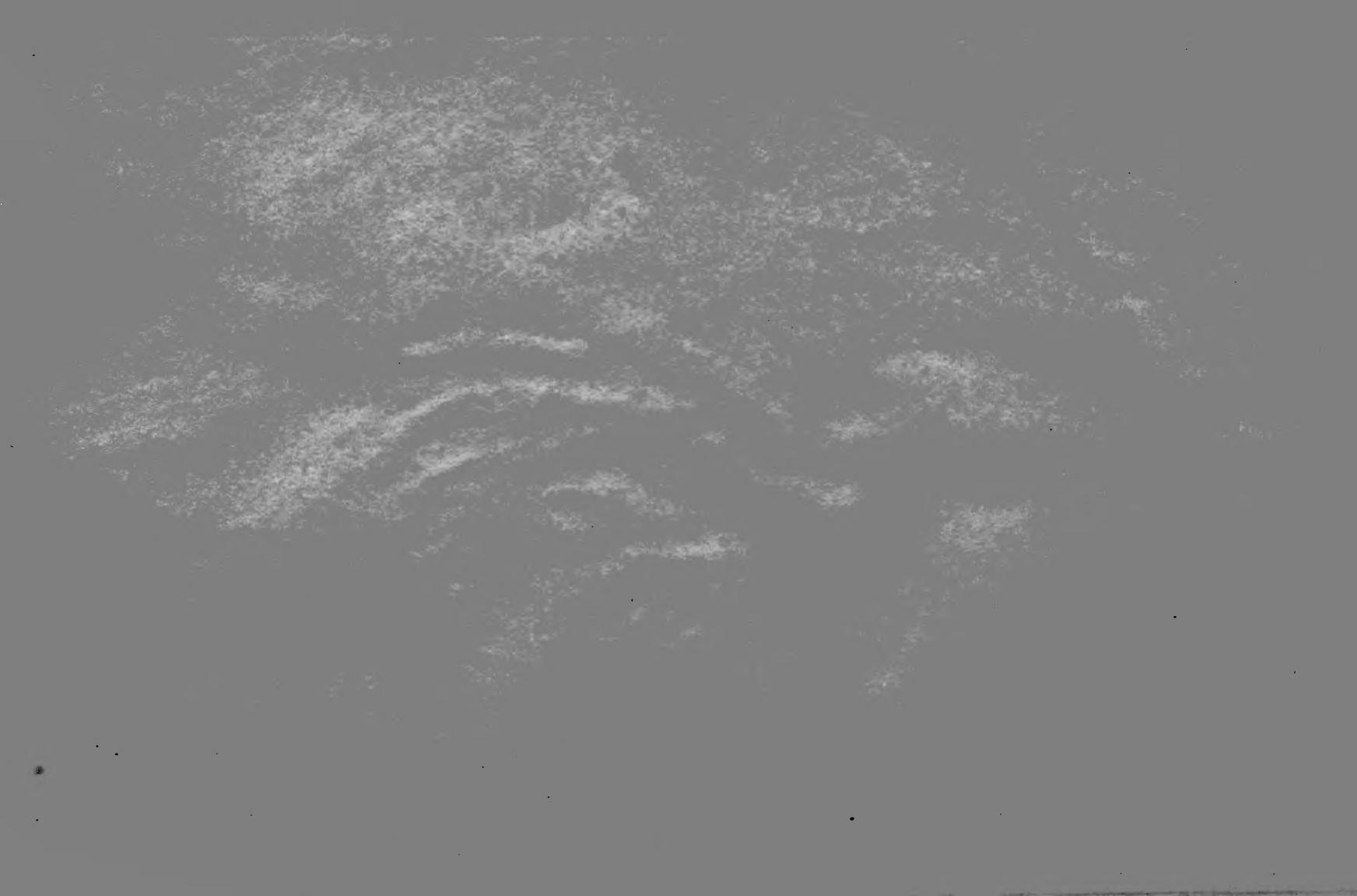

FRONTISPIECE. Group of loblolly pines two hundred years old growing with hardwoods on Quality I. Such trees yield 55 per cent of No. 1 and No. 2 grades of lumber. The hardwoods have been cut out.

NORTH CAROLINA GEOLOGICAL AND ECONOMIC SURVEY

JOSEPH HYDE PRATT, State Geologist

BULLETIN No. 24

LOBLOLLY OR NORTH CAROLINA PINE

BY

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(and former Forester of the North Carolina Geological and Economic Survey)

Prepared in Co-operation with the
Forest Service, United States Department of Agriculture
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LETTER OF TRANSMITTAL

CHAPEL HILL, N. C., October 1, 1914.

To His Excellency, HON. LOCKE CRAIG,
Governor of North Carolina.

SIR:—There has recently been prepared for the North Carolina Geological and Economic Survey a report on the Loblolly or North Carolina Pine by Mr. W. W. Ashe. It is for the use of landowners and lumbermen alike and is designed to meet the needs of all our people who are in any way interested in timber.

I submit this report for publication as Bulletin 24 of the bulletin series of the Survey.

Yours respectfully,

JOSEPH HYDE PRATT,
State Geologist.

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PREFACE

The loblolly or North Carolina pine is by far the most important tree now being cut for lumber in North Carolina. While distributed over only the eastern half of the state, yet this tree furnishes more than half of the annual lumber cut of the whole state. Most of the lands which many years ago were denuded of longleaf pine by the turpentine operators and the lumbermen and then devastated by fires and hogs, later came up to loblolly pine and now 50 to 100 years later are furnishing another and a more remunerative crop of timber.

Loblolly combines all the essentials for an ideal forest management tree. It seeds profusely and regenerates readily, is adapted to nearly all types of soil, grows rapidly, becomes marketable at an early age, grows densely, making large yields per acre, and produces material for which there is a general demand at a fair and increasing price.

The study of the loblolly or North Carolina pine in eastern North Carolina, which formed the basis of this report, was made jointly by the Forest Service of the United States Department of Agriculture and the North Carolina Geological and Economic Survey. The first field work was begun in 1898 and the entire study completed in 1913.

The growth and volume figures apply only to eastern North Carolina. The mill studies were made in Gates, Wayne, Beaufort, and Pitt counties; and the sample plots and stem analyses were made in twelve additional counties: Chatham, Nash, Northampton, Washington, Bertie, Craven, Hyde, Harnett, Johnston, Wake, Pender, Lenoir, and Onslow.

A considerable part of the original field data was collected under the immediate direction of the author by H. S. Curran and E. A. Cahoon of the North Carolina Geological Survey, and A. K. Mlodziansky, of the United States Forest Service. Some of the mill cut data were collected by Messrs. J. S. Holmes, Forester of the North Carolina Geological and Economic Survey, and W. D. Sterrett, of the Forest Service. In the process of the study many courtesies were extended by the Hines Bros. Lumber Company of Kinston, N. C., Short Lumber Company of Washington, D. C., and Lyon & Dennis of Suffolk, Va., while information in regard to prices of certain grades at different periods was furnished by Mr. W. B. Roper, Secretary of the North Carolina Pine Association.

This bulletin takes up the growth and proper forest management of loblolly pine in North Carolina. It deals with the occurrence and silvical requirements of the tree, its growth in height, diameter and volume on different soils and situations, and the yields which can be obtained under varying conditions. The amount of lumber of different grades which can be cut from timber of different ages and qualities is also shown in tabular form.

Under forest management is taken up the determination of the best age at which to cut for saw timber or cordwood, in order to utilize most profitably the forest crop. The best methods of cutting in order that the forests may be perpetuated is discussed for the different types. Protection from fire, especially for the young growth, is advocated and the advisability of artificial restocking by seeding or planting is considered.

This report has been prepared for the use of landowners and lumbermen alike, and is designated to meet the needs of all of our people who are in any way interested in timber, but especially those in the eastern half of North Carolina.

Two bulletins previously issued by the United States Department of Agriculture treat of this tree along somewhat different lines and will be found helpful to read in connection with this report. "The Loblolly Pine in Eastern Texas, With Special Reference to the Production of Cross-ties," by Raphael Zon, Forest Service Bulletin 64, was published in 1905; while "Forest Management of Loblolly Pine in Delaware, Maryland, and Virginia," by W. D. Sterrett, Bulletin of the United States Department of Agriculture, No. 11 (new series), has only recently been published. The present report should have been issued at the same time, but the delay in publishing this has been much greater than was anticipated.

JOSEPH HYDE PRATT,
State Geologist.

LOBLOLLY OR NORTH CAROLINA PINE

(Pinus tæda, *Linnæus*)

ITS GROWTH AND MANAGEMENT

By W. W. ASHE

THE TREE AND ITS IDENTIFICATION.

The loblolly or North Carolina pine grows under many diverse conditions which affect its form, size, and the character of its wood, and in consequence it is known by many names. The general use of the name "North Carolina pine" for the lumber cut from the tree commonly known as "shortleaf pine" through the Coastal Plain region of North Carolina would seem sufficient excuse for adopting the use of one or both these names in this report.

The former name is used on the title page in order to clearly identify the tree, but its general acceptance is not recommended. This name is applied only to a very limited extent to the tree itself, while the name "loblolly pine," though not often used locally in the Carolinas or Virginia, either for the tree or its lumber, has a wide and ever-extending use, not only by foresters but by readers of the lumber journals and the public generally. For this reason and because it is the only name which is applied exclusively to this tree, the name loblolly is used throughout the body of this report, notwithstanding the strong arguments for continuing the local name of "shortleaf pine—of the coast," or adopting the lumber trade name of "North Carolina pine."

OTHER COMMON NAMES.

Shortleaf pine and *Short straw pine,* names usually applied to the growing tree in eastern North Carolina and farther south, are used to distinguish loblolly from longleaf pine. In the middle portion of North Carolina and in the hill section of the states farther south, the name shortleaf pine is applied to a different tree (*P. echinata*). This tree, however, occurs sparingly in the Coastal Plain, where it is known either as spruce pine or rosemary pine. In the former region where the loblolly pine occurs it is sometimes called "longleaf" pine.

Old-field pine, a name applied to young growth of loblolly pine on land once under cultivation in eastern North Carolina and southward.

Slash pine, a name common in Virginia, the Carolinas, and farther south, refers to large trees with thick heartwood which occur in swamps in mixture with hardwoods.

Rosemary pine, a name infrequently applied to large trees growing with hardwoods in swamps; more generally used in the Coastal Plain

to designate large trees of *Pinus echinata,* the common shortleaf pine of the Piedmont Region.

Swamp pine, a very common name for loblolly pine growing in swamps.

Sap pine and *black-bark pine* are names applied by lumbermen to young growth possessing these characteristics. The latter name is applied more frequently to pocoson pine.

On the eastern shores of Maryland, in southeastern Virginia, and in Piedmont North Carolina, where associated with shortleaf, scrub and other pines having much shorter leaves, loblolly pine in some places is known as *longleaf* or *foxtail pine.*

Botanically the tree is known as *Pinus taeda, L.,* an inappropriate term so far as the specific designation is concerned, as *taeda* means torch. The torch or lightwood pine is the longleaf pine. The latter furnishes the wood for light, its brands until recently being the chief source of light at night in thousands of homes in the Coastal Plain of the southern states.

DISTINGUISHING BOTANICAL CHARACTERISTICS.

There are three pines which are intimately associated with the loblolly pine in different portions of the Coastal Plain region, and as two of them are apt to be confused with it, the following characteristics will be found of assistance in separating them:

Branchlet of loblolly or North Carolina pine with old cones open after the dispersal of seed in early winter, and small cones which will develop next season, just below the terminal bud.
Two-fifths natural size. (Author's illustration.)

DISTINGUISHING CHARACTERISTICS OF LOBLOLLY AND ASSOCIATED PINES OF EASTERN NORTH CAROLINA.

