portable sawmills occasionally found in the more accessible parts, there are about five lumbering operations in virgin timber, with large sawmills supplied by logging railroads. A large amount of hemlock, poplar, oak, and other lumber is produced. Minor products include chestnut oak and hemlock tanbark; chestnut and, to some extent, chestnut oak extract wood; and, in the northeastern part of the region, pulpwood made from the smaller sizes of poplar, cucumber, basswood, and hemlock. Other woods are sometimes cut for special purposes, such as sugar maple, beech, and birch for bobbins, and dogwood and persimmon for shuttle blocks. Some white oak cross-ties are also produced.

The forests cover nearly all the rough, steep mountain slopes and higher coves of the region. Virgin timber, however, is confined to the most inaccessible sections, the largest bodies occurring in the

eastern parts of Sevier, Blount, and Monroe Counties. The cut-over lands are covered by irregular, uneven-aged stands of defective and suppressed old trees mixed with young growth. Even-aged, second-growth forests are found only in the vicinity of old iron furnaces or on old fields where clear cutting took place. The most important commercial timbers are yellow poplar, hemlock, and chestnut, although a great variety of valuable hardwoods as well as white pine and spruce are also found. Altitude and exposure are of great importance in determining the character of the forest. Two broad types may be distinguished—coves and slopes. While the slope type comprises a much larger proportion of the territory, the coves are of greater commercial importance, since they contain by far the heavier stands and better quality of timber. A survey of a tract of 110,000 acres in Polk and Monroe Counties shows 12 per cent of the total area to be cove land.

Coves.—The cove type includes the sheltered belts along drainage lines and the hollows at headwaters of creeks and branches. The soil is deep and fertile, with a constant and even supply of moisture. Yellow poplar and hemlock are the characteristic trees of the type, the former comprising from 3 to 10 per cent of the stand and the latter from 25 to 50 per cent. The associated species include chestnut, birch, basswood, hickory, white pine, maple, red and white oaks, buckeye, and cherry. At the higher elevations the proportion of hemlock, birch, maple, and cherry increases at the expense of yellow poplar, oak, and chestnut. Yellow poplar, chestnut, and white pine occur as dominant trees singly or in small groups, their crowns reaching above the tops of the other trees. In virgin stands the ground is usually covered with a deep humus and a good accumulation of litter, since ground fires are not frequent in this type because of the moisture. A scattering undergrowth is usually found, chiefly of hornbeam, holly, beech, dogwood, and witch hazel. Reproduction of oak and chestnut takes place where light is admitted through openings in the crown cover; while scattered seedlings of the more tolerant trees, such as hemlock, birch, basswood, beech, and maple, are found here and there under the older trees. Because of the fertility of the soil and the prevalence of a good moisture supply, the trees are of good form, with long, straight trunks, clear of branches to a great height. Virgin stands in this type will average from 8,000 to 10,000 board feet to the acre over extensive areas, while individual acres will, in some cases, yield from 20,000 to 35,000 feet. Thrifty second-growth

WHITE AND CHESTNUT OAK ON WEST SLOPE—POLK COUNTY.

stands are rare. When the cut-over lands have not been used for farming, as is sometimes possible, they have usually been so severely burned that natural tree reproduction is inferior in amount and quality.

Slopes.—The long, undulating slopes and narrow ridges are covered with many local forest types in which different species predominate. At the lower elevations, chestnut, chestnut oak, black, scarlet, and white oaks, hickory, and sometimes scrub and short-leaf pines, are the chief trees. Chestnut is very often the predominating tree, preferring northerly slopes; while scarlet, or chestnut, or white oak sometimes predominate, especially on southern exposures. White pine also grows on the northerly slopes at the lower elevations. Scarlet oak is most commonly found along the foothills just above the limestone outcrops. At higher elevations (above 2,000 feet on Little River) pitch pine is found on the more exposed southern slopes in patches that mark the poorer situations. Here white oak is largely confined to the warmer sites, such as the lower, less exposed ridges and the flatter south slopes. Chestnut oak is also found on such situations, and is abundant on nearly all the ridges and upper slopes of medium elevation. At the higher elevations, especially on slopes with northern and eastern exposures, beech, cherry, basswood, and buckeye are the most important hardwoods. Spruce begins to appear at elevations as low as 4,000 feet, on shallow, stony soil, but reaches its best development above 5,000 feet. It is associated with beech, yellow birch, and maple, and at the very highest elevations with balsam.

The direction toward which the slope faces has a great influence upon the size of the trees and the amount of merchantable timber as well as upon the composition of the stand. The south and west slopes receive the direct rays of the sun during the hottest part of the day, as well as the full force of the prevailing winds of summer. They are, therefore, more subject to drought, to wind break, and, since growth starts earlier in the spring, to frost damage, than the more sheltered north and east slopes. The soil is also thinner and less fertile, due partly to the action of the wind in blowing the leaves up the slopes and over the ridges so that they cannot decompose and enrich the soil. Consequently, the timber is smallest and of poorest quality on south slopes, and usually consists of trees best able to endure such unfavorable conditions, among which chestnut oak is most abundant, with chestnut next. White and black oak, hickory, short-leaf pine, sourwood, and black gum are also typical

of such situations. On the other hand, the north slopes are characterized by a greater variety of species, and the sheltered lower portions are classed with the cove lands. The more exposed ridges are usually covered with a stunted, scrubby growth of the hardiest trees and shrubs.

There is considerable damage to timber from fires, especially on the drier, southwest slopes. The burned-over land often becomes covered with briers, laurel, rhododendron, and other shrubs, which choke out tree reproduction. Fires are set purposely by cattlemen to improve grazing, and accidentally by hunters and campers. Cut-over lands are always in danger from fire because of the slash left after lumbering. Sometimes the impetus gained by a fire on such lands will carry it into virgin stands which would not ordinarily be in danger. For this reason lumber companies often make an effort to keep fire out of their cut-over lands.

Valley of East Tennessee.

That portion of the Great Appalachian Valley within the State forms the Valley of East Tennessee, a belt lying west of the Unakas with an average width of 50 miles, a general elevation of 1,000 feet, and an area of 9,200 square miles. It is made up of a series of minor valleys and low ridges which rise from 300 to 500 feet above the stream levels. The long, northeast-southwest valleys are underlaid by limestone and shale. The intervening ridges formed by standstone strata are either narrow and sharp-crested or mountainous in character; while the cherty dolomite ridges are broad, with rounded or level tops. The entire region is drained southwestward by the Tennessee River and its tributaries. These become smaller and swifter above Knoxville, where the general slope is somewhat steeper. The railroad transportation facilities are very good, with two trunk lines south of Knoxville and one north. Most of the land is held in farms of moderate size, although there are also a few large tracts owned by individuals or corporations.

This is a well-settled region in which agriculture is the chief industry. The timber is of relatively small commercial importance, since the virgin stands have long been cut off and little has been done to encourage and protect second growth. Nevertheless, there are many portable mills producing inferior grades of lumber, chiefly for local use, and a considerable amount of wood is cut for fuel and extract purposes. Cross-ties and chestnut poles are also produced. Within the region are several cities where various manufacturing

FIG. A.—EFFECT OF SURFACE FIRES ON CHESTNUT—MONROE COUNTY.

FIG. B.—EROSION OF CLEARED LAND—BLOUNT COUNTY.

industries center which use timber both from this and adjoining regions. In addition to planing mills, furniture and box factories, there are tannic acid plants using both wood and bark, handle and spoke factories, and other wood-using industries. Practically all of the higher grade timber comes from the mountains.

The forests are very broken in distribution, being largely confined to the crests and steeper slopes of the ridges; many of the broader ridge tops, as well as the valleys, are in cultivation. The stands are, for the most part, uneven-aged, except on old fields and on tracts which have been cut clear for charcoal or fuel. The trees are generally from 7 to 18 inches in diameter, with the exception of an occasional old chestnut or other tree which is considered too hollow or decayed to be worth cutting. The silvicultural condition of the forest is poor owing to the prevalence of fire, the grazing of hogs, and the continued culling out of the best trees.

The forest may be divided into two original types—ridge and slope; and one temporary type—old field. The ridge type includes the ridge tops and the upper south slopes, while the slope type is found on north slopes and the more fertile and sheltered southern exposures. Chestnut oak and chestnut are the characteristic trees of the ridge type, although black and Spanish oaks sometimes predominate, especially on high flats. Other common trees of this type are scarlet and post oaks, pignut hickory, black gum, and short-leaf and scrub pines. The slope type is characterized by red oak, white oak, and yellow poplar, with which are associated chestnut, hickory, maple, butternut, an occasional walnut, and many other hardwoods.

The old-field forests are usually found on lower slopes or on ridge tops which were once cleared for agricultural purposes. The first woody growth on old fields is usually pine, sassafras, and persimmon; but later the composition becomes more similar to the original type, except that there is in most cases a much higher proportion of short-leaf and scrub pines. Sometimes the pine reproduces in practically pure stands, while it very often forms groups covering from 20 to 50 per cent of the area. In the original types, pine is confined to the poorer situations and rarely occupies more than from 10 to 15 per cent of the ground. The proportion of short-leaf to scrub pine on the old fields varies greatly, and seems to be determined chiefly by the proximity of seed trees of one or the other species. Possibly a little over one-half of the old-field pine in the southern counties consists of the more valuable short-leaf pine, while in the northern counties about three-fourths is scrub pine.

Red cedar is also a common conifer in the various types of this region, chiefly on limestone land.

A local type of some importance in the northern part of the region might be called "short-leaf pine flats." The soil is a dry, loamy sand, sometimes mixed with clay, and the ground cover is either entirely absent or consists of a thin layer of grass, weeds, and leaves. Dense groups of sumach, sassafras, huckleberry, and blackberry form an irregularly scattered underbrush. Short-leaf pine and black oaks, including scarlet and Spanish, and occasionally a willow oak and some scrub pine, are the chief trees. These are associated with a scattering of other hardwoods and an occasional loblolly pine in moister situations. Short-leaf pine predominates and is the most valuable tree. While the pine is sometimes pure, it is common to find pine and hardwoods mixed, either by groups or as single trees.

CUMBERLAND PLATEAU.

The Cumberland Plateau is a high table-land, 5,000 square miles in extent and 2,000 feet in elevation, which lies west of the Valley of East Tennessee and is separated from it by a fairly regular line of precipitous sandstone cliffs. The western boundary, which is also marked by sandstone cliffs, is much more irregular, following a series of projecting headlands inclosing rich coves. The surface of the table-land is cut by numerous ravines and deep valleys, and is especially well dissected toward the north and west. Most of the northern part is drained in a northerly direction by tributaries of the Cumberland. South of Cumberland County the drainage is tributary to the Tennessee River. There are no navigable rivers in the region, but facilities for railroad transportation are fair. The central part is crossed by the Tennessee Central Railroad, while the Cincinnati Southern extends across the plateau north of Harriman, and then runs southwest from this point just beyond and parallel to the eastern escarpment. It is also penetrated by branches of the Nashville, Chattanooga and St. Louis Railway from the south and west. Probably about half of the land is concentrated in large holdings of value chiefly for coal or timber, or for both.

Lumbering and coal mining are the chief industries. Agriculture is of minor importance at present. In addition to saw timber, important forest products are cross-ties, chestnut poles, spokes, handles, extract wood, and tanbark. The largest lumbering oper-

GROWTH OF ABOUT FIFTEEN YEARS ON OLD FIELD ON LOWER SLOPE; CHIEFLY POPLAR, WITH SOME OAK—SCOTT COUNTY.

FIG. A.—RIDGE TYPE OF CUMBERLAND PLATEAU; OAKS, HICKORY, AND BLACK GUM—CLAIBORNE COUNTY.

FIG. B.—UPLAND SWALE TYPE, CUMBERLAND PLATEAU; WHITE, RED, AND CHESTNUT OAKS AND MOCKERNUT HICKORY—CLAIBORNE COUNTY.

ations are found in the north and northwest portion of the region, where private logging railroads have been constructed. Small operations, usually conducted with portable mills, are numerous and widespread. Throughout the region are small and scattered tracts of practically virgin timber which have been held for one reason or another. The larger bodies and those containing timber of the best quality are found in the northern part in Pickett, Overton, Fentress, and Scott Counties.

There are four distinct types of forest land in this region—coves, slopes, plateau ridges, and plateau swales. Of these, the cove and slope types are the most important from the commercial standpoint.

The proportion of land in each type varies greatly in different sections of the region. A careful survey of a large and fairly typical tract on the waters of Rocky River showed about one-sixth of the area to be cove and slope land, one-third plateau swales, and one-half plateau ridges. On the other hand, in a well-dissected section farther north nearly a third of the area consisted of cove land, while practically all of the rest was of the slope type.

Coves.—The cove lands consist of the better portions of the valley slopes and hollows well below the level of the plateau. The characteristic soil is a deep, moist loam, rocky or stony, upon which is a layer of humus, often several inches in depth. The underbrush varies in density and usually consists of rhododendron, laurel, red bay, witch hazel, persimmon, dogwood, and viburnum. The characteristic and dominant trees of the type are white oak, yellow poplar, and chestnut. Beech and sugar maple are also very numerous. Among the associated species are hickory, black oak, red oak, chestnut oak, buckeye, red maple, basswood (linn), ash, elm, and an occasional walnut, cucumber, and cherry. Hemlock is also found, sometimes singly, but usually in groups, and sometimes with white pine. The chief difference between this type and the true Appalachian cove type lies in the smaller proportion of hemlock and the larger amount of white oak. Reproduction is fairly good, although shade conditions in the typical older stands favor seedlings of tolerant species, such as sugar maple and, to a less extent, hickory and ash. Oaks, red maple, and yellow poplar come up in the natural openings of the forest. Yellow poplar reproduces best, however, on abandoned fields, where it sometimes forms an almost pure stand.

The characteristic timber of this type is straight, tall, clean, and of excellent quality. Virgin stands yield on the average about 8,000 board feet per acre.

Slopes.—The slope type includes south and upper north slopes, and is intermediate, both in situation and quality, between the cove and plateau types. The characteristic trees are chestnut oak, black, scarlet, and white oaks, and hickory. Usually either chestnut oak or one of the black oaks predominates. Chestnut, black gum, and short-leaf pine are also common, the pine usually in groups. The quality and amount of timber is somewhat inferior to that found in the coves, virgin stands yielding only about 6,000 board feet per acre.

Plateau Swales.—The plateau swales are the lower portions of the table-land, including the flat lands and shallow depressions along drainage lines that lie below the general level of the ridges. The soil is of good depth, especially if the land receives the wash from the slopes, and it is fairly moist because the water does not drain off rapidly. Black, white, Spanish, and scarlet oaks, with a varying proportion of hickory, predominate in this type. Black gum, post and chestnut oaks, chestnut, and short-leaf pine are also sometimes included in the mixture. The swampy bottoms, which are of very limited extent, contain thickets of red maple, black gum, and sweet gum, often with an undergrowth in which large holly trees are conspicuous. The timber does not grow as high as that of the coves and is not so clear and free from defects. The yield per acre of virgin timber averages about 4,000 feet.

Plateau Ridges.—These are the highest and most exposed portions of the table-land, with thin, sandy, unproductive soil. They are covered with a short and stunted growth of inferior hardwoods, such as post, black jack, scarlet, and chestnut oaks, sand hickory, and black gum, with some scrubby chestnut. Scrub pine, and sometimes short-leaf, grow on this land in mixture with the hardwoods or in pure stands. The timber is not only short-boled and limby, but is usually badly injured by insect and fungus enemies, partly owing to the frequency with which fires occur. The stand is open and at best yields only about 2,000 board feet per acre.

HIGHLAND RIM.

The Highland Rim is a high, broad shelf surrounding the Central Basin, with an area of 9,300 square miles and average elevation of 950 feet above sea level. It is a rolling country, with broad valleys and rounded hills. The underlying rock is chiefly limestone. There is great variety in the quality of the soil, perhaps the poorest being found on the cherty formations that immediately surround

SLOPE TYPE OF CUMBERLAND PLATEAU; CHIEFLY WHITE, BLACK, AND SPANISH OAKS—SCOTT COUNTY.

the Central Basin. The drainage system is well developed, and there is very little swamp land. The greater part of the land drains south and west toward the Tennessee River, although a section on the north is included in the basin of the Cumberland.

In addition to the Cumberland and Tennessee, which are both navigable rivers, there is a good system of railroad transportation, so that few places are more than 12 miles from shipping points. The most inaccessible portion is found in Wayne County, in the southwest corner of the region. By far the larger part of the land is in farm holdings of moderate size.

The chief industry is agriculture, although lumbering and mining for phosphate and iron are also of local importance. Lumber, cross-ties, spokes, and handles are the most important forest products. Most of the lumbering operations are on a small scale, since, with the exception of a few of the more inaccessible counties, the merchantable timber is distributed in a very scattered manner in farm wood lots and small tracts. There is very little virgin timber left, the principal bodies lying about halfway between the railroad and the Tennessee River, in Wayne, Lawrence, and Perry Counties, and in the northeast corner of the region, in Pickett and Overton Counties.

There is a great diversity in the character of the forests of this region, but they may be roughly grouped into slope and ridge types. A cove type, very similar to that described for the Cumberlands, is also found in this region at the base of the Cumberland Plateau, along the margin of the Central Basin and in the southwestern counties along the Tennessee River. There is more or less land which was once cleared, but which proved either too poor or too steep for farming and is now reverting to forest or has already done so. The stands are uneven-aged except in the neighborhood of old iron furnaces, which were once very common in the western part of the region. Here the forest was cut clean for charcoal, and even-aged stands have resulted, covering extensive areas.

Slopes.—The soil of the slopes, which, as a rule, are moderately steep, is somewhat better than that of the ridges, but most of the agricultural soils have been cleared and put under cultivation. The type is characterized by a mixture in which the oaks predominate, especially black, red, Spanish, and white oaks. Hickory is also a very constant constituent of the stand. A great many other hardwoods are included, the most important of which are chestnut, yellow poplar, black gum, and ash. Beech is also found on the lower slopes, and sycamore along the streams.

Ridges.—The ridges are either narrow and rounded or broad and flat, but are characterized by a thin, sandy, unproductive soil, often strewn with chert fragments. Scarlet, black jack, and post oaks, and hickory are the common ridge trees, constituting a type similar to the Cumberland Plateau ridges, but on the whole of somewhat better quality. In the southern part of the region, especially in Wayne and Perry Counties, there are occasional belts of shortleaf pine, either pure or associated with scattering post and black jack oaks. The quality of the pine is much better than that of the hardwoods of this type.

CENTRAL BASIN.

The Central Basin, an oval depression 5,400 square miles in area, about 400 feet below the level of the surrounding Rim, is, on the whole, a gently rolling region underlaid by limestone and possessing very fertile soils. The outer portions of the region are somewhat rougher. The drainage is toward the north, south, and west through the Cumberland, Duck, and Elk Rivers, the two latter being tributaries of the Tennessee. Numerous railroads radiate from Nashville, affording, together with the Cumberland River, good means of transportation. The principal wagon roads are macadamized. With the exception of a few large estates, the land is held in small farms.

The chief industry of the region is agriculture. A few select saw logs are shipped from various points, principally to the veneer factories; while small mills, often run by threshing-machine engines, saw a little lumber for local use. The red-cedar industry centers at Murfreesboro, where there is a pencil-wood factory which depends principally upon this region for its supply. This species also supplies the market with a great many fence posts and small poles.

The forest is largely confined to small, ornamental groves and to belts or patches of timber on broken land along the creeks and on the poorer hillsides and ridges. The groves are, as a rule, located near or about the farmhouses on good agricultural land. The ground is usually covered with blue grass, with no tree reproduction. These remnants of the original forest are preserved for their natural beauty, for shade about the house, or to protect the cattle from the sun in the heat of summer. Stands of this type are usually composed of mature or overmature trees, which are often widespreading and limby. Many of these old trees, especially the elm,

FIG. A.—SLOPE TYPE OF THE HIGHLAND RIM; OAK, POPLAR, AND CHERRY—STEWART COUNTY.

FIG. B.—RIDGE TYPE OF THE HIGHLAND RIM; WHITE OAK, BLACK OAK, AND HICKORY—STEWART COUNTY.

are dying out, sometimes as a result of changes in drainage conditions. The most common species are white, cow, chinquapin, and bur oak, hard maple, ash, walnut, sycamore, elm, buckeye, and butternut.

The scattering bodies of timber on broken land near creeks are composed of about the same species that are included in the pastured groves. On the hills and ridges, however, many other hardwoods are represented, including chestnut and other oaks, beech, sugar maple, and hickory. Red cedar is sometimes found in mixture with these hardwoods and sometimes in pure groups. It is especially characteristic of thin-soiled, stony, limestone hillsides.

The abandoned fields show a great variety of tree growth. Sassafras, persimmon, hickory, patches of black locust, groups of poplar on moister situations, and red cedar in dense thickets, or scattered singly, may frequently be met with all on the same farm.

West Tennessee Plateau and Bottom Lands.

The country between the Tennessee and Missisippi Rivers may be considered as one forest region, although it includes two physiographic divisions and part of a third. The Plateau and Slope lands comprise an area of about 8,850 square miles, and the bottom lands of the Tennessee and Mississippi Rivers nearly 1,500 square miles. The region is mostly under 600 feet in elevation, the uplands rising from 200 to 400 feet above the stream bottoms. The greater part of the region is a low, rolling upland, with a short slope on the Tennessee side, and a long, gentle, westward slope to the bluffs that border the Mississippi bottom lands. The underlying rock seldom outcrops and is covered by a deep mantle of unconsolidated deposits of clay, loam, and sand. The soil of the bottoms is alluvial in origin and of great fertility, although not always available for agriculture because of insufficient drainage and danger of overflow. The upland soils vary considerably in quality, the more fertile loams covering the western half of the plateau. They are, as a rule, compact and wash badly even on very moderate slopes. In addition to the two navigable rivers that bound the region, a network of railroads affords good transportation facilities. The farms are mostly small, averaging about 100 acres, while the large holdings are practically confined to portions of the Mississippi bottom lands.

This is primarily an agricultural country, with cotton as the chief money crop. Lumbering on a large scale is carried on only in the bottom lands of the Mississippi. The principal forest products are

lumber, cross-ties, box veneers, cooperage stock, and spokes. The greater part of the timber cut comes from the bottom lands.

Uplands.—The upland forests are of two types—one in which post oak is the characteristic tree, and another in which the better oaks predominate. The post oak type is found on the higher ridges and upper slopes of the hilly sections and on sandy, sterile flats. It is particularly characteristic of the soil type described by the United States Soil Survey as Lexington sandy loam. With post oak are most commonly associated black jack, scarlet and Spanish oaks, and pignut hickory. The trees are small-sized and short-boled, averaging from 6 to 14 inches in diameter and yielding little timber of value. In the southwestern counties of Hardin and McNairy the type is occasionally interspersed with stands of short-leaf pine.

On the lower ridges and slopes and on gently rolling lands of the soil type described as Memphis silt loam a better group of hardwoods prevails. The principal species are white, Spanish, and black oaks, pignut and mockernut hickories, and scattered chestnuts. Along drainage lines, tulip poplar, sweet gum, beech, and sycamore are also found. The stands are uneven-aged, and the trees generally run from 8 to 16 inches in diameter. This type is naturally productive, but has suffered from unsystematic cutting and general neglect.

Bottom Lands.—The bottom-land forests reach their greatest extent and importance on the broad flood plain of the Mississippi, but also occur on the various rivers and creeks that drain the uplands. The virgin stands are dense, with tall, clear trees which form an unbroken canopy of foliage. The typical tree is red gum, which makes up about 50 per cent of the forest. Oak, ash, cottonwood, hickory, cypress, elm, sycamore, soft maple, and tupelo gum are the common associates. The black-oak group is represented by red, swamp Spanish, and some few pin and willow oaks. Cow oak is the chief bottom-land white oak. Among the hickories are included the bottom shellbark, shagbark, and mockernut. Cottonwood is an important constituent of the forest on the Mississippi bottoms, especially on low, sandy land of recent origin; while on the bottoms of the smaller streams the oaks are of greater importance. Some beech is found on low ridges and is one of the few bottom-land timbers for which there is almost no market. There is usually a scattered underwood of hawthorn, holly, dogwood, and young growth of gum, hickory, hackberry, and other trees.

Few virgin forests of this type remain, the most extensive of

PASTURED WOOD LOT, UPLAND TYPE OF WEST TENNESSEE PLATEAU; SPANISH BLACK, AND WHITE OAKS—HARDEMAN COUNTY.

RIGHT OF WAY CUT FOR LOGGING RAILROAD THROUGH MISSISSIPPI BOTTOM-LAND FOREST; CHIEFLY GUM, SYCAMORE, AND ELM—DYER COUNTY.

which are on the Mississippi bottoms in the northwestern part of the region. Such forests have an average stand of from 10,000 to 12,000 board feet per acre. The gum, oak, and cottonwood timber is of excellent quality; but the cypress is very defective, running at least 50 per cent "pecky." Growth is very rapid on cut-over lands, and the fire damage is small on account of the wet character of the situation. This is not, however, a permanent type, since most of the land will eventually be reclaimed for agricultural purposes.

FOREST PROBLEMS.

UNAKA RANGE AND CUMBERLAND PLATEAU.

While the forest types in the Unaka Range, the more mountainous ridges of the Valley of East Tennessee, and the Cumberland Plateau differ somewhat, the problems of forest management are in general very similar. In contrast to the rest of the State, they are essentially timber-exporting regions and should always remain so. Moreover, they constitute an important part of what is known as the southern Appalachian region, which is bound to be the chief source of the future hardwood supply of the United States. The other regions in the United States from which hardwood lumber is obtained are nearly all agricultural in character and must eventually be used primarily for that purpose. While the soil of the Unaka Range is in many cases fertile, the mountain sides are so steep that farming is not practicable and timber is bound to be the chief crop. The Cumberlands, on the other hand, have certain agricultural possibilities. The level plateau land may eventually be farmed with profit by the liberal use of fertilizers and other intensive methods, when market conditions warrant the expense. Nevertheless, there probably will always be much more absolute forest land than is necessary to supply the local demand for timber and wood.

The fact that the Cumberland and Tennessee Rivers head in these regions also gives them peculiar importance. The forests of the mountain slopes should be maintained to check the run-off and to regulate stream flow. Their preservation is essential for the successful utilization of water power and effectual artificial storage. The protective function of the forest cover is of especial importance in the Unaka Range because of the great height of the slopes. These problems are discussed in detail in the "Report of the Secre-

tary of Agriculture on the Southern Appalachian and White Mountain Watersheds,"* and need not be enlarged upon here.

The small proportion of virgin timber which remains is very inaccessible and must be logged at considerable expense. The private companies who own this timber regard it as necessary to cut all the trees that can be handled at a profit, in order to pay the cost of constructing the logging railroad and other fixed expenses. Accordingly, they do not intend to cut conservatively nor to protect the young growth for a second crop.

The greater part of the land is already heavily cut over. Many small tracts have also been cleared for farming, worn out in a few years, and then abandoned. In the more inaccessible sections the usual practice is to kill the large trees by girdling and to leave them standing. On these abandoned farm lands even-aged stands have sometimes started as a result of seeding from neighboring trees.