	Bark and Branches of Mature Trees	Leaves	Cones	Soil Preference
Loblolly Pine Shortleaf Pine (of the Coast.) North Carolina Pine (*Pinus tæda*).	Bark on large trees generally more than one inch thick at stump; bright red brown, broken into large oblong plates; branches ascending except on large trees.	Leaves in 3s, 3 to 7 inches long.	Cones oblong. 3 to 6 inches long, opening soon after maturing and falling from the tree.	Grows nearly everywhere, except on the wettest sandy and peaty soils and on sand hills.
Pocoson Pine Pond pine Black bark pine (*Pinus serotina*).	Bark on large trees seldom one inch thick at stump; dark brown, broken into square or roundish plates; branches nearly horizontal.	Leaves in 3s, 3 to 5 inches long.	Cones oval, pointed, 2 to 4 inches long; seldom opening, persistent on the tree.	Wet, sandy soils, black peaty or muck lands.
Longleaf pine Pitch pine (*Pinus palustris.*)	Bark thin and scaly, not arranged in plates, bright, red-brown	Leaves in 3s, 5 to 9 inches long.	Cones 5 to 7 inches long, opening at maturity and at once falling from the tree.	Sandhills and sandy or clayey soils that are not too wet.
Shortleaf pine Spruce pine Rosemary pine (*Pinus echinata*).	Bark broken into oblong plates; light red-brown, somewhat scaly; branches ascending except in old trees.	Leaves usually in 2s, 2 to 4 inches long.	Cones about 2 inches long, opening at maturity, persistent on the tree.	Well drained, loamy, clayey or gravelly uplands.

Very young trees and seedlings of the pocoson pine when growing in dense stands in mixture with loblolly pine are not easily distinguished from the latter, as the crowding tends to cause the branches of both species to ascend and the bark of the young pines is dark and furrowed. The two pines, however, are very distinct; the pocoson pine is inferior in every respect to the loblolly pine. This is generally recognized by the lumbermen who know that the pocoson or black-bark pine, especially in large stocks, is apt to be defective; either very knotty, rotten or with redheart. The pocoson pine is found associated with the loblolly pine

on savannas and on all wet, sandy, coarse-grained soils, particularly below an elevation of 100 feet above sea level.

The shortleaf pine occurs with the loblolly pine, chiefly on well-drained, loamy, gravelly or clayey uplands. In the coastal plain they are most frequently associated north of the Neuse River, but are seldom found together to the southward, except on hills along streams. They are found together on the oak uplands of the eastern portion of the Piedmont plateau region on well-drained, loamy or gravelly knolls and hills, where the shortleaf pine is the remnant of the old forest and the loblolly pine forms a portion of the second growth. Only in a few localities are all four pines found growing together. Near the coast the loblolly, pocoson, and longleaf pines are sometimes associated on sandy hummocks; the wettest places, however, are as a rule occupied by the pocoson pine; the pocoson and the loblolly pines are associated on savannas and slightly drier knolls; on better drained soils the longleaf replaces the pocoson pine in the mixture and on thoroughly drained soils only the longleaf pine is found.

ECONOMIC STATUS OF LOBLOLLY PINE.

Loblolly pine is the most important timber tree in southeastern Virginia, in eastern North Carolina, and in northeastern South Carolina north of Georgetown; while to the south of Georgetown not only in South Carolina but in Georgia and westward in the Gulf States its importance is yearly increasing with the decrease in the supply of longleaf pine. (See Map, Fig. 1.) Its value and its importance as a commercial tree are best indicated by the extent of the lumber industry which is dependent upon it and by the annual output of North Carolina pine lumber in southeastern Virginia, in North Carolina and in the adjacent portion of South Carolina. While no attempt is made in the census figures to separate the cuts of the various pines which are sawed in this region, all of them being grouped under the head of yellow pine, it is possible to approximate closely the cut of loblolly pine. The lumber cut of certain counties is entirely from loblolly pine (the shortleaf pine of the coast) and that of other counties is very largely from this species. In southeastern Virginia the cut of pine in 1912 in nine counties which are within the loblolly pine belt was 397,344,000 bd. ft. In North Carolina the cut of pine in 40 coastal plain pine counties was 1,079,061,000 bd. ft. In South Carolina in 15 counties the cut north of Georgetown was 548,138,000 bd. ft. A small amount of the pine cut in these nine counties in southeastern Virginia is from the shortleaf pine (of the Piedmont); in North Carolina small amounts of the pine cut in the coastal plain are from the shortleaf pine and from the longleaf or pitch pine; in South Carolina probably less than 10 per cent of the pine cut of the counties north of Georgetown is at present from long-

Fig. 1. Distribution of loblolly pine and of shortleaf pine in the Southern States.

leaf pine. The cut by counties for nine counties* in Virginia south of the James River is as follows:

	Board Feet.
Isle of Wight	12,500,000
Norfolk	100,683,000
Nansemond	62,726,000
Prince George	5,600,000
Princess Anne	5,500,000
Southampton	98,425,000
Surry	58,385,000
Sussex	13,525,000
Greenesville	40,000,000
Total	397,344,000

The cut by counties for 40 counties in eastern North Carolina is as follows:

	Board Feet.		*Board Feet.*
Beaufort	44,428,000	Jones	20,790,000
Bertie	34,137,000	Lenoir	20,136,000
Bladen	29,125,000	Martin	9,795,000
Brunswick	16,877,000	Nash	31,778,000
Camden	1,170,000	New Hanover	43,432,000
Carteret	5,240,000	Northampton	7,318,000
Chowan	25,824,000	Onslow	23,563,000
Columbus	67,970,000	Pamlico	22,109,000
Craven	107,209,000	Pasquotank	49,950,000
Cumberland	16,700,000	Pender	58,700,000
Duplin	60,841,000	Perquimans	23,627,000
Dare	4,000,000	Pitt	8,510,000
Edgecombe	7,112,000	Robeson	43,761,000
Gates	14,695,000	Sampson	66,917,000
Greene	2,600,000	Scotland	2,960,000
Halifax	41,290,000	Tyrrell	1,390,000
Harnett	32,360,000	Washington	23,046,000
Hertford	17,980,000	Wayne	20,810,000
Hoke	1,700,000	Wilson	21,870,000
Hyde	1,881,000		
Johnston	45,460,000	Total	1,079,061,000

The cut by counties for 15 counties in South Carolina north of Georgetown is as follows:

	Board Feet.
Beaufort	8,527,000
Berkeley	13,265,000
Charleston	48,343,000
Colleton	64,384,000
Darlington	82,373,000
Dillon	6,075,000
Dorchester	31,761,000
Florence	21,310,000
Georgetown	129,948,000
Hampton	21,700,000
Horry	28,472,000
Lee	1,000,000
Marion	54,235,000
Marlboro	21,035,000
Williamsburg	15,710,000
Total	548,138,000

*The total cut of yellow pine in the 36 counties of eastern Virginia in which loblolly pine is the prevailing tree is about 1,200,000,000 board feet. It is probable that three-fourths of this cut is from loblolly pine.

The pine industries of southeastern Virginia and northeastern North Carolina are so closely associated that it is impossible to separate them. A large portion of the logs cut in northeastern North Carolina is manufactured in Virginia chiefly at or in the vicinity of Norfolk, Suffolk, Franklin, Emporia, and Whaleyville. It is estimated that 175,000,000 feet, or nearly half of the output of the mills in this section of Virginia, are from logs brought from North Carolina, the importations being distributed approximately as follows: 50 per cent of the output of Nansemond County; 90 per cent of the output of Norfolk County and 60 per cent of the output of Southampton County. Some of the other counties which lie on or near the state line, such as Greenesville, also obtain small amounts of their timber from North Carolina. It is conservative therefore to say that the cut of loblolly pine timber in North Carolina in 1912 exceeded 1,250,000,000 board feet. The timber from which this was cut had a stumpage value of not less than $4,000,000, while the value of the entire output of loblolly pine in North Carolina embracing both the lumber delivered on the cars and the round timber which was cut in the State, but manufactured outside, amounted to more than $16,000,000. The cut of North Carolina pine lumber in North Carolina has probably attained its maximum.

Small operators still cut a large amount of North Carolina pine lumber. Of the total number of operations there were in 1912 only 22 in North Carolina that had an annual cut in excess of 10,000,000 board feet. These 22 had a combined cut of 384,000,000 board feet, compared with a cut of 695,061,000 board feet for the remaining 600 operations. At the same time in the counties north of Georgetown in South Carolina there were only six operations that had an output in excess of 10,000,000 board feet, and in the nine southeastern counties of Virginia only 12 operations had outputs of this volume.

The largest single operation in the North Carolina pine field is at Georgetown, S. C., with an estimated output of about 100,000,000 board feet a year. A wood alcohol plant is operated in connection with this sawmill to utilize the waste. The Norfolk District embracing the five counties of Norfolk, Nansemond, Princess Anne, Isle of Wight, and Southampton, with an output of more than 180,000,000 board feet a year, still maintains its supremacy not only as a distributing center but also as a producing center.

The amount of mature loblolly pine timber in North Carolina is about 15,000,000,000 board feet. This pine occupies in pure growth or associated with other species more than 8,000 square miles in North Carolina. Since the rate of growth of this species even under present unfavorable conditions is not less than 150 board feet per acre of commercial saw-timber a year replacement is at the rate of about 800,000,000 board feet a year and consequently is taking place at more than half of the rate of utilization for lumber. It is believed that if the forest lands of eastern North Carolina were being well managed the present cut could be maintained permanently.

PHYSIOGRAPHY OF COASTAL PLAIN AND PIEDMONT PLATEAU REGIONS.

In order to understand the distribution of the loblolly pine in North Carolina, its growth under various conditions and the systems of management best adapted to them, it is necessary to have a clear idea of the topography and other general physical characteristics of the Coastal Plain and of the eastern portions of the Piedmont Plateau regions.

THE COASTAL PLAIN REGION.

The coastal plain region of North Carolina extends inland from the coast for a distance of one hundred to one hundred and fifty miles, and has an aggregate area approximating 24,000 square miles. Its surface is that of a gently undulating plain of slight elevation (10 to 50 feet above sea level) and nearly level eastward, becoming more elevated (300 to 500 feet) and rolling along its western border. In the neighborhood of the coast, where the drainage is insufficient to remove the rainfall rapidly, there are extensive areas of lowland or swamp, with clear, slowly flowing, or stagnant water. These are mostly forest covered. Westward the fall permits a more thorough drainage and the swamps are largely restricted to narrow strips of alluvial land contiguous to the streams which have muddy, rapidly flowing water when the streams head beyond the costal plain, and clear, slow-flowing water when the streams head within the coastal plain. These swamps of the muddy streams extend in a northwesterly and southeasterly direction through the entire coastal plain. The total swamp area of the coastal plain region in North Carolina aggregates nearly 4,600 square miles.

The upland soils of the coastal plain are unconsolidated sands, sandy loams, silts and loams, and over limited areas stiff clays. To the north of the Neuse River loams and heavier soils are the more widely distributed upland soils; to the south of this river the soils are generally of a sandy type. The water table during the growing season is seldom as much as 20 feet below the surface, except in the tier of counties which lies just east of the Piedmont and in the sandy and hilly region of Moore, Cumberland, Richmond, and the adjoining counties. The soils in the swamps, except those of alluvial origin, are prevailingly of the same general textures as those of the uplands, but with a mucky or peaty top soil, or peaty throughout. The soils of the alluvial swamps bordering the large streams, which have their headwaters beyond the coastal plain region, are silty with a varying admixture of vegetable matter.

The soils of the coastal plain which are occupied by loblolly pine are practically all available for farming with the exception of the sand dunes on the banks and some of the river swamps which are subject to periodic and deep flooding. Many of the best loblolly pine soils require artificial drainage before they can be profitably farmed. There is little

doubt, however, that eventually the larger portion of all of the land now in loblolly pine will be cleared and placed in cultivation.

In the Coastal Plain Region the average annual temperature is about 61° F., with a normal range of 36° F. The winters are comparatively mild, the temperature seldom falling below 15° F. The average temperature during the five growing months is 74° F. The average annual rainfall is about fifty-five inches, the seasonal distribution being heavier in the spring and summer than in the autumn and winter. The region of heaviest precipitation and greatest humidity lies eastward of a north and south line through New Bern and Wilmington. The rainfall, while heavy, is irregular and concentrated, and the snowfall scant, although sleet is frequent. The atmospheric humidity is high, especially during the summer.

PIEDMONT PLATEAU REGION.

The eastern portion of the Piedmont plateau region, which is the portion in which loblolly pine occurs most frequently, is more rugged and its topography rougher than that of the coastal plain. Its elevation varies from 350 to 600 feet above sea level. In general its surface is rolling though along the streams and in some other places there are bold hills.

On the uplands the predominating soils may be described as loams and clays, sandy and gravelly in some places, but generally with much stiffer red or yellow subsoil, formed by the decay *in situ* of slates, gneisses, (hornblende-bearing) schists, pegmatites, and other crystalline rocks; while over some limited areas sandy soils occur derived from sandstone and granite. Along the numerous small streams are narrow, alluvial deposits, moist, dark-colored loams, containing a variable proportion of organic matter. Along the larger streams these fluvial deposits are often clayey or silty. All soils occupied by the loblolly pine in the Piedmont plateau region, except where too rough or steep are suitable for farming.

The average annual temperature for the region is somewhat less than that of the coastal plain, being about 59° F.; the annual rainfall is only about fifty inches, and the humidity is lower. The water table is from 30 to 50 feet below the surface of the hill summits, while the surface drainage is far superior to that of the coastal plain, swamps being limited to the borders of the streams. The average temperature during the five growing months is 73° F.

COMMERCIAL DISTRIBUTION.

The commercial distribution of the loblolly pine in North Carolina is from Granville, Person, Orange, Chatham, and Union counties, somewhat east of the center of the State, eastward and southeastward to the coast, where it occurs over a total area of not less than 30,000 square miles. As a commercial tree it is largely absent, however, from Cumberland, Moore, Richmond, and Hoke counties in eastern North Caro-

lina, which have prevailing dry sandy soils. There are also less extensive areas of swamp in which it does not occur. But it is capable of growing as a commercial tree on 22,000 square miles of this area (See map, Fig. 2.) In Virginia it is the prevailing species south and east of Petersburg and Lunenburg, covering the southeastern portion of the state, while to the north of Petersburg it is common along and near Chesapeake Bay, on both the eastern and western shores. In South Carolina it is common south and east of Chester wherever the soil and moisture conditions are suitable for its growth.

ORIGINAL FOREST.

In the coastal plain the loblolly pine was originally largely confined to the following situations: (1) River swamps, where it occurred on the best drained portions, as single trees in mixture with hackberry, sweet gum, red maple, white and red oaks, deep swamp ash, and water gum; (2) shallow interior swamps with loamy soils where it grew in groups of a few trees, or more generally single trees, among maple, water oaks, and gums; (3) shallow swamps with stiff soils, where single trees occurred irregularly distributed among white oaks and red oaks, ash, elm, holly, white bay, beech, and gums; (4) deep swamps, in which it was not common and where it occurred with cypress, water gum, and water ash; (5) hummocks and the edges of swamps, savannas, and pocosons, where on a wide range of moist soils of sand, silt, clay or peat, it grew sparingly with longleaf and pocoson pines; (6) best grade of loams, silts, clays (Portsmouth soil series) and peaty soils seldom subject to flooding, with the water table usually from five to eight feet below the surface where it formed compact groups or stands covering many acres; (7) on peaty soils where it occurred with yellow poplar, white cedar (juniper), white bay, sweet bay, and sweet gum.

Specimens of best development (Plate I, Frontispiece) are met with in shallow swamps on clayey or loamy soil growing with mixed hardwoods. The pure groves on well-drained peaty soil are mostly formed of comparatively young and small trees from 100 to 150 years old and in even-aged stands. There are traditions supported by other evidence, that these pure groves on the peaty lands have followed old fires. Under natural conditions it is probable that this species did not form extensive pure forests in North Carolina except in the extreme northeastern section. Loblolly pine was absent from the best drained soils which were occupied by the longleaf pine in the coastal plain and by mixed hardwoods and shortleaf pine in the Piedmont plateau region.

In the Piedmont plateau the original growth of loblolly pine was chiefly confined to the forests of the narrow stream swamps of the eastern portion of the plateau. It formed only a very small proportion of the timber in these forests which are distinctively of hardwoods. While most abundant in the Piedmont along its eastern edge, isolated trees

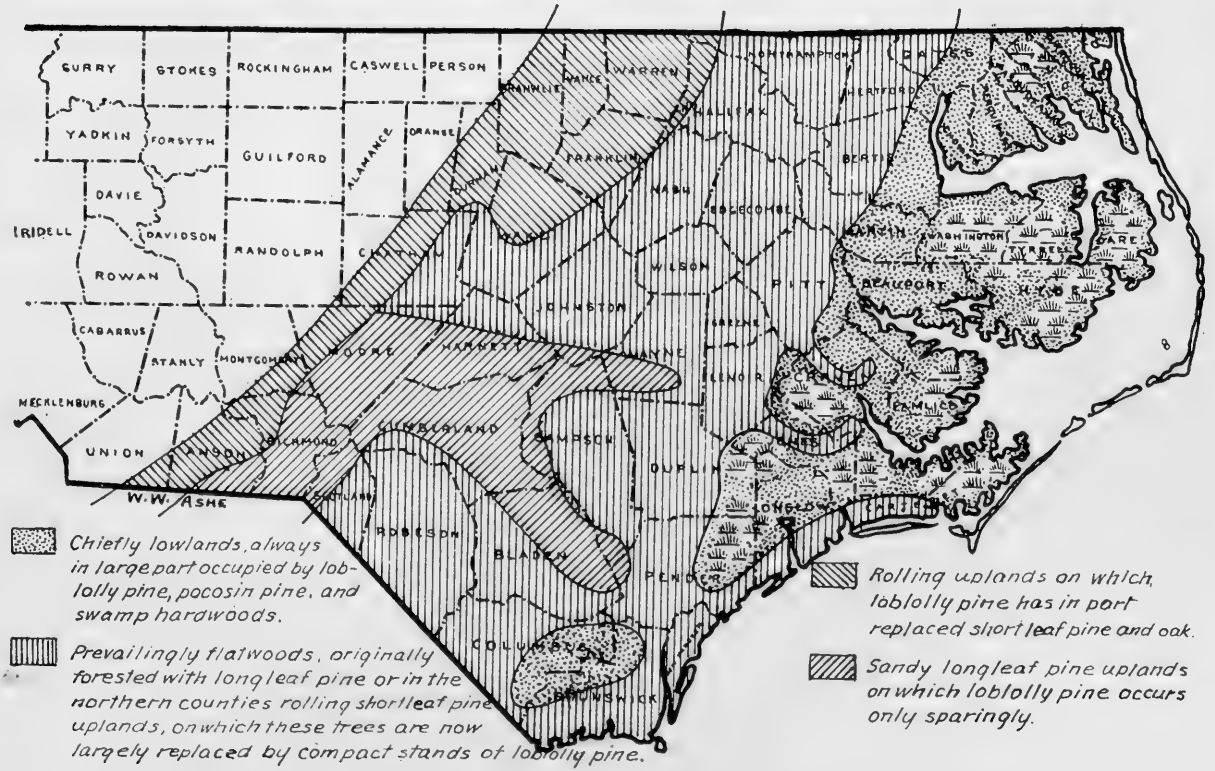


Fig. 2. Distribution of loblolly pine in North Carolina.

have been found on alluvial lands as far west as the eastern end of Surry County and at an altitude of about 700 feet, although 500 feet is the prevailing altitudinal limit in North Carolina.

PRESENT FOREST.

Accidental influences, largely circumstances incidental to the settling and development of the country, and other influences which have followed these, have enabled the tree, by means of its prolific and early seeding and rapid growth, to become locally far more widely distributed and much more abundant than in the original forest. The most important of these influences which have facilitated the reproduction and distribution of this species have been the abandonment of farming lands, fires, lumbering, and live stock, especially hogs. On account of its adaptability, loblolly pine has increased in abundance in wet situations as well as on dry sites. In swamps it has often followed cypress, when cypress was cut, wherever standing water during the growing season did not prevent the pine from establishing itself. When hardwoods on the coastal plain were culled, or severely burned, loblolly pine became more abundant in the hardwood forests, until its young growth is now common, both on the uplands and in the swamps. It has extensively replaced the longleaf pine, except on the dryest or sandiest soils. When the longleaf pine died after being exhausted by turpentine or was broken down by the wind, or where it was burned or thinned by lumbering, the loblolly pine succeeded it on all moist, loamy, or clay soils. At the same time hogs destroyed the seeds and seedlings of the longleaf pine, while both seed and seedlings of loblolly were largely neglected, the former because of their small size and the latter because the roots are tough and fibrous. The loblolly pine now occupies in nearly pure forests, much of it more than 100 years old, practically all of the cutover longleaf pine lands north of the Neuse River, and a great proportion of the longleaf pine lands south of the Neuse River and east of Fayetteville and Laurinburg, and is gradually invading the sandhills of Moore, Cumberland, and Richmond counties. Worn-out farming lands exhausted of humus, which have been turned to fallow, and lands which have been found too poor or often too wet to cultivate, or which were abandoned on account of scarcity of labor, have been stocked with loblolly pine by means of self-sown seed whenever seed-bearing trees were near by. Thus this pine has become extensively distributed, and while 100 years ago the longleaf pine was the characteristic forest tree in the Coastal Plain Region of North Carolina, at present the loblolly pine is the prevailing tree; and its relative abundance and importance are steadily increasing.

The distribution of the loblolly pine has also been extended in the Piedmont plateau, though not to the same extent as in the coastal plain. In the eastern part of the Piedmont plateau it has established itself in old fields, often in association with shortleaf pine, and in stands of hardwoods which have been culled. It is now abundant in the second growth

stands on the hills near the rivers and is gradually extending away from the streams, in spite of the increasing dryness of the soil.

The growth in the old fields along the eastern edge of the Piedmont plateau in many places is nearly pure loblolly pine. Where young trees of the shortleaf pine appear they are often overtopped and suppressed, being outnumbered and overgrown by the loblolly pine. To the westward, however, there are fewer seed trees, and where there is competition between the two species, the shortleaf pine has the advantage, except on moist or sandy soils.

ASSOCIATED SPECIES.

With such a wide range of soil adaptability loblolly pine is associated with many species and is a component of many forest types. In the mixed stands in the swamps and on poorly drained sites some of the associated species are fully as valuable as the pine and are well adapted to silvicultural purposes. Other species are less valuable than the loblolly. The following list gives the most important associated species.

LIST OF THE MOST IMPORTANT SPECIES ASSOCIATED WITH LOBLOLLY PINE IN ORDER OF THEIR RELATIVE IMPORTANCE.

TREES.

Longleaf pine	*Pinus palustris.*
Shortleaf, spruce or rosemary pine	*Pinus echinata.*
Sweet or red gum	*Liquidambar styraciflua.*
Water gum	*Nyssa aquatica.*
Southern red oak	*Quercus digitata.*
Swamp red oak	*Quercus pagodæfolia.*
Pocoson, black bark or pond pine	*Pinus serotina.*
Red maple	*Acer rubrum tridens.*
Yellow poplar	*Liriodendron tulipifera.*
Water oak	*Quercus nigra.*
Green ash	*Fraxinus lanceolata.*
Deep swamp ash	*Fraxinus profunda.*
Water ash	*Fraxinus caroliniana.*
White elm	*Ulmus americana.*
White hickory	*Hicoria alba.*
Sand hickory	*Hicora pallida.*
White oak	*Quercus alba.*
Swamp white or swamp chestnut oak	*Quercus Michauxii.*
Post oak	*Quercus minor.*
Round leaf blackjack oak	*Quercus marylandica.*
Forked leaf or sand blackjack oak	*Quercus Catesbœi.*
Runner oak	*Quercus Margaretta.*
Black gum	*Nyssa sylvatica.*
Tupelo gum	*Nyssa uniflora.*
Cottonwood	*Populus deltoides.*

SHRUBS.

Gallberry	*Ilex glabra.*
Tall gallberry	*Ilex lucida.*
Fetterbush	*Andromeda*, several species.

FOREST TYPES.

Wherever similar soil and moisture conditions prevail there is a definite association of species. This association which is called a forest type remains practically constant until the natural conditions are disturbed by fire, cattle, lumbering, or other causes. The type is formed of those species which are best suited to soil and moisture conditions, but this does not necessarily mean that the natural mixture of species would be the most profitable one or the most desirable one economically for that site. The rate of growth of the different species which form a type is practically always the same in that type, and the yield of the type at a given age is constant.

Table 1 shows the composition of the important commercial forest types of the coastal plain of North Carolina and their relation to soil and drainage. The great number of forest types in which loblolly pine occurs is noteworthy as showing the virility and aggressiveness of this species.

TABLE I—CHARACTERISTIC FOREST TYPES OF EASTERN NORTH CAROLINA ACCORDING TO SOIL AND DRAINAGE.