The growth of woody vegetation is so vigorous that cut-over lands which have not been plowed seldom become bare and totally unprotected against erosion, even in spite of fire and other adverse influences. The chief danger from washing is along old skid roads which follow drainage lines, and thus give a foothold for the destructive action of water. In a few cases this danger has been guarded against by piling slash in the skid roads after the last logs have been hauled down, in order to check washing until vegetation has had a chance to establish itself. Little is done to prevent fires on cut-over land, except when necessary to protect fences and virgin timber. The effect of the repeated burning is to prevent the reëstablishment of a valuable forest growth. An inferior growth of sprouts comes up from the burned stumps, and the development of hardy, but valueless, shrubs is encouraged. The most valuable trees, such as yellow poplar, chestnut, and white pine, are the most sensitive to fire injury. Such a growth as persists in spite of repeated burning, while it often is sufficient to prevent the soil from washing off of the steep slopes, does not have the effect in regulating run-off that a better forest growth possesses. There is not as good shade, the spongy layers of humus and leaf litter are destroyed, and the capacity of the soil to absorb moisture is reduced.

As soon as the fire risk is reduced to a minimum, other measures can be taken to improve the forests and make timber growing profitable. The composition and rate of growth can be improved by thinning out the inferior species and poorer individuals from

* United States Senate Document 91.

FIG. A.—A ROUGH, LIMBY CHESTNUT OAK TOPPED AT 23 INCHES, WASTING TWO STANDARD TIES—SULLIVAN COUNTY.

FIG. B.—WASTE IN CUTTING STAVE BOLTS; TOP, 28.3 INCHES IN DIAMETER, LEFT ON ACCOUNT OF KNOTS AND WATER SOAK—GILES COUNTY.

crowded stands. In making final cuttings, certain principles can be observed that will insure a second crop from the young trees in the shortest possible time, as well as reproduction from seed and sprouts. In these regions the chief object of management will be the production of saw timber, although many other products will also be obtained. For this purpose yellow poplar and chestnut are the most promising in the Unaka Range, while white oak may be included with these in the Cumberlands. Short-leaf pine will also be a very valuable tree on the driest soils of the Cumberland Plateau lands where valuable hardwoods will not thrive. Hickory is likewise important, especially in the Cumberlands. While the best hickory timber grows on upper north slopes in mixture with oak, the younger growth is of fair quality in almost all situations. Reproduction is good and growth rapid enough to make it well adapted to management and an important tree for the future. Excellent fuel can be obtained from the smaller trees cut out in thinning, while the larger timber is of especial value in the manufacture of vehicles.

A large amount of woodland in the Cumberlands is underlaid by workable coal. This land should be managed for the production of mine timbers, in order to render the mines independent of the general market for their supply. At present there is very little method in the selection of timber for use in the mines, this usually being left to the contractor. Consequently, the most convenient trees are cut without regard to the effect on the forest. Usually the slopes nearest the mines are devastated, while more remote bodies of timber belonging to the same property are deteriorating from decay and overcrowding. Whether the land is owned by the mining company or merely leased, it would be profitable to all concerned to institute improved methods of cutting so as to conserve the supply and improve the condition of the forest. Owners of coal lands should see to it that provisions to this end are inserted in mining leases. A few of the more progressive companies have already taken steps in the right direction. The fact that small-sized trees of all kinds can be utilized gives an exceptionally good opportunity to thin out the forest in such a way as to increase the growth and improve the quality of the timber produced. Just how this can best be accomplished would be an important subject for investigation by a State Forester.

One of the most important problems before the State is the affording of adequate fire protection to forest land, and this problem

is especially vital in these timbered regions. Legislative and other means toward this end will be discussed in another part of this report. The State should also inaugurate studies of the rate of growth and silvicultural requirements under local conditions of the more important species, in order to show the probable results that can be obtained in growing timber and the best methods to use. An investigation of short-leaf pine and the conditions under which it reproduces would be of great practical value, especially in the Cumberlands. A study of second-growth chestnut and yellow poplar in Tennessee has already been started by the State Geologist in coöperation with the Forest Service for the purpose of determining the most practicable methods of management. A study of the management of coal lands for mine timbers, to find the methods that are most suitable and the probable yield in each type, is greatly needed in the Cumberland Plateau.

Valley of East Tennessee and Highland Rim.

While these regions are separated by the Cumberland Plateau, the character and distribution of the forests and the broad problems of forest management are similar, if the more mountainous ridges of the Valley of East Tennessee be excepted. Both contain a considerable proportion of absolute forest land, possibly one-fourth of the total area. Forestry will, however, always be subordinate to farming. The forest is broken in distribution and owned mainly by farmers. It is largely depleted of valuable timber, and its productive capacity has deteriorated because of fires, indiscriminate grazing, and repeated culling of the best trees.

A considerable proportion of the timber produced in the future will be used directly upon the farm. There is also a good general market for nearly all classes of forest products in the numerous towns and cities. Management can, therefore, be on a rather intensive basis, and the farmer can well afford to use his spare time in keeping his woodland in the best possible condition. He can usually find ways of using on his own place the material that he thins out, even if no other market can be found for it. Unfortunately, the improvement of farm wood lots ordinarily receives little consideration. Trees are cut because they are handy and suit the purpose, even if it would be much more profitable in the long run to leave them and use instead inferior or overmature trees that might be a little more difficult to get at or work up. It is also a common mistake to try to combine timber and grass production, with poor

results in both directions. Grass will grow but very sparsely under trees which are close enough together to produce good timber, so that pasture land should be cleared except for a few scattered, wind-firm, shade trees. On the other hand, woodlands should be kept fairly dense, and no attempt should be made to graze them heavily. It is especially necessary to keep out all live stock during a period when it is desired to establish a young growth of trees. Hogs are particularly destructive in such a period, since they devour the seed of nut-bearing species and root up many young seedlings.

All of these questions, however, require further investigation under the special conditions that prevail in different sections. Also a great deal of educational work is needed in order to acquaint the people with the fundamental principles of forest management. More accurate information should be obtained in regard to the growth and requirements of the important species, such as chestnut, yellow poplar, Spanish oak, black oak, hickory, and short-leaf pine. Methods of thinning and otherwise improving the even-aged stands on furnace lands in the western part of the Highland Rim should also be studied.

CENTRAL BASIN.

Although the Central Basin does not contain nearly enough land which can profitably be devoted to raising timber to supply its own needs, it nevertheless presents certain problems in forest management that are of local importance. Many of the small pasture and ornamental groves are dying out because of the old age of the trees, or changes in drainage, or other conditions. The usual sod of blue grass, the trampling of stock, and close pasturage, prevent natural restocking with young trees. This might be secured by breaking up the sod and excluding stock. Such treatment is not usually advisable, however, since satisfactory results can be obtained by planting in small groups and leaving the greater part of the grass undisturbed. Of course, all seedlings must be fenced for protection until they are large enough so that stock will not injure them. In regard to the present stand, the cutting must be made with a view to keeping as many of the older trees as long as possible. The strengthening of decrepit old trees by mechanical means, as well as pruning, may often be justified because of their ornamental value. Such measures, however, belong to the field of arboriculture rather than of forestry.

The very limited area that can be used as wood lots should be made to yield as many posts and other farm timbers as possible. The principal problems connected with wood-lot management are similar to those that have already been mentioned for the Valley of East Tennessee and the Highland Rim. In many cases it may be necessary to plant young trees in order to secure a full growing stock. The natural locust groves may often be made more productive by judicious thinning. There should be a good profit in growing red cedar on stony hill sides that are not of much value for other purposes, since fence posts can probably be grown in open stands in twenty-five years. Information on methods of management of red cedar for pencil wood may be obtained from Circular 102 of the United States Forest Service.

West Tennessee Plateau and Bottom Lands.

The management of farm wood lots is the chief problem of the uplands here, as in the other agricultural districts. Also the problem of the best use of land presents itself in another form. In this case woodland is being unwisely cleared by negro farmers in order to secure fresh land for cotton. Since the soil is compact and there is a strong tendency to form gullies even on moderate slopes, considerable land which should be retained in forest is ruined in this way.

As the bottom lands are drained and protected, the forests there will eventually be reduced to small farm wood lots in the lowest and poorest situations. Since this drainage work goes on slowly, it will be possible on many tracts to obtain one or several crops of timber before it is completed, especially as most of the bottom-land trees are very rapid growers. In order to obtain the greatest increment in both volume and quality on such forest lands, it is necessary in the original cutting to use a higher diameter limit than if no future cutting were in view. Also it is often possible in the case of dense stands of moderate-sized trees to thin them out in the first cutting, thereby stimulating greatly the growth of those that remain and procuring large timber for the next cutting. Cottonwood is especially adapted to such treatment. It is also wise to remove old, decadent trees that take up a great deal of room and hinder the development of young poles and saplings, even if there is no profit in handling them. One company has adopted this policy of conservative cutting, using a diameter limit of 24 inches on the stump for gum, but such far-sighted methods are not general. Of course,

WASTE IN LOGGING; A WHITE OAK STUMP 3 FEET HIGH—PERRY COUNTY.

there would be no inducement for a timber operator, owning only the stumpage rights, to adopt such a policy unless some special arrangement were made for this by the landowner.

FOREST POLICY FOR THE STATE.

NECESSITY FOR ACTION.

It was not possible with the time and funds available for the preliminary study upon which this report is based to estimate the amount of standing timber or determine how soon a scarcity of the supply is likely to be felt. However, it is already becoming difficult for consumers of high-grade lumber to get enough raw material for their uses. All indications point to a continued supplanting of higher grade timber, with lower grades as far as this is possible, and to a period of scarcity and restricted production in the not far distant future. Eventually the annual cut will have to adjust itself to the annual growth of timber on the forest lands of the State.

The exhaustion of the virgin timber is not in itself a disadvantage. It is even necessary that mature and decadent timber be cut out to prevent loss and to allow younger trees room for development. The great evil lies in the fact that little or no attention is paid to securing and fostering a valuable second growth. There is a great deal of land in the rougher parts of Tennessee that will yield little or nothing in any other crop than forest trees. Yet in the face of the growing scarcity of timber, these lands are being allowed to become unproductive through neglect. If timber lands are to remain in a productive state, they must be treated intelligently. No one expects to grow any other crop without attention, and yet no other crop matures so slowly as the forest crop or requires so long a time for the rectifying of mistakes in management.

The forest land of Tennessee is practically all held by private individuals, and by far the greater part will continue to be so held. If forestry is to be practiced, it must, therefore, be by these private owners. Most of them will do little or nothing along this line unless the State shows them the need and advantage and assists them in using proper methods. In addition, the State should help in giving the landowners protection from fire. There is now a fire law on the statute books which provides penalties for setting forest fires carelessly or willfully, but it lacks an appropriation to make it effective.

In this connection it should be remembered that the Appalachian

Bill which has recently become a law appropriates the sum of $200,000 from the Federal Treasury to enable the Secretary of Agriculture to coöperate with the States, when requested to do so, in organizing and maintaining a system of fire protection on private or State forest lands situated upon the watersheds of navigable rivers. The amount expended in any State cannot exceed the amount appropriated by that State for the same purpose in the same fiscal year. No agreement will be made, however, with any State that has not provided by law for a system of fire protection. In order, therefore, that Tennessee may take advantage of this provision and obtain a share of the appropriation, the State should undertake at once the organization and support of such protective system.

In addition to mere legislation, an educational campaign to show the damage that results from surface fires in woodland is greatly needed and will do much to protect the forests from this danger. It is now recognized by many States that it is to their advantage to promote better methods of forestry just as they are encouraging improvement in agriculture. Sixteen States employ one or more trained foresters in such work, and some of these have also State forest reserves.

The need of educating the owners to increase the productiveness of their woodland is especially important in Tennessee. It is estimated that about 35 per cent of the total area of the State, or 9,300,000 acres, is in woodland. The average annual growth per acre of forest throughout the State is probably not over 100 board feet. Through the application of forestry this should be more than doubled. If, however, it were increased by only 10 board feet, this would mean that the annual timber production of the State would be greater by 93,000,000 board feet. At the low rate of $15 per thousand, this is equivalent to an increased annual income from timber products of $1,395,000, to be distributed among the landowners and those who furnish the labor and materials for marketing these products. Such a gain might be very easily obtained on second-growth lands by giving them a little attention and protection; and as soon as better methods become general, the increase should be much greater. Since culled lands in which old growth still predominates has practically no annual increment, their productiveness can be increased even more by the introduction of proper forest management. The State could well afford to invest an annual appropriation of $20,000 or $30,000 in order to increase the annual income from forest products by over a million dollars.

PROPOSED LEGISLATION.

The legislation in regard to forestry now on the statute books is of a very scattered nature. In addition to the fire law, it consists chiefly in giving investigative functions to three different departments—the State Geological Survey, the Department of Game, Fish, and Forestry, and the Commissioner of Agriculture. It is time to consider what legislation is needed in order to unify and round out a consistent and complete forest law. It is believed that forestry education and forest fire protection are of sufficient importance to warrant the creation of a new department or State Board of Forestry. Accordingly, a plan of legislation is outlined upon this basis. In case it does not seem practicable to adopt this policy, it would be of great advantage to make a special appropriation for the continuation of forest investigations under the direction of the State Geological Survey, either independently or in coöperation with the Federal Forest Service.

The proposed Board of Forestry should be so constituted that it will be free from politics and fitted to take charge of scientific and educational work. Therefore, it is suggested that the board consist of the Governor, the State Commissioner of Agriculture, State Geologist, State Game Warden, Director of the Tennessee Agricultural Experiment Station, and two timber land owners, to be appointed by the Governor, one of whom shall be a manufacturing lumberman. The members should serve without compensation except for necessary expenses.

This board should direct the promotion of the forest interests of the State, and should make a biennial report to the Legislature showing the nature and extent of the work accomplished. It should employ a State Forester, who should be a graduate of a reputable forest school, and a man of experience and ability in his profession. His duties should include (1) the organization of a fire protective force and the administration of the fire laws; (2) the administration of State forests for demonstration and experimental purposes; (3) educational work, such as lecturing on forestry and related subjects before farmers' institutes and other public meetings, and the publication of bulletins; and (4) scientific investigations with a view to increasing the knowledge of the forest resources of the State and to finding out the methods of forest management best suited to local conditions in different sections.

(1) The forestry law of 1907 provides for a system of fire protection under the office of the State Game Warden, giving the

County, Special, and Deputy Game Wardens the duties of forest fire wardens. They are authorized to take charge of fire fighting, to summon assistance, to inspect railroad rights of way, and to arrest, without warrant, offenders against the fire laws. The law has failed in effectiveness because no provision was made for funds to pay the expenses of fire fighting. Also no arrangement was made for posting warning notices; and, therefore, the provisions of the law are not generally known. It is believed that better results would be obtained by not trying to burden the game wardens with this aditional work, which has little relation to their regular duties, and for which they may or may not be fitted. Therefore it is recommended that the State Forester be made State Fire Warden, and that he be empowered to request the Board of Supervisors of each county to appoint, with his approval, a county fire warden, or to appoint one himself should the County Board fail to take action. The county wardens should be subject to removal by the State Forester. The powers and duties conferred upon the game wardens by the law of 1907 should be transferred, with some modifications and additions, to the fire wardens thus provided for, who should likewise be given the powers of sheriffs in enforcing the forest laws of the State. The county wardens should be required to report each fire to the State Forester on suitable forms, to post warning notices, and to patrol in dangerous seasons if directed to do so by the State Forester. If the State Forester deems it advisable, deputy wardens should be appointed by the county warden, with the approval of the State Forester, to work under his direction, with the same powers and duties. The State Forester should also have authority to appoint special wardens, to serve voluntarily without pay, or with compensation from private owners. This would enable suitable employees of parties interested in fire protection to secure the powers of wardens and to coöperate in fire protection without expense to the State or county.

It should further be provided that whenever the State Forester becomes convinced that a dangerously dry time exists, and that it is imprudent to set fire on any land, he shall cause a notice to this effect to be posted in three public places in each county concerned, and that any person setting a fire upon any land in that county after the posting of such notices shall be guilty of a misdemeanor. This provision should not apply to camp fires built in safe places and extinguished before leaving, or to log piles, stumps, and brush located at least a quarter of a mile from other combustible material.

However, the escape of fire from such camp fires, log piles, stumps, or brush should be *prima facie* evidence that the burning was unsafe and in violation of the statute.

Section 11* of the present law provides that " nothing contained in this Act shall take away or impair the right to damages or other legal remedy which the party injured may now have under the laws of this State." This would be strengthened by adding the provision that the liability of persons or corporations for all damages shall include the injury to young growth resulting from fires, and that, upon request of the court, the State Forester shall make an examination and give an expert opinion as to the amount of damages to forest growth. It should also be provided that in a prosecution for the willful or negligent setting fire to forests, it shall be within the discretion of the court to take evidence as to the cost of fighting the fire which the accused is charged with setting, and to assess such costs as part of the penalty if the person or persons charged with the offense shall be found guilty.

The railroads should be required to post in stations warning notices, furnished by the State Forester, calling attention to the fire laws. Section 14 of the 1907 law, which provides that logging locomotives must be furnished with spark arresters, is unjust in that it discriminates against a particular class. This provision should be extended to cover all locomotives and engines operating in or near forest land not burning oil for fuel.

(2) The forestry law of 1907 authorizes the State Game Warden to collect statistics in regard to forest conditions, to investigate the suitability of public lands for forest reserve purposes, to take charge of such reserves as might be created, and to accept gifts of land for forest reserves. These duties lie naturally within the province of the State Board of Forestry, and should be transferred to that board, to be administered by the State Forester under its direction. Further authority should be given the board to make rules and regulations for the State forests, including the right to sell timber. In the case of sales amounting to over $100 in value, advertisement for bids should be required.

The sections† in regard to forest reserves should be so modified as to permit the use of mineral land for this purpose, the mineral rights to be retained by the original owner, if the land is acquired by purchase or gift. Section 23 makes it necessary for a nonresi-

* Acts of 1907, Chapter 397.

† Sections 21 and 22.

dent of the State to obtain the services of a warden as guide in case he wishes to camp within the State forest reserves. This section should be repealed, since regulations safeguarding the camping privilege can best be made by the State Board of Forestry, which should be given the necessary authority.

The State now owns two tracts of land suitable for forest reserve purposes—the Brushy Mountain tract, in Morgan County, and the Herbert Domain, in Cumberland and the adjoining counties on the southwest. The former is about 12,000 acres in area, and includes 3,000 acres of practically virgin timber. The Herbert Domain covers between 10,000 and 11,000 acres, but the timber probably does not exceed the amount that is likely to be needed for the development of coal mines on the property. Both of these tracts should be handled so as to produce as much timber as possible in the long run. The Board of Prison Commissioners, which now controls these lands, has no authority to sell timber or practice forestry. It is recommended that the surface and timber on these tracts be turned over to the Board of Forestry to administer as State forests. Thus an opportunity may be given to start at once valuable object lessons in the practice for forestry, as well as experimental investigations. It would also make it possible to stop the loss now incurred by the State through the decay of overmature timber, which cannot be sold under existing statutes. It is further recommended that the Board of Forestry be authorized to purchase land for State forest purposes, at a rate not to exceed $5 an acre. This authority would probably not be exercised for the present, at least, owing to lack of sufficient funds at the disposal of the board, but would be desirable in case any small tract is needed in connection with the administration of lands now owned by the State and made State forests in accordance with these recommendations.

(3) The need for educational work by the State Forester, particularly in regard to fire protection and the introduction of conservative methods of forest management, has already been clearly brought out. Special emphasis should be laid on the damage done in stock-raising sections by the practice of burning the woods every year in order to keep down the brush and to get new grass earlier in the spring. Not only does the forest growth deteriorate under such treatment, but the more nutritious annuals and winter grasses are gradually replaced by tougher perennials, so that the grazing

interests eventually suffer. Since much serious injury results from these causes, it should certainly be within the power of the landowner to regulate or prevent grazing on his own property. This is not possible in the counties which have not secured the passage by the Legislature of a law prohibiting stock from running at large. These are, for the most part, in the more thinly populated districts with large areas of woodland. The permanent welfare of such counties requires the passage of stock laws. Educational work along this line, supplemented by an investigation to demonstrate the injurious effect of annual fires on the quality of the grasses, would be an important duty of a State Forester.

The State Forester should be give authority to assist private owners at their request, also by making plans for conservative management of woodlands and advising in regard to the execution of such plans, provided that the applicant in each case pays at least the expenses of the field work that may be necessary. A careful record should be kept of the results secured by such working plans, which would furnish practical examples of what may be accomplished by rational management of woodlands.

(4) The State Forester should, of course, take charge of the investigation of forest problems within the State. The most important subjects for investigation in the different regions have already been mentioned. In connection with such studies, it should be possible to make detailed forest surveys and estimates of some of the typical timber counties as a start toward a forest type map and description of the State. The map work should be done in considerable detail, showing cleared land and types of forest. If this were done independently of other work, it would cost about $400 to map and estimate a county. It is recommended, however, that if such surveys are undertaken at all, it be in connection with investigations of special problems. The State Forester should be authorized to cooperate with the Federal Government and with other branches of the State Government in scientific investigations, when this can be done to the advantage of the State.

The expense of carrying out the forest policy outlined naturally divides itself into two parts—the cost of the State Forester's office in educational, scientific, and administrative work, and the cost of fire protection. The first should be met by a State appropriation of $10,000 annually. This should be supplemented by a State forest fund, into which all receipts from the sale of timber on the State forests and fines for violations of the forestry laws would be paid.

This fund should be used in the protection, improvement, and extension of the State forests. In emergency cases the State Forester should have the right to draw upon it for fighting fire in a county which has exhausted its annual allowance for this purpose.

The cost of the general fire protective system should be shared equally between the State and the individual counties in which the money is spent. This division prevents the placing of too great a burden on more thinly populated counties, and is perfectly fair, since the protection of the forests benefits indirectly the entire State as well as the individual counties. To secure promptness in payment of fire fighters, the State should pay the accounts and collect one-half from the county in which they were incurred. The rate of compensation for fighting fire is fixed in the present law at $3 a day. This is unnecessarily high, and might be an inducement to set fires in order to get employment in putting them out. It is recommended that the rate be changed to 20 cents an hour, and that the county and deputy wardens be paid at the rate of 25 cents an hour for time actually employed in patroling, fighting fire, posting notices, making reports, or doing other official work. They should also be reimbursed for reasonable expenses for necessary equipment and transportation. All accounts, including those for wages, should be approved by the State Forester before payment. The amount to be spent for fire protection in any county in any one year might be limited to $200, and in the entire State to $10,000. On this basis the total cost to the State of the forest policy recommended would not exceed $15,000 per year, and the cost to any one county would not exceed $100 per year, while the maximum total expense per year would be $20,000. This expenditure is to be regarded as an investment, the returns to come in the saving of loss through fire, in the increased productivity of the woodlands, and in the maintenance of wood-using industries.

APPENDIX I.

List of Tree Species Native to Tennessee.

The following list of tree species native to Tennessee is compiled from Sudworth's Check List (Forest Service Bulletin 17), supplemented by the observations of the author and of W. W. Ashe, of the Forest Service. After the scientific name, first the accepted common name according to the Check List, is given, and then any local names that are commonly used within the State. In case the spe-

cies is not listed in the Check List, merely local names are given. The letters E, M, and W indicate the divisions of the State within which the species occur, whether East, Middle, or West Tennessee.

Pinus strobus, Linn.	White pine	E
Pinus taeda Linn.	Loblolly pine Old-field pine	E
Pinus rigida Mill.	Pitch pine	E
Pinus virginiana Mill.	Scrub pine Black pine Nigger pine	E M
Pinus pungens Michx, f.	Table-mountain pine	E M
Pinus echinata Mill.	Short-leaf pine Yellow pine	E M W
Picea mariana (Mill.) B. S. P.	Black spruce Balsam	E
Picea rubens Sargent	Red spruce Balsam	E
Tsuga canadensis (Linn.) Carr	Hemlock Spruce pine	E M
Tsuga caroliniana Engelm.	Carolina hemlock Spruce pine	E
Abies fraseri (Pursh) Lindl.	Fraser fir She Balsam	E
Taxodium distichum (Linn.) Rich.	Bald cypress	W
Taxodium distichum imbricarium (Nutt.) Sarg.	Pond cypress	W
Thuja occidentalis Linn.	Arborvitæ White cedar	E
Juniperus virginiana Linn.	Red Juniper Red cedar	E M W
Juglans cnierea Linn.	Butternut White walnut	E M W
Juglans nigra Linn.	Black walnut	E M W
Hicoria pecan (Marsh) Britton	Pecan (hickory)	W
Hicoria minima (Marsh) Britton	Bitternut (hickory) Pignut hickory	E M W
Hicoria aquatica (Michx. f.) Britton	Water hickory Bitter pecan	W
Hicoria ovata (Mill.) Britton	Shagbark (hickory)	E M W

Hicoria carolinae-septentrionalis Ashe	Shagbark hickory	E
Hicoria laciniosa (Michx. f.) Sargent	Shellbark (hickory) Kingnut	M W
Hicoria alba (Linn.) Britton	Mockernut (hickory) White hickory	E M W
Hicoria glabra (Mill.) Britton	Pignut (hickory) Black hickory	E M W
Hicoria odorata (Marsh.) Sargent	Small pignut (hickory) Black hickory	E M W
Hicoria villosa (Sarg.) Ashe	Pale-leaf hickory Sand hickory	E M W
Salix nigra Marsh.	Black willow	E M W
Salix wardi Bebb.	Ward willow	M
Salix amygdaloides Anderss	Almond-leaf willow	W
Salix discolor Muehl.	Glaucous willow	W
Populus grandidentata Michx.	Large-tooth Aspen Poplar	E
Populus heterophylla Linn.	Swamp cottonwood Black cottonwood	W
Populus deltoides Marsh.	(Common) Cottonwood	E M W
Betula nigra Linn.	River birch	E M W
Betula lutea Michx. f.	Yellow birch	E
Betula lenta Linn.	Sweet birch Black birch	E M
Ostrya virginiana (Mill.) Koch	Hornbeam Ironwood	E M W
Carpinus caroliniana Walt.	Blue beech	E M W
Fagus atropunicea (Marsh.) Sudworth	Beech	E M W
Castanea pumila (Linn.) Mill.	Chinquapin	E M W
Castanea dentata (Marsh.) Borkh.	Chestnut	E M W
Quercus alba Linn.	White oak	E M W
Quercus Minor (Marsh.) Sarg.	Post oak	E M W
Quercus macrocarpa Michx.	Bur oak Overcup oak	M W
Quercus lyrata Walt.	Overcup oak Bur oak	M W
Quercus prinus Linn.	Chestnut oak	E M W
Quercus acuminata (Michx.) Houba	Chinquapin oak	E M W
Quercus platanoides (Lam.) Sudworth	Swamp white oak	E

Quercus michauxii Nutt.	Cow oak Bur oak	E M W
Quercus rubra Linn.	Red oak Water oak	E M
Quercus texana Buckl.	Texan oak Red oak	M W
Quercus coccinea Muenchh.	Scarlet oak Spotted oak	E M
Quercus velutina Lam.	Yellow oak Black oak	E M W
Quercus digitata (Marsh) Sudworth	Spanish oak Red oak	E M W
Quercus palustris Muenchh.	Pin oak	M W
Quercus marilandica Muenchh.	Black jack	E M W
Quercus nigra Linn.	Water oak	M W
Quercus imbricaria Michx.	Shingle oak	M W
Quercus phellos Linn.	Willow oak	M W
Quercus pagodaefolia Ashe	Swamp Spanish oak Red oak Yellow-bottom oak	M W
Ulmus crassifolia Nutt.	Cedar elm	E M
Ulmus pubescens Walt.	Slippery elm Red elm	E M W
Ulmus serotina Sargent	Bluff elm	E M
Ulmus americana Linn.	White elm	E M W
Ulmus racemosa Thomas	Cork elm	M W
Ulmus alata Michx.	Wing elm	E M W
Planera aquatica (Walt.) Gmel.	Planertree	W
Celtis occidentalis Linn.	Hackberry	E M W
Celtis georgiana Small	Georgia hackberry	M
Celtis mississippiensis Bosc.	Sugarberry Hackberry	E M W
Celtis smallii Beadle	Hackberry	E
Morus rubra Linn.	Red mulberry	E M W
Magnolia glauca Linn.	Sweet magnolia Swamp magnolia	E M W
Magnolia acuminata Linn.	Cucumber tree	E M
Magnolia macrophylla Michx.	Large-leaf umbrella	E M
Magnolia tripelata Linn.	Umbrella tree	E M