Drainage	Best Clay Soils, Fine-grained Stiff Loams or Marls	When drained Good Agricultural Soils, Loams, Sandy Loams, Medium to Fine-Grained	Sands, Coarse or Medium-grained	Peaty Soils, Mucks
	(1)	(2)	(3)	
Very dry and well drained; rolling or hilly, (as stream bluffs); water-table below 20 ft. *Both surface and subsoil drainage good.*	Hardwoods, small red, post and roundleaf black jack oaks, hickories with some shortleaf pine. (Young loblolly pine appearing in openings.) *Oak and pine uplands.*	Shortleaf pine with small oaks, especially Q. margaretta and hickories. Occasionally longleaf pine intermixed. (Young loblolly pine in openings.)	Sand hills with longleaf pine and sand blackjack oak. Loblolly pine is infrequent even in old fields. *Longleaf pine sand hills.*	
	(4)	(5)	(6)	
Longleaf piney woods and flatwoods; moist subsoils; water-table seldom below 20 ft. *Surface drainage good. Subsoil drainage slow.*	Longleaf pine of fine quality passing with poorer drainage into hardwoods; *pine and post oak flatwoods.*	Longleaf pine of best quality, with dogwood and post oak. The longleaf largely replaced by loblolly pine, which now forms extensive forests; or when water table is stable near surface, pure loblolly pine. *Flatwoods.*	Longleaf pine, pure. *Pine barrens.*	

TABLE I—*Continued.*

Drainage	Best Clay Soils, Fine-grained Stiff Loams or Marls	When drained Good Agricultural Soils, Loams, Sandy Loams, Medium to Fine grained	Sands, Coarse or Medium-grained	Peaty Soils, Mucks
	(7)	(7a)	(7b)	(7c)
Loblolly pine (shortleaf pine of the coast) forest. Very moist subsoil. Water table seldom below 12 ft. *Surface drainage poor.*	Loblolly pine in large pure groups	Loblolly pine of good quality, pure. *Natural, permanent or reproducing pine lands.*	Loblolly pine in pure groups	Loblolly pine in pure groups on best drained sites.
	(8)	(9)	(10)	(11)
Clear or discolored water, shallow swamps; slow drainage, standing water during part of the year. Subject to slight overflow. *Surface drainage very poor even in summer.*	Oaks, beech, hickory, red maple, deep swamp ash, water gum, sweet gum, white bay, cypress, loblolly pine, singly or in groups. The pine less frequent and smaller as the drainage becomes poorer. *Flat swamps, hardwood flats.*	Water oaks, cypress, red maple, water gum; loblolly pine. The pine less frequent and smaller, as the drainage becomes poorer and cypress and water gum more abundant. *Flat swamps.*	Loblolly pine, pure, passing into white cedar, maple, bay, small water gum. *Cedar or juniper swamps.*	Sour peats, white cedar, poplar, red maple and bays. Water table stable. *Cedar swamps, bays.*
	(12)	(13)	(13a)	(14)
Clear or discolored water, deep swamps, ponds, and slow flowing streams. *Water seldom below the surface.*	Large cypress, water and tupelo gums, deep swamp ash and red maple, occasional loblolly pines where drainage best. *Cypress swamps.*	Large cypress, water and tupelo gums, deep swamp, water ashes and red maple, occasional loblolly pines. *Cypress swamps.*	Same as No. 13 but trees much smaller. Much water ash.	Mucks, large cypress, water and tupelo gums, red maple, occasional loblolly pines.
	(15)	(16)	(17)	(18)
Nearly saturated level lands; the pocosons or briary bays, and reedy bogs. *Water table fluctuating. Aeration deficient.*	Small pocoson pine and bays. *Bays. Pocosons.* Where best drained, *savannas.*	Pocoson pine and bays. *Pocosons.* Where best drained, *savannas.*	Pocoson pine and longleaf pine; loblolly pine scantily replacing them on the best sites. *Pocosons.*	Raw peats, pocoson pine and bays. *Moss bogs, quaking bogs. Pocosons.*

TABLE I—*Continued.*

Alluvial soils along the muddy rivers—overflow irregular and often deep—3 to 30 feet.	The character of the growth much the same as that on clear water, shallow swamps (8 and 9), but conifers and evergreen trees are infrequent, probably on account of the destruction of their foliage by its being covered with a coating of mud. Silver maple, hackberry, sycamore, green ash, elm, oaks and gums. In sloughs where there is much standing water, tupelo.
Water surface widely fluctuating. *No surface drainage.*	The pine barren ponds which may be deeply flooded during winter and spring or after rains but in which the water table may sink to 10 feet during droughts, have a growth limited to the pond cypress (*Taxodium distichum imbricarium*) water gum and black gum.

The optimum conditions for the development of individual trees of loblolly pine are offered by sites 8 and 9, on which occur trees of large size either in small groups or scattered singly among the hardwoods. The optimum conditions for the development of pure stands are offered by sites 7 to 7c. On these sites there is less competition from the hardwoods and loblolly pine is truly gregarious, dominating to the practical exclusion of other trees.

Between the typical conditions there are gradations of all kinds. When the forest is lumbered or severely burned, its distinctive characters are often almost obliterated, though the constant tendency, when natural forces are permitted to re-assert themselves, is for the reëstablishment of the original forest type. Near the coast, a number of these conditions will sometimes be represented on an area of less than an acre. In addition to the above original or permanent types there are four important temporary types: (1) mixed oak and hickory, which have followed pine on loams and clays; (2) *Quercus Margaretta* and round-leaf blackjack oak, which have followed pine on dry sandy loams; (3) sand blackjack oak which has followed longleaf pine on sand hills; (4) loblolly pine in old fields and on cut-over longleaf pine land. These pure stands of loblolly in old fields and on cut-over longleaf pine lands are very extensive, and occupy all classes of soils; they are of all ages and are in every condition of thrift and density, and constitute an important source of pine timber.

The conditions under which the loblolly pine occurs, as shown in Table 1, may be grouped for convenience under seven heads as follows:

(1) Old field growth on dry sites;
(2) Loblolly pine in pure stands on porous loams and peaty soils (Table 1, numbers 7 and 10, in part);
(3) Loblolly pine on longleaf pine flat lands (Table 1, numbers 4 to 6);
(4) Loblolly pine with hardwoods in swamps chiefly in the coastal plain (Table 1, numbers 8 and 9);
(5) Loblolly pine with pocoson pine on savannas (Table 1, numbers 15 to 16);

(6) Loblolly pine with cypress in deep swamps (Table 1, numbers 12 to 14);
(7) Loblolly pine in hardwood and shortleaf pine forests chiefly on the Piedmont uplands (Table 1, numbers 1, 2).

OLD FIELD GROWTH ON DRY SITES.

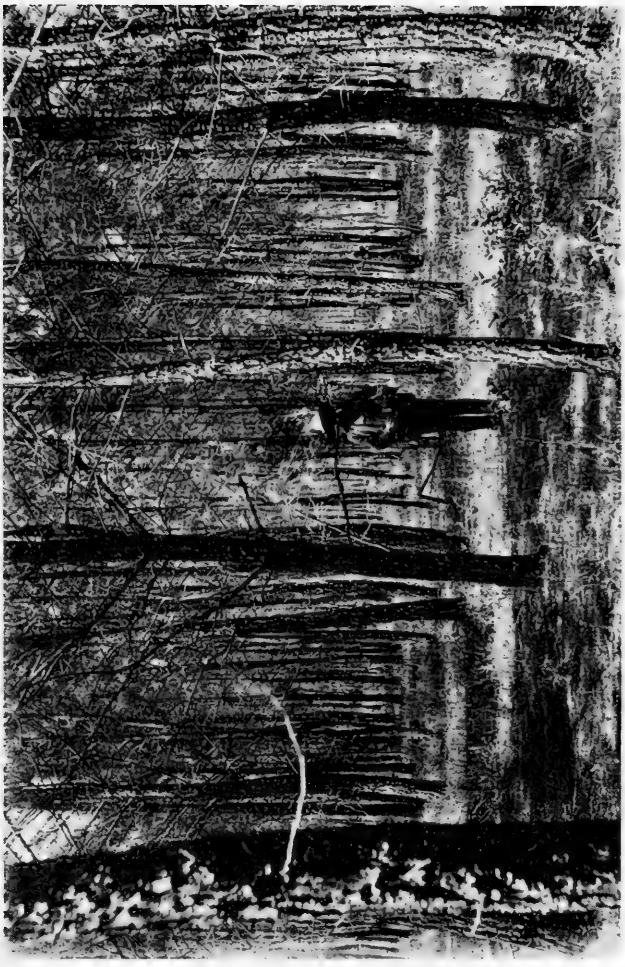
These sites were originally occupied by longleaf pine or by shortleaf pine mixed with upland oaks and hickories. The longleaf pine sites, which are confined to the coastal plain, are for the most part heavy upland clays and coarse upland sands (largely Norfolk sand); they are of the greatest extent south of Neuse River. The shortleaf pine sites are largely restricted to the eastern tier of Piedmont counties, but extend into the coastal plain in Halifax, Northampton, and Nash counties. The soils for the most part are loams or heavier soils of the Cecil and Durham series, the water table as a rule lying between 20 and 45 feet beneath the surface. These lands have been cultivated, but after the exhaustion of the scant humus they were found too poor and were abandoned; later they were stocked by wind-sowed seed of loblolly pine. Some stands on sites on which longleaf pine formed the original forest contain an admixture of longleaf pine; and on sites which were originally occupied by shortleaf pine and upland hardwoods, an admixture of shortleaf pine.

Table 2 shows the range of diameters and the composition of characteristic stands of loblolly pine in upland old fields.

TABLE 2.—COMPOSITION OF LOBLOLLY PINE STANDS ON UPLAND OLD FIELDS.

AVERAGE NUMBER OF TREES PER ACRE.

Diameter breast-high Inches	Stand 50 years old on dry sandy soil following longleaf pine in the Coastal Plain				Stand 62 years old on Durham sand, in Chatham County, following shortleaf pine and post oak				Stand 60 years old on Cecil red clay in Orange County following shortleaf pine, southern red oak, Spanish oak, black oak and hickory				
	Loblolly pine			Other species	Loblolly pine			Other species	Loblolly pine			Shortleaf pine	Other species
	Dominant	Intermediate	Suppressed		Dominant	Intermediate	Suppressed		Dominant	Intermediate	Suppressed		
Under 6				7				14					29
7				5				4			3	10	
8				1				3			7		
9								7			10	7	
10								5		3		3	
11			3	1				6			6	2	
12		2	10	1					3	6	7	3	
13		5	5							7			
14		13	8					4	4	6		2	
15	7	5					4		10	3			
16	17	6				13	4	4	6				
17	16	5				9			20				
18	13				4	13			10				
19	10				21	2			16				
20	2				17	2			7				
21					13				3				
22					8								
Total over 6 inches	65	36	26	8	63	39	8	33	79	25	33	27	
Per cent of number	48	27	19	6	45	27	5	23	48	15	20	17	
Per cent of volume in bd. ft.	78	13	7	2	80	16	1	3	80	9	6	5	



Stand of loblolly pine about twelve years old on dry sandy soil in old field. Stand is too open, the stems consequently are short and crooked, set with many branches, and the wood is knotty. An undesirable condition, due to open stocking on dry soil. (Photo. U. S. Forest Service.)

Loblolly pine attains on the upland old field sites a height of from 60 to 80 feet, a range of diameters of from 12 to 22 inches, and an age of 75 years. The rate of growth is extremely rapid for several decades, far more rapid than on similar uncultivated soils, after which there is an abrupt decline in the rate of height as well as diameter growth. (Table 14, Column 4, and Table 18, Column 4.) The total volume of the stand culminates between the fortieth and sixtieth years, according to the site. At the time of culmination not only has the growth in height practically ceased and the rate of diameter growth declined to about an inch a decade, but the stand has begun to disintegrate by the dying of the dominant trees. The growth of such a stand may be Quality I for the first two decades; Quality II for the third decade; after which it may decline to Quality III. (See p. 57.)

On account of the open crown cover, oaks and other upland hardwoods gradually enter the stand. In stands more than 40 years old these species often form a moderately dense lower story beneath the pines. When the loblolly pine is cut, they partly replace the loblolly pine, being supplemented either by longleaf or shortleaf pine. These species largely form the succeeding stands unless special means are taken to secure loblolly pine. The forest thus tends to revert to the original or permanent types.

On account of the rapid thinning out of the stand, the trees are short bodied and scrubby. (Plate III, A.) The trees yield two or three logs mostly of third and fourth grades. The wood is coarse grained and knotty, making largely box lumber. (Plate XII.) Unthinned stands will seldom yield more than 20 per cent lumber of No. 3 grade and better.

(For description of log grades, see page 98; of lumber grades, page 100.)

LOBLOLLY PINE IN PURE STANDS ON POROUS LOAMS AND PEATY SOILS.

This type comprises a very large portion of the productive loblolly pine forests of North Carolina. It occurs on small flats or basins which are comparatively well-drained and seldom flooded for a long period or for more than a few inches, or it occupies extensive areas of upland which are mostly near the coast. The soils are largely sandy loams, clayey, or silty (Portsmouth soil series), or they are peaty, humified, with some silt or clay intermixed, or with marl subsoil. The water table seldom sinks below twelve feet. These are the so-called "permanent, natural or reproducing" pine lands. These sites furnish the optimum conditions for the development of pure stands. There is situated within this type a large area of poorly drained old fields on which loblolly pine has the same rate of growth as on forest soils of the same class. A great portion of the soil occupied by this type of forest has been placed under cultivation, and such areas as are suitable for tillage are still being drained and cleared as rapidly as they are logged. It is best suited to the growing of corn.

In their typical condition the forests on these lands are in pure even-aged stands or groups, or the pine is associated with occasional gums, water oaks, and yellow poplars, but it is always the predominating species in the stand. Although the humus is deep the soil is sufficiently moist for young growth to come up freely and young trees appear in large even-aged groups where old trees have died or have been cut. Beneath the pine there is generally a dense undergrowth of gall berries and ericaceous shrubs. The age of the pine seldom exceeds 200 years and individual trees are not so large as in the hardwood swamps. The height of mature trees ranges from 115 to 130 feet and the diameter from 24 to 36 inches. The wood is moderately fine and even-grained. The logs largely grade I and II. The best yield is obtained in this type. It is believed that by thinning stands an increment of from 900 to 1,000 board feet a year can be obtained, including thinnings. Even in old groups the crown cover maintains a complete canopy. The rate of growth is excellent and stands can generally be classed in Quality I.

Table 3 shows the composition of this type on peaty soil, measured in a stand two miles northeast of Leechville, N. C. The average age of the trees is about 100 years, the height of the dominant trees is from 110 to 120 feet. The stand consists of about 120 merchantable trees per acre and will yield about 30,000 feet, B. M. of pine.

TABLE 3.—COMPOSITION OF A PURE LOBLOLLY PINE STAND ON PEATY SOIL, HUMIFIED, NEAR LEECHVILLE, NORTH CAROLINA.

Diameter breast-high Inches	AVERAGE NUMBER OF TREES PER ACRE.			
	Loblolly Pine	Sweet Gum	Black Gum	Other Species
Under 9	2	13	9	11
9	4	1	2	----
10	4	----	----	1
11	4	----	1	----
12	6	1	----	----
13	4	----	----	----
14	20	----	1	----
15	10	----	----	----
16	20	----	----	----
17	20	----	----	----
18	12	----	----	----
19	10	----	----	----
20	10	----	----	----
21	2	----	----	----
Total above 8	126	2	4	1

After lumbering the land normally comes up to heavy young growth of pine seedlings. Areas cut over ten or twenty years ago are now covered with a dense stand of young pines. Interspersed among the young trees are the old suppressed trees which were left when the mature stand was cut and which have now recuperated, and many small hardwoods which have been overtopped.

Dense stand of pure loblolly pine five to eight years old. Desirable condition, insuring long, straight stems which are well cleaned of branches. (Author's illustration.)

LOBLOLLY PINE ON LONGLEAF PINE FLAT LANDS.

This type forms the great body of productive loblolly pine lands, occupying possibly one-half of the total loblolly pine area. Its yield, however, is not commensurate with the area it occupies on account of understocking. The soils are clayey, loamy, or sandy. The surface of the flat lands is nearly level or slightly rolling and well drained; these areas when stocked in longleaf pine were known as the flatwoods or piney woods. As the moisture in the soil becomes less subject to fluctuations they pass into hardwood flats and flat swamps. As they become more level and less thoroughly drained, they grade into savannas, pocosons, and bog swamps. As they become sandier and more thoroughly drained and drier they approach in their forest characters the longleaf pine sand hills.

TABLE 4.—COMPOSITION OF LOBLOLLY PINE STAND ON LONGLEAF PINE FLAT LANDS.

Diameter breasthigh Inches	AVERAGE NUMBER OF TREES PER ACRE.							
	Loblolly Pine	Longleaf Pine	Black Gum	Sweet Gum	Oak	Hickory	Maple	Dogwood
Between 3-6	15.42	.05	4.13	3.01	6.01	1.50	2.40	.42
6	5.77	.63	1.03	.96	3.13	.58	.32	.07
7	4.89	.22	2.13	.47	3.01	.41	.06	.02
8	4.27	.13	1.17	.32	2.11	.17	.01	.005
9	4.03	1.01	.63	.40	2.36	.22	----	----
10	3.33	.76	.58	.16	1.27	.15	----	----
11	2.67	.98	.54	.38	.09	.08	----	----
12	2.41	1.21	.31	.22	.12	.11	----	----
13	2.18	.38	.12	.20	.03	.09	----	----
14	1.84	1.45	.07	.12	.02	.02	----	----
15	1.45	1.03	.05	.03	.02	.01	----	----
16	1.29	.64	.07	.08	.01	----	----	----
17	1.18	.32	.02	.01	.01	----	----	----
18	.94	.43	.01	.02	.01	----	----	----
19	.83	.17	.01	.01	----	----	----	----
20	.53	.18	.005	.01	----	----	----	----
21	.52	.04	.01	.01	----	----	----	----
22	.44	.11	.01	----	----	----	----	----
23	.43	.07	.01	----	----	----	----	----
24	.31	.05	----	----	----	----	----	----
25	.21	.06	----	----	----	----	----	----
26	.21	.02	----	----	----	----	----	----
27	.19	----	----	----	----	----	----	----
28	.13	----	----	----	----	----	----	----
29	.06	----	----	----	----	----	----	----
30	.07	----	----	----	----	----	----	----
31	.04	----	----	----	----	----	----	----
32	.05	----	----	----	----	----	----	----
33	.04	----	----	----	----	----	----	----
34	.01	----	----	----	----	----	----	----
Total	54.75	9.94	10.905	6.41	18.20	3.34	2.79	.515

The original forest was formed of longleaf pine which, after lumbering, turpentining, and repeated fires has now nearly or entirely disappeared. The loblolly pine is not uniformly distributed; it occurs as scattered dense groups varying from a few trees to several or many acres in extent. (Plate VI, A.) In the open spaces the ground is covered with thick grass (chiefly wire grass) 1 to 2 feet high. The irregularity of the stand and its open condition is due to periodic fires, which are particularly damaging where the growth of grass is heavy. Small trees of various kinds of hardwoods, especially black gum, roundleaf blackjack oak, southern red oak, and white and sand hickories occur with the pine in greater or less abundance. A few longleaf pines occur in places, especially south of the Neuse River. Table 4 shows the composition of this type based on measurements of nearly 700 acres, of both logged and unlogged forest.

After logging loblolly pine, usually the same species restocks the ground and generally overtops the hardwoods. In many places, however, the hardwoods by their dense cover tend to prevent the reproduction of the pine after lumbering. (Plate VIII, A.)

Under the best conditions the trees attain a height of from 120 to 125 feet and a diameter of 25 to 30 inches when 150 to 200 years old. Usually, however, the height ranges from 95 to 110 feet, and the diameter from 18 to 25 inches. The rate of growth is that of Quality II (Tables 14 and 18, column 3.) The trees are generally sound, but the upper logs in those more than 150 years old are likely to be affected by redheart. Groups of trees are found 200 years old, which possibly originated in the first extensive breaks in the longleaf pine forests made by the early settlers, such as around old turpentine-distillery sites and upon tar-kiln mounds. When the trees are solitary they are short bodied and yield only coarse lumber; in groups the stems are longer and clear. Logs are largely of Grades II and III. Under management these stands will produce about 600 board feet per acre a year. The lumber sawed from a 60-year old stand will grade 35 per cent No. 1 and No. 2.

LOBLOLLY PINE WITH HARDWOODS IN SWAMPS CHIEFLY IN THE COASTAL PLAIN.

This type is largely confined to the coastal plain and occurs in clear water swamps which are seldom flooded deeply or for a long period. The soils are silt clays, marls, or fine-grained, stiff loams or fine sands of the best quality, particularly of the Portsmouth series. These swamps are one of the most common habitats of the loblolly pine, affording the optimum conditions for the development of the individual tree. The pine is associated with water oak, swamp chestnut oak, deep swamp ash, yellow poplar, sweet gum, beech, red maple, holly, cypress, water gum and other less abundant species. The pine occurs either in groups of a few trees which are usually even-aged, or more generally as single trees

A. Characteristic stand of loblolly and pocoson pine on savanna. The scattered short-bodied trees are typical. Such a stand yields about 15 per cent of No. 1 and No. 2 grades of lumber.
(Photo. U. S. Forest Service.)

B. Margin of pine, cypress and gum swamp. Old cypress in center; old pine on left.
(Photo. U. S. Forest Service.)

scattered among the hardwoods. While it constitutes less than five per cent of the number of trees in the virgin stand it may form 25 per cent of the merchantable saw timber. The old pine trees grow on low mounds or hummocks, 5 to 10 feet wide and two or three feet high, which are largely formed by the trees themselves, by the gradual accumulation of bark, cones and leaves, which are yearly deposited about their bases. (Plate I.)

Since the pine is very intolerant of shade it comes up only in openings. Consequently, young pines as a rule are infrequent except in windfalls or where the oaks were cut for staves. Such cuttings made often as long as 100 years ago, were favorable for the increase of the pine.

TABLE 5.—COMPOSITION OF LOBLOLLY PINE WITH HARDWOODS IN SWAMP, BEECHGROVE, BEAUFORT COUNTY, NORTH CAROLINA.

Diameter breasthigh Inches	AVERAGE NUMBER OF TREES ON ONE ACRE.							
	Loblolly Pine	Water Gum	Water Oak	Deep swamp Ash	Swamp Chestnut Oak	Yellow Poplar	Sweet Gum	Red Maple
Under 10	1	18	14	51		1	57	13
10		4	2	4			3	5
11		2	1	7			2	
12		2					1	
13		6	1					
14		4		1			2	
15		2	1					
16		3		6			1	1
17		1						1
18		3			1			
19		2	2		1			1
20		2	1					
21		2						
22		3						
23						1		
24		1						
25		1						
26								
27		2						
28	1						1	
29			1					
30	2	1						
31								
32	1	1						
33								
34	1							
35								
36	1	1				1		
Total	7	61	23	69	2	3	67	21

The first general logging of the pine began about 1880; for a period of 15 or 20 years, up to 1900, the pine was cut but the hardwoods were generally left. This has resulted in reducing the proportion of pine in many of the stands. In later cuttings when it has become the prac-

tice to cut some of the best hardwoods, the proportion of pine in the restocking has again increased.

Table 5 shows the composition of a loblolly pine stand in a virgin hardwood swamp. This area shows a larger proportion of pine by volume in board feet than occurs in most such swamps, but the distribution of the diameter classes is typical. Young pine is not abundant.

Loblolly pine in these swamps attains a height of from 135 to 165 feet, a maximum stump diameter inside bark of 54 inches, and an age of over 240 years. The height of the associated broadleaf trees is from 100 to 130 feet, pines overtopping most of them, except possibly yellow poplar and sweet gum. (Plate V, B.) The rate of growth of the pine is rapid. For several years the rate of height growth of dominant trees exceeds four feet a year, and even in old trees an excellent rate of height growth is well maintained. The rate of diameter growth of young trees is not rapid since the crowns of young trees are for many years crowded by the surrounding hardwoods, and receive light only from above. The rate of diameter growth, however, is sustained and a large annual volume increment is produced by many of the oldest trees. (Tables 14 and 18, column 1.) On account of the rapid height growth and the small crowns, the stems are slender with clear boles from 80 to 110 feet in length.

The wood is of the best quality, soft and even-grained. Even in the center of the butt logs, the summer bands are comparatively narrow. (Plate IX, B.) It consequently resembles in quality that of the shortleaf pine of the Piedmont, the so-called rosemary or forest pine. It is rich orange in color and rather more pitchy than that growing in other situations. The sapwood is comparatively thin for the species though it forms in trees even two hundred years old one-half of the total volume of the stem. Large trees often yield several logs of Grade 1, and cut 60 to 65 per cent of No. 1 and No. 2 lumber. (Plate XII, C.)