Magnolia fraseri Walt.	Fraser umbrella Indian physic	E
Liriodendron tulipifera Linn.	Tulip tree Yellow poplar White wood	E M W
Asimina triloba (Linn.) Dunal.	Pawpaw	E M W
Sassafras sassafras (Linn.) Karst.	Sassafras	E M W
Hamamelis virginiana Linn.	Witch hazel	E M W
Liquidambar styraciflua Linn.	(Red or) Sweet gum	E M W
Platanus occidentalis Linn.	Sycamore Buttonwood	E M W
Pyrus coronaria Linn.	Sweet crab	E M W
Pyrus ioensis (Wood) Bailey	Iowa crab	M W
Pyrus angustifolia Michx.	Narrow-leaf crab	E M
Pyrus americana (Marsh.) de C.	Mountain ash	E
Amelanchier canadensis (Linn.) Medic.	Serviceberry Shad-bush	E M W
Crataegus punctata Jacq.	Dotted haw	E M W
Crataegus cordata (Mill.) Ait.	Washington haw	E M W
Crataegus viridis Linn.	Green haw	M W
Prunus americana Marsh.	Wild plum	E M W
Prunus hortulana Bailey	Garden wild plum	M W
Prunus angustifolia Marsh.	Chickasaw plum	E M W
Prunus pennsylvanica Linn. f.	Wild red cherry	E
Prunus virginiana Linn.	Choke cherry	E M W
Prunus serotina Ehrh.	Black cherry	E M W
Cercsi canadensis Linn.	Redbud Judas tree	E M W
Gleditsia triacanthos Linn.	Honey locust	E M W
Gleditsia aquatica Marsh.	Water locust	M W
Gymnocladus dioicus (Linn.) Koch.	Coffeetree	M W
Cladrastis lutea (Michx. f.) Koch.	Yellow wood	E M
Robinia pseudacacia Linn.	Locust	E M W
Robinia viscosa Vent.	Clammy locust	E
Ptelia trifoliata Linn.	Hoptree	E M W
Cotinus cotinoides (Nutt.) Britton	American smoketree	E
Rhus hirta (Linn.) Sudworth	Staghorn sumach	E M

Rhus copallina Linn.	Dwarf sumach	E M W
Rhus vernix Linn.	Poison sumach	E M W
Ilex opaca Ait.	American holly	E M W
Ilex decidua Walt.	Deciduous holly	E M W
Ilex monticola Gray	Mountain holly	E
Euonymus atropurpureus Jacq.	Waahoo Burning bush	E M W
Acer spicatum Lam.	Mountain maple Low maple	E
Acer pennsylvanicum Linn.	Striped maple	E
Acer saccharum Marsh.	Sugar maple Sugar tree	E M W
Acer saccharum rugelii Rhed.	Sugar maple	E
Acer saccharum nigrum (Michx. f.) Britton	Black maple	E M W
Acer saccharum leucoderme (Small) Sudworth	White-bark maple Sugar maple	E
Acer saccharinum Linn.	Silver maple Soft maple	E M W
Acer rubrum Linn.	Red maple Soft maple	E M W
Acer rubrum tridens Wood	Red maple	E M
Acer negundo Linn.	Boxelder	E M W
Aesculus glabra Willd.	Ohio buckeye	E M W
Aesculus octandra Marsh.	Yellow buckeye	E M W
Aesculus austrina Small	Buckeye	W
Rhamnus caroliniana Walt.	Yellow burkthorn	E M W
Tilia americana Linn.	Basswood Linn	E M W
Tilia heterophylla Vent.	White basswood Linn	E M
Tilia eburnea Ashe	Linn basswood	E
Aralia spinosa Linn.	Angelica tree Hercules Club	E M W
Cornus florida Linn.	(Flowering) Dogwood	E M W
Cornus alternifolia Linn. f.	Blue dogwood	E
Nyssa silvatica Marsh.	Black gum	E M W
Nyssa aquatica Linn.	Cotton gum Tupelo	W

Vaccinium arboreaum Marsh.	Tree huckleberry	E M W
Oxydendron arboreum (Linn.) de C.	Sourwood Sorrel tree	E M W
Kalmia latifolia Linn.	Mountain laurel	E
Rhododendron maximum Linn.	Great rhododendron Rosebay Great laurel	E
Bumelia lanuginosa (Michx.) Pers.	Shittimwood Gum elastic	W
Diospyros virginiana Linn.	Persimmon	E M W
Mohrodendron carolinum (Linn.) Britton	Silverbell tree	E M W
Fraxinus quadrangulata Michx.	Blue ash	E M W
Fraxinus americana Linn.	White ash	E M W
Fraxinus biltmoreana Beadle	Biltmore ash	E
Fraxinus pennsylvanica Marsh.	Red ash	E M
Fraxinus profunda Bush	Pumpkin ash	M W
Fraxinus lanceolata Borkh.	Green ash	E M W
Catalpa speciosa Warder	Hardy catalpa	M W
Viburnum lentago Linn.	Sheepberry	E
Viburnum prunifolium Linn.	Nannyberry	E M

APPENDIX II.

GROWTH OF WHITE AND CHESTNUT OAKS.

The following extracts from Forest Service circulars contain information in regard to the growth of white and chestnut oaks, based on measurements obtained, for the most part, in Tennessee. They are reprinted here on account of the scientific and practical value of the tables.

WHITE OAK.*

The most important feature of the growth of white oak, as well as the most significant characteristic of the tree, is its inherent persistence. The growth of white oak is comparatively slow. Young trees are often outstripped and suppressed by other species. They will, however, grow slowly, but persistently, for many years under adverse conditions.

In white oak the duration of vigorous growth is greater than in any of its associates except yellow poplar and possibly chestnut. It retains its vigor and resistent qualities to an advanced age. For these reasons white oak in the long

* Circular 105, "White Oak in the Southern Appalachians."

run overcomes and replaces in the mature virgin stands the black and red oaks, which have such a marked advantage over it in early life. As a rule, in virgin woods, the proportion of white oak increases steadily in the older-age classes. It often forms the bulk of the mature timber in stands where but 10 per cent of the young growth is white oak.

The very slow rate of growth of white oak seedlings under virgin forest, as well as their persistence under adverse conditions, is shown in the last column of Table 1. It is based upon measurements of seventy-seven white oak seedlings in virgin coves in the Holston Mountains of Northeastern Tennessee. The forest in this case was exceptionally dense, and the rate of growth is undoubtedly much lower than the average on virgin lands in the region as a whole. The growth of white oak seedlings, however, is slower than that of seedlings of most of the important timber trees associated with it. Under similar site conditions, young black and red oak will almost invariably outstrip white oak.

The rate of growth in height of white oak sprouts under virgin woods is given in the three middle columns for the cove and slope types of the Cumberland Mountains and for the cove type of the Holston Mountains.

TABLE 1.—HEIGHT OF YOUNG WHITE OAK AT DIFFERENT AGES IN EASTERN TENNESSEE.

AGE	CUMBERLAND MOUNTAINS		HOLSTON MOUNTAINS	
	Sprout		Sprout	Seedlings
	Cove	Slope	Cove	Cove
Years	*Inches*	*Inches*	*Inches*	*Inches*
1	13.0	12.5	10.0	4.0
2	40.0	26.0	16.5	5.5
3	57.0	39.5	21.0	6.8
4	70.0	48.2	24.0	8.0
5	82.0	56.0	26.7	9.0
6	.....	.....	29.0	10.0
7	.....	.....	31.0	10.8
8	.....	.....	33.0	11.7
9	.....	.....	35.0	12.4
10	.....	.....	36.6	13.0

The sprouts measured upon the cove lands of the Holston Mountains were growing under an old stand of unusual density, which accounts for their comparatively slow rate of growth. These figures can be compared directly with those for the rate of growth of white oak seedlings, which were obtained from exactly the same coves. By such comparison, it is seen that under the same conditions as to soil, moisture, and light, the sprouts of white oak grow about three times as fast during the first ten years as the seedlings.

The rate of growth of young white oak sprouts, while vigorous, is considerably less rapid than that of chestnut and of black oak and red oak. Instances are frequently found in the oak belt of Central and Western Tennessee and Kentucky where white oak sprouts have been outstripped in growth and badly suppressed by black and red oak sprouts of the same age.

Table 2 shows the growth in diameter of virgin white oak up to 21 inches. It is based on measurements of 509 trees taken in Jackson County, Ky., but represents the average rate of diameter growth of white oak throughout the Southern Appalachian region.

TABLE 2.—HEIGHT AND DIAMETER OF VIRGIN WHITE OAK AT DIFFERENT AGES.

AGE	Height	Diameter breast high
Years	*Feet*	*Inches*
20	11	1.1
30	18	2.2
40	25	3.2
50	31	4.2
60	38	5.3
70	44	6.3
80	49	7.4
90	55	8.5
100	60	9.7
110	65	11.0
120	69	12.3
130	72	13.5
140	74	14.7
150	76	15.4
160	79	16.3
170	82	17.8
180	84	18.9
190	85	19.9
200	87	21.0

The development of second-growth white oak after logging, with much better light conditions, is considerably faster than that of virgin timber. Measurements of second-growth white oak were obtained in Decatur County, Tenn., on lands which were cut clean for charcoal from fifty to sixty years ago. The rate of growth of this young timber in height, diameter, and volume is given in Tables 3 and 4.

TABLE 3.—RELATION OF HEIGHT AND DIAMETER TO AGE OF SECOND-GROWTH WHITE OAK IN DECATUR COUNTY, TENN.

AGE	Height	Diameter breast high
Years	*Feet*	*Inches*
5	6	0.2
10	12	1.0
15	19	2.0
20	25	3.3
25	31	4.6
30	37	5.9
35	44	7.1
40	50	8.3
45	56	9.4
50	61	10.3
55	66	11.2
60	70	11.7
65	73	12.2
70	74	12.6
75	75	12.9
80	76	13.2
85	77	13.4
90	78	13.6

TABLE 4.—VOLUME *a* OF SECOND-GROWTH WHITE OAK OF ALL TYPES, DECATUR COUNTY, TENN.

Diameter breast high	All types	Diameter breast high	All types
Inches	*Board feet*	*Inches*	*Board feet*
10	24	15	106
11	34	16	130
12	47	17	155
13	65	18	180
14	85		

a Logs scaled by Doyle's rule.

The better soil and moisture conditions found on the cove and slope lands produce more rapid growth in height and diameter than on the ridges, and much more rapid volume increment.

CHESTNUT OAK.*

The rate of growth of chestnut oak is slower both in height and diameter than that of any of the associated oaks. This and its intolerance account for its being so largely excluded from the shady coves. Table 5 shows the development in diameter, total height, and clear length of trees in the virgin forest of the slope type in Polk and Monroe Counties, Tenn. The growth, as shown in this table, seems, on comparison with measurements made in other portions of the region of slope, ridge, and cove trees, to represent about the average rate of growth for virgin timber throughout the region. Second-growth trees and trees which have had more favorable light conditions in culled forests would show much more rapid diameter increment at least.

TABLE 5.—TOTAL HEIGHT, CLEAR LENGTH, AND DIAMETER GROWTH OF VIRGIN CHESTNUT OAK IN POLK AND MONROE COUNTIES, TENN.

Age	Diameter breast high	Total height	Clear length	Age	Diameter breast high	Total height	Clear length
Years	*Inches*	*Feet*	*Feet*	*Years*	*Inches*	*Feet*	*Feet*
20	1.2	12	5	120	12.0	63	24
30	2.4	19	8	130	13.0	65	24
40	3.4	25	11	140	13.9	67	25
50	4.3	31	13	150	14.9	69	25
60	5.4	36	15	160	15.8	70	26
70	6.5	41	17	170	16.7	72	26
80	7.7	47	19	180	17.5	73	26
90	8.8	52	21	190	18.4	74	27
100	10.0	57	22	200	19.3	75	27
110	10.9	60	23				

* Circular 135, "Chestnut Oak in the Southern Appalachians."

Table 6 contains average figures for the rate of growth of seedling sprouts and seedlings of chestnut oak for the first ten years in virgin woods. Two localities were studied—the Cumberland Mountains, of Claiborne County, Tenn., and the Holston Mountains, in Sullivan County, Tenn. Separate averages were made for each locality by types.

TABLE 6.—HEIGHT GROWTH OF YOUNG CHESTNUT OAK.

AGE	Cumberland Mountains, slope, and ridge, seedling coppice (101 trees)	Holston Mountains			
		Slope and ridge, seedling coppice (90 trees)	Slope, root suckers (29 trees)	Cove	
				Seedling coppice (48 trees)	Seedlings (30 trees)
	Inches	*Inches*	*Inches*	*Inches*	*Inches*
1 year	13	12	6	9	5
2 years	30	22	7	21	7
3 years	46	38	8	33	8
4 years	62	61	9	44	9
5 years	76	75	9	53	10
6 years	89	.....	10	59	11
7 years	100	.....	10	64	12
8 years	.....	.....	11	.....	13
9 years	.....	.....	11	.....	13
10 years	.....	.....	12	.....	14

From this table the rate of growth of seedlings and seedling sprouts of chestnut oak in the same locality and type can be directly compared. Such comparisons show the rate of growth of seedling coppice in height to be from three to five times as rapid as that of seedlings. The rate of growth of root suckers is seen to run slightly less than that of seedlings.

The following tabular statement, made from measurements taken in different portions of Tennessee and North Carolina, shows the average height, clear length, and diameter breast high of old chestnut oak growing under different conditions. Each measurement is averaged from a number of trees in the same locality, growing under the same conditions, but, except in the ridge trees measured in Jackson and McDowell Counties, N. C., only averages of mature trees above 20 inches are included.

County and State	Trees growing in coves			Trees growing on slopes			Trees growing on ridges		
	Average height	Average clear length	Average diameter	Average height	Average clear length	Average diameter	Average height	Average clear length	Average diameter
	Feet	*Feet*	*Inches*	*Feet*	*Feet*	*Inches*	*Feet*	*Feet*	*Inches*
Sullivan County, Tenn.	102	42	32	77	35	31	.....	.....	.....
Claiborne County, Tenn.	90	45	32	60	30	24	59	19	22
Perry County, Tenn.	85	40	23	75	30	23	51	20	23
Jackson and McDowell Counties, N. C.	81	34	24	.....	.....	.....	a 21	7	6

a Includes trees with diameters less than 20 inches.

The relation of total height to clear length, showing the extent of self-pruning, is also observable. The relative length of crown on the several types is exhibited, and the greater sizes attained in the cove type than in the slope or ridge type.

The largest dimensions are attained along and west of the Allegheny and Cumberland Mountains, in West Virginia, Kentucky, and Tennessee. Individual specimens occasionally reach a height of 115 and 118 feet, and maximum diameters of 50 and 52 inches.

10—B (Of Tenn. Geol. Surv. Series)

STATE OF TENNESSEE—STATE GEOLOGICAL SURVEY
GEORGE H. ASHLEY, State Geologist

IN COOPERATION WITH THE FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE
HENRY S. GRAVES, Forester

CHESTNUT IN TENNESSEE

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Chestnut in Tennessee

COMMERCIAL OUTLOOK

Chestnut, because of the extensive and rapidly increasing use of its wood as a source of tanning material, has become one of the most important forest trees of Tennessee. There are now seven tannic extract plants in operation within the State, and all use chestnut wood and bark, though some use in addition, the wood or bark of chestnut oak. To supply these plants more than 50,000 cords of wood are cut yearly in Tennessee with a value of about $187,500 at the shipping points. In addition to the extensive use of the wood for tannin, the census of 1909 reports 71,962,000 feet of chestnut lumber cut in Tennessee, with a mill value of $1,121,888. There were also produced 120,000 sets of heading valued at $5,520, and a large number of staves, ties, and poles valued at not less than $325,000. On a most conservative basis the chestnut is, therefore, worth $1,640,000 annually to the State. With the continued reduction in the available supply of other native tannin materials, the chief of which are hemlock and chestnut oak bark, chestnut must become the chief remaining source of supply, and its use will increase. Since low grade chestnut wood and small-sized pieces, including the bark, can be used for tannin stock, this industry in connection with lumbering, permits the complete utilization of the tree. Chestnut has a comparatively rapid growth; it occupies extensive areas either in pure stands or as the dominant species in mixed stands; it grows on land which has a comparatively low value for agriculture, and reproduces freely by sprouts as well as by seed. These are natural advantages which the tree offers for management. Further, its yield can be largely augmented by protecting the forest from fire, and by thinning young stands; and the value of the forest can be additionally enhanced by systems of cutting designed to produce the most valuable class of commercial products. All these things combine to make the commercial management of chestnut forests a feasible and profitable undertaking.

DISTRIBUTION

Chestnut is commercially important throughout middle and eastern Tennessee and as far west as Perry and Stewart Counties; farther west it is comparatively unimportant. It is most abundant on the slopes of the Unaka and Smoky Ranges embracing the Great Smoky, Unaka, Stone, and Iron Mountains, and on such outlying ranges as the Holston, Frog, and Yellow Mountains. In many places in all of these mountains it forms as much as twenty-five per cent of the forest over tracts several thousand acres in extent. In the Unaka and Smoky Ranges it is locally most abundant on elevated benches of the north and west slopes and on the crests of northern spurs, between altitudes of 1,800 and 3,500 feet. In such situations it may occur pure or nearly pure over areas as large as 100 acres. Between the Unakas and the Cumberland Plateau chestnut forms less than 15 per cent of the timber. Here it is largely confined to hollows and north slopes, and pure stands rarely occupy more than a few acres. On the valley lands, irrespective of soil, it constitutes less than 5 per cent of the forest. It is common on the slopes of the Cumberland tableland, especially on the sandstone soils which have a sufficient depth and are not too rocky; in such situations it forms a large portion of the forest. Chestnut is almost entirely absent, however, on the thin-soiled and stony portions of the tableland, especially near the southern end. In Claiborne, Campbell, Anderson, Morgan, and Cumberland Counties it forms possibly 15 per cent of the timber.

Chestnut constitutes only a small proportion of the forests of the Central Basin, but is one of the chief trees of the Highland Rim. In portions of Hickman County, which occupies a typical situation on the western part of the Highland Rim, 10 per cent of the forest aggregating several thousand acres, consists of chestnut. On the sandier soils of the Highland Rim chestnut comprises up to 20 per cent of the forest on the better sites.

SILVICAL CHARACTERISTICS

SOIL AND MOISTURE REQUIREMENTS:

Chestnut requires for its best growth, deep, moist loams or sandy loams. The soils on which it grows must be of considerable depth to permit the penetration of its ample, deeply ramifying roots, and must be moderately supplied with moisture in the subsoil, but well drained on the surface. It seldom grows on clay

soils, and practically never on limestone soils. On clay soils it grows only where the surface of the land is sufficiently rolling to insure surface drainage, and even then it forms only a small proportion of the forest growth. It makes excellent growth on highly acid soils where it is frequently associated with rhododendron (laurel) on north slopes, or with kalmia (ivy) on west slopes, but it also grows in pure stands. Although less exacting than yellow poplar, walnut or ash, in respect to depth of soil and amount and uniformity of moisture supply, it is more exacting than white oak, by which it is replaced on the drier soils, even where there is considerable depth. On the thoroughly drained sandy or gravelly soils it gives way on cool slopes to white pine, and on somewhat stiffer soils to scarlet oak, especially at middle elevations, and to black oak at lower elevations.

While chestnut is exacting in regard to depth and porosity of soil, and makes moderate demands upon soil moisture, it does not require either a sweet or a fertile soil. Unlike poplar, basswood, and ash, it will grow thriftily upon sandy soils with a subsoil deficient in lime as well as potash, and in addition to its capacity for germinating and growing on the peaty soil of the rhadodendron (laurel) thickets, it does well also on soils with scant humus cover. In these respects it is one of the least exacting of the hardwoods. Of species which require a deep soil, it is intermediate between species like yellow poplar, ash, and walnut, which require considerable soil fertility and the less exacting white and short leaf pines.

As a rule, especially at altitudes between 1,000 and 3,000 feet, chestnut occupies soils which are too acid and sandy to be of high agricultural value unless limed. On the other hand, the soils within these altitudes which are more uniformly moist in the subsoil and are neutral or only slightly acid, such as are occupied by yellow poplar, walnut and locust, are regarded as well suited for farming purposes. At altitudes below 1,000 feet, the soils usually occupied by shortleaf pine, black oak, and hickory, are also considered superior for general farming purposes, to those occupied by chestnut. Above 3,000 feet altitude much of the soil occupied by chestnut is regarded as of good quality for pasture land, if set in redtop (herds) grass, which will grow on more acid soils than will clover and bluegrass.

TEMPERATURE AND LIGHT

Chestnut is adapted to a wide range of climatic conditions. It flourishes from an altitude of less than 500 feet elevation in southwestern Tennessee, where the average annual temperature is 59 degrees Fahrenheit (the mean of the summer maxima 89 degrees, and the winter minimum seldom as low as zero), to elevations of more than 5,500 feet along the Smoky and Unaka Mountain ranges, where the average annual temperature is below 50 degrees (the mean of the summer maxima not more than 80 degrees, and the winter minimum frequently 30 degrees below zero). Its best growth, however, is on moderately cool sites, such as shady slopes, coves, and elevated benches of the eastern mountains between 1,000 and 3,000 feet in altitude. Here it not only attains its maximum dimensions, but is numerically more abundant, occupying large areas to the practical exclusion of other species. Rainfall has but little effect on its distribution, since Tennessee has a rainfall which is seldom below 40 inches a year, with an equable seasonal distribution.

REPRODUCTION

For seedling reproduction, chestnut requires only a limited amount of light. The seedlings will persist for many years under the shade of old trees, and when twenty to thirty years old may not exceed 15 feet in height and 3 inches in diameter. As a rule, when the large trees which are overtopping these suppressed seedlings are cut, the seedlings respond quickly to the increased light and make accelerated growth. If suppressed for a great many years, however, the seedlings either die or lose their power of rapidly recuperating when eventually favored by more light. Even though they continue to live, they ultimately develop into slow-growing specimens similar to the large trees which form the present old forest. Although sprouts will grow for a few years under poor light, they ultimately require more light than seedlings, and their best development can take place only under full light. When single scattered trees are cut in a stand of normal density there is frequently insufficient light for the sprouts, which die after a few years.

Production of Seed.—Chestnut bears seed or mast abundantly at intervals of a few years. In intervening years the seed crop is lighter, but seldom entirely wanting. The flowers appear in midsummer, too late to be killed by frost, but rainy weather, during

the pollination period, may prevent the setting of the fruit and curtail the crop of nuts. A heavy mast year is usually followed by one of small mast. Even though large quantities of nuts are collected for sale, enough are left on the ground to insure abundant reproduction; these, however, are often eaten by hogs, or burned, and small seedlings that may get started are destroyed by fires and by cattle.

Seedling Reproduction.—The sprouting capacity of chestnut is much more important to its regeneration than its ability to reproduce by seed. Sprouts can be relied upon for reproduction in pure stands or in large groups, or when chestnut is in mixture with other sprout species and is managed on a short rotation. It is necessary, however, to supplement sprouts with seedlings in order to make up for those stumps, whose sprouting power has ceased. Where large timber is desired, as when chestnut is to be grown with oak or poplar for lumber purposes, seedlings are more desirable than sprouts. One-half to two-thirds of full light is most favorable to germination. If the nuts are too exposed they may dry out in the spring before the young root is thoroughly fixed in the soil. It is desirable that nuts lying on the ground in the forest be lightly covered during the winter, not only to keep the kernel moist and in condition to germinate, but to bring it in direct contact with the soil to facilitate rooting. To accomplish this the nuts might be planted or lumbering operations carried on during a season which promises a good mast year; or pigs might be turned in temporarily before the nuts fall. Under ordinary conditions, when nuts are collected for market, the leaves and litter are sufficiently disturbed by the nut gatherers to cover a large number of nuts; and many seedlings are thus assured, unless the nuts left are subsequently destroyed by swine, or the seedlings killed by fire.

Sprouting.—Most vigorous sprouting is obtained from stumps of trees cut in spring, early summer, or late in winter; least vigorous sprouting is secured from trees cut during August and September. Most sprouts appear either immediately at the root collar or just above the ground, and as a rule from partially independent root systems. It is exceptional for sprouts to develop near the tops of stumps. Such sprouts seldom make large and thrifty trees, and since they cannot form an independent root system, they frequently break from the parent stump as they become large and the stump is weakened by decay. Chestnut does not sucker.

The sprouting capacity of chestnut is far superior to that of any other important hardwood growing in Tennessee, and it is exceptional when an unburned stump fails to sprout. On the north slope of Roan Mountain, above Burbank, at an altitude of about 3,000 feet, 99 per cent of stumps of trees 3 to 5 feet in diameter, and varying in age from 150 to 300 years, sprouted, and the sprouts from most of the stumps were both numerous and vigorous. In such a situation chestnut is probably at its best. Several vigorous stands were seen which were composed of the second set of stump sprouts. Stumps should be cut low and obliquely, and the fertility of the soil maintained by preserving the humus. Where this is done and the trees are protected from fire, it is probable that many successions of sprouts can be grown from the same roots before their vigor is exhausted or even seriously impaired. The period of sustained vigor depends on the age at which the successive crops of sprouts are cut, and, to some extent, upon the season of the year.

ROOT SYSTEM

The chestnut seedling has a central tap-root and long lateral, fibrous roots and rootlets. Early in life this tap-root divides into many vertical roots, above which are numerous widely ramifying laterals that lie from 6 to 8 inches below the surface of the ground. In mature trees the roots frequently descend to a depth of 4 or 5 feet. Such a root system firmly anchors the tree and renders it extremely wind-firm.

Diseases and Defects.—Until past the pole stage, chestnut suffers severely from fire because of its thin bark. Sprout trees not only have thinner bark, but are likely to be injured through the burning of the old stumps. Since the sprout stands are those left after lumbering, they have been frequently burned, and the trees are either hollow or defective at the base, although the fire scars may have healed over so that there is no external mark.

In addition to plainly evident physical defects, the exposure of wood following the killing of the bark by fire affords an entrance to destructive insects. The most important of these are the chestnut timber worm* and the two-lined chestnut borer.** The chest-

* For information on the chestnut timber worm, see Circular 126 of the United States Bureau of Entomology, "Insect Injuries to the Wood of Living Trees," by A. D. Hopkins.

** For information on the two-lined chestnut borer, see "Injuries to Forest Trees by Flat-Headed Borers," by H. E. Burke, Yearbook, United States Department of Agriculture, 1909.

nut timber worm causes the common defect known as "wormy chestnut," a defect which greatly reduces the value of much otherwise high grade timber. The two-lined borer kills living trees by girdling them by mining beneath the bark. This pest causes the death of many trees, sound ones as well as those injured by fire.