LOBLOLLY PINE WITH POCOSON PINE ON SAVANNAS.

This type occurs on poorly drained sites saturated with water during most of the year. The stand for the most part is open. It consists of loblolly pines mixed with pocoson pines, occasional stunted longleaf pines, black gums, and white bays. Formerly there was a larger proportion of longleaf pine. There is usually a scant undergrowth of fetterbush and other ericaceous shrubs, and a dense mat of grass, which withers in the autumn and consequently burns with a hot fire during winter and spring. (Plate V, A.) Probably one-thirtieth of the loblolly forest land of North Carolina belongs to this type. Its producing capacity, however, is low and it yields a relatively small amount of timber.

The loblolly pine occurs in even-aged groups of a few trees, or singly, all ages being represented on a small area. Trees 150 years old are between 75 and 105 feet in height, 20 to 25 inches in diameter, and

A. Groups of loblolly pine poles with old longleaf pine which it is replacing on grassy flat lands. (Photo. U. S. Forest Service.)

B. Cut-over loblolly pine land, showing the undesirable character of the seed trees which are left by the present method of cutting. (Photo. by J. S. Holmes.)

the largest scale by Doyle-Scribner rule not more than 700 feet. The trees are short bodied and frequently crooked and yield logs largely of Grades III and IV. The rate of growth is slow and irregular, yet the wood is tough and hard and the sapwood generally thick. (Plate X, B.) The wood is fine grained but except in the butt log the quality is not high.

Table 6 shows the average condition of more than four hundred acres of savanna land measured by the chain method.

TABLE 6.—COMPOSITION OF LOBLOLLY PINE WITH POCOSON PINE ON SAVANNAS. BASED ON 422 ACRES.

Diameter breasthigh Inches	Average Number of Trees Per Acre.					
	Loblolly Pine	Pocoson Pine	Longleaf Pine	Black Gum	White Bay	Maple
Between 3-6	10.81			16.15	14.33	7.21
6	5.67		.41	8.23	2.17	3.23
7	3.01	.31	.21	3.12	1.07	2.10
8	2.07	.43	.37	3.24	.31	.95
9	1.53	.26	.29	2.61	.01	.02
10	1.21	.46	1.03	2.13		
11	1.22	.13	.62	2.33		
12	.84	.31	.57	1.07		
13	.31	.12	.28	.41		
14	.27	.11	.21	.13		
15	.26	.10	.23	.06		
16	.18	.80	.11			
17	.17	.80	.14			
18	.16	.10	.08			
19	.11	.06	.07			
20	.14	.09	.02			
21	.09	.08	.03			
22	.02	.04	.01			
23	.01	.03	.01			
24	.01	.02				
25	.005	.01				
Total	28.095	4.26	4.69	39.48	17.89	13.51

LOBLOLLY PINE WITH CYPRESS IN DEEP SWAMPS.

This type occurs in non-alluvial as well as in alluvial swamps. These alluvial swamps border clear water streams within the Coastal Plain, and the lower reaches of the muddy streams which head beyond the Coastal Plain, where flooding is always shallow but may last for several weeks. Around the Dismal Swamp in the Albemarle Sound section and elsewhere there are large areas of non-alluvial swamp, in which a considerable portion of the forest growth is cypress and loblolly pine with water gum. The proportion of pine decreases as the flooding becomes deeper. Its growth also becomes slower. The pine and cypress have nearly the same rate of growth. (Tables 14 and 18, column 6.)

The pine reaches a height of from 80 to 100 feet and a diameter of from 20 inches to 3 feet. The trees yield 3 and 4 logs. The wood is fine grained and the quality of the butt and second logs excellent. Big Bay in Brunswick County and the Lumber River Swamp yielded some excellent pine timber from this type. Plate XII, C shows a pile of No. 1 and No. 2 logs which were cut in Big Bay. The pine tends to reseed and maintain its position and proportion in the forest after lumbering if it is not cut at too small a diameter. There is no danger of fires on this type.

LOBLOLLY PINE IN HARDWOOD AND SHORTLEAF PINE FORESTS CHIEFLY ON THE PIEDMONT UPLANDS.

Loblolly pine has appeared in these forests (particularly on the Durham soil series, in Person, Wake and Durham counties and in the sandier phases of the Cecil soils in the eastern Piedmont counties and in Halifax, Northampton, and Nash counties) where the oaks and shortleaf pine have been cut, especially on slopes near streams. The trees of loblolly pine are generally young, varying in age from the smallest seedling to 40 or 60 years old. They seldom form more than five per cent of the entire stand. The number of loblolly pines is increasing, however, as the breaks in the forest cover become larger, and as the number of seed-bearing pines of this species increases. The associated trees are white oak, southern red oak (*Quercus digitata*), black oak, scarlet or Spanish oak (*Quercus coccinea*), white hickory, red hickory, sand hickory, yellow poplar, and shortleaf pine. These species are more tolerant of shade than the loblolly pine which, however, makes rapid growth for the first two or three decades, though the rate usually decreases rapidly after the thirtieth year. When the stand of hardwoods is open, the pines have large crowns, short stems, and knotty and coarse-grained wood. (Plate VII.) When 60 to 70 years old, which is about the age limit, the trees are 70 to 75 feet high and 14 to 18 inches in diameter, and the scale of the average log is about 55 feet. The logs grade as Nos. 3, 4, and 5.

FOREST CHARACTERISTICS.

FORM.

Stem.

In young trees the stem continues through the crown without dividing. In old forest trees the trunk, as a rule, divides into massive spreading branches. The division of the main stem into a number of branches usually takes place soon after the period of rapid height growth is well passed. In trees growing in open stands the division of the trunk into branches takes place earlier and lower on the stem than in crowded stands. As a rule the stems of young trees are nearly straight. Those of old trees, especially when grown in open stands or on poor soil, are

Loblolly pine with mixed oaks and shortleaf pine. Three-log tree, eighty years old, cutting 20 per cent of No. 1 and No. 2 grades of lumber.
(Photo. N. C. Geological Survey.)

often slightly curved or crooked, though never to the same extent as those of the pocoson pine. The stems are rarely forked except when the leading shoot is injured by a weevil or by sleet breaking it. The greatest amount of taper in the stem is in the top, consequently the mill cut of top logs of a given diameter inside the bark at the small end is greater than that of logs of the same diameter from the lower part of the stem measured in the same manner. (Table 23.)

As the trees in the stand become older they are less tapering. Old trees of the same diameter breasthigh and of the same height as young trees have, therefore, a larger volume in cubic feet and produce more lumber. This is shown in Table 7.

TABLE 7.—YIELD IN BOARD FEET PER LINEAR FOOT OF MERCHANTABLE LENGTH OF BOLE FROM TREES OF THE SAME DIAMETER AND HEIGHT AT DIFFERENT AGES.

1-7" SAW KERF.

Diameter breasthigh Inches	Yield in Board Feet Per Linear Foot of Used Length	
	Stand	
	45 years old	65 years old
8	.8	.85
9	.9	.95
10	1.1	1.2
11	1.3	1.5
12	1.7	1.9
13	2.1	2.3
14	2.4	2.6
15	2.9	3.1
16	3.5	3.7
17	4.1	4.3
18	4.7	4.9
19	5.3	5.6
20	6.2	6.5

The larger trees in the 45 year stand are dominant and intermediate. Those of the same diameters in the 65 year old stand, which is on a somewhat poorer quality site, are largely intermediate and suppressed. The difference thus amounts to from 5 to 10 per cent of the contents in board feet.

Taper measurements of butts at intervals of 1 foot are given in Table 8. They are useful in converting stump measurements on cut-over land into breasthigh diameter measurements. This table is based on age class over 75 years, Quality II. The taper would be slightly more for younger trees of the same quality, and for Quality III of the same age class; but somewhat less for old trees of Quality I. On account of natural individual variation such a table should only be used in considering a number of specimens.

TABLE 8.—TAPER OF BUTTS OF LOBLOLLY PINE FOR USE IN CONVERTING STUMP INTO BREASTHIGH DIAMETERS.

Diameter breasthigh Inches	Height above ground—Feet				
	1	2	3	4	5
	Diameter outside bark—Inches				
9	11.3	10.0	9.4	9.2	8.8
10	12.5	11.3	10.5	10.2	9.8
11	13.8	12.5	11.7	11.2	10.8
12	14.8	13.6	12.7	12.1	11.8
13	16.1	14.7	13.7	13.3	12.8
14	17.2	15.8	14.8	14.3	13.8
15	18.5	16.8	15.7	15.3	14.8
16	19.7	17.9	16.9	16.3	15.8
17	20.8	18.9	17.0	17.3	16.7
18	22.0	20.0	19.1	18.3	17.7
19	23.2	21.2	20.1	19.4	18.7
20	24.4	22.5	21.2	20.4	19.7
21	25.5	23.7	22.4	21.4	20.7
22	26.7	24.8	23.4	22.4	21.7
23	28.0	25.9	24.5	23.4	22.7
24	29.0	26.9	25.5	24.3	23.7
25	30.0	28.0	26.5	25.3	24.7
26	31.0	28.9	27.3	26.3	25.7
27	32.0	30.0	28.2	27.2	26.7
28	33.0	31.0	29.1	28.2	27.8
29	34.0	32.0	30.1	29.1	28.8
30	35.0	33.0	31.0	30.1	29.7

Taper measurements inside of bark of stems of different diameters and heights for middle-aged and old trees are given in Tables 9 and 9*a*. The measurements can be used directly in scaling logs of any length which is a multiple of 8.15 feet or for ascertaining the number of ties or poles of a given size which can be obtained from trees of different diameters. The height above the stump of any desired diameter can be fixed by interpolation. Tables 9 and 9*a* should be employed only in considering a number of specimens on account of individual variation. Age classes less than 50 years have considerably more taper than the table shows for trees under 75 years old; while trees more than 150 years old have less taper than shown for trees over 75 years old.

TABLE 9.—TAPER MEASUREMENTS OF LOBLOLLY PINE OF DIFFERENT DIAMETERS AND HEIGHTS.

TREES UNDER 75 YEARS OLD.

40-foot trees

Diameter breasthigh	At breast-height	Height above stump—Feet				
		8.15	16.30	24.45	32.60	40.75
Inches	Diameter inside bark—Inches					
4	2.8	2.5	2.0	1.5	.7	----------
5	3.7	3.3	2.7	1.9	.9	----------
6	4.5	4.1	3.4	2.5	1.2	----------
7	5.3	4.8	4.0	3.0	1.4	----------
8	6.2	5.6	4.7	3.5	1.5	----------
9	7.0	6.3	5.3	3.9	1.9	----------
10	7.8	7.1	6.0	4.4	2.2	----------
11	8.6	7.8	6.6	4.9	2.4	----------
12	9.5	8.6	7.2	5.4	2.7	----------
50-foot trees						
4	2.9	2.6	2.3	2.0	1.5	.8
5	3.8	3.5	3.1	2.7	2.0	1.1
6	4.7	4.3	3.8	3.3	2.5	1.4
7	5.5	5.1	4.6	3.9	3.0	1.6
8	6.4	5.9	5.3	4.6	3.5	1.9
9	7.3	6.7	6.0	5.2	3.9	2.1
10	8.2	7.5	6.9	5.9	4.4	2.4
11	9.0	8.4	7.6	6.5	4.9	2.6
12	9.8	9.1	8.2	7.1	5.4	2.9
13	10.8	9.9	9.0	7.8	5.9	3.2
14	11.6	10.8	9.7	8.4	6.3	3.4
60-foot trees						
4	5.1	2.9	2.6	2.4	2.1	1.6
5	3.9	3.7	3.4	3.1	2.7	2.1
6	4.8	4.5	4.2	3.8	3.3	2.6
7	5.7	5.3	4.9	4.5	3.9	3.1
8	6.5	6.1	5.6	5.1	4.5	3.6
9	7.4	7.0	6.4	5.8	5.1	4.1
10	8.3	7.8	7.1	6.5	5.7	4.5
11	9.1	8.6	7.9	7.2	6.2	5.0
12	10.1	9.4	8.6	7.8	6.7	5.3
13	10.9	10.3	9.3	8.4	7.3	5.9
14	11.8	11.1	10.1	9.1	7.9	6.3
15	12.7	11.9	10.7	9.7	8.4	6.8
16	13.5	12.7	11.4	10.3	9.1	7.2

Stump height 1 foot for trees 4 to 16 inches in diameter breasthigh, 1.5 feet for trees 17 to 22 inches.