For many years the chestnut on the lower mountains in the southeastern portion of the State has been dying out, a few trees at a time. Examples of this were noted on the English Mountains, Gray Knobs, Chilhowie Mountain, Stars, Bear, Frog, and Red Mountains. Some of these are killed by the two-lined chestnut borer, but while this decline is in part due to the ravages of the borer, it seems to be due more to excessive burning and to the consequent destruction of humus and impoverishment of the soil. Trees in hollows, on cool north slopes and on land where a moderately dense shade and soil cover exist have not been affected. The remedy for the trouble would seem to be to stop fires, to permit humus to accumulate, and to let the young timber grow up thick enough to shade the soil. The dying off of the trees is certainly not due to the chestnut bark disease (diaporthe parasitica), a very destructive parasitic malady from Virginia to Southern New England, no evidence of which was seen in Tennessee.

Chestnut is seldom thrown by the wind, and the stem rarely breaks unless hollowed at the base by fire. The leaders are sometimes broken by sleet and icestorms, and large branches torn away by windstorms.

Forest Types and Associated Trees

Chestnut enters largely into the composition of five well-marked forest types:

(1) Pure chestnut type with less than one-third of other species.

(2) Lower cove type, with yellow poplar, oaks, basswood (or linn), ash and locust.

(3) Upper cove type, with hemlock, birch, hard maple, beech, ash, and basswood.

(4) Chestnut oak and chestnut type, frequently with scrub pine.

(5) Mixed oak and chestnut type, frequently with yellow pine and sourwood.

Of these five, two are cove types, the upper and lower coves; one, pure chestnut, is a north slope type; and two are ridge or south slope types. These topographic divisions are arbitrary and can be applied only roughly, since topography is but one factor influencing drainage, depth of soil, and temperature, and, consequently, the distribution and local abundance of chestnut. On the north and west slopes chestnut is at its optimum. The upper cove marks the minimum temperature it will endure; in the chestnut oak type it reaches its limit so far as shallowness of soil is concerned, while in the mixed oak type it approaches its minimum limits of soil moisture and compactness of soil.

The proportion of chestnut in the mixed types may amount to as much as 65 per cent or as little as 15 per cent, depending upon conditions of soil, drainage, or climate. In each type, chestnut has a different rate of growth, and the system of cutting must be modified for each to obtain the maximum returns and leave the forest in the best shape for growth and for future cuttings.

Growth of Individual Trees

The growth and yield of chestnut vary greatly according to the situation. Three qualities of situation have been recognized: The first includes the lower cove type and that part of the pure chestnut type, where, on the lower slopes, there are the most rapid-growing stands; the second, or average quality includes the greater portion of the pure chestnut type and some of the stands in both the chestnut oak and chestnut type, and the upper cove type; the third, or poorest quality, includes the mixed oak and chestnut type, and the greater portion of the chestnut oak and chestnut type.

Table 1 shows the rate of height growth of the dominant or tallest trees in stands of sprout chestnut for each of these three classes.

Table No. 1: Growth in height of dominant trees in sprout chestnut stands, based on 117 plats on different sites.

	First Quality.		Second Quality.		Third Quality.	
Age—Years	Height of Trees	Growth in height during preceding decade	Height of Trees	Growth in height during preceding decade	Height of Trees	Growth in height during preceding decade
	Feet.				Feet.	Feet
5	18	..	15	..	12	..
10	33	33	27	27	22	22
15	45	..	37	..	30	..
20	55	22	45	18	36	14
25	64	..	52	..	41	..
30	71	16	58	13	46	10
35	78	..	63	..	49	..
40	84	13	68	10	52	6
45	88	..	71	..	55	..
50	92	8	75	7	57	5
55	96	..	77	..	59	..
60	98	6	80	5	61	4
65	101	..	82	..	63	..
70	103	5	84	4	64	3
75	105	..	85	..	65	..
80	107	4	87	3	66	2

As the table shows, the rate of height growth decreases rapidly as the trees become older. In all qualities more than one-half of the total height growth of dominant trees is made by the twentieth year. The rate of height growth decreases to less than one foot a year by the forty-fifth year in first quality stands; by the fortieth year in second quality stands, and by the thirtieth year in those of third quality. Beyond the seventieth year in all qualities the annual height growth is inconsiderable. In most trees the length of the stem has been definitely fixed before the sixtieth year by its division into branches. Its clear length at this age varies in dominant trees from about 60 feet in first quality stands to 45 feet in third quality. Although the trees continue to grow slowly in height as long as they are alive, the clear length can extend only by the loss of lower branches.

Table 2 shows the growth in diameter of trees of each of the three classes in unthinned, even-aged stands.

Table 2: Growth in diameter of sprout chestnut stands; time required to grow one inch in diameter. Based on 117 sample plots.

	Quality I.		Quality II.		Quality III.	
Diameter, breast-high	Age—	Time to grow 1 inch in diameter	Age—	Time to grow 1 inch in diameter	Age—	Time to grow 1 inch in diameter
Inches	Years	Years	Years	Years	Years	Years
10	26	..	33	..	40	..
11	31	5	39	6	48	8
12	36	5	46	7	59	11
13	41	5	53	7	76	16
14	47	6	61	8	..	..
15	53	6	71	10	..	..
16	59	6	83	12	..	..
17	66	7	..	..	..	..
18	73	7	..	..	..	..
19	81	8	..	..	..	..

The rate of diameter growth decreases uninterruptedly after the first few decades. In stands of the first quality during the first decade it takes only three years to grow an inch; by the fiftieth year it takes six years.

MANAGEMENT.

By the management of a forest is meant the use of a definite system of protection and cutting which seeks to perpetuate it and to increase its productive value. Protection may consist in preventing fires and overgrazing, controlling insect attacks or sparing the young growth during lumbering. A stand may be perpetuated by cutting so as to obtain sprouts or seedlings; it may be cut at a period to develop its maximum yield; it may be thinned to accelerate its growth, or to produce material most suitable for special uses. The same methods of management are not applicable to all conditions.

Chestnut is a large component of several mixed types of forest, although it also forms pure stands. It is found in extensive even-aged stands of second growth, as well as in uneven-aged, old forests; it has a slow rate of growth on poor soils, and on better situations its growth is rapid. Some of it is still quite inaccessible, so that only the large timber is merchantable; other stands are close to market, which makes possible a much more

complete utilization. The wood is extensively cut for special uses. Under such a great variety of conditions it is impossible to apply a uniform system of management, and a special system must be developed for each class of forest, if the best results are to be obtained.

The important classes of chestnut forests in Tennessee are:

(1) Uneven-aged stands, consisting mainly of old timber, in which large-sized, overmature, and defective trees often predominate. Most of the old timber is in mixed stands, though there are some pure stands.

(2) Even-aged, second-growth stands, either pure or mixed.

These classes can again be classified according to accessibility; some tracts are near railroads, or connected with farms, or otherwise so situated that close utilization and intensive management is possible; others are distant from shipping points, or cover large areas of rough land, where close utilization at present is not possible.

Forest management of the chestnut in the forests of Tennessee should aim:

(1) To foster chestnut and pine in the mixed stands on the poorer sites at the expense of the slower-growing chestnut oak and white oak.

(2) To get more seedlings of ash, poplar, and red oak in the mixed stands in the hollows, since these species sprout only sparingly, while chestnut will do so abundantly. White pine, also, should be encouraged where it is present. Seedling reproduction of chestnut should be encouraged in the hollows, since seedlings make larger trees than sprouts do.

(3) To maintain on chestnut soils pure sprout stands of chestnut reinforced by seedlings of this species, together with chestnut oak and red oak.

This scheme is based on the supposition that the destructive chestnut bark disease will not reach Tennessee. In the event that it does, cuttings should be made so as to increase the amount of white pine and poplar in the cove type, and the amount of pine on chestnut lands having southern exposures. If the pure chestnut forests are destroyed by this disease, it will be necessary either to plant other species in order to re-establish remunerative forests, or to rely on the slower means of natural reforestation to establish a new growth of other species.

PROTECTION.

Young chestnut is so subject to fire damage that it is of first importance to protect young stands. Old timber with thicker bark is less injured, though it cannot be burned without some injury. While the protection of large tracts is difficult and costly, thick stands and heavy yields of sound timber cannot be obtained unless fires are prevented. There is a striking contrast in the condition of the young timber on repeatedly burned coaled-over land, and the same class of timber in farmers' woodlots which have had few, or no fires. The yield of the burned stands is seldom two-thirds that of protected stands, and the timber is of inferior quality.

Posting the forest fire laws of the State, co-operation with adjoining land owners, and regulating of nut gathering and grazing, all these will help to solve the fire problem. Assistance in fighting fires should be required for the privilege of gathering nuts or pasturing cattle. On large tracts it is possible to maintain a patrol, but it is seldom practicable to establish cleared fire lines. A patrol would undoubtedly be the best manner of protecting recently cut-over land and young timber. Fire guards would be required only during the dry and windy weather, at which times arrangements should be made for securing help promptly when needed. Small tracts, particularly those connected with farms, are more easily protected. Fires are discovered earlier, before they have made great headway, and as a rule assistance for fighting them can more readily be secured. In fighting fire, young timber should be given first consideration, since it is more easily damaged. When clean cutting or heavy culling is practiced, especially summer cutting, it may be necessary to pile and burn slash. This may not be necessary after moderate culling, especially if the trees are not in foliage, or if the tops are closely utilized for extract wood. As a rule it is desirable if hemlock or pine are mixed with chestnut and are cut with it.

Land in process of restocking either by sprouts or seedlings should never be pastured. After it is restocked and the top shoots of the young trees have grown out of reach of stock, limited pasturage can be permitted as in old stands. In any case, the number of cattle grazed should be carefully regulated, especially on recently cut-over land, so that no damage will result.

IMPROVEMENT CUTTINGS.

Improvement cuttings are made for the purpose of removing defective trees, either old or young, and eliminating species of low value. The object in making them is to obtain a stand formed entirely of sound trees of desirable species. As a rule, they can be conducted without cost only where there is a market for material for low grade or small dimensions, and thus they are practically restricted to forests connected with farms or to those near towns, shipping points, and tannic acid extract plants.

In old timber they should remove spreading trees which are overtopping vigorous thickets of young growth, and should reduce the number of seed-bearing trees of slow-growing or low grade species, such as black gum, red maple, beech, and white oak. In second-growth stands they should eliminate trees of slow-growing species, individuals with large overtopping crowns and trees with very crooked or short, forked stems, or sound trees of inferior species should be removed. Small poplar may be cut for pulpwood, and chestnut, and chestnut oak for tannic acid extract works. On the Cumberland tableland, there is a demand for mine props; near towns and on farms fuel affords an excellent opportunity for disposing of the products of improvement cuttings.

THINNINGS.

The object of thinnings is to accelerate growth. Consequently they are of value only to young stands in which the trees will readily respond to them. The smaller and less promising trees, even of chestnut and other desirable species, as well as those of undesirable species, are removed in successive cuttings, leaving a smaller number of very vigorous, well-spaced stems from which are selected the trees that are to form the ultimate mature stand. All cuttings are for the benefit of these select trees, and are made at frequent intervals to prevent any check in their rate of growth. The prolonged struggle between competing trees is thus prevented by greatly reducing the number of stems per acre. The individual trees of the mature thinned stand are probably no taller than those in unthinned stands, but they have so much larger diameters that the yield of merchantable timber is greatly augmented.

Thinnings should begin between the fifteenth and thirtieth year, according to the rapidity of growth, size of trees, and density of the stand. Sprout stands, because of their more vigorous growth

during the first few decades, can be thinned earlier than seedling stands. The interval between thinnings should vary from five to ten years, depending upon the rate of growth of the trees and the rapidity with which the crown cover becomes filled. As a rule, frequent light thinnings give better results than heavy ones at long intervals. Trees should be removed evenly through the stand, and large clusters of sprouts should be well thinned. By repeating the thinnings it is possible to maintain practically the same rate of diameter increase for a long period and to prevent the progressive decline which takes place in close, unthinned stands. (Table 2).

Thinnings are seldom profitable unless the wood that is removed can be used, or can be sold for enough to cover the cost. Early thinnings will yield only small wood suitable for fence posts or cordwood. Later thinnings will yield some ties and poles, particularly when the stand is being held for large sized sawtimber.

In order to cut trees to best advantage into hewn ties or into poles, it is necessary to maintain sufficient crowding to prevent the stems from being too tapering and to cut before the butts become too large. In the production of sawtimber it is desirable to obtain the largest diameters. For this reason thinnings to accelerate diameter growth become of even greater importance in providing sawtimber than in stands intended for poles and hewn ties. Thinnings should begin earlier and should be heavier than in stands managed for ties and poles.

It is often advisable to thin the sprouts around large stumps. This can be done during the first winter by breaking off the smaller ones, and leaving vigorous sprouts about one foot apart around the stump.

Comparative Yield of Thinned and Unthinned Stands—A comparison of the thinned and unthinned plots in Table 3 shows the actual results in increasing the merchantable volume of stands even by a thinning which was unsystematic. Had the thinning been systematic, the yield would undoubtedly have been higher, and if these two thinned stands had been removed in two cuttings, made at intervals of from 10 to 15 years, it is probable that their yield could have been increased to 25,000 board feet, or that more than 700 sawed ties 7x7 inches and 8 feet long could have been obtained per acre.

Table 3: Number of trees and yield in lumber or ties per acre, of unthinned and thinned stands in similar situations.

	Unthinned Stands.		Yield Per Acre.	
Age—	Trees under 10 inches	Trees 10 inches and over	Lumber—	Ties—
Years	No.	No.	Bd. feet	Number ...
45	220	110	4,220	158
56	184	116	7,980	178

	Thinned Stands.		Yield Per Acre.	
Age—	Trees under 10 inches	Trees 10 inches and over	Lumber—	Ties—
Years	No.	No.	Bd. feet	Number
47	84	148	18,800	555
59	52	132	18,728	553

Clean Cutting and Culling—A comparison of even-aged, second-growth stands which have followed clean cutting for charcoal, with second-growth stands of mixed age which have followed cullings, shows the straightest and thriftiest timber on the areas which were clean cut. The competition between trees of the same height on the clean-cut lands is mutually beneficial, resulting in long, straight stems with low taper. In the mixed-aged stands, on the other hand, there are many trees with short, crooked stems and long, wide-spreading crowns, the result of a long period of suppression.

While clean cutting is by no means possible at the present time in the great majority of lumbering operations, it is the ideal method of cutting chestnut, and should be approximated whenever the market will justify it, and when the cut-over land can be protected from fire. When the land has not been grazed and there have been no fires there will invariably be found beneath the old trees an abundance of small seedling chestnuts. This will often obviate the neces-

sity of leaving seed trees of this species in those places where it is necessary to restock with seedlings.

Culling consists in cutting the larger trees and leaving the smaller ones to grow. Its practice is based on the theory that small trees growing near or beneath large trees will recuperate after the cutting of the larger trees and make accelerated growth. This is by no means invariably the case, and when such small trees have passed through a protected period of suppression their rate of growth is permanently impaired. If suppression is not of too long duration—more than 35 years—and if the trees are growing in good soil, they will recover. Their rate of height growth, however, will not be so rapid and their rate of diameter growth will seldom equal that of trees which have grown thriftily from the first. Culling must be relied upon chiefly in cutting forests which can not be thinned, and where there is no market for small wood. It enables moderate cuttings of large timber to be made at comparatively short intervals—15 to 25 years—but it fails to develop the maximum increment. It is suited particularly to seedling stands, since the partial light is unfavorable for the growth of sprouts, but very favorable for the early growth of seedlings. It is the method which must be used in managing a great portion of the mountain forests of large and old chestnut which are cut to a diameter limit. It is desirable to fix a diameter limit, but this, however, should not always be closely adhered to. In some cases it should be used in the nature of a general guide to the cutting limit. Where only sawtimber can be taken, and many large, unsound trees are left, a diameter limit for chestnut of 18 inches is not too high. When poles and ties can be cut the limit can be lowered to 14 inches.

UNEVEN-AGED STANDS.

The situation of a forest in reference to transportation facilities, the possibility of close utilization, and the rapidity of growth determine the method of management and consequently the character of the cutting.

Tracts so inaccessible that there is no present or prospective market for small material should be managed primarily for sawtimber, which can stand a higher cost of logging and transportation. In cutting old timber on tracts which are to be managed primarily for sawtimber, the trees should be cut to a diameter of not less than 18 inches breast high on good sites and 14 inches on poor

sites. But even in cutting to such limits considerable discretion should be used. A thrifty young, smooth-barked tree, with a long, straight stem, might well be held over for the second cutting, even if as large as 20 inches in diameter, since such a tree would undoubtedly be making a rapid growth. On the other hand, trees below these diameters, if short-bodied, crooked, and defective, or trees which are shading a thrifty group of young saplings, or crowding a group of poles, might well be cut, even if the profit in cutting them is very small. Thrifty young trees, the cutting of which would yield only a small profit, should be left if the cost of logging is low enough to permit it.

The utilization of large, old timber should be as clean as possible, but it will be impossible to use many of the old trees which are too defective for sawtimber. These can be left, since they will not only serve as seed trees, but may eventually be used for tannic extract stock. In localities where the market is better and where posts, ties, and extract stock can be sold, even if the local transportation must be done by flume or road, the forest can be left in much better condition for future earning value. It will be possible to cut out most of the old, defective trees and convert the seedling stand into a sprout stand, which will have a greater capacity for growth. Seedling chestnuts eight inches or less in diameter should not be cut, however, but should be left to replace exhausted stock at the second cutting. All other species which are mixed in with groups of chestnut, and which can be used, should be cut at the same time as the chestnut in order that the chestnut sprouts may have full light for their growth. When there is a market for poplar or pine pulpwood, seed trees of these species should be left, since they make a good mixture with the chestnut. Red maple and black gum, if taken for paper stock, should be cut to the smallest merchantable diameter. Seed trees of chestnut oak and red oak can be left, but Spanish oak and white oak should be cut to smallest merchantable size.

Timber which has a rate of growth as slow, or slower than that on second-quality sites, should be managed so as to secure even-aged sprout stands. This would apply not only to much of the timber on the south slopes, ridges, and upper north slopes of mountains in the eastern part of the State and the Cumberland plateau, but to chestnut stands as far west as Stewart and Hickman counties. The chestnut on poor sites is largely associated with chestnut oak, which

is also a vigorous sprouting species. The poorer the site, the less is the difference in the rate of growth between chestnut and chestnut oak, since chestnut oak is less affected by a poor condition than is chestnut. Managed as sprout forests, these sites can produce timber large enough for extract stock in a comparatively short time, while many trees will become large enough for ties and a few for poles. On the Cumberland tableland, where mine props are used, much of the small timber can be cut for this purpose. The production of larger timber for sawlogs is not advisable, since the growth of the trees becomes too slow after reaching a diameter of 14 to 16 inches. Stands should be cut close, but seedling chestnut 8 inches or less in diameter should be left in a first cutting in order that they may replace exhausted stumps and become old enough to seed. Seed trees of red oak, chestnut oak, and yellow pine should also be left.

When there is no market for tannic extract stock the timber on the ridges should be managed for tie production in sprout stands. It should be managed as seedling stands for sawtimber only where there is no possibility of marketing smaller material which can be grown from sprouts.

In slopes and hollows the rate of growth is usually equal to, or better than that on second-quality sites. On tracts at a distance from shipping points, chestnut should be managed only for sawtimber, poles, or ties, and old timber should be cut in the same general manner as on the ridges. Seedling reproduction should be encouraged. The old trees should be cut, as nearly as market conditions will permit to a minimum diameter of 20 inches for sawtimber, but to 14 inches for ties. All crooked and defective trees which can be used should be cut. As the quality of the soil improves, chestnut becomes relatively less valuable than some other species, such as popular and white pine, and these should be favored so as to have a mixed stand of chestnut and these species.

Near shipping points poles are relatively more valuable than sawtimber, and where there is a certain market for poles old timber should be cut to a diameter of 14 inches, and sprout reproduction, supplemented by seedlings, encouraged. However, it is always advisable to reserve a few large trees of poplar, white pine, red oak or ash.

EVEN-AGED STANDS.

There are in Tennessee probably more than 100,000 acres of even-aged, second-growth chestnut, either in pure stands or where chestnut forms more than one-half of the stand. These are largely sprout forests on old "coalings," which were made to supply charcoal with which to operate forges, furnaces, or smelters. A small number of these stands are in "deadenings," which were never cultivated or were cultivated only a few years. Few of them have resulted from lumberings, but as closer utilization becomes possible, lumbering will approximate clean cutting and even-aged stands of young growth will largely replace the uneven-aged forest. While these even-aged sprout stands give high yields of straight, clean-bodied timber, there is one drawback in their management which cannot be overlooked; that in order to obtain vigorous sprouts it is necessary to cut at the inconvenient seasons of winter, spring, or early summer. If the stumps are cut in autumn many will fail to sprout, and early summer cutting is also objectionable, because the bark from which the sprouts arise is easily separated from the stump, and is likely to be torn off during the lumbering operations.

In the management of even-aged stands yield tables, which show the amount of wood that can be cut at different ages, are necessary. Their chief value is to indicate the age at which stands that have different rates of growth may reach the period of maximum growth, or maturity, and should be cut. It is necessary to determine this age for each product into which the timber can be converted, since the age of maturity varies for various products. Yield tables can also be used for estimating the quantities of material which can be expected from the second-growth stands which will follow after the old timber is cut. In using yield tables to make such forecasts, however, it is necessary to make proper allowance when the mixture of other species differs from that allowed in the yield tables.

Under present conditions yield tables of this character can seldom be used in timber estimating, since they are constructed for dense, second-growth stands which have been uninjured by fire or cattle, and are applicable only to such conditions. The yield of most second-growth stands is much below that of the tables. The tables, however, serve to indicate the large yields which can be obtained by protecting clean-cut land and securing dense, even-aged stands.

Cordwood—Chestnut cordwood is chiefly used for tannic acid

extract stock, while a relatively small amount is used for fuel. Consequently the dimensions for wood used in constructing the cordwood yield tables conform to the manufacturers' specifications for the tannic acid extract wood. The wood in Tennessee is used with the bark attached. Split-stem wood is most desired, but a small proportion of round wood is taken to a diameter of three inches if straight and free from large knots. This permits the use of much branch wood and the cutting of trees as small as five inches in diameter. Wood with large knots, as from the crowns of old trees, is rejected by the manufacturers. If trees less than 25 inches in diameter are well handled the tops can be completely worked up, except for the crooked parts of the limbs and the portions having a diameter less than 3 inches.

Table 4 gives the yield in long cords (160 cu. ft.) per acre of chestnut stands at different ages, and of different qualities of growth. In the second column under each quality is given the growth in cords during each decade. The maximum growth in the first quality site takes place during the fifth decade; in the second and third during the sixth decade.

The first and second quality stands contain about 10 per cent of the species other than chestnut, and the third about 15 per cent, which is not included in the tables. In the first and second qualities the associated species are chiefly yellow poplar, red oak and white pine. In the third it is largely chestnut oak, the wood of which to a limited extent is also used for extract stock.

Table 4—Yield of long cords per acre in wood and bark of pure stands of chestnut at various ages on different quality sites. Trees taken to a minimum diameter of 5 inches, and split as required in specifications for tannic extract wood.

Age—Years	First Quality. Yield per acre	First Quality. Growth during preced. decade	Second Quality. Yield per acre	Second Quality. Growth during preced. decade	Third Quality. Yield per acre	Third Quality. Growth during preced. decade
			LONG CORDS.			
15	3.8	....	1.0	....	....	....
20	7.9	7.0	3.9	3.5	....	....
25	12.6	....	7.6	....	3.3	....
30	18.4	10.5	12.0	8.1	6.1	6.0
35	25.3	....	17.1	....	9.1	....
40	33.1	14.7	22.7	10.7	12.3	6.2
45	45.1	....	28.9	....	15.6	....
50	58.4	25.3	36.0	13.3	19.2	6.9
55	70.2	....	43.6	....	22.8	....
60	78.3	19.9	50.4	14.4	26.7	7.5
65	83.1	....	55.5	....	30.8	....
70	86.8	8.5	59.8	9.4	31.6	4.9

Table 5 gives the average annual growth in long cords per acre for stands on different quality sites at various ages. In stands of the first quality the average annual yield of tannic acid cordwood is greatest about the sixtieth year; in those of the second and third qualities, the average annual yield is greatest about the sixty-fifth year. Since the average annual yield is less, both before and after these ages, they represent maturity for cordwood stands, which therefore should be cut at 60 or 65 years, according to site.

Table 5—Average annual yield in long cords per acre of pure stands of chestnut at various ages on different quality sites.

Age of Stand, Years.	YIELD First Quality.	Second Quality.	Third Quality.
	LONG CORDS.		
20	0.4	0.2	...
25	0.5	0.3	...
30	0.6	0.4	0.2
35	0.7	0.55	0.3
40	0.8	0.65	0.3
45	1.0	0.6	0.3
50	1.2	0.7	0.4
55	1.3	0.8	0.4
60	1.3	0.84	0.4
65	1.3	0.85	0.47
70	1.2	0.85	0.45

Cordwood stands should be cut clean, except for seedlings or seedling sprouts of sapling size, which can form a part of the succeeding crop. The best quality sites can probably be utilized more profitably for growing larger timber for ties, poles, and sawlogs. The poorer sites can be most advantageously used for cordwood on account of the generally poor growing conditions.

Mixed stands which contain only a small proportion of chestnut cannot be profitably managed exclusively for extract cordwood, unless other species can be cut simultaneously with the chestnut for cordwood, or unless the chestnut occurs in large, pure groups scattered through the forest. This would apply to the larger portion of the mixed oak and chestnut forest of the Highland Rim and farther west. If single, scattered trees of chestnut are cut in such mixed stands there will frequently be insufficient light for the growth of the sprouts, and this would ultimately result in a great decrease in the proportion of chestnut in the forest.

Many second-growth stands on good soils contain a variable proportion of yellow poplar, ash, white pine, and red oak, which are too small to be very valuable for sawtimber at the age when chestnut is best suited for cordwood, or even for ties or poles. Well-formed trees of these species, particularly the ones with slender stems, might be left. They would interfere very little with the reproduction of the chestnut sprouts, and would increase rapidly in diameter. They would make extremely large and valuable sawlogs by the time the next stand of chestnut sprouts was ready to be cut.

Pole Ties—At the present time chestnut ties are not cut extensively in Tennessee, oak timber suitable for ties being still abundant and comparatively cheap. The use of chestnut ties, however, is increasing so rapidly that chestnut can be regarded as a standard tie wood in Tennessee, as it has already become in many States farther north. In Eastern Tennessee chestnut is cut only into pole ties 7 by 9 inches by 8.5 feet long. Since the ties are hewed and the logs are rarely split, there is considerable waste in the larger logs from the lower part of trees more than 16 inches in diameter. There is also a large waste in small trees in the unused length of stem in the top. (See Table 6.) A 7 by 9-inch tie, 8.5 feet long, contains 3.7 cubic feet of solid wood if it is sawed. The hewed ties contain more wood than this, probably as much as 4.5 cubic feet, on an average. Trees which yield ties with the least waste are those from 14 to 16 inches in diameter. In trees below 13 inches, and in those above

18 inches, more than twice the volume called for in the specifications is consumed. In trees below 15 inches in diameter the waste largely lies in the unused upper length of the stem; in trees above 16 inches, the waste is in the diameter in excess of that called for in the specifications.

Table 6—Cubic contents of trees of various diameters, cut to a 4-inch top diameter, average number of ties per tree, and average waste in clear length.

Diameter, breast-high,	Total volume of stem,	Average ties per tree	Actual contents of stem wood to produce each tie*	Total length of clear stem,	Length of clear stem not used,
inches	cubic ft.	No.	Cubic ft.	ft.	feet
10	9.60	1.0	9.6	41	32
11	12.3	1.4	8.8	42	30
12	16.8	2.1	8.0	44	26
13	22.6	3.1	7.3	47	20
14	28.4	4.0	7.1	50	16
15	35.0	5.0	7.0	56	13
16	38.0	5.5	6.9	57	10
17	43.9	6.1	7.2	60	8
18	49.3	6.4	7.7	61	6
19	56.8	6.6	8.6	61	4
20	63.9	6.8	9.4	61	3

Note—*Specifications require four cubic feet.

Table 7 gives the number of pole ties 8.5 feet long by 7 by 9 inches wide, which can be cut from trees of different heights and diameters. The number of oak and locust ties in trees of different diameters are shown in the last column. Both the oak and locust yield fewer ties than chestnut from trees of the same diameter on account of their thicker bark and shorter, more crooked, and more tapering stems. The proportion of oak and locust ties in the stands is less than 33 per cent.

Table 7—Tie volume table, giving average number of pole ties (8.5 feet long by 7 by 9 inches) in trees of different heights and diameters.

D. B. H., Inches	Chestnut. Height—Feet. 50	60	70	80	90	100	Oaks and Locust 110	All Heights
	Number of Ties Per Tree.							
10	....	0.7	0.9	1.1	1.2	1.2	1.2	....
11	0.8	1.1	1.3	1.5	1.7	1.8	1.9	0.7
12	1.3	1.7	2.0	2.3	2.5	2.7	2.8	1.4
13	1.8	2.3	2.7	3.1	3.5	3.7	3.8	2.0
14	2.3	2.9	3.4	3.9	4.3	4.5	4.7	2.8
15	2.7	3.4	4.1	4.7	5.1	5.4	5.5	3.7
16	2.7	3.5	4.3	5.0	5.6	6.0	6.3	4.0
17	2.8	3.7	4.6	5.4	6.0	6.4	6.6	4.3
18	2.8	3.8	4.8	5.7	6.3	6.7	6.9	5.0
19	2.9	3.9	4.9	5.8	6.5	6.9	7.2	5.3
20	2.9	4.1	5.1	5.9	6.6	7.1	7.4	5.7

The number of ties which can be cut from a stand increases with its age up to a certain limit, after which there is no additional increase, or only a slight one. The greatest annual yield of ties from a first quality site is obtained when the stand is about 60 years old. On second and third quality sites the maximum annual yield is not obtained until the stands are at least 70 years old, because of the longer time required for the trees to reach tie size. By cutting the entire stand clear, a yield of more than 600 No. 1 ties per acre can be obtained from 60-year-old stands of first quality; a yield of 364 ties at the same age from stands of the second quality, and more than 200 ties from stands of the third quality. Table 8 gives the yield of pole ties which can be obtained per acre from unthinned stands of different qualities at different ages. While this table shows the yield which can reasonably be expected from one clear cutting of dense stands, it by no means gives the maximum yield which can be obtained at intervals in two or three cuttings, or from thinned stands.

Table 8—Tie yield table. Yield of pole ties per acre in unthinned stands of chestnut (less than 33 per cent other species) at various ages. (Pole ties 7 by 9 inches by 8.5 feet long).

	Quality I.		Quality II.		Quality III.	
Years.	Total Ties	Average annual yield	Total Ties	Average annual yield	Total Ties	Average annual yield
	Number of Ties.					
25	39	....	....	....	....	....
30	99	3.3	18	....	....	....
35	176	....	60	....	9	....
40	269	6.7	107	2.7	51	1.2
45	359	....	167	....	98	....
50	471	9.4	231	4.6	145	2.9
55	565	....	299	....	184	....
60	619	10.3	364	6.0	217	3.6
65	659	....	406	....	244	....
70	685	9.8	433	6.2	265	3.9

Unthinned second-growth stands should not be cut clean for ties, since the ultimate yield of ties from such a stand can be increased by cutting only trees which have reached a diameter large enough to give a high yield of ties per tree. Cutting in stands within easy hauling distance of a shipping point should not take place until the largest trees are 16 inches in diameter, breast high, at which time all trees of 15 and 16 inches should be removed. Cuttings can be repeated at intervals of a few years, removing each time only the trees of these diameters. This assures an average yield of five ties per tree in quality 1; more than three in quality 2; and nearly three in quality 3. When the third cutting is made it is desirable to cut clean in order to secure an approximately even-aged stand of sprouts. If cutting is continued for too long, not only is the stand converted into an uneven-aged one, but the sprouts from many of the chestnut stumps die on account of the shade, resulting in a large increase in the young stand of oak, maple, beech, sourwood, and other tolerant species which seed abundantly. While the trees removed should be as evenly distributed as their sizes will permit, it is desirable to retain the trees of seedling origin until the last cutting. In making cuttings of this kind great care must be exercised in the last cuttings not to break down the sprouts which have already appeared.

When stands are situated at a distance from transportation

facilities, and it is impossible to make several cuttings at short intervals, cuttings need not begin until the largest trees are 17 inches in diameter, and all trees can be cut to a diameter of 13 inches. This would make possible a heavy cutting and still leave a large number of very slender trees less than 13 inches in diameter, most of which would become merchantable within 15 years when the stand could be cut clean.

Young forests of poles, 12 inches or less in diameter, on farms or near a market, should be treated as cordwood stands for extract wood. If correctly done, the thinnings will greatly increase the yield of ties over that given in Table 7, and enable most of the trees to be simultaneously developed to tie size. They can then be removed in two cuttings made at such short intervals as to amount practically to a clean cutting.

Poles—There is a regular market for poles in Tennessee, and this is one of the most profitable forms in which small chestnut timber can be marketed. Poles are best produced in sprout stands in qualities one and two; that is, in the mountain coves and on other soils of good quality. On the poor sites the stems of the trees are apt to be crooked, and have too little taper to meet pole specifications for the larger sizes. Specifications are more easily complied with when the growth is very thrifty. Pole production should be attempted only when logging is easy and transportation by railroads or streams is close at hand. The cost of handling large and long poles is so great that inexperienced contractors frequently fail to make a profit in handling them. Stands intended for poles should be thinned in the manner described for ties. Tall, straight, and sound poles, many of which will have approximately the taper called for in the specifications of the American Telephone and Telegraph Company, can be grown in this way. Table 9 gives the specifications for poles as required by this company. These are approximately the same as required by other users of poles.

Table 9—Specifications for poles. American Telephone and Telegraph Company. Minimum dimensions for peeled poles.

MINIMUM DIMENSIONS OF PEELED POLES.

Length of Poles,	50, 60, 70 or 80-Wire Line		Heavy Trunk Line		Light Trunk Line		Light Line		Branch Line	
	Circumf'r'nce		Circumf'r'nce		Circumf'r'nce		Circumf'r'nce		Circumf'r'nce	
	6 ft. from top	6 ft. from butt,	6 ft. from top,	6 ft. from butt,	6 ft. from top,	6 ft. from butt,	6 ft. from top	6 ft. from butt	6 ft. from top,	butt
feet	inchs.	inchs..	inchs..	inchs.	inchs..	inchs	inchs.	inchs..	inchs.	inchs.
20	..	..	..	..	..	..	..	..	15½	23
22	..	..	..	..	..	..	..	..	15½	24
25	..	..	..	..	20	30	20	27	15½	26
30	24	40	22	36	20	33	20	31	15½	29
35	24	43	22	40	20	36	20	35	20	34
40	24	45	22	43	20	40	20	39	20	38
45	24	48	22	47	20	43	20	43	20	42
50	24	51	22	50	20	46	20	46	20	46
55	22	54	22	53	20	49	..	..	..	..
60	22	57	22	56	..	..	..	..	..	..
65	22	60	22	59	..	..	..	..	..	..
70	22	63	22	62	..	..	..	..	..	..
75	22	66	22	65	..	..	..	..	..	..
80	22	70	22	69	..	..	..	..	..	..
85	22	73	22	72	..	..	..	..	..	..
90	22	76	22	75	..	..	..	..	..	..

Sawtimber—Second-growth sprout stands will seldom give any heavier yield of large saw timber than seedlings of the same age, since the rate of growth of sprouts eventually declines and becomes less than that of seedlings. Sprout stands are best suited to the production of smaller stems than those required for the best saw-logs. Sprout timber, however, can very well be sawed into ties, and, in addition to the ties, several boards can be obtained from the larger logs.

Table 10 shows the yield in board feet, both on the basis of the Doyle-Scribner log scale and on the basis of the actual mill cut, which can be obtained from stands of different qualities at different ages. It also gives the supplemental yield in cords of extract wood from tops and from trees below 10 inches in diameter, and the total value of the stands at different ages. These tables are based on 132 sample plots.

QUALITY I.

Table 10(*a*)—Total yield and value of stands of chestnut in board feet and cords at different ages.

Yield Per Acre of Trees 10 Inches and Over.			Yield of trees from 5 in. to 10 in. and tops of trees 10 in. and over.	Value per acre at $2 a thousand board ft. and $1 a cord.
Age Years	Doyle-Scribner, Board feet	Actual cut, Board feet	Long cords	Dollars
25	900	2,000	16.0	20.00
30	2,100	4,500	15.3	24.30
35	3,800	7,600	13.5	28.70
40	5,800	10,900	12.3	33.10
45	8,300	14,900	11.0	40.80
50	11,100	19,300	9.5	46.10
55	14,400	24,300	8.0	56.80
60	18,100	29,900	7.0	66.80

QUALITY II.

Table 10(*b*)—Total yield and value of stands of chestnut in board feet and cords at different ages.

Yield Per Acre of Trees 10 Inches and Over.			Yield of trees from 5 in. to 10 in. and tops of trees 10 in. and over.	Value per acre at $2 a thousand board ft. and $1 a cord.
Age Years	Doyle-Scribner, Board feet	Actual cut, Board feet	Long cords	Dollars
30	200	500	17.3	18.30
35	1,200	2,600	16.5	21.70
40	2,300	4,800	15.5	25.10
45	3,700	7,400	14.0	28.80
50	5,400	10,200	13.0	33.40
55	7,300	13,300	11.5	38.10
60	9,400	16,700	10.0	43.40

QUALITY III.

Table 10(*c*)—Total yield and value of stands of chestnut in board feet and cords at different ages.

Yield Per Acre of Trees 10 Inches and Over.			Yield of trees from 5 in. to 10 in. and tops of trees 10 in. and over.	Value per acre at $2 a thousand board ft. and $1 a cord.
Age Years	Doyle-Scribner, Board feet	Actual cut, Board feet	Long cords	Dollars
40	400	1,000	17.5	19.50
45	1,300	2,800	18.0	23.60
50	2,400	4,900	17.0	26.80
55	3,600	7,200	15.3	29.90
60	5,000	9,600	13.5	32.70

RELATION OF BOARD FEET TO CUBIC FEET AND CORDS.

Table 11 shows the number of board feet (scaled by the Doyle-Scribner rule) to 1 cubic foot and to 1 cord of merchantable volume for trees of different diameters. It is evident from this table that as the diameters of the trees increase a greater number of board feet can be obtained for every cubic foot and consequently for every cord of merchantable volume. Thus, only 3 board feet can be obtained per cubic foot for trees 12 inches in diameter, while from trees 30 inches in diameter 5.2 board feet can be obtained for every cubic foot. In addition the lumber from the larger trees is of better quality than from the smaller ones. This means that, in many instances, it is more profitable to convert the smaller trees into extract wood than into lumber. For instance, if the stumpage price of lumber is $2 per thousand board feet and of extract wood $1 per cord, the same amount of material from 12-inch trees would be worth $1 if sold as extract wood and 63 cents if sold as lumber. On the other hand, from 30-inch trees the same amount of material would be worth $1 if sold as extract wood and $1.11 if sold as lumber. At these stumpage prices the timber is worth more as extract wood from trees up to 24 inches in diameter, and more as lumber from larger trees. If the actual mill cut, which overruns the values given by the Doyle-Scribner rule, were used as a basis, the number of board feet per cord would be greater, and the value of the trees for lumber correspondingly increased. In these calculations the slabs from the saw logs are given no value, and tops, which would not be merchantable as sawlogs, are excluded.

Table 11—Board feet (Doyle-Scribner rule) per cubic foot and per cord for trees of different diameters.

Diameter, breast-high.	Board feet per cubic foot of merchantable volume.	Board feet per cord of merchantable volume.	Value of a cord at $2 per thousand board ft.
Inches	Board feet	Board feet	Dollars
12	3.0	313	$0.63
13	3.1	322	0.64
14	3.2	333	0.67
15	3.4	342	0.68
16	3.5	364	0.73
17	3.6	376	0.75
18	3.8	386	0.77
19	4.0	407	0.81
20	4.2	429	0.86
21	4.3	448	0.90
22	4.4	461	0.92
23	4.6	472	0.94
24	4.8	493	0.99
25	4.9	515	1.03
26	5.0	526	1.05
27	5.0	535	1.07
28	5.1	538	1.08
29	5.2	546	1.09
30	5.2	556	1.11

SUMMARY.

Chestnut is one of the most widely distributed trees of Tennessee, and the most important tree in the mountains of the eastern portion of the State, occupying large areas of land which have a low agricultural value.

The great number of uses to which the wood is put enables extremely close utilization not only of all portions of sound trees, including limbs and bark, but also a large amount of more or less defective wood. Small trees are used for poles, posts, and ties; large, sound trees for lumber and shingles. Tops and low-grade wood are used for tannic extract, fuel wood, and paper pulp stock.

Chestnut is not only a tree of rapid growth, but reproduces easily from seed and vigorous and abundant sprouts even from large old stumps. It forms pure stands or large, pure groups over extensive areas, permitting cheap utilization, and makes heavy yields at an early age. Under average conditions of growth, yields of 40 cords of tannic acid extract wood; or more than 300 No. 1 (7-in. by 9-in. by 8.5-ft.) ties; or 90 large poles; or 10,000 board feet of lumber, can be obtained per acre within 50 years from unthinned but protected second-growth stands. When logged for poles, lumber, or ties, about 13 cords of extract wood can also be obtained. If the

stands are thinned, the yield can probably be doubled in the same time. For these reasons chestnut is one of the most promising trees for forest management.

To obtain the best yields from chestnut stands, protection from fire is absolutely necessary, because the trees, and particularly the young trees, are extremely sensitive to fire injury. It is also necessary to protect young stands from cattle, since considerable damage results from browsing the foliage and young shoots.

In order to develop the maximum producing value of the forest, different methods of cutting should be used in different types and classes of forest. Large sawtimber should be grown only in the coves and on other good situations. Inaccessible old stands which can be used only for lumber should be cut to a relatively low diameter limit (16 inches), the large, unsound trees being left for possible future cutting for extract wood and for seed trees, and the smaller trees for increase in growth. Seedling stands are desirable and would be encouraged by this method of cutting. When extract wood can be sold, old stands on good soils should be cut to about the same diameter limit, if the production of sawtimber is the chief object of management, but all of the large, old defective trees should be removed for extract wood. On the ridges old timber should be cut for extract wood to a diameter of 8 or 10 inches, with the object of obtaining even-aged sprout stands which on such sites will give in a short rotation a higher yield than seedling stands, because of the more rapid growth of sprouts than seedlings when young. When there is no market for extract wood, and only sawtimber can be exploited, chestnut on the ridges can be cut to a diameter of 14 inches breast high, which would permit a second profitable cutting to be made within 15 years.

Even-aged, second-growth sprout and seedling stands, such as occur on farms, and on old charcoal cuttings, should be cut clean in not more than three cuttings, made at intervals of from 5 to 10 years, in order to replace the stands by even-aged sprout stands. The yield of such stands, in ties, poles, and lumber, and even in cordwood, can be greatly increased by thinning the stands while young, at regular intervals, removing the large crooked and forked trees and the tall, slender trees with narrow or one-sided crowns, and leaving the larger best-formed trees for the mature stand.

CORRECTIONS

Page 5. Line 4 from top read: "69,612,000" in place of "69,612."

Line 5 from top read: "1,567,000,000" in place of "1,567,000."

Page 16. Line 2 from bottom read: ".23 per cent." in place of "23 per cent."

Page 17. Line 6 from bottom read: "different" in place of "difficult."

Page 29. Line 13 from top read: "The values" in place of "The value."

Page 30. Following heading of the table read: *"Estimated."*

Page 32. Line 18 from top read: "The advantages" in place of "The advantage."

Page 36. Line 14 from top read: "5 per cent. a year" in place of "5 per cent."

Page 54. In footnote insert: "Table 20."

Page 55. Lines 25 and 26 read: "thinned stands" (page 17) in place of "thinning stands."

(NOW is the best time to make the corrections.)

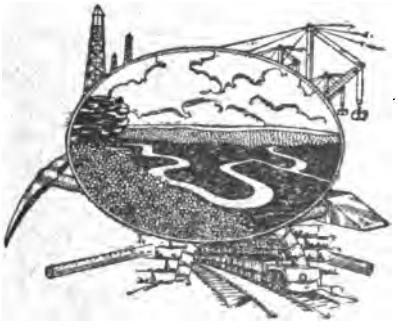
STATE OF TENNESSEE
STATE GEOLOGICAL SURVEY
GEORGE H. ASHLEY, STATE GEOLOGIST
SUCCEEDED BY
A. H. PURDUE

IN CO-OPERATION WITH THE
FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE
HENRY S. GRAVES, FORESTER

BULLETIN 10-C

YELLOW POPLAR IN TENNESSEE

BY
W. W. ASHE
FOREST EXAMINER, U. S. FOREST SERVICE



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PREFATORY STATEMENT

The study upon which this report is based was undertaken by the State Geological Survey in coöperation with the Forest Service, the work being done under the office of State Coöperation in the Forest Service, and under the local instruction of the State Geologist of Tennessee. By the terms of the coöperative agreement the state is authorized to publish the findings of the investigation. At the time arrangements for the work were made, George H. Ashley was State Geologist, but he subsequently resigned and was succeeded by A. H. Purdue.

YELLOW POPLAR IN TENNESSEE.

By W. W. Ashe.

COMMERCIAL OUTLOOK.

On the basis of the present cut of lumber, yellow poplar* ranks as the second tree in importance in Tennessee. In 1912 there were 378,747,000 board feet of oak sawed in Tennessee; 107,265,000 board feet of yellow poplar; and 69,612 board feet of red or sweet gum. The total cut of lumber in the state was 1,567,000 board feet. The total cut of yellow poplar in the United States was 623,287,000 board feet. The value of the cut of 1912 is not yet available from the census returns. Oak leads, with a cut during the year 1911 of 382,000,000 feet board measure, valued at $7,790,000, followed by yellow poplar with a cut of 119,000,000 feet board measure, valued at $3,360,000. Chestnut and red gum each had about one-half the cut of yellow poplar, but the output of each was only about one-third as valuable. The average value of oak lumber in 1911 at the mills in Tennessee was $20.68 per 1,000 feet board measure; poplar $28.22; red gum $12.33, and chestnut $16.91.

In 1906 the cut of yellow poplar in Tennessee was 110,480,000 board feet, the state contributing 19 per cent. of the total cut of yellow poplar in the United States.

In 1907 the cut was 137,900,000 feet board measure, being 16 per cent. of the total cut of the United States, the average price of yellow poplar lumber in Tennessee being $24 per 1,000 board feet.

In 1910 the cut was 138,705,000 board feet, 19 per cent. of the total cut of this species in the United States, the average price of its lumber in Tennessee being $28.10 per 1,000 board feet.

In 1911 it was 119,000,000 board feet, about 19 per cent. of the total cut of the United States. In 1912 the cut declined to 107,265,000 board feet, 17 per cent. of the total cut of the United States.

Many lumber companies that were interviewed in Tennessee report from 15 to 20 years supply of yellow poplar timber. On the basis of 20 years' supply the total stand of old yellow poplar timber in Tennessee is about 2,500,000,000 board feet.

The highest production of yellow poplar lumber in Tennessee was doubtless obtained between 1907 and 1910. Since 1910 the output from Tennessee has declined from 138,000,000 board feet to 107,000,000 board

*Botanically, yellow poplar is known as *Liriodendron tulipifera L.* The tree is also known as tulip tree and whitewood.

feet. While this decline in cut will continue for some time it is possible, by protecting and managing the young growth, to have it replace the old timber, and in this manner to maintain a continuous, though undoubtedly reduced, output of this valuable lumber.

The greater and more valuable portion of the cut of yellow poplar is the product of old timber. In order that the lumber may average $28 per 1,000 board feet, the trees from which this lumber is sawed must have, at present prices of lumber, an average diameter of 27 inches, breast-high. Although the amount of young timber which is cut for commercial purposes is small, it has a standard and rapidly increasing value for saw timber. With the continued reduction in the supply of old timber, the second growth must become the chief source of future supply. And consequently it is extremely important to know something of the amount of young growth and its probable future price. It is also desirable to know the rate of growth of the young timber, the possible profit in growing it, and the best methods of management for accelerating its growth and increasing its value.

The results of an investigation in Tennessee show that yellow poplar has a comparatively rapid rate of growth while young; it seeds abundantly and reproduces freely on suitable sites, forming either pure groups or a considerable proportion of mixed seedling stands. On account of its soft, white wood, which is very free from large knots, it is merchantable even when of small diameter, while on account of its straight stem with only moderate taper it yields under the saw as large a proportion of lumber per cubic feet of total volume as do the pines. On account of its intolerance of shade its yield per acre is less than that of chestnut and some of the pines, but this is offset by the rapid growth of the individual tree and its vigorous response to thinnings. On the whole, no other species of tree which has a wide distribution in Tennessee offers such excellent inducements for the protection of small trees, and even for propagation and planting. Not only is there an assured and remunerative market for the timber of small sized trees but its rate of growth is so rapid that returns are obtained at an early period for a forest tree. Second growth trees are largely "sapwood" or "white poplar," but there is now no discrimination against lumber from this grade of timber, and the clear sap lumber at present commands a higher price than the best yellow heartwood did 20 years ago.

Yellow poplar is also extensively used in Tennessee for wood pulp for the manufacture of paper. While some wood from the limbs of large trees which are cut for saw timber goes into this product the greater portion of it comes from young trees of pole size the white wood of which renders such trees very desirable.

It is also extensively employed for veneers for baskets and crates and for excelsior.

DISTRIBUTION.

Yellow poplar is commercially important throughout Tennessee. It is most abundant on the limestone valley lands of the great basin and in the valley of East Tennessee; in the coves and hollows of the Cumberland Mountains; and in the lower coves of the Unaka and Smoky mountain ranges; but it nevertheless reaches a large size in such counties of West Tennessee as Obion, Dyer, and others which lie west of the barrens. Above 3,500 feet elevation in the Unaka and Smoky mountains it occurs only irregularly. It is very largely absent from the thin soiled summit of the Cumberland Mountains, from the drier portions of the shale and sandstone ridges and from the barrens. Even when most abundant it seldom forms numerically as much as 10 per cent. of the forest over more than a few acres, but on account of the large size of the trees it frequently contributes from 20 to 25 per cent. of the merchantable timber in the bottoms and on the lower slopes, and may form 50 per cent. of the value of stand. The yield of poplar lumber seldom amounts to as much as 500 board feet per acre over a large tract, and frequently is less than 200 feet per acre.

The following table shows the number of trees of different diameters per acre in Tennessee on a large tract which has been examined by the Forest Service. If this tract represents average conditions of the hardwood forest of Middle and Eastern Tennessee, there is sufficient young poplar in the stands to assure a large future cut of timber, provided the young trees are not cut before they reach the size of maturity for saw timber.

Number of trees of yellow poplar per acre on an unlumbered tract.

Diameter Inches Breast-high	Scott and Anderson counties (Cumberland Mt.)
Under 12	4.
13-20	1.3
21-30	1.3
Over 30	.1

On cut-over and closely culled land which has not been badly burned, there is as a rule a large number of small poplar trees in the coves and hollows. These trees have sprung up in the openings which were made in logging. Occasionally they form a continuous stand in the narrow mountain valleys or form groups, pure or nearly pure, from a square rod to several rods in extent. There is often a far larger proportion of pop-

lar numerically in young stands on cut-over land than there was in the original forest. This young timber will constitute a very important element in the yellow poplar supply of the future. On the other hand on forest lands from which the old yellow poplars were removed before any of the other hard woods were cut, there is usually a poor replacement of young yellow poplar. There was not enough light for the establishment of yellow poplar, and seedlings of other species which are more tolerant of shade, occupied the space from which the yellow poplar was cut. Where tracts have been badly burned, the young yellow poplar has been largely killed.

In farmers' wood lots there is as a rule a large amount of young poplar except where the pasturage of cattle has suppressed the young trees, which is the case on many farms. There are, however, many pure stands of young yellow poplar of sapling and pole size, on farms which have sprung up in old pastures that were under fence so that cattle were excluded. While the total acreage of these stands is not large, they can be made where they occur, extremely valuable, if given proper management.

There is likewise a considerable acreage of second growth timber in old coalings. While these stands are largely formed of chestnut and oak sprouts, they generally contain, in the coves and hollows, a larger percentage of yellow poplar than the original forest.

While there is undoubtedly an excellent representation throughout Tennessee, of sapling and small pole-sized yellow poplar in second growth, there is a deficiency of large pole-sized trees which might become merchantable as large saw timber, during the next 20 to 25 years.

Notwithstanding the generally excellent representation of young growth yellow poplar, the future supply of this timber is threatened by the inroads which are being made on the young growth, by cutting it before it is mature, for paper-pulp stock and box-board bolts.

FOREST CHARACTERISTICS.

Form of stem and root system.—Mature poplar trees attain large sizes. It is one of the largest, if not the largest, species occurring in Tennessee. In diameter it may occasionally be surpassed by the sycamore, and in height by the cottonwood and hemlock (spruce pine), but none of these equals yellow poplar in both dimensions. Individual trees in Tennessee have been measured which had total heights of more than 140 feet, and diameters measured above the root swelling of more than 60 inches; while heights of more than 150 feet and diameters exceeding 75 inches have been recorded, but not in the same tree. The length of stem free of branches of mature trees varies from 50 to 75 feet. The crown generally occupies from 40 to 50 per cent. of the total height. The stem is column-

lar, tapering very slightly, and is very free from crooks and forks. About the middle of the crown, the stem divides into branches and its identity is lost. The lower branches die off rapidly until the full length of the stem is formed, and the scars which are left by them heal quickly and smoothly. This is one of the most valuable characteristics of the tree. Water sprouts occasionally appear on the trunks of trees exposed to sunlight, but the stems are never injured by the growth of such sprouts, as is the case with white oak.

While the stem of the old trees usually forks within the crown, young trees, particularly those in even-aged crowded stands, as a rule have

FIG. 1. Trees of yellow poplar which have been isolated in a second-growth stand by the removal of the chestnut and red oak. As a result of the isolation these trees are in condition to make rapid diameter growth. Since there is no undergrowth the restocking should be largely formed of poplar. (Photo Forest Service.)

straight undivided stems to the very top of the crown. Since the branches on them are small, logs which lie within the crowns of young trees are suitable on account of their straightness both for sawlogs and for pulpwood. This character which permits the close utilization of young trees, adds to their value.