TABLE 9—*Continued.*

70-foot trees

Diameter breasthigh	At breast-height	Height above stump—Feet								
Inches		8.15	16.30	24.45	32.60	40.75	48.90	57.05	65.20	73.35
	Diameter inside bark—Inches									
6	4.9	4.8	4.6	4.4	4.0	3.5	2.8	1.8	----	----
7	5.8	5.7	5.4	5.1	4.6	4.0	3.2	2.2	----	----
8	6.7	6.5	6.1	5.7	5.2	4.5	3.6	2.4	----	----
9	7.6	7.3	6.8	6.4	5.9	5.1	4.0	2.6	----	----
10	8.4	8.1	7.6	7.1	6.5	5.7	4.6	3.0	----	----
11	9.3	8.9	8.3	7.8	7.1	6.3	5.0	3.3	----	----
12	10.2	9.7	9.1	8.5	7.8	6.9	5.5	3.6	----	----
13	11.1	10.5	9.8	9.2	8.4	7.4	6.0	3.9	----	----
14	12.0	11.4	10.5	9.9	9.2	8.1	6.5	4.3	----	----
15	12.9	12.2	11.3	10.6	9.8	8.7	7.0	4.7	----	----
16	13.7	12.9	12.0	11.3	10.4	9.2	7.4	5.0	----	----
17	14.6	13.7	12.7	12.0	11.1	9.7	7.8	5.3	----	----
18	15.5	14.5	13.5	12.7	11.7	10.3	8.2	5.5	----	----
	80-foot trees									
8	6.8	6.6	6.4	6.1	5.8	5.3	4.7	3.8	2.5	----
9	7.7	7.4	7.1	6.8	6.4	5.9	5.3	4.2	2.8	----
10	8.5	8.2	7.9	7.5	7.0	6.6	5.8	4.7	3.1	----
11	9.4	9.0	8.6	8.2	7.7	7.1	6.3	5.1	3.4	----
12	10.3	9.8	9.4	8.9	8.4	7.8	6.9	5.5	3.7	----
13	11.2	10.7	10.1	9.7	9.0	8.3	7.3	5.9	3.9	----
14	12.1	11.5	10.9	10.4	9.7	8.9	7.9	6.3	4.3	----
15	12.9	12.3	11.7	11.1	10.4	9.5	8.4	6.7	4.5	----
16	13.8	13.2	12.5	11.9	11.1	10.1	8.9	7.2	4.8	----

17	14.7	14.0	13.2	12.5	11.7	10.7	9.4	7.6	5.0	----------
18	15.6	14.9	14.0	13.3	12.4	11.4	10.0	8.0	5.3	----------
19	16.5	15.7	14.8	14.0	13.1	11.9	10.4	8.3	5.6	----------
20	17.4	16.6	15.6	14.7	13.7	12.5	11.0	8.8	5.9	----------
				90-foot trees						
10	8.7	8.3	7.9	7.5	7.1	6.5	5.7	4.7	3.6	2.4
11	9.5	9.1	8.7	8.2	7.7	7.1	6.3	5.3	4.1	2.8
12	10.4	10.0	9.4	9.0	8.5	7.9	7.1	5.9	4.7	3.2
13	11.3	10.8	10.3	9.8	9.3	8.6	7.7	6.6	5.2	3.6
14	12.2	11.7	11.0	10.5	10.0	9.4	8.4	7.2	5.7	3.9
15	13.1	12.5	11.9	11.3	10.8	10.0	9.1	7.9	6.3	4.3
16	14.0	13.4	12.6	12.1	11.5	10.8	9.8	8.5	6.8	4.8
17	14.9	14.1	13.5	12.8	12.2	11.4	10.4	9.0	7.3	5.1
18	15.9	15.0	14.3	13.6	12.9	12.1	11.0	9.6	7.9	5.6
19	16.7	15.9	15.1	14.4	13.7	12.8	11.7	10.2	8.3	6.0
20	17.6	16.7	15.9	15.1	14.4	13.5	12.4	10.8	8.9	6.4
21	18.5	17.6	16.7	15.9	15.1	14.2	13.0	11.4	9.4	6.8
22	19.4	18.4	17.5	16.6	15.8	14.9	13.6	12.0	9.8	7.2

Stump height, 1 foot for trees 6 to 16 inches in diameter breasthigh, 1.5 feet for trees 17 to 22 inches.

TABLE 9—*Continued.*

100-foot trees

Diameter breast-high	At breast-height	Height above stump—Feet											
		8.15	16.30	24.45	32.60	40.75	48.90	57.05	65.20	73.35	81.50	89.65	97.80
Inches	Diameter inside bark—Inches												
10	8.6	8.4	8.0	7.5	7.0	6.5	5.9	5.2	4.3	3.4	2.3	----------	----------
11	9.6	9.3	8.8	8.3	7.9	7.3	6.6	5.8	4.9	3.9	2.8	----------	----------
12	10.5	10.1	9.6	9.1	8.6	8.0	7.3	6.5	5.5	4.5	3.3	----------	----------
13	11.4	11.1	10.5	10.0	9.4	8.8	8.0	7.1	6.1	5.0	3.7	----------	----------
14	12.4	11.9	11.3	10.8	10.2	9.5	8.8	7.8	6.7	5.5	4.1	----------	----------
15	13.3	12.7	12.0	11.5	11.0	10.3	9.4	8.5	7.4	6.1	4.5	----------	----------
16	14.3	13.7	12.9	12.4	11.8	11.1	10.2	9.2	8.0	6.6	5.0	----------	----------
17	15.1	14.5	13.7	13.2	12.5	11.7	10.8	9.7	8.5	7.0	5.2	----------	----------
18	16.0	15.3	14.5	14.0	13.3	12.5	11.5	10.4	9.1	7.5	5.6	----------	----------
19	16.9	16.1	15.3	14.7	14.0	13.2	12.2	11.1	9.7	8.1	6.1	----------	----------
20	17.8	17.0	16.1	15.5	14.8	13.9	12.9	11.7	10.3	8.6	6.5	----------	----------
21	18.7	17.9	17.0	16.3	15.6	14.7	13.6	12.4	10.9	9.2	7.0	----------	----------
22	19.6	18.7	17.8	17.1	16.3	15.4	14.3	13.0	11.5	9.7	7.4	----------	----------
		110-foot trees											
12	10.7	10.2	9.6	9.2	8.7	8.1	7.5	6.9	6.2	5.4	4.5	3.3	----------
13	11.5	11.1	10.4	9.9	9.4	8.9	8.3	7.6	6.8	6.0	4.9	3.7	----------
14	12.4	11.9	11.2	10.8	10.2	9.6	9.0	8.3	7.5	6.5	5.4	4.0	----------
15	13.3	12.7	12.1	11.5	11.0	10.4	9.7	8.9	8.1	7.1	5.9	4.4	----------
16	14.2	13.6	12.9	12.4	11.9	11.2	10.5	9.6	8.7	7.7	6.4	4.8	----------
17	15.1	14.4	13.7	13.2	12.5	11.8	11.1	10.2	9.3	8.1	6.7	5.0	----------
18	16.0	15.3	14.6	14.0	13.4	12.6	11.8	10.8	9.8	8.7	7.3	5.4	----------
19	16.8	16.1	15.4	14.8	14.1	13.4	12.5	11.5	10.4	9.2	7.7	5.8	----------

20	17.7	17.0	16.2	15.6	14.9	14.1	13.2	12.2	11.0	9.7	8.1	6.1	----------
21	18.6	17.9	17.0	16.4	15.7	14.9	13.9	12.8	11.6	10.3	8.7	6.6	----------
22	19.5	18.7	17.9	17.1	16.4	15.6	14.6	13.5	12.2	10.9	9.2	6.9	----------
120-foot trees													
12	10.5	10.2	9.7	9.2	8.7	8.2	7.7	7.1	6.5	5.9	5.2	4.3	3.3
13	11.4	11.1	10.5	10.0	9.5	8.9	8.4	7.8	7.2	6.5	5.7	4.7	3.7
14	12.3	12.0	11.4	10.8	10.2	9.7	9.1	8.5	7.9	7.1	6.2	5.2	4.1
15	13.3	12.8	12.2	11.6	11.1	10.5	9.9	9.2	8.5	7.7	6.7	5.7	4.4
16	14.1	13.7	13.0	12.4	11.8	11.2	10.6	9.9	9.2	8.3	7.2	6.0	4.7
17	15.1	14.5	13.8	13.2	12.6	11.9	11.3	10.5	9.7	8.7	7.7	6.4	4.9
18	16.0	15.4	14.7	14.0	13.4	12.7	12.0	11.2	10.4	9.3	8.2	6.9	5.4
19	16.9	16.3	15.5	14.9	14.1	13.4	12.6	11.9	11.0	9.9	8.7	7.3	5.7
20	17.9	17.1	16.3	15.7	15.0	14.2	13.4	12.5	11.6	10.5	9.1	7.7	6.0
21	18.7	18.0	17.1	16.5	15.7	14.9	14.1	13.2	12.2	11.0	9.6	8.1	6.3
22	19.7	18.9	18.0	17.3	16.5	15.7	14.7	13.8	12.8	11.5	10.1	8.6	6.7

Stump height, 1 foot for trees 10 to 16 inches in diameter breasthigh, 1.5 feet for trees 17 to 22 inches.

TABLE 9—TAPER MEASUREMENTS OF LOBLOLLY PINE.

TREES OVER 75 YEARS OLD.

90-foot trees

Diameter breasthigh	At breast-height	Height above stump—Feet										
Inches		8.15	16.30	24.45	32.60	40.75	48.90	57.05	65.20	73.35	81.50	89.65
	Diameter inside bark—Inches											
14	12.1	11.5	11.1	10.6	10.0	9.2	8.4	7.3	5.9	4.1	2.1	----
15	13.0	12.3	11.9	11.4	10.6	9.9	9.0	7.8	6.3	4.4	2.2	----
16	13.9	13.3	12.8	12.3	11.5	10.7	9.7	8.4	6.8	4.8	2.5	----
17	14.7	14.0	13.5	12.9	12.1	11.2	10.2	8.9	7.2	5.0	2.5	----
18	15.7	14.9	14.3	13.7	12.9	12.0	10.9	9.5	7.7	5.3	2.6	----
19	16.5	15.7	15.1	14.4	13.6	12.7	11.5	10.1	8.1	5.6	2.7	----
20	17.4	16.6	15.9	15.3	14.4	13.5	12.3	10.7	8.6	6.0	2.9	----
21	18.3	17.4	16.7	16.0	15.2	14.2	12.9	11.2	9.0	6.3	3.1	----
22	19.3	18.3	17.6	16.9	15.9	14.8	13.4	11.7	9.4	6.6	3.3	----
23	20.1	19.1	18.3	17.5	16.6	15.5	14.1	12.4	10.0	7.0	3.5	----
24	20.9	19.9	19.0	18.3	17.4	16.2	14.7	12.9	10.4	7.3	3.7	----
					100-foot trees							
14	12.3	12.0	11.5	10.9	10.3	9.7	9.1	8.3	7.2	5.9	4.2	----
15	13.1	12.7	12.1	11.6	11.0	10.3	9.6	8.8	7.7	6.4	4.6	----
16	13.9	13.5	13.0	12.5	11.8	11.2	10.4	9.5	8.4	6.9	5.1	----
17	14.8	14.3	13.7	13.1	12.4	11.7	10.9	10.0	8.8	7.2	5.2	----
18	15.7	15.3	14.6	13.9	13.2	12.5	11.7	10.7	9.5	7.8	5.6	----
19	16.5	16.1	15.3	14.6	13.9	13.2	12.3	11.3	10.0	8.2	5.9	----
20	17.5	17.0	16.2	15.5	14.7	13.9	13.0	11.9	10.6	8.7	6.3	----
21	18.5	17.9	17.1	16.3	15.5	14.7	13.8	12.6	11.2	9.3	6.7	----
22	19.3	18.7	17.7	17.0	16.3	15.4	14.4	13.1	11.7	9.8	7.1	----
23	20.0	19.4	18.5	17.7	16.9	16.0	15.0	13.8	12.3	10.2	7.4	----