The seedling yellow poplar has a long, straight taproot, which bears only a few fleshy rootlets. The taproot interferes with transplanting. Seedlings when transplanted do not readily establish themselves on account of the few rootlets.

Old trees have a very deep-seated and strong root system which renders them windfirm.

SILVICAL CHARACTERISTICS.

Soil and moisture requirements.—Yellow poplar requires for its best growth a deep, fertile and moist, but well drained, soil. It has a strong preference for soils which are derived from limestone, although it is common on other fertile soils which are rich in humus. It makes very slow growth and reaches only a small size, however, on either wet or extremely dry soils. The most congenial sites for it are the lower slopes and hollows of the mountains, and the soils of the rolling limestone valleys which are well drained through the underlying fissured rock. The soils occupied by yellow poplar are usually of high agricultural value for the growing of grain and grass, and, consequently when not too steep have been largely cleared and placed in cultivation. The chief remaining areas of considerable size which contain merchantable yellow poplar and which are best suited for its growth are the hollows along the Cumberland Mountain, the lower slopes and coves of the Smoky and Unaka range, and the hollows of the intervening ridges. The small tracts of forest which yet remain on the farms of the limestone valleys frequently contain considerable old poplar, and on many tracts a large amount of young timber, and are well suited for its growth.

Temperature and light.—In spite of its exacting requirements respecting soil moisture, yellow poplar demands considerable warmth. It grows well from the lowest elevations in Tennessee up to altitudes of 3,000 feet on the north slopes of the Unaka and Smoky mountains, but it becomes sporadic on north aspects above this altitude. It demands a large amount of direct sunlight for its best growth, at all ages after it is thoroughly established.

The seedling and young tree will endure considerable side shade, more on moist than on dry soils, but if the overhead shade is too dense or is prolonged, the tree dies. A very light overhead shade or a side shade is beneficial to seedlings until they are two years old, by which time they

should be well established. On account of its intolerance of shade the stem clears itself of branches thoroughly when the trees are crowded.

Reproduction.—Yellow poplar reproduces chiefly by means of seed. It reproduces to a limited extent by means of sprouts but only from small trees until they reach the size of poles; the sprouting of old trees is unreliable. Sprouting is best in full sunlight. The sprouts from trees which are shaded are weak. The seeds, which are borne in small cones, are about one inch long, including the slender wing, and are so light that they may be blown several hundred yards from the parent tree. The seeds from the top of the cone and from the exterior will not germinate. These are the last to fall from the tree, often remaining until the following spring, and in collecting seed for planting they should be discarded. Trees begin to bear fertile seed when about 40 years old. Seeds are produced on older trees in great abundance and almost annually, but a large proportion, as a rule about 90 per cent., are infertile. They ripen in September and October and are in great part distributed at once by the wind. They largely germinate during the following spring and the early part of the summer, but some seem to lie over on the ground until the second spring. Germination takes place wherever the soil is moist, and the seedlings easily establish themselves, but they fail to survive the dry periods of the first summer unless on a moist or shady site. Stocking, consequently, is better on north slopes, in coves and hollows or in lower slopes, than on the drier upper slopes and on southern exposures. It is also best where the mineral soil has been exposed, as in old fields or where the soil has been upturned by logging or by hogs. A thick layer of dry leaves is unfavorable.

Diseases and defects.—While old trees of yellow poplar have many defects, such as wind-shake, frost crack, and stained wood, there are, so far as known, no destructive fungous diseases or insects which attack and kill trees.

Sensitiveness to fire.—Seedlings and small trees of yellow poplar are extremely sensitive to fire, being more easily injured even than chestnut. This is due primarily to the thin and smooth bark of the young tree of yellow poplar. An additional reason for their great injury is that the sap and inner bark of yellow poplar become active earlier than in the associated trees. This greatly exposes this species to early spring fires, which, when they take place during dry and windy periods before the forest foliage is out, are very hot and destructive. Fortunately yellow poplar is somewhat protected by being largely confined to the damp hollows and coves. Seedlings of yellow poplar which are killed down by fire will usually sprout from the root, unless they are shaded. This power, however,

is feeble when compared with that of many other broad-leaf species with which it is associated, particularly with that of chestnut, because after a small poplar has been killed down by fire a few times, the root generally dies. Old trees of yellow poplar are protected by their thick bark, and are rarely killed outright. However, many old trees on dry sites have butt hollows, which open on their upper side and which resulted from fire.

FIG 2. A group of yellow poplars which are growing on a rocky slope and which have been injured at the butts by fire. Note the hollow on the left of the base of the large tree and the scar to the right of the hollow, both caused by fire.

Other injurious agencies.—The tender shoots and leaves of small yellow poplars are freely eaten by cattle and sheep. For this reason stock should not be grazed on areas which are in process of stocking until the small trees become 8 to 10 feet in height. Hogs do not eat yellow poplar roots. They dig up seedlings, however, while rooting for other food on

fertile slopes and coves. The leader of yellow poplar is rarely broken by sleet. Both old and young trees are very windfirm.

Properties and uses of the wood.—The wood of yellow poplar is soft, light, stiff, and rather brittle, but close-grained. The heartwood varies in color from nearly white to a yellowish brown; the sapwood is white. The heartwood shows only a slight tendency to warp and shrink, and is durable when exposed to the weather, but only moderately so in contact with the soil. The sapwood is much less durable than the heartwood when exposed; and shrinks, warps and checks more, but if carefully kiln-dried the tendency to these defects is reduced. Air-dried, the wood has a specific gravity of .42 and weighs from 26 to 28 pounds* per cubic foot. Rough, kiln-dried lumber weighs about 2,800 pounds to the 1,000 board feet, but the green wood is much heavier. While slightly heavier than white pine, poplar has about the same relative strength (Modulus of elasticity 1,716,000; modulus of rupture, 10,850)†, and is consequently adapted to nearly the same uses. It withstands end-compression well, has high shearing strength and abrades quite even and slowly. While it does not split easily, the fracture is straight and clean.

In the center of thrifty second-growth trees there are frequently as few as three rings of annual growth to an inch of radius; while the periphery of young trees, stimulated to growth by isolation, may be equally as coarse-grained. In old trees, twelve rings per inch of radius is usual, and commercial timber will generally show from ten to fifteen rings per inch. There is a little difference in density between the early and late wood in the annual band. The numerous pores are small and uniformly distributed through both early and late wood of the annual band. The pith rays or medullary rays are of uniform size, nearly invisible to the naked eye, and scarcely raised when the wood is split radially. While the grain of the wood is as a rule extremely straight, it is occasionally wavy or curly, a characteristic which is usually limited to one face or one side of a tree. Occasionally trees are burly or bird's eyed.

The proportion of heartwood varies with age, and is much greater in old trees. It begins to form at from fifteen to thirty-five years of age, earlier on good than on poor sites. Its formation, however, does not continue regularly and at the same rate as the growth of the tree, but more slowly, since a tree seventy-five years old will usually have more than forty rings of sapwood. Young trees on average soils which are fifty years old or less, are for this reason largely sapwood and have only a small core of heartwood. In young trees this large proportion of sap-

*Sargent, Tenth Census.

†Tests by Branch of Products, U. S. Forest Service.

wood has retarded their use for lumber to a considerable extent. Young, thrifty sap trees are called "hickory poplar," on account of the toughness of their wood.

Soil and moisture conditions cause a considerable variation in the amount and color of heartwood and the percentage of moisture in the wood. Trees growing on uniformly moist but well-drained soils (well aerated), such as fertile coves and best limestone soils have a thin sapwood, heartwood, dark brownish-yellow or canary yellow in color, containing a low percentage of moisture and the lumber from such trees consequently is not so subject to shrinking, checking, or warping. Large old trees on such sites, as a rule, have less than one inch of radial sapwood. Second growth trees on similar sites, 12 inches in diameter and sixty years old, often have less than 1.5 inches of sapwood on the radius. On the other hand, on dry soils, the trees have a small, pale yellow or nearly white heartwood ("white" or blue poplar") and a very thick sapwood. Such dry soils may be either physically dry as in the case of coarse sands, fissured slates or very fine grained clay, when the water table is low or fluctuates, or physiologically dry, as in the case of such sour soils as are poorly drained, because of deficient aeration. On "dry" sites the sapwood which acts as a water reservoir is sometimes so thick as to include one-half the radius of a tree two feet in diameter. The wood of "white poplar" and "blue poplar" has a high percentage of moisture and is subject to shrinking, checking, and warping, but is tougher than that which is deep yellow. Trees with pale-colored heartwood are most subject to windshake and discolored (calico) wood. The canary yellow wood is most prized for general uses.

The lumber can be easily and quickly kiln-dried. The best results in commercial kiln drying are obtained by first subjecting the wood to live steam or to hot moist air which is subsequently replaced by a free circulation of warm dryer air; but the wood is not refractory when a dry chamber system is employed, and is not prone to case harden and check. Sapwood blues if piled closely. This can be prevented by immersing the timber in a 10 per cent. solution of bicarbonate of soda. Air drying, though slow, is effective. The wood is easily impregnated with preservatives, either with copper sulphate by the gravity process or with creosote or zinc chloride.*

The wood has other qualities which give it a very wide range of usefulness. It works easily and smoothly when dried, that from any one tree being comparatively uniform in quality and as a rule that from trees in one locality is very uniform in character. It absorbs stain easily, but on

*Branch of Products, U. S. Forest Service.

account of its dull uniform texture it seldom shows a handsomely grained surface. It is too soft to retain a high polish on untreated wood, but it takes paint well and if the paint is highly glossed, it holds the gloss indefinitely. The knots, which are small and infrequent, even in the case of small trees, except in lumber cut from the crown, are usually light colored and tight, plane smoothly and also take and hold paint well. For doors, paneling, vehicle bodies, especially for automobiles and office and church furniture, the wood is especially desirable. It holds glue strongly, and is desirable as a backing for costly veneers. The heartwood of trees with the deep yellow-colored wood, while not as durable in contact with the soil as that of many conifers, has been extensively employed for water pipes, wooden pumps, and outside steps. Such wood is durable on exposure to the weather—as for weather boarding, shingles, fencing, dugout boats, and troughs—and was largely employed in Tennessee for these uses until its scarcity and high price required the substitution of cheaper woods. On the other hand, the sapwood of yellow-hearted trees and the entire wood of the "white poplar" are not durable if subject to the weather. Other uses of the wood are for the manufacture of packing boxes, printers' materials, especially type cases, drawers, domestic and culinary woodenware. Among such articles which are made in Tennessee are dough bowls for bakers, which are turned in sizes up to four feet in diameter from one piece of wood. It is extensively employed in the manufacture of toys, cheap furniture, and interior woodwork. It is used in the form of veneer for baskets and crates. For the grape trade, which demands a white wood basket, the sapwood is used or the heartwood is bleached with sulphur.

A large amount of rotary-cut veneer is also produced in Tennessee for use in the manufacture of furniture, for built up stock, for packing boxes and trunks. Small and low grade logs are made into excelsior, wood fiber and ground wood; while slabs, veneer cores, small trees and limb wood of large trees are also used for paper pulp,* being reduced by the soda process and forming a close-felting and easily bleached fiber. Extra wide boards, twelve to thirty inches, cut in thin stock and cleated or bound in bundles, are largely exported from Tennessee to Europe and South America, where they are used for paneling and for vehicle bodies, but the timber is also exported in the squared log. The quarter-sawed lumber, which is manufactured in considerable amount, especially in wide widths, does not warp and is consequently more desirable than flat sawed lumber as a backing for veneers, for wide paneling and for vehicle bodies.

*The Columbia Paper Company, of Bristol, is the largest user of poplar pulpwood in Tennessee.

The wood also enters largely into the construction of piano cases and other musical instruments. On account of lack of odor it is a desirable wood for cases for dairy goods, such as cheese boxes and butter tubs, and for cracker boxes and candy pails. It is extensively used in the manufacture of cigar boxes, either as a core for Spanish cedar veneer, or simply stained and printed in imitation of it. It is employed for bobbins and yarn spools, and in the manufacture of refrigerators, boats, and car finish. While the heartwood of old trees is preferred for most of these uses, the sapwood is being less discriminated against when well kiln-dried, and eventually must be largely used instead of the heartwood. To a great extent cheaper woods, like gum and tupelo, are replacing it for headings, for slack cooperage stock, for pumps, for cheap packing cases and for tobacco hogsheads. But it is still a standard wood for small packing boxes of the lock-end type, such as are largely used for drugs, as it shows for this use a greater strength for its weight than any other competing wood.* The white sapwood which admits of direct printing is preferable for this use. It is being substituted for white pine in making staves for fish kits and pails, patterns for castings, drawing boards and engineer's tables, and for pontoon bridge timbers, uses which demand clear boards. On the other hand it has been in part replaced by cheaper materials, such as gum and cottonwood in agricultural implements; by cottonwood and sap pine for wagon bodies, and by pine for exterior construction work.

On account of its great shearing strength, its capacity for withstanding end compression and the straightness of its stem, yellow poplar poles are well suited for mine props. In temporary workings (robbings) second growth sap timber can be used untreated, but where durability is essential the timber should be impregnated with a preservative. Treated wood is also adaptable for use as poles and fence posts. This adds greatly to the usefulness of the second-growth timber. It is well adapted for match sticks on account of the straightness of its grain, the ease with which the wood ignites, its free burning resulting in a steady flame, and the completeness of combustion. It has been used for this purpose, however, only to a limited extent.

The wood burns well and quietly, the embers glowing for a long while in still air. The fuel value of the wood compared with that of hickory, is low. The amount of ash is small, 23 per cent.† It makes a light charcoal which is held in low esteem.

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*Tests of the woods used in the box trade made by Branch of Products, U. S. Forest Service, show that for its weight yellow poplar has the highest shearing and cross breaking strength. Cottonwood ranks next to it

†Sargent, Tenth Census.

GROWTH

The possibility of profitable management of yellow poplar largely depends upon the rate of growth of the young trees, both as individual trees in mixed stands and when in pure groups or pure stands. Table 1 gives the rate of growth of young trees in mixed stands, and of the dominant trees in irregularly thinned stands in height, diameter, volume in board feet, circular sawed ¼-inch kerf, cubic feet of wood only without bark, and cords of 160 cubic feet of peeled wood, measured after it is stacked and dry. The peeled cordwood is measured as required for paper-pulp stock.

TABLE 1.—*Rate of growth of young trees of yellow poplar.*

	Scattered trees in the mixed forest					Dominant trees in pure, even-aged, thinned groups	
	Height	Diameter breast-high	Volume saw cut ¼ in. kerf	Volume wood without bark		Diameter breast-high	Volume saw cut ¼ in. kerf
Age of trees				Cubic ft.	Cords of 160 ft.		
Years	Feet	Inches	Bd. ft.			Inches	Bd. ft.
20.....	40	4.6	...	2.2	.02	5.7	
30.....	61	7.7	44	7.6	.07	8.5	54
40.....	78	10.5	111	22.	.19	11.1	121
50.....	87	12.8	177	29.2	.20	13.7	200
60.....	94	14.7	241	42.1	.38	16.1	286

The rate of growth of single young trees in the mixed hardwood forest is slower than that of the larger or dominant trees in pure even-aged groups which occur in cut-over land and in old fields. This is largely due to the fuller light conditions under which the pure even-aged groups grow. The narrow crowned intermediate trees in the pure stands, whose tops do not enjoy full sunlight, have nearly the same rate of growth as the scattered trees in the mixed, many-aged forest. It is believed that by systematically thinning young stands, an average diameter of 20 inches, breast high, can be obtained for all trees in a stand when 60 years old.

The figures in Table 1 are an average of the growth under many difficult conditions of soil and moisture. On the less favorable sites, such as upper slopes and on wet bottoms, the rate of growth is slower than that of the average; on the more favorable sites, such as the better coves and limestone valleys, the rate of growth is more rapid. Individual trees in particular will be found, which depart widely from the average—espe-

cially larger trees among the dominant class in the even-aged stands, the growth of which is far more rapid, and the small trees in the suppressed class, the growth of which is much slower.

FIG. 3. Section of stem of yellow poplar 12 inches in diameter, illustrating accelerated growth following isolation. The growth in diameter during the last eight years amounted to 7 inches compared with the previous growth of 5 inches during 30 years while the stand was crowded.

Table 2 shows the volume in board feet ¼-inch saw kerf of trees of different heights and diameters.

TABLE 2.—*Volume in board feet of second growth trees of yellow poplar. Mill cut, ¼-inch saw kerf.*

Diameter breast-high Inches	Number of 16-foot logs per tree							Diameter inside bark of top Inches
	1	1½	2	2½	3	3½	4	
	Volume — Board feet							
7	19	38	54	..	..	..	..	6
8	20	41	59	78	..	..	..	6
9	23	44	64	85	..	..	..	6
10	25	48	70	90	120	..	..	6
11	27	52	77	99	130	150	..	7
12	29	57	83	110	140	170	210	7
13	32	61	90	120	150	190	230	7
14	33	68	99	140	170	210	250	7
15	35	72	110	140	180	230	270	7
16	37	78	120	150	200	240	290	7
17	39	85	130	170	220	260	320	7
18	41	90	140	180	230	290	340	8
19	..	110	150	200	250	310	360	8
20	..	..	170	220	270	320	390	8
21	..	..	..	230	290	350	410	8
22	..	..	..	250	320	380	440	8
23	..	..	..	..	330	410	470	8
24	..	..	..	..	350	420	500	8
25	..	..	..	..	..	440	520	8
26	..	..	..	..	..	470	550	8

TABLE 3.—*Volume of trees of yellow poplar of different diameters and heights as scaled by the Doyle-Scribner rule. Age class,* 50 *to* 100.

Diameter breast-high	Height of tree — Feet							Diameter inside bark of top
Inches	70	80	90	100	110	120	130	Inches
	Volume — Board feet in tens							
9	1	1	1	..	..	..	..	6
10	2	2	3	3	..	..	..	6
11	3	4	4	5	..	..	..	7
12	4	5	6	7	..	..	..	7
13	6	7	8	10	..	..	..	8
14	8	9	11	12	14	15	..	8
15	10	11	13	15	17	19	..	8
16	..	13	16	19	21	24	..	8
17	..	15	19	23	26	29	..	9
18	..	18	23	27	31	34	37	9
19	..	20	26	31	36	40	43	9
20	..	23	30	36	42	46	50	10
21	..	..	34	41	48	53	57	10
22	..	..	39	47	54	60	64	10
23	..	..	44	53	60	67	72	11
24	..	..	50	58	66	74	80	11
25	..	..	..	63	74	82	87	12
26	..	..	..	69	80	89	95	12
27	..	..	..	75	88	98	103	12
28	..	..	..	..	96	106	112	13
29	..	..	..	..	104	115	120	13
30	..	..	..	..	113	124	129	14

This table was made from taper curves by scaling the merchantable length in log lengths to the top diameters shown. Logs were 16.3 ft. long whenever possible, with some 14.3-ft., 12.3-ft., and 10.3-ft. logs to avoid waste. The assumed stump height was 2 feet.

TABLE 4.—*Volume in board feet of old trees of yellow poplar scaled by Scribner Decimal C rule.*

Diameter	Number of 16-foot logs											Diameter inside bark of top
	1	1½	2	2½	3	3½	4	4½	5	5½	6	Inches
	Volume — Board feet											
19	33	47	62	..	..	..	..	..	..	..	6
20	35	51	70	93	..	..	..	..	..	..	6
22	39	58	82	110	..	..	..	..	..	..	7
24	44	65	93	130	170	..	..	..	..	..	7
27	49	74	110	140	190	..	..	..	..	..	8
30	54	83	120	160	200	250	..	..	..	..	8
33	60	93	130	180	230	280	..	..	..	..	8
36	68	100	150	200	250	300	350	..	..	..	8
39	76	120	160	220	270	330	390	..	..	..	9
42	84	130	180	240	310	370	430	480	..	..	9
..	93	150	200	260	330	400	470	530	..	..	9
..	..	160	220	290	370	440	520	590	660	..	10
..	..	..	230	320	400	480	560	650	730	..	10
..	..	..	250	340	430	530	620	710	800	890	10
..	..	..	..	370	470	580	680	780	880	980	11
..	..	..	..	410	510	640	740	850	960	1,070	11
..	..	..	..	..	560	680	800	930	1,050	1,170	12
..	..	..	..	..	600	730	870	1,000	1,140	1,280	12
..	..	..	..	..	..	790	940	1,090	1,250	1,400	12
..	..	..	..	..	..	840	1,010	1,180	1,350	1,520	13
..	..	..	..	..	..	..	1,070	1,260	1,450	1,650	13
..	..	..	..	..	..	..	1,150	1,350	1,560	1,780	14

TABLE 4 should read: Volume in board feet of old trees of yellow poplar scaled by Scribner Rule; if the figures are rounded off to the nearest ten and read in tens, the reading is that of the Scribner Decimal C Rule.

e conversion of cubic feet into cords of pulp wood closely piled, dry and when the sticks are more than 12 inches in diameter, split, nber of cubic feet of solid wood required to make a cord, varies ng to the diameter of the trees. Large wood piles more compactly nall, consequently a cord of such wood contains a larger number ic feet solid wood than a cord of wood from small trees. Table /s the number of cubic feet of closely piled, peeled and split stem :o three inches in diameter in the top, required to make a cord.

TABLE 5.—*Number of cubic feet of peeled stem wood in trees of different diameters to a cord of* 160 *cubic feet.*

Diameter of trees breast-high	Number of cubic feet of solid wood to a cord of 128 feet	of 160 feet	Per cent of solid wood in a cubic foot
Below 7 inches.....	81.3	101.6	62.6
7 to 9 inches.....	88.3	110.4	69.
10 inches and over.....	91.4	113.6	71.

Table 6 gives the volume in cords of 160 cubic feet of stem wood only, peeled, to three inches.

TABLE 6.—*Volume in cords of* 160 *cubic feet, of second growth trees of yellow poplar, stem wood, peeled, only to* 3 *inches in diameter.*

Diameter breast-high	Height of trees — Feet							
Inches	40	50	60	70	80	90	100	110
	Cords of 160 feet							
5	.018	.025	.032	.038	..	..	..	..
6	.027	.033	.042	.052	.060	..	..	..
7	.034	.043	.053	.064	.074	.083	..	..
8	.043	.055	.067	.080	.091	.103	.117	..
9	.053	.068	.084	.099	.113	.127	.140	..
10	.065	.085	.103	.121	.138	.153	.169	.187
11	.078	.103	.126	.147	.166	.185	.205	.226
12	.093	.125	.152	.176	.199	.222	.245	.269
13	.108	.150	.180	.208	.235	.263	.289	.316
14	..	.178	.212	.243	.274	.305	.336	.365
15	..	.210	.246	.280	.314	.349	.384	.418
16	..	..	.283	.319	.356	.393	.433	.470
17	..	..	.322	.361	.400	.440	.483	.523
18	..	..	..	.405	.446	.489	.532	.575
19	..	..	..	.450	.493	.538	.583	.628
20	..	..	..	..	.540	.587	.633	.682

Table 7 gives the number of mine props which can be cut from trees of different heights and diameters.

TABLE 7.—*Second-growth yellow poplar. Volume table for mine props from trees of different heights and diameters.*

Diameter breast-high	Height — Feet						
	40	50	60	70	80	90	100
	Number of sections 5 ft. long and more than 5 in. inside bark at top						
Inches							
5	..	..	2	..	..	..	..
6	2	3	4	..	..	..	..
7	2	4	5	5	7	..	..
8	3	5	6	7	8	..	..
9	4	5	6	8	9	..	..
10	4	6	7	8	10	..	..
11	4	6	7	9	10	10	..
	Number of sections 5 ft. long and more than 7 in. inside bark at top						
5	..	..	..	..	..	..	..
6	..	..	..	..	..	..	..
7	..	..	..	1	1	..	..
8	1	1	2	2	2	..	..
9	2	3	3	4	5	..	..
10	2	4	4	5	6	..	..
11	3	4	5	6	7	7	..
12	..	..	6	7	8	9	..
	Number of sections 7 ft. long and more than 5 in. inside bark at top						
5	..	..	1	..	..	..	..
6	1	2	3	..	..	..	..
7	2	3	3	4	5	..	..
8	2	3	4	5	5	..	..
9	2	4	4	5	6	..	..
10	3	4	5	6	7	..	..
11	3	4	5	6	7	8	..
	Number of sections 7 ft. long and more than 7 in. inside bark at top						
5	..	..	..	..	..	..	..
6	..	..	..	..	..	..	..
7	..	..	..	..	1	..	..
8	..	1	1	1	1	..	..
9	1	2	2	3	3	..	..
10	1	2	3	4	4	..	..
11	2	3	4	4	5	5	..
12	..	..	4	5	6	6	..

Yield.—Throughout Tennessee, in old pastures and in hollows on cut-over land, there are stands of second growth poplars. These are sometimes pure, consisting only of poplars, but as a rule contain varying proportions of other species, which are chiefly pine, oak, locust, and chestnut. Yield tables show the probable volume per acre of such stands at different ages, as well as the possibilities of plantations.

As in the case of individual trees, the growth of trees in such stands varies widely with the quality of the soil. Table 8 gives the yield per acre under different conditions of growth of pure unthinned stands of yellow poplar at different ages, in board feet from all trees 10 inches and over in diameter breast-high, outside of bark, and the cord wood suitable for pulp in small trees and tops. Stands which have been thinned and otherwise cared for should give larger yields than shown.

TABLE 8.—*Column "a" includes the saw timber from trees 10 inches and over; column "b", the cordwood in trees 5 to 9 inches which are too small to be cut into saw timber; column "c", the cordwood in the tops of trees in column "a"; column "d", the sum of columns "b" and "c"; column "e", the cordwood in column "a" converted into cordwood plus columns "b" and "c".*

Age of stand	Yield of saw timber from trees 10 in. and over in diameter outside bark breast-high	Yield of cordwood in connection with saw timber			Yield in cords of all the stem wood in all the trees 5 inches and over in stand
		From trees 5 to 9 in. in diameter outside bark breast-high	In tops of trees 10 inches and over in diameter breast-high	Total yield of cordwood in addition to saw timber	
	a	*b*	*c*	*d*	*e*
Years	Board feet	Long cords	Long cords	Long cords	Long cords
		Good condition of growth			
20	5,490	11.4	1.1	12.5	19
30	14,310	12.1	2.6	14.7	31
40	21,780	11.2	3.2	14.4	41
50	28,440	9.4	4.0	13.4	49
60	34,020	7.5	4.2	11.7	56
		Average conditions of growth			
20	540	9.5	0.3	9.8	13
30	7,020	12.0	1.8	13.8	23
40	13,950	12.2	2.7	14.9	31
50	20,160	11.4	3.4	14.8	37
60	25,830	10.0	3.7	13.7	43
		Poor condition of growth			
30	1,800	10.5	1.0	11.5	17
40	7,920	12.0	1.8	13.8	23
50	13,680	12.2	2.3	14.5	28
60	18,630	11.5	3.0	14.8	..

Graded volume tables.—With the increase in the diameter of the tree there is also an increase in the width of the boards which can be sawed from the logs; a decrease in the amount of sapwood on the boards, and in the proportion of knots to the total width of boards and even in the actual number of knots. Yellow poplar lumber increases in value as the boards become wider, as the proportion of heartwood increases and as

the number and size of the knots decrease. Consequently, lumber sawed from large trees is worth more per thousand feet than that from small trees which are growing under the same conditions.