24	21.1	20.3	19.4	18.6	17.7	16.8	15.7	14.5	12.9	10.7	7.8	----------
25	21.9	21.1	20.1	19.3	18.5	17.5	16.3	15.1	13.5	11.3	8.3	----------
26	22.9	22.0	20.9	20.0	19.2	18.2	17.0	15.6	13.9	11.6	8.4	----------
27	23.7	22.7	21.6	20.7	19.9	18.9	17.7	16.3	14.5	12.0	8.7	----------
28	24.7	23.5	22.4	21.6	20.7	19.7	18.3	16.9	15.1	12.6	9.1	----------
29	25.5	24.1	23.1	22.3	21.3	20.3	19.0	17.5	15.6	13.0	9.6	----------
30	26.4	24.9	24.0	23.2	22.3	21.1	19.7	18.2	16.2	13.5	10.0	----------

110-foot trees

14	12.5	12.1	11.6	11.1	10.6	10.0	9.4	8.7	7.9	6.9	5.6	4.2
15	13.3	12.9	12.3	11.9	11.4	10.8	10.1	9.3	8.5	7.4	6.2	4.6
16	14.1	13.7	13.1	12.6	12.1	11.5	10.8	10.1	9.2	8.1	6.7	5.0
17	15.1	14.5	13.9	13.5	12.9	12.2	11.5	10.7	9.8	8.6	7.0	5.2
18	16.0	15.4	14.7	14.3	13.7	13.0	12.2	11.4	10.4	9.1	7.4	5.6
19	16.9	16.2	15.5	15.0	14.5	13.8	13.0	12.2	11.1	9.7	8.0	5.9
20	17.7	16.9	16.2	15.7	15.1	14.4	13.7	12.8	11.7	10.2	8.4	6.2
21	18.6	17.8	17.1	16.6	16.0	15.3	14.4	13.5	12.4	10.8	8.9	6.6
22	19.5	18.5	17.7	17.2	16.6	15.8	15.1	14.2	12.9	11.3	9.3	6.9
23	20.4	19.4	18.6	18.2	17.5	16.7	15.8	14.8	13.6	11.9	9.8	7.3
24	21.4	20.3	19.5	18.9	18.3	17.4	16.5	15.5	14.2	12.5	10.3	7.6
25	22.3	21.2	20.3	19.7	19.0	18.2	17.2	16.1	14.8	13.0	10.8	8.0
26	23.2	22.0	20.9	20.4	19.7	18.9	17.9	16.7	15.3	13.3	11.0	8.2
27	24.1	22.8	21.8	21.2	20.5	19.6	18.6	17.4	15.9	13.9	11.5	8.5
28	25.1	23.6	22.6	22.0	21.2	20.2	19.2	18.0	16.4	14.4	11.9	8.8
29	25.9	24.5	23.4	22.7	21.9	20.9	19.8	18.6	17.1	15.0	12.4	9.2
30	26.9	25.3	24.1	23.3	22.5	21.5	20.5	19.2	17.6	15.5	12.9	9.6
31	27.8	26.2	25.0	24.2	23.3	22.3	21.2	19.8	18.2	16.0	13.3	9.9
32	28.6	27.1	25.7	24.8	24.0	22.9	21.8	20.4	18.7	16.4	13.7	10.1
33	29.6	27.9	26.6	25.7	24.8	23.7	22.5	21.1	19.4	17.1	14.2	10.6
34	30.5	28.7	27.3	26.5	25.5	24.4	23.2	21.7	19.9	17.6	14.7	11.0

The stump height was 1 foot for trees 6 to 16 inches in diameter breasthigh, 1.5 feet for trees 17 to 25 inches, and 2 feet for trees 26 inches and over.

TABLE 9—*Continued.*

120-foot trees

Diameter breast-high	At breast-height	Height above stump—Feet												
Inches		8.15	16.30	24.45	32.60	40.75	48.90	57.05	65.20	73.35	81.50	89.65	97.80	105.95	114.10
		Diameter inside bark—Inches													
14	12.4	12.0	11.5	11.1	10.7	10.1	9.6	8.9	8.1	7.2	6.1	4.9	3.5	----------	----------
15	13.3	12.8	12.3	12.0	11.5	10.9	10.3	9.6	8.8	7.8	6.7	5.4	4.0	----------	----------
16	14.1	13.7	13.2	12.8	12.3	11.7	11.0	10.3	9.5	8.5	7.3	6.0	4.4	----------	----------
17	15.0	14.4	13.8	13.5	13.0	12.4	11.7	11.0	10.1	9.1	7.8	6.3	4.7	----------	----------
18	15.9	15.3	14.7	14.4	13.9	13.2	12.5	11.8	10.9	9.7	8.4	6.8	5.0	----------	----------
19	16.7	16.0	15.5	15.1	14.5	13.9	13.1	12.4	11.5	10.4	9.0	7.3	5.5	----------	----------
20	17.7	16.9	16.3	15.9	15.4	14.7	14.0	13.2	12.3	11.1	9.7	7.9	5.9	----------	----------
21	18.6	17.7	17.1	16.7	16.1	15.4	14.7	13.9	13.0	11.7	10.2	8.4	6.3	----------	----------
22	19.6	18.6	18.0	17.5	17.0	16.2	15.4	14.6	13.6	12.4	10.8	8.9	6.7	----------	----------
23	20.4	19.4	18.8	18.3	17.6	16.9	16.1	15.2	14.2	12.9	11.3	9.3	7.0	----------	----------
24	21.4	20.3	19.6	19.0	18.4	17.7	16.8	16.0	14.9	13.5	11.9	9.9	7.4	----------	----------
25	22.2	21.1	20.4	19.7	19.1	18.3	17.5	16.6	15.5	14.1	12.4	10.4	7.9	----------	----------
26	23.2	22.0	21.2	20.6	19.9	19.0	18.1	17.1	16.0	14.6	12.9	10.7	8.1	----------	----------
27	24.1	22.7	22.0	21.3	20.6	19.7	18.8	17.9	16.7	15.2	13.4	11.2	8.5	----------	----------
28	25.1	23.7	22.8	22.1	21.3	20.5	19.5	18.5	17.3	15.8	14.0	11.8	9.0	----------	----------
29	25.9	24.6	23.6	22.7	21.9	21.1	20.1	19.1	17.8	16.3	14.5	12.3	9.4	----------	----------
30	26.9	25.4	24.4	23.5	22.7	21.9	20.9	19.8	18.5	17.0	15.1	12.8	9.8	----------	----------
31	27.7	26.2	25.1	24.2	23.4	22.5	21.5	20.3	19.0	17.5	15.6	13.2	10.1	----------	----------
32	28.7	27.1	25.9	24.9	24.1	23.2	22.2	21.0	19.7	18.1	16.2	13.7	10.6	----------	----------
33	39.6	28.0	26.6	25.7	24.8	23.9	22.8	21.6	20.2	18.6	16.7	14.3	11.1	----------	----------
34	30.6	28.8	27.5	26.4	25.5	24.5	23.5	22.3	20.9	19.3	17.3	14.7	11.4	----------	----------
35	31.4	29.7	28.2	27.1	26.1	25.2	24.1	22.8	21.4	19.8	17.7	15.1	11.7	----------	----------
36	32.4	30.5	29.0	27.8	26.8	25.8	24.7	23.5	22.0	20.3	18.3	15.6	12.2	----------	----------

130-foot trees

20	17.8	16.9	16.3	15.9	15.3	14.7	14.0	13.4	12.7	11.9	10.8	9.6	8.1	6.3	4.3
21	18.8	17.9	17.2	16.7	16.1	15.5	14.8	14.2	13.4	12.5	11.5	10.2	8.6	6.7	4.5
22	19.8	18.8	18.1	17.6	17.0	16.3	15.6	14.9	14.1	13.2	12.0	10.7	9.1	7.1	4.8
23	20.7	19.7	19.0	18.5	17.9	17.2	16.4	15.6	14.7	13.7	12.5	11.1	9.5	7.4	5.0
24	21.7	20.6	19.9	19.3	18.6	17.9	17.1	16.4	15.5	14.4	13.2	11.7	10.0	7.9	5.5
25	22.6	21.4	20.6	20.1	19.4	18.5	17.8	17.0	16.1	15.0	13.7	12.3	10.5	8.3	5.6
26	23.5	22.3	21.4	20.8	20.0	19.2	18.4	17.6	16.7	15.5	14.1	12.6	10.8	8.5	5.7
27	24.3	23.0	22.1	21.5	20.7	19.9	19.1	18.3	17.3	16.1	14.7	13.1	11.2	8.8	6.0
28	25.3	23.9	22.9	22.3	21.5	20.7	19.9	19.0	18.0	16.8	15.4	13.7	11.7	9.2	6.2
29	26.1	24.7	23.6	23.0	22.2	21.3	20.5	19.5	18.5	17.3	15.9	14.2	12.2	9.7	6.6
30	26.9	25.5	24.4	23.6	22.8	22.0	21.1	20.2	19.1	17.9	16.5	14.8	12.7	10.0	6.8
31	27.9	26.3	25.2	24.4	23.5	22.7	21.7	20.8	19.7	18.5	17.0	15.3	13.1	10.3	7.0
32	28.7	27.3	26.0	25.1	24.2	23.4	22.4	21.4	20.3	19.1	17.6	15.9	13.6	10.8	7.3
33	29.5	28.0	26.6	25.7	24.9	24.0	23.0	22.0	20.9	19.7	18.2	16.3	14.0	11.1	7.6
34	30.3	28.9	27.4	26.3	25.5	24.6	23.6	22.5	21.4	20.2	18.7	16.9	14.5	11.5	7.8
35	31.2	29.6	28.1	27.1	26.1	25.2	24.2	23.2	22.1	20.8	19.3	17.3	14.9	11.9	8.1
36	32.1	30.4	28.8	27.7	26.7	25.9	24.9	23.8	22.6	21.4	19.8	17.9	15.4	12.3	8.4

140-foot trees

24	22.1	20.9	20.1	19.6	19.0	18.4	17.7	17.0	16.3	15.6	14.6	13.5	12.0	10.3	8.3
25	22.9	21.6	20.9	20.2	19.6	19.0	18.4	17.6	16.9	16.1	15.1	14.0	12.5	10.7	8.5
26	23.8	22.3	21.6	21.0	20.4	19.7	18.9	18.2	17.4	16.5	15.6	14.4	12.9	10.9	8.6
27	24.7	23.1	22.4	21.7	20.9	20.2	19.4	18.7	17.9	17.0	16.0	14.8	13.1	11.2	8.8
28	25.5	24.0	23.1	23.4	21.7	20.9	20.1	19.3	18.5	17.5	16.5	15.2	13.6	11.6	9.2
29	26.2	24.8	23.9	23.1	22.3	21.5	20.7	19.9	19.0	18.1	17.0	15.7	13.9	11.9	9.4
30	27.2	25.7	24.6	23.8	23.0	22.2	21.4	20.6	19.7	18.7	17.5	16.1	14.4	12.3	9.8
31	28.0	26.4	25.4	24.5	23.7	22.9	22.1	21.2	20.2	19.1	18.0	16.6	14.8	12.6	10.0
32	28.9	27.3	26.1	25.2	24.4	23.5	22.7	21.8	20.8	19.7	18.4	17.0	15.2	13.0	10.4
33	29.7	28.0	26.8	25.9	25.1	24.2	23.3	22.3	21.3	20.2	18.9	17.4	15.5	13.3	10.6
34	30.7	29.0	27.7	26.7	25.8	24.9	24.0	23.1	22.0	20.7	19.4	17.8	15.9	13.6	10.9
35	31.4	29.7	28.3	27.3	26.3	25.4	24.5	23.5	22.4	21.2	19.8	18.2	16.2	13.9	11.2
36	32.3	30.6	29.1	28.0	27.1	26.2	25.2	24.2	23.0	21.7	20.3	18.7	16.7	14.3	11.4

Stump height 1 foot for trees 6 to 16 inches in diameter breasthigh, 1.5 feet for trees 17 to 25 inches, and 2 feet for trees 26 inches and over.

Crown.

Branchlets are commonly borne in whorls of three. They develop not only at the tip of the leader, but also at intermediate points along the season's growth, the growth of the leader being recrudescent. In young rapidly-growing trees there are usually three whorls and consequently three internodes on the leader in one season (Plate II). Although the nodes may be close together in loblolly pine, the knots in the tree may be distant and irregularly distributed, as not all branchlets in a whorl develop into branches.

The crown of the young thrifty growing tree is sharply conical, the rather slender arched branches ascending at an angle of 45 degrees or more. At middle age the crown becomes oval, and in old age broadly oval