Table 9 gives the per cent of the different grades of lumber sawed from trees of yellow poplar of different diameters, using a circular saw which takes ¼-inch kerf and sawing the boards 1⅛ inches thick to allow for shrinkage. This table, above a diameter of 12 inches, is derived from one prepared by E. A. Braniff, showing the yield of trees of yellow poplar when sawed with a band saw taking seven cuts to the inch. Mr. Braniff's figures were obtained at a mill in eastern Tennessee. There is a constant increase in the proportion as well as in the amount of the higher grades with trees of a larger diameter and a corresponding decrease in the proportion of the less valuable grades.

TABLE 9.—*Percentage of different grades of lumber sawed out of yellow poplar trees of different diameters. Diameters 13 inches and over, by E. A. Braniff.*

Diameter breast high Inches	Nos. 1 and 2	Saps and selects	Wide box	No. 1 common	No. 2 common	No. 3 common	Total yield per tree Bd. ft.
				Per cent			
9	..	..	..	4	74	22	30
10	..	..	..	8	70	22	41
11	..	..	..	11	66	23	54
12	..	1	..	12	64	23	68
13	..	2	..	14	62	22	86
14	..	3	..	14	61	22	117
15	..	4	..	15	59	22	144
16	..	5	..	16	57	22	180
17	1	6	..	17	55	21	210
18	2	7	..	18	52	21	248
19	3	8	..	19	50	20	293
20	4	9	..	20	47	20	342
21	5	10	..	20	45	20	395
22	6	11	..	21	43	19	456
23	8	12	1	21	40	18	521
24	9	13	1	22	38	17	591
25	11	13	1	22	36	17	669
26	12	13	2	23	34	16	749
27	14	13	2	23	33	15	833
28	16	12	3	23	31	15	932
29	19	11	4	23	29	14	1,030
30	20	11	4	23	28	14	1,125
31	22	10	5	23	27	13	1,227
32	23	10	5	23	26	13	1,326
33	24	9	5	23	26	13	1,427
34	26	9	6	22	25	12	1,533
35	28	8	6	22	24	12	1,649
36	29	8	6	22	23	12	1,742

The percentage of grades given in trees of diameter above 14 inches applies only to old growth trees. As a rule, small trees in second growth stands, 14 inches or less in diameter breast-high, saw out largely lumber of the grades No. 2 common and cull, together with smaller amounts of No. 1 common and sap grades than are given in the table. Clean stemmed second growth trees which are from 14 to 20 inches in diameter saw out a far larger, but somewhat variable, proportion of clear saps and a much smaller proportion of No. 1 and 2 grade than old forest trees of the same diameter.

Table 10 shows the amounts of the different grades of lumber sawed from trees of yellow poplar of different diameters and their values at Chattanooga, Knoxville, Nashville, Bristol, and other large shipping points in Middle and East Tennessee. Prices at points in West Tennessee are usually about 25 cents per 1,000 board feet lower.

The following prices of the different grades are used in determining the values of the lumber in totals:

Nos. 1 and 2	$53.50 per 1,000 board feet
Saps and selects	38.50 per 1,000 board feet
Wide box	40.00 per 1,000 board feet
No. 1 common	29.00 per 1,000 board feet
No. 2 common	18.00 per 1,000 board feet
No. 3 common	13.25 per 1,000 board feet

These were the prices in carload lots for July, 1913, at the important lumber centers of Tennessee.

TABLE 10.—*Amounts and values of the different grades of lumber sawed out of yellow poplar trees of different diameters, ¼-inch saw kerf. Values f. o. b. Nashville and other important points.*

Diameter breast-high	No. 1 and 2		Saps and selects		Wide box		No. 1 common		No. 2 common		No. 3 common		Total volume per tree	Total value per tree
Inches	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value
9	..	..	..	..	..	..	1	$ 0.03	22	$0.40	7	$0.09	30	$ 0.52
10	..	..	..	..	..	..	3	.09	29	.52	9	.12	41	.73
11	..	..	..	..	..	..	6	.17	36	.65	12	.16	54	.98
12	..	..	1	$0.04	..	..	8	.23	44	.79	16	.21	68	1.27
13	..	..	2	.08	..	..	12	.35	53	.95	19	.25	86	1.63
14	..	..	4	.15	..	..	16	.46	71	1.28	26	.34	117	2.23
15	..	..	6	.23	..	..	22	.64	85	1.53	32	.42	144	2.82
16	..	..	9	.35	..	..	29	.84	103	1.85	40	.53	180	3.57
17	2	$ 0.11	13	.50	..	..	36	1.04	116	2.09	44	.58	210	4.32
18	5	.27	17	.65	..	..	45	1.31	129	2.32	52	.69	248	5.24
19	9	.48	23	.89	..	..	56	1.62	147	2.65	59	.78	293	6.42
20	14	.75	31	1.19	..	..	68	1.97	161	2.90	68	.90	342	7.71
21	20	1.07	40	1.54	..	..	79	2.29	178	3.20	79	1.05	395	9.15
22	27	1.44	50	1.93	..	..	96	2.78	196	3.53	87	1.15	456	10.83
23	42	2.25	63	2.43	5	$0.25	109	3.16	208	3.74	94	1.25	521	13.08
24	53	2.84	77	2.96	6	.30	130	3.77	225	4.05	100	1.33	591	15.25
25	74	3.96	87	3.35	7	.35	147	4.26	241	4.34	114	1.51	669	17.77
26	90	4.82	97	3.73	15	.75	172	4.99	255	4.59	120	1.59	749	20.47
27	117	6.26	108	4.16	17	.85	192	5.57	275	4.95	125	1.66	833	23.45
28	149	7.97	112	4.31	28	1.40	214	6.21	289	5.20	140	1.86	932	26.95
29	196	10.49	113	4.35	41	2.05	237	6.87	299	5.38	144	1.91	1030	31.05
30	225	12.04	124	4.77	45	2.25	259	7.51	315	5.67	158	2.09	1125	34.33
31	270	14.45	123	4.74	61	3.05	282	8.18	331	5.96	160	2.12	1227	38.50
32	305	16.32	133	5.12	66	3.30	305	8.85	345	6.21	172	2.28	1326	42.08
33	342	18.30	128	4.93	71	3.55	328	9.51	371	6.68	186	2.46	1427	45.43
34	399	21.35	138	5.31	92	4.60	337	9.77	383	6.89	184	2.44	1533	50.36
35	462	24.72	132	5.08	99	4.95	363	10.53	396	7.13	198	2.62	1649	55.03
36	505	27.02	139	5.38	105	5.25	283	11.11	401	7.22	209	2.77	1742	58.72

Increase in value with size.—Table 11 shows the value per 1,000 board feet of lumber sawed from trees of different diameters and the value of lumber sawed from each tree f. o. b. Knoxville, Tennessee, and the stumpage value per tree under operating expenses of $10, $12, $14, and $16 per 1,000 board feet.

TABLE 11.—*Stumpage values of trees of different sizes under different costs of operation and the stumpage value per 1,000 feet of the lumber from such trees.*

Diameter breast-high	Value of lumber per 1,000 ft. f. o. b. Nashville	Value of stumpage per 1,000 Bd. ft. costs per 1,000 Bd. ft.				Value of stumpage per tree operating costs per 1,000 Bd. ft.			
		$10	$12	$14	$16	$10	$12	$14	$16
Inches									
9	$17.33	$ 7.33	$ 5.33	$ 3.33	$ 1.33	$ 0.22	$ 0.16	$ 0.10	$ 0.04
10	17.80	7.80	5.80	3.80	1.80	.32	.24	.16	.08
11	18.15	8.15	6.15	4.15	2.15	.44	.33	.22	.11
12	18.68	8.68	6.68	4.68	2.68	.59	.45	.32	.19
13	18.95	8.95	6.95	4.95	2.98	.77	.60	.43	.26
14	19.06	9.06	7.06	5.06	3.06	1.06	.83	.59	.35
15	19.58	9.58	7.56	5.56	3.56	1.38	1.09	.80	.51
16	19.83	9.83	7.83	5.83	3.83	1.77	1.41	1.05	.69
17	20.57	10.57	8.57	6.57	4.57	2.22	1.80	1.30	.96
18	21.13	11.13	9.13	7.13	5.13	2.76	2.26	1.77	1.28
19	21.91	11.91	9.91	7.91	5.91	3.49	2.90	2.32	1.74
20	22.64	12.64	10.64	8.64	6.64	4.29	3.61	2.92	2.23
21	23.16	13.16	11.16	9.16	7.16	5.20	4.41	3.62	2.83
22	23.75	13.75	11.75	9.75	7.75	6.27	5.36	4.45	3.54
23	25.11	15.11	13.11	11.11	9.11	7.87	6.83	5.79	4.75
24	25.80	15.80	13.80	11.80	9.80	9.34	8.16	6.98	5.80
25	26.56	16.56	14.56	12.56	10.56	11.08	9.74	8.40	6.06
26	27.33	17.33	15.33	13.33.	11.33	12.98	11.48	9.98	8.48
27	28.15	18.15	16.15	14.15	12.15	15.12	13.45	11.79	10.13
28	28.92	18.92	16.92	14.92	12.92	17.63	15.77	13.90	11.03
29	30.15	20.15	18.15	16.15	14.15	20.75	18.69	16.63	14.57
30	30.52	20.52	18.52	16.52	14.52	23.08	20.83	18.58	16.33
31	31.38	21.38	19.38	17.38	15.38	26.23	23.78	21.32	18.86
32	31.73	21.73	19.73	17.73	15.73	28.82	26.17	23.52	20.87
33	31.84	21.84	19.84	17.84	15.84	31.16	28.31	25.45	22.59
34	32.85	22.85	20.85	18.85	16.85	35.03	31.96	28.90	25.84
35	33.37	23.37	21.37	19.37	17.37	38.54	35.24	31.94	28.64
36	33.71	23.71	21.71	19.71	17.71	41.30	37.82	34.33	30.84

Operating expenses embrace the costs of logging, sawing, selling, grading, insurance, carrying stock, carrying timber, salaries and all overhead charges; cost of hauling or transporting from mill to railroad; an allowance for difference in freight to compensate for the difference in the price

of lumber at points which have a higher freight rate than the lumber centers, and includes all profits in operating and selling. Operating expenses vary with the accessibility of timber, class of operation, and the ability of the operators. The average expense at present in producing yellow poplar in Tennessee is above $14 per 1,000 board feet. The allowance for difference in freight rates amounts to 30 cents per 1,000 board feet for each difference of 1 per cent per 100 pounds in the freight rate. This difference should be deducted from the value shown in Table 11 when the freight rate is less than the rate from the lumber centers, and added when the freight rate is higher. The prices given for lumber are based on well graded and well sawed stock in car lots. When lumber is sold through brokers and commission men the prices are from 5 to 8 per cent. less.

The value of the yellow poplar trees in a stand are determined by ascertaining by measuring and tallying the number of trees of each diameter, and multiplying these numbers by the value of trees of the respective diameters under the appropriate cost of operating.

Increase in price.—In addition to the increase in volume and increase in quality, which accompanies growth, due to increase in the proportion of higher grades, there is a third but irregular increase in value due to increase in price. Since this increase varies with the proportion of the different grades of lumber which can be sawed from the tree, it can be calculated only by considering the increase in the price of these component grades. During the past 20 years there has been a greater per cent. of increase in the prices of lower grades than in those of the higher grades. The higher grades, consisting of Nos. 1 and 2, and saps, have increased in price at Knoxville about 3.7 per cent, compounded per year; lower grades No. 2 common and No. 3 common at a rate of about 4.9 per cent. a year. This increase in the price of the lower grades should be considered as one of the elements of increased value in plantations and in young stands which contain a large proportion of poplar trees and which are being managed as investments. Second growth trees of small saw log size yield largely No. 2 common grade of lumber. The rate per cent. of increase in the price of this grade during the past 10 years indicates the probable rate of increase in the price of small sap trees during the next 10 or 20 years. In 1903 this grade sold for $13 per 1,000 board feet at Tennessee points. Under an operating cost of $12 per 1,000 board feet this grade at that time had a stumpage value of $3 per 1,000 feet; its stumpage value in 1913 under an operating cost of $12 per 1,000 board feet is $5. The rate of increase in value during the decade was 5.2 per cent a year. If this rate of increase in price continues for the next two or three decades, and is considered in connection with the increase in the value of stands and individual trees by growth and quality, there is an

assurance of an excellent rate of profit from the management of pure stands of young trees and from plantations.

Table 12 shows the rate per cent. of increase in the price of the most important grades of lumber at the chief Tennessee shipping points:

TABLE 12.—*Rate per cent., compound, increase in the price of the important grades of yellow poplar lumber at Tennessee points during the 20-year period* 1893-1913.

Grades	Price in 1893	Price in 1913	Rate per cent. of increase in price compound
No. 1 and 2	$25.00	$53.00	3.9
Saps and selects	19.00	38.50	3.6
No. 1 common	16.00	29.00	3.
No. 2 common	7.00*	18.00	4.8
No. 3 common	5.00*	13.25	5.

Estimated stumpage has increased at a higher rate than lumber. A 28-inch tree may be regarded as of average size in operation during the past 20 years. In 1893 lumber from trees of this diameter had an f. o. b. value of $11.86 per 1,000 board feet. No logs which would cut largely No. 2 and No. 3 common would be taken to the mill. The average cost of operation at that time may be placed at $10.70 per 1,000. In 1913, on account of the increase in wages and supplies, the cost of operation under the same conditions is $16 per 1,000 board feet. In 1913 the f. o. b. value of lumber from an average tree 28 inches in diameter breast-high is $28.92 per 1,000 feet, at important shipping points in Tennessee. These figures give stumpage values of $1.16 per 1,000 board feet in 1893; and $12.92 per 1,000 board feet in 1913. The increase in value of the stumpage of a tree of this diameter has been at a rate of 13 per cent., compounded, a year. Such a rate will scarcely continue for the next decade, since the tendency of the rate of increase is to decline as the base on which it is calculated becomes larger, although the actual amount of increase may be the same.

INCREASING THE YIELD FROM TIMBER LAND.

The rate of growth of trees and the yield of timberland are as a rule greatly overestimated by owners. Their opinions have been formed as a result of the method of cutting which has been used on many tracts of timber. While it is true that many tracts have been cut over several times, only a small portion of the merchantable timber was cut in the earlier operations. In the first cutting, as a rule, the larger and more valuable trees were taken to 24 or 30 inches in diameter. A subsequent cutting removed some of the inferior large trees, and cut the more valua-

able trees to 20 inches; and a third one, made probably 20 years after the first, removing a lower grade, cut to 16 inches. No cutting has thus far removed all of the stand. So long as there remains a large number of trees 14 to 20 inches in diameter, the annual growth in board feet per acre is large, and if cutting is not below a diameter of 18 or 20 inches, comparatively heavy yields can be obtained every 15 or 20 years from the same tract. As soon, however, as cutting is to a diameter below 10 inches, not only must a very much longer time elapse before another profitable cutting of large timber can be obtained, but there is a loss in converting into lumber, since, while the waste of kerf and slabs in the case of larger timber is only 50 per cent., it is 75 per cent. in the case of small timber. While cutting to too small a diameter over an entire tract is to be avoided, other requirements must be considered.

There is no single operation or process the use of which will develop the maximum earnings of a forest which contains yellow poplar. The following are the most important points to consider in seeking to develop and maintain on a tract a high yield of yellow poplar, and to secure a product of high value.

Management.

(1) Developing a form of stand which permits intensive operations.
(2) Cutting trees only at or above a size which indicates maturity.
(3) Obtaining full-stocked stands by preventing fires and by regulating grazing.
(4) Eliminating species of low value from stands.
(5) Thinning young stands in order to accelerate growth.

Better Utilization.

(6) Reduction of waste and closer utilization of timber.
(7) Selling timber in its most profitable form.

MANAGEMENT.

Developing a desirable form of stand.—By procuring a suitable form of stand, the conditions are obtained which are best suited for the replacement and most rapid growth of the valuable species in the stand, since yellow poplar requires a large amount of light for its establishment and growth, and its most rapid development takes place in even-aged stands and groups.

Sprout forms.—While young trees sprout sufficiently to be managed as sprout stands, this form of stand can be used only for the production of small timber, such as pulp wood, and is advisable only on good sites where pure stands of yellow poplar can be grown, or mixtures of yellow poplar

with chestnut, red oak, locust, and other species which sprout. The rotation or period required for the maturity of a coppice stand is from 20 to 35 years. Sprout trees which are much older than 35 years, frequently become so defective at the butt that they break off. Sprout stands should be even-aged or in even-aged groups.

High forest forms.—For the production of saw timber, yellow poplar can be managed only with seedling trees in high forest. Of the different high-forest forms, yellow poplar is well suited only to even-aged stands, in which all the trees in one cutting unit or block are of the same age or approximately so; or to a group or strip form in which the trees occur in even-aged strips or groups. The groups or strips can be made so small as to develop a group or strip selection form. Such stands can be either pure or mixed. The single tree selection form of forest (which consists of trees of all ages mixed in the stand) with its more restricted light conditions is not so well adapted to securing the replacement of yellow poplar. The group and strip forms seem to particularly meet the requirements of yellow poplar in mountain forests.

(1) The advantage of the group or strip forms are that profitable cuttings of large timber can be made in the same cove or valley at short intervals. When the growth is rapid, the intervals between cuttings might not exceed 15 years.

(2) Since the mature groups are cut clean, there is no breakage of small timber in felling as is the case when culling and simple selection is practiced.

(3) Large timber can be logged to loaders by cable with less serious breakage of small trees.

(4) Restocking with yellow poplar and white pine is more easily obtained in the center of openings, while nearby oaks seed up the edges.

(5) The soil is better protected from erosion than it is in the case of clean cutting, and there is less danger of destruction by fire on the cut-over areas. The intermixture of species with heavy crowns, likewise assures protection of the soil from drying winds.

(6) With groups of young timber adjacent to groups which are mature, more intensive management can be practiced than is possible in the case of selection stands. It is possible to make thinnings in groups of immature trees, thus freeing the larger trees in these groups, and accelerating their growth. At the same time, the small timber which is removed in thinnings, and which otherwise would be lost, can be utilized.

Applying this method of cutting to a farm forest of 100 acres in which an ideal form of stand has already been developed, there would be one group of trees which would be mature and which would be cut that year or during the cutting period, which might be as long as 10 years. If 50 years

were required for the trees to fully mature, one-fifth of the forest, or 20 acres, would be mature and ready to be cut during this period of 10 years. One-fifth, or 20 acres, would have been cut over during the preceding 10 years, and would have restocked in small seedlings; 20 acres would bear a stand with an average age of 15 years. The stand on 20 acres would have an average age of 25 years; while that on 20 acres would have an average age of 35 years. At the same time that saw timber was being cut in the mature stand, large poles would be removed in thinning the 35-year-old tract; small poles would be removed in thinning the 25-year-old stand, and small saplings in thinning the 15-year-old stand. This would insure a continuous supply of large timber as the areas of the different age-classes matured. At the same time there is always an area in process of restocking equal to that which is being cut over. In a large tract, each cove might take the place of the 100-acre tract, and a suitable grouping of age classed be obtained in it.

In developing groups, they may vary in size from 100 feet square to two or three acres in extent. Strips, which in a mountainous region might be located up and down the slope, may be from three to five chains wide, or as might often be advisable in the mountains, they might coincide with the limits of narrow coves or hollows. On small tracts, such as farm forests, blocks or cutting units which are designated with the object of facilitating management, might be so small as to form in reality a group selection form.

Natural forests seldom occur in the forms which have been recommended, but the tendency is for even-aged stands to result from clean cutting. There is also a tendency in the mountainous portions of Tennessee for the formation of even-aged second growth stands in the coves and hollows, where these are cut clean and for the formation on the slopes of even-aged groups or strips of young timber alternating with groups or strips of old timber which were not felled, either because they were less accessible or because they were largely composed of inferior species or low-grade trees. In extensive operations, this last condition forms a basis for ultimate conversion into a form of groups or strips which is adapted to logging at frequent intervals. It is impossible to convert from the present irregular form of stand without some slight cost; and in the case of large and inaccessible tracts on which operating charges are high, conversion must be affected gradually in order to reduce the cost. A compromise, consequently, is necessary. The owner foregoes a part of his present profit with the expectation of greatly increasing the earning power of his land at the date when future cuttings are made. A tree is left in one place which could be removed at a slight present profit, but which is increasing in value at a high rate. Another tree

is taken which offers less profit, because it is declining in value and interfering with the growth of valuable young timber. The action in both cases looks toward the resultant form of forest and the profit accrues to the date of future cuttings. It is as desirable that a definite form of forest be developed in the management of small tracts of from 50 to 100 acres as in the case of large tracts of 10,000 or more acres. While it is often impossible on a large tract, on account of increasing logging costs, to cut for the best future interests of the forest, there are no such restrictions in the case of small tracts on farms. The farmer can generally use his own teams and can log carefully, cutting a portion of this tract each year. In this way, he is in a position in a few decades to obtain a form of forest which will produce more profitably a much higher yield than is possible in the case of large and inaccessible tracts. The tendency of yellow poplar to occur in groups in second growth stands is shown.

FIG. 4. Group of yellow poplar poles in a crowded stand of mixed species 20 to 30 years old. The crowding should be relieved by cutting some of the middle size (intermediate) trees and the defective dominant (large) trees. The well shaped dominant trees should not be cut at the present time, neither should the suppressed trees which, while they can not be expected to make sawlogs, still serve a useful purpose in shading the soil and maintaining its moisture supply. This illustrates the tendency of yellow poplar to form groups. (Photo Forest Service.)

MATURITY OF TIMBER.

Single trees in mixed stands.—Single trees of yellow poplar can be considered mature financially when their annual rate of increase in value becomes equal to the current rate of interest on money. If timber is held after the rate of increase in value falls below the interest rate, there is a loss, since if the timber had been sold, the proceeds could have been invested as loans at the current interest rate on money. Table 13 shows the rate of increase in value by growth of trees of yellow poplar under different costs of logging while increasing one inch in diameter. This does not include the increase in price, and the current increase in price should always be considered in connection with this table. While price increase of large poplar has been very high in the past, the rate will probably decline in the future.

The rate of increase in the price of second growth for the past decade has been only about 5 per cent. Although yielding well above the current rate of interest, if the present rate of increase in price is also considered, 16 inches might be considered a diameter for cutting when the cost of operating is low; 18 inches when the cost is about $13 per 1,000 board feet; and 20 inches when the cost of operating is more than $15 per 1,000 board feet. The rate of growth of the timber also affects its increase in value. On the best sites, such as very fertile coves where poplar will produce four and five logs 16 feet long, including the cull top log, these diameters might be two inches larger respectively. On very poor sites where only two and three logs can be cut from the trees, and those are sappy, knotty, or otherwise low grade, the diameter for cutting can be 15 inches breast-high, under a low cost of operation, 17 inches under an average cost, and 19 inches under a high cost of operation.

FIG. 5. A virgin stand of mixed hardwoods which contains a large proportion of yellow poplar. The merchantable trees in this stand of other species, as well as yellow poplar, are mostly of very large size. The small trees in the stand are suppressed or specimens of small tolerant species. This stand requires cutting clean except for seed trees. It will be necessary to destroy the heavy undergrowth of trees and shrubs which are tolerant of shade in order to be assured of a large proportion of yellow poplar in the restocking. (Photo Forest Service.)

TABLE 13.—*Time required for trees of yellow poplar to grow one inch in diameter, under average conditions, and annual rate per cent. of increase in value by growth.*

Diameter of tree breast-high	Time required to grow 1 inch in diameter	Operating costs $12 a 1,000 board feet		Operating costs $16 a 1,000 board feet	
		Stumpage value per tree	Rate of increase in value a year	Stumpage value per tree	Rate of increase in value a year
Inches	Years	Value	Per cent.	Value	Per cent.
9	..	.16	..	.04	..
10	3.5	.24	12.3	.08	21.9
11	4.0	.33	8.3	.12	13.3
12	4.0	.45	8.1	.19	10.6
13	4.0	.60	7.5	.26	8.1
14	4.0	.83	8.4	.35	7.7
15	4.5	1.09	6.2	.51	8.7
16	5.0	1.41	5.3	.69	6.2
17	5.5	1.80	4.5	.96	6.2
18	5.5	2.26	4.2	1.28	5.4
19	5.5	2.90	4.6	1.74	5.7
20	6.0	3.61	3.7	2.23	4.2
21	7.0	4.41	2.9	2.83	3.5
22	7.0	5.36	2.8	3.54	3.3
23	8.0	6.83	3.1	4.75	3.7
24	9.0	8.16	2.0	5.80	2.2
25	9.0	9.74	2.0	7.06	2.2
26	9.0	11.48	1.8	8.48	2.0
27	10.0	13.45	1.6	10.13	1.8
28	10.0	15.77	1.6	11.03	0.9

Determination of the future yield in mixed selection stands.—In connection with the management of selection stands of mixed forest, it is frequently desirable to know what yield of yellow poplar can be expected from a tract at different future periods, or what number of poplar trees of different diameter classes it would be necessary to have growing, to provide for a sustained yield (normal distribution of age classes). The following table enables this to be determined, if the poplar in the stand is in unthinned groups. It shows for average conditions of soil what should be the relative number of trees of different diameter classes to an acre, to provide for a sustained annual yield of 430 board feet on average quality sites, which would be the yield from fully stocked acres of pure stands if each diameter class occupies the same proportional crown area.

FIG. 6. A second-growth stand of mixed hardwoods which contains a large number of medium sized yellow poplars. A diameter limit (selection system) for cutting could advantageously be applied to this stand since it contains many small and medium sized trees. Openings should be made sufficiently large, however, by group cutting to ensure the replacement of poplar on them, since the site is evidently well suited to the growth of this species. The absence of young growth indicates that the present forest cover is dense. (Photo Forest Service.)

Number of trees in different diameter classes per acre, required to obtain a continuous yield from a fully stocked group selection stand of pure poplar.

Diameter classes breast-high	Number of trees per acre on average quality sites	Approximate per cent of each diameter class which should exist in a normal stand
Inches		
2- 4	280	54.00
5- 8	151	30.00
9-12	57	11.00
13-16	19	4.00
17-20	5	1.00
above 20	1	.30
Total per acre	513	

Since this table is based on fully stocked pure stands, it is necessary in the consideration of a mixed stand to ascertain the average number of trees of the different diameter classes per acre. The relation of this number in each diameter class to the corresponding table number gives the proportional annual yield which is to be expected from this diameter class when mature, that is, when larger than 20 inches in diameter.

If in place of 19 trees to the acre, in the 13 to 16 inch diameter class there were 6 trees, the proportion of stocking would be 6-19, so far as this diameter class were concerned. The annual yield per acre from a fully stocked stand is 430 board feet, consequently the annual yield with the proportion of stocking given would be $6\text{-}19\times430=135$ board feet. If the average diameter of the 6 trees per acre in this diameter class were 15 inches, it would be (see table 13) 22 years before they were 20 inches and ready to cut. If the interval between cuttings was 10 years the yield would be $10\times135=1{,}350$ board feet per acre at that time. This is based on the assumption that poplar trees growing in groups in mixed stands have approximately the rate of growth that they have in pure stands. In strict selection or natural irregular stands in which single trees of yellow poplar compete with slower growing species, the young poplars are more persistent than when they occur in pure groups, and a smaller proportion of them die during the life of the stand.

If such mixed selection stands where the yellow poplar trees occur as single trees, the crown spread of the dominant trees is the most reliable basis to use in determining the proportion which yellow poplar contributes to the stocking of the stand. There is given below the average diameter of the crown spread in feet of dominant and intermediate trees of yellow poplar from 7 to 22 inches in diameter breast-high. Dominant trees,

particularly such trees in thinned stands, have a wider crown spread than is given. The maximum crown spread which can be obtained without unduly developing the crown at the expense of the clear length of stem would be one-half more than is given.

Breast-high diameter of tree, inches	Spread of crown feet	Breast-high diameter of tree, inches	Spread of crown feet
7	11	15	16.5
8	11.6	16	17.2
9	12.4	17	17.9
10	13.3	18	18.6
11	13.7	19	19.4
12	14.4	20	20
13	15.1	21	27.7
14	15.8	22	21.3

Pure stands.—The maturity of pure, even-aged stands is determined by the date at which the largest profit or per cent. is earned on the investment. The investment embraces—

(1) The value of the soil;

(2) The cost of establishing the stand, which might consist either in leaving seed trees, or increased cost of logging the old stand, or the cost of seeding or planting;

(3) The cost of protection, which may be a yearly cost or might be required only while the stand was young, and the interest on such costs;

(4) Taxes on soil and timber, and the interest on taxes;

(5) The cost of thinning and cleanings and the interest on such expenses.

The volume of a pure, even-aged stand increases rapidly at first, then more slowly and finally becomes stationary. The value of the timber based on the quality or proportion of grades increases in the same manner. Value increment continues long after the volume of the stand has become stationary.

There is also, as has been explained, a fluctuating increase in price of grades of lumber, which affects the value of stumpage. This is neglected in all calculations, but it should be given careful consideration by owners of stands in fixing the period of cutting. Table 14 shows the cost per 1,000 board feet of growing yellow poplar in pure stands, and the most profitable age at which to cut, when the cost of stocking is $3 an acre and when the detailed items of expense are as shown. The greatest profit per 1,000 board feet, 49 cents, in excess of all costs and interest, is made by cutting at 35 years of age. At 30 years the profit is 42 cents per 1,000 feet; at 40 years it is 36 cents a 1,000 feet. Price increase is neglected.

TABLE 14.—*Second-growth yellow poplar. Most profitable age for cutting unthinned stands for lumber, and the cost per* 1,000 *board feet of growing timber with natural reproduction. Average sites. Interest rate,* 5 *per cent; value of soil,* $5 *per acre; cost of stocking,* $3 *per acre.*

Age of stand	EXPENSES IN GROWING TIMBER								Profit or loss in excess of 5 per cent. on the basis of present stumpage values.	Cost of 1,000 Bd. ft. of growing stand.	Value per 1,000 Bd. ft. of stand on basis of present prices of lumber.	Per cent. of increase in stumpage values necessary to yield 5 per cent. net.
	Cost of land, stocking and protection				Taxes on timber		Taxes on land	Total cost of growing timber to the end of each 5-year period.				
	Value of stumpage per acre at end of each 5-year period at present prices	Accrued interest on value of land to end of each 5-year period	Cost of stocking and interest on it to end of each 5-year period	Cost of protection 5 cents per acre per year, and accrued interest to end of each 5 year period.	Annual for each 5-year period at 1 per cent. on a two-thirds valuation of stand.	Taxes and accrued interest at 5 per cent. to end of each 5-year period.	Taxes at 1 per cent. on land at uniform value and accrued interest to end of each 5-year period.					
Years	Per acre	Per acre	Per acre	Per acre	Per acre	Per acre	Per acre	Per acre	Per acre	Per 1,000 feet	Per 1,000 feet	Per cent
20	$ 17	$ 8.27	$ 7.96	$ 1.65	$0.12	$....	$ 1.65	$ 19.53	$*2.53	$3.83	3.33	..
25	29	11.93	10.16	2.39	.18	0.66	2.39	27.53	1.47	3.03	3.19	..
30	43	16.61	12.96	3.32	.28	1.84	3.32	38.05	4.95	2.95	3.33	..
35	60	22.58	16.55	4.52	.40	3.90	4.52	52.07	7.93	3.19	3.68	..
40	78	30.20	21.12	6.04	.52	7.20	6.04	70.60	7.40	3.64	4.02	..
45	97	39.93	26.95	7.99	.64	12.09	7.99	94.95	2.05	4.24	4.33	..
50	114	52.34	34.40	10.47	.76	19.01	10.47	126.69	*12.69	5.03	4.52	0.2
55	130	68.18	43.91	13.64	.87	28.53	13.64	167.90	*37.90	6.04	4.68	.5
60	143	88.40	56.04	17.68	.95	41.33	17.68	221.13	*78.13	7.30	4.72	.7

*Loss.

Table 15 shows the most profitable diameters and ages at which to cut stands of second growth yellow poplar which have been established without cost and which are unthinned, cutting to different diameters. When the current rate per cent. of increase in value falls below 6 per cent. the stand can be considered as mature. It should be noted that price increment is neglected.

TABLE 15.—*Yellow Poplar. Period of maturity of natural unthinned second-growth stands for saw-timber. Average conditions of growth. Price increment neglected.*

	Cutting to 7 inches breast-high				Cutting to 10 inches breast-high		
Age of stand	Average diameter breast-high of trees in stand	Value of stand per acre saw-timber only	Average annual increase in value	Current rate of increase in value	Average diameter breast-high of trees over 10 inches in diameter	Value of stand per acre saw-timber only	Average annual increase in value
Years	Inches			Per cent.	Inches		
20	4.9	$ 17	$0.85	23.0	10.5	$ 6	$0.30
25	5.9	29	1.16	11.0	11.2	22	.88
30	6.8	43	1.43	8.0	11.7	39	1.30
35	7.6	60	1.71	7.0	12.1	55	1.60
40	8.3	78	1.95	5.0	12.3	73	1.82
45	9.0	97	2.16	4.5	12.6	92	2.04
50	9.5	114	2.28	3.3	12.8	110	2.20
55	10.0	130	2.36	2.7	13.0	126	2.30
60	10.4	143	2.38	2.0	13.1	139	2.33
65	10.8	154	2.37	1.5	....	....	....

Table 16 shows the cost of growing cordwood and the most profitable age at which to cut cordwood in natural stands. The greatest profit per acre, in addition to interest, is at 25 years, and amounts to $10.47 an acre. The cost of growing timber at this age is only $1.45 a cord; much lower than when the stand is either younger or older.

TABLE 16.—*Second-growth yellow poplar. Most profitable age for cutting cordwood in unthinned natural stands, and the actual cost per cord of growing it with natural reproduction. Cost of growing as given in Table* 14.

	Average conditions of growth.				
Age of stand Years	Yield per acre in cords of 160 cord feet of peeled stem wood Cords	Value of stand at $2.00 a cord stumpage	Total cost per acre of growing stand	Profit per acre at any period	Cost per cord of growing timber
20	13	$26	$ 19.53	$ 6.47	$1.50
25	19	38	27.53	10.47	1.45
30	23	46	38.05	7.95	1.65
35	27	54	52.07	1.93	1.93
40	31	62	70.60	loss 8.60	2.28
45	34	68	94.54	loss 26.54	2.78
50	37	74	126.69	loss 52.69	3.42
55	40	80	167.90	loss 87.90	4.20
60	43	86	221.13	loss 135.13	5.14

GENERAL INSTRUCTIONS.

Protection.—It is necessary to protect from fire and cattle, areas which are in process of stocking with yellow poplar, young stands, and plantations of yellow poplar. This species is extremely sensitive to fire, particularly to early spring fire, until the bark becomes thick and rough. In the case of large areas, as of cut-over land, patrol during spring and in autumn until the newly fallen leaves are thoroughly compact and moist, is the most effective method of preventing fires. It is sometimes possible, particularly in the case of small tracts or single coves, to isolate by means of fire lines, but these should never be exclusively relied upon. It is generally desirable to lop the under limbs of tops of felled trees in order to bring the trunks in close contact with the soil and hasten their decay. Unless there is a large amount of pine or hemlock (spruce pine) slash, the piling and burning of brush is not desirable, since it destroys humus. When large tracts are being grazed, it is necessary either to herd cattle to pre-

vent destruction of small yellow poplar seedling, or to fence areas on which the young growth could be injured.

Unless plantations are protected, the destruction of a part of the stand is likely to result in understocking. The results of understocking are: short-bodied and scrubby trees, the stems being set with numerous large knots so that the lumber is low grade; and in spite of the relatively large diameters of the individual trees a low yield per acre.

Elimination cuttings.—In natural stands of yellow poplar on cut-over land there will often be a very large proportion of low grade species. When these are rapid growing and might seriously interfere with the growth of the poplar, or entirely crowd it out, it is necessary to eradicate them. The material which is cut in this manner often will have no sale value, the cutting being made entirely for the benefit of the mature stand. Such cuttings can sometimes be combined with thinnings

FIG. 7. A pole stand of hardwoods, containing much yellow poplar killed by a severe spring fire. Note sprouts around bases of trees.

Thinnings.—Thinnings are made for the purpose of accelerating the growth of the remaining trees in a stand. They cover two periods. Those which are made in very young stands of sapling and pole size, the result

of which, in addition to lessening overcrowding, is the elimination of trees of undesirable species from the stand. The smaller trees with the poorest formed stems should be removed. Thinnings in young stands should be light, but should be repeated as soon as the crowns of the trees have again become so close together that they interfere. The crowns will seldom touch after the trees have reached small-pole size. Thinnings of this character do not retard height growth or materially interfere with the cleaning of the stem of branches. Thinnings in young stands should never be severe enough to permit the development of large branches. (Fig. 8.)

The second period in thinning is after the stand has reached the large-pole stage and the trees, according to site, are from 80 to 110 feet in height. Clear length of stem has already been developed, and but slight additional growth in height will take place. The best trees should be isolated. These will soon form large crowns and rapid growth in diameter will take place. Additional diameter means not only increased volume, but a higher proportion of upper grades. The diameter of the trees is more important than their number. It will be far more profitable to have 70 trees per acre which have average diameters of 20 inches than 160 trees which have diameters of 15 inches. The 20-inch trees have a stumpage value of $3.61 each under an operating cost of $12 per 1,000 board feet, or $252.70 an acre. The 15-inch trees have a stumpage value of 83 cents each or only $132.80 an acre. The yield in board feet is approximately the same in both cases—about 23,000 feet per acre. (See Fig. 1.)

The trees removed in thinning from stands after they have passed the sapling stage, should pay for all thinnings. Even-aged second growth stands have a form of forest which requires thinning in order to develop their maximum yields. It is impossible for lumbermen economically to apply thinnings on a large and rough tract, until a suitable form of forest shall have been developed. But second growth stands, owned by farmers or others who live on their land, even when they are irregular in form, but which are in easy handling distance of a market, can be profitably thinned at any time, although the profits are greater from stands in which a definite form has been secured.

There are many thousand acres of even-aged, second-growth stands in Tennessee which could be profitably thinned, even if no returns were obtained from the thinnings. Table 17 shows the composition and range of diameters of the different species in such a stand.

FIG. 8. A 20-year-old stand of yellow poplar, first quality, the larger trees being from 60 to 70 feet high and 9 to 11 inches in diameter. This stand was thinned and cleaned 5 years ago when most of the chestnut, oak and other species which were crowding the poplars were cut out. The stand now consists largely of yellow poplar and is ready for a second thinning. This should be made by removing the marked trees. It is necessary to cut some of the larger poplars whose crowns are being crowded. One such tree is marked for removal in the foreground. The heavy undergrowth of dogwood and other species which are tolerant of considerable shade is noteworthy. (Author's illustration.)

TABLE 17.—*Second-growth on coaled-over land, the stand composed of poplar and locust seedlings, chestnut sprouts, and oak seedlings and seedling-sprouts. Site as good for poplar as for chestnut. Age of stand 54 years. One acre. Carter County.*

Diameter breast-high	Poplar	Chestnut	Oak	Locust	Others
1— 3	8	12	..	..	56
6— 9	12	28	8	4	..
10—12	24	36	..	..	..
13—15	20	32	..	..	..
16—18	8	20	..	4	..
	72	128	8	8	56
Total per acre above 9 inches.	54	88	..	4	..

The poplars above 12 inches in diameter are 115 feet high; the chestnut of the same sizes are from 108 to 110 feet high. Such a site is well suited for the production of large sized poplar timber, and the crowns of the poplars, which are still being crowded by the chestnut, should be freed by cutting the latter. This would be a combined thinning and elimination cutting. Had some of the chestnut been removed in successive earlier thinnings, it would have been possible to have forced all of the poplar to diameters above 14 inches. The chestnuts can now be removed for poles, the most profitable form in which they can be marketed, and the locust should be cut, but the poplar should be held until the accelerated growth which followed the thinning begins to decline. (See Figs. 1 and 3.)

BETTER UTILIZATION.

Reduction of waste.—Since the most valuable timber in the trees is in the butt log, stumps of sound trees should be cut just as low as possible. In the case of crooked trees, log lengths should be varied so that there will be no crooked logs or so that the crooks will be near the end of the logs. Sound timber in the top should be used whenever the selling price of the lumber in it, less the discount, exceeds the value of the labor in converting it. This secures the removal of tops which may be a fire menace, without materially reducing profits or stumpage value. As soon, however, as the value of the lumber in a log is less than the cost of the labor to convert it, its removal results in a reduction in the value of the remaining logs of a tree. Consequently, very limby and knotty top logs which will yield not to exceed 25 per cent. of No. 2 Common or better, and the lumber from which would have a net value of $10 per 1,000 feet, after deducting overhead charges, stumpage and trade discounts, should

not be removed when labor items, including delivery on cars, amount to more than this.

Where trees are short bodied and low grade, but sound, a large portion of the timber being of unprofitable character, the tree should be held, since some growth is taking place and this, added to the appreciation in the price of stumpage which is rapid in the case of low grade timber (see Table No. 12), will eventually assure the removal of such trees at a profit.

Selling timber in the most profitable form.—The wood of second growth yellow poplar is commonly measured either as logs scaled by Doyle-Scribner rule, or as cords of 128 cubic feet of piled wood with the bark on, or as cords of 160 cubic feet of piled wood with the bark peeled. It is frequently desirable to determine before cutting the most profitable form in which to market small trees. Veneer is generally cut from logs 16 inches and over in diameter, and is measured by the cubic feet of solid wood in the log. There is consequently no difficulty in ascertaining the relative value of logs marketed for veneer stock, and measured by a log scale.

The relative value of small trees of different sizes for pulp cordwood and for saw timber is shown in Table 18. Stumpage values in the table are placed at $1 per 1,000 feet for lumber, measured by Doyle-Scribner rule; and at $1 a cord of 160 cubic feet for wood measured after it is rossed, dried, and racked. To use this table it is necessary to multiply the volumes which are given in the table for trees of each diameter, by the relation of the stumpage at $1 to the actual stumpage price which is offered, using as a basal diameter the diameter breast-high of the average sized tree on the tract. For example: if board measure stumpage were worth $1.50 per 1,000 feet, the volume which is given for the average tree in the board-measure column should be multiplied by 1.50. If the cordwood stumpage measured after peeling were worth 50 cents a cord, the value given of the average sized tree which is under this head should be multiplied by .50. A comparison of the two resultant figures will show in which form the timber could be marketed most profitably.

Table 19 shows the number of trees required to make a cord of 160 cubic feet after they are peeled, split, and dried.

TABLE 18.—*Comparative value of trees of yellow poplar of different sizes for cordwood, peeled, and for lumber (scaled by Doyle-Scribner rule).*

(Based on the average tree.)

Diameter breast-high Inches	Cordwood, 160 cubic feet, measured after peeling, at $1.00 per cord	Saw logs scaled by Doyle-Scribner rule, at $1.00 per 1,000 board feet
6	....	....
7	.04	....
8	.066	.01
9	.086	.014
10	.11	.024
11	.13	.031
12	.163	.05
13	.20	.075
14	.25	.10
15	.32	.13
16	.40	.163
17	.48	.20
18	.52	.243

TABLE 19.—*Number of trees of yellow poplar split and peeled in second-growth stands 25 to 50 years old required to make a long cord of 160 cubic feet; the percentage of bark, and the percentage of waste in stump, top, and bark.*

Diameter breast-high Inches	Number of trees (stem wood only to 3 inches) to a long cord split and peeled	Double thickness of bark at breast-high Inches	Percentage of bark in the stem	Height of stump feet	Percentage of wood lost in stump, bark and top of stem (top used to 3 inches)
7	23.	.9	20	1.3	27
8	15.2	1.0	19	1.3	25
9	12.0	1.5	18	1.4	24
10	9.4	1.1	18	1.4	23
11	7.6	1.2	17	1.4	22
12	6.1	1.3	17	1.4	22
13	5.0	1.4	17	1.5	21
14	4.0	1.4	17	1.5	21
15	3.1	1.4	16	1.6	21
16	2.5	1.5	16	1.7	21
17	2.1	1.5	16	1.7	21
18	1.9	1 5	16	1.8	21
19	1.7	1.5	15	1.9	20
20	1.5	1.6	15	2.	20

PLANTATIONS.

Yellow poplar can be easily and cheaply grown from plants raised in a nursery or taken from the forest or edges of fields and pastures. Seeds cost from 40 cents to $1.00 a pound. There are about 9,000 seeds to a pound. Their vitality, however, is low, it being the exception when more than 15 per cent. of the seed are sound. The seed can be planted either in the fall or in the spring. If planting, however, is to be deferred until spring, the seed should be stratified in moist sand immediately after collection in the fall, and kept in this manner until they are to be planted in the spring. If they are permitted to dry out and then planted the succeeding spring, not only do most of them lie over in the soil a year before germinating, but there is a decline in germinability. Seed should be sown in broad shallow rows 18 inches apart and covered not more than one-half inch. Unless the seed bed is established in the forest, and receives some shade from the surrounding trees, the seedlings should be given a light shade with a screen of laths or brush during the first summer. If the soil of the seed bed is fertile, the seedlings when a year old should be at least one foot high. They will have long tap-roots which must be cut off when out-planted. It is not desirable to transplant in the nursery. While one-year-old plants will usually be used for permanent planting it is possible to outplant the seedling when from three weeks to two months old. The taproot at this age is small and need not be cut. On fertile sites spacing in permanent planting should be six by six feet; on poor sites five by five feet.

Plantations can be made on any sites which have a deep, porous soil, well provided with humus, and neither wet nor extremely dry. Heaviest yields can be expected from sites on which large trees of yellow poplar occurred in the original forest. It is possible, however, to grow poplar in plantations on far drier sites than are naturally occupied by the trees, but it is desirable in planting on such dry sites to mix the poplar with some species like white pine, red oak, white oak, or chestnut, which have a more dense canopy than poplar and will better protect the soil than this species. On moist sites, poplar can be mixed with hard maple, white pine, or basswood. At high elevations in the Cumberland Mountains and in the mountains between North Carolina and Tennessee, poplar can be mixed with white ash or black cherry. Such mixture, however, should be made only on fertile soils, preferably on north slopes. Where there is a good market for locust posts and the locust is not seriously attacked by the borer, this species can be mixed with yellow poplar. The locust can be removed for posts in thinnings, leaving the poplar for the permanent tree.

It is necessary to thin plantations of yellow poplar as the trees become large and crowding takes place. This requirement should be considered

in making mixtures and at least a portion of the trees in such mixtures should be species, the wood of which can be profitably used when of small size. In establishing mixed plantations, the different species can be planted in separate rows, or each species can be planted so as to occupy a small group. The cost of planting is cheaper when the species are separated in rows, but the thinnings are easier executed when the species are separated in groups. The groups can be from one-half to one rod square.

It is not necessary that the land should be plowed, but it is necessary that it should be open, and that there should be no growth which will smother or choke the young plants. Plantations should never be established on very grassy sites or beneath thickets or shrubs. In planting cut-over land, this must be kept in mind, and plantations should be only on sites which are open. The growth of the seedling, however, is far more rapid on good sites than on poor sites, and while it will soon overtop brambles and such low shrubs in the rich soil of coves, it is likely to be smothered by them in less favorable localities. Table No. 20 shows the most profitable age for cutting yellow poplar in thinned planted stands, and the cost per 1,000 board feet of growing the timber. The profit shown is the net profit above all interest on the investment, which is calculated at 5 per cent. a year, compounded. There is an additional profit, which is not shown, in the increase in the value of stumpage. If this should be at the rate of 3 per cent. per annum, which is one-fourth of the rate of increase in price during the past 20 years, the investment would earn more than 10 per cent a year, compounded, when the stand is 40 years or more old.

TABLE 20.—*Most profitable age for cutting yellow poplar in thinned planted stands, and cost per* 1,000 *board feet of growing timber. Interest rate* 5 *per cent.; value of land* $5 *an acre; cost of planting* $6 *an acre.*

Age of stand	AVERAGE CONDITION OF GROWTH											
	Value of stumpage on basis of present prices			Expenses in producing timber								
				Land	Cost of Planting	Protection	Taxes on Timber		Land			
	Value of saw-timber at end of each 5-year period	Estimated value of thinnings at $2 a cord	Value of thinnings and accrued interest thereon at 5 per cent. compounded to end of each 5-year period	Accrued interest on value of land to end of each 5-year period	Cost and interest of each 5-year period.	At 5c per acre a year and accrued interest to end of each 5-year period	Annual taxes at 1 per cent. on a 2-3 valuation of stand to end of each 5-year period	Accrued interest at 5 per cent. to end of each 5-year period.	Taxes at 1 per cent at uniform value, accrued to end of each 5-year period.	Total expenses to end of each 5-year period.	Total value of timber with accrued interest on thinnings to end of each 5-year period	Profit or loss on stand to end of each 5-year period	Cost of growing stand
Years	Per acre											Per 1,000 ft.
20	$ 25	$ 6.40	$....	$8.27	$ 15.92	$ 1.65	$0.16	....	$ 1.65	$ 27.49	$ 25.00	$ 2.49	$4.10
25	45	....	8.17	11.93	20.32	2.99	.30	$ 0.88	2.39	37.91	53.17	15.26	3.11
30	67	10.00	10.40	16.61	25.93	3.32	.45	2.79	3.32	51.97	77.40	25.43	3.11
35	92	....	26.03	22.58	33.10	4.52	.62	6.06	4.52	70.78	118.03	47.52	3.44
40	114	10.00	33.21	30.20	42.24	6.04	.76	11.18	6.04	95.70	147.21	51.51	3.99
45	136	....	55.14	39.93	53.91	7.99	.91	18.51	7.99	128.33	191.14	62.81	4.75
50	155	8.00	70.36	52.34	68.80	10.47	1.03	28.72	10.47	170.80	225.36	54.56	5.69
55	172	....	99.97	68.18	87.81	13.64	1.14	42.45	13.64	225.72	271.97	46.25	6.92
60	186	....	127.56	88.40	112.08	17.68	1.24	60.64	17.68	296.48	313.56	17.08	8.42

Table 21 shows the cost of growing yellow poplar in unthinned plantations on different sites, and the rate per cent. which would be yielded on the initial investment indicated in the table.

TABLE 21.—*Cost per* 1,000 *board feet of growing yellow poplar in plantations. Interest rate* 5 *per cent; cost of stocking* $6 *an acre.*

Age of stand Years	Value of stand at present prices Per 1,000 feet	Average annual increase in value per acre	Total* expenses in growing timber per acre	Profit or loss in excess of 5 per cent. per acre	Cost of growing stand Per 1,000 feet	Value of stumpage at present prices Per acre	Rate of increase in stumpage values necessary to yield 5 per cent. net Per cent.	Rate of increase in value of stand per acre Per cent.
			Good conditions I—Value of soil $10 an acre					
20	$4.18	$2.30	$ 37.41	$ 8.59	$ 3.40	$ 46	..	20.0
30	4.80	3.13	73.80	20.20	3.77	94	..	7.4
40	5.34	3.58	137.39	5.61	5.13	143	..	4.2
50	5.44	3.60	244.88	64.88	7.40	180	.6	2.3
60	5.29	3.38	423.00	220.00	11.02	203	1.2	1.6
			Average conditions II—Value of soil $5 an acre					
20	$3.33	$0.85	$ 27.49	$ 10.49	$ 5.39	$ 17	2.2	23.0
30	3.33	1.43	51.01	8.01	3.95	43	.6	9.4
40	4.02	1.95	91.72	13.72	4.73	78	.4	6.0
50	4.52	2.28	161.39	47.39	6.40	114	.7	3.8
60	4.72	2.38	277.17	134.17	9.15	143	1.1	2.3
			Poor conditions III—Value of soil $3 an acre					
20	$3.57	$0.25	$ 23.52	$ 18.52	$16.80	$ 5	8.4	23.0
30	3.16	.83	41.82	16.82	5.29	25	1.7	16.0
40	3.72	1.28	73.81	22.81	5.39	.51	.9	7.2
50	4.30	1.60	128.00	48.00	6.88	80	.9	4.6
60	4.59	1.75	218.82	113.82	9.56	105	1.2	2.7

*See Table— for detailed statement of elements expense.

Soil value.—The cost of growing yellow poplar in plantations as shown in Table 21 is based on a soil value of $10 an acre for best quality sites, of $5 an acre for average quality sites, and $3 an acre for poor quality sites. These are reasonable values for sites which are in a suitable condition for planting. If the land is situated in a farming section the values of soils which produce yellow poplar, even if the sites are extremely rough, will not be less than these. If it is situated in a cut-over mountainous section where the average value of the soil does not exceed $2 an acre, the sites suited for yellow poplar would embrace only the very best soils—the coves and lower slopes—which would amount probably to less than 20 per cent. of the area of any large tract. One-third of this 20 per cent. might have a growing capacity equal to that given for the best quality sites, while that of the remaining two-thirds would be less. Its relative value consequently would be far greater than that of the other 80 per cent. of the tract. If the land were foul, making it necessary to cut off some of the brush, as would often be the case, this would add to the cost of planting and counterbalance its apparent cheapness.

Cost of planting.—The cost of planting one-year-old seedlings, including the cost of the planting stock as well as the labor, is placed at $6.00 an acre, a low figure, but possible if the work is economically done and if the seedlings are home grown. On the best sites where spacing need be only 8x8 feet (680 trees to the acre) the cost would be less. On poor sites where a spacing of 6x6 feet should be used (1,200 trees to the acre) the cost of planting yearlings should not exceed $6.00.

Yield.—Yield of plantations is calculated on the basis only of thinning stands (page —) since it is doubtful if any plantations will be established except where thinning can be made. The material from thinning is given a value of $2.00 a cord, a high value for the small-sized wood from the early thinning but low for the larger-sized wood from the older stands. Interest is allowed on the value of thinnings of four per cent. net, accrued for each five years.

Interest rate.—A five per cent. rate is allowed on all expenses connected with establishing the plantation and taxes, except in the returns from thinnings, on which only four per cent. is allowed.

Protection.—For the cost of protection and superintendence, five cents an acre a year is allowed. In the case of estates and farmer's plantations this cost can be entirely eliminated. In the case of forest plantations the cost of protection may exceed this item for the first 20 years. It should rapidly decrease, however, with the age of the stand and with succeeding thinnings.

Taxes.—A uniform tax of 1.20 per cent. on the actual soil value ($5 an acre) is allowed for the entire period. The tax on the timber is assumed not to begin until the stand is 20 years old, at which period the stand begins to acquire merchantable value. The actual value at the end of each five years is taken as the assessed value, with a tax rate of one per cent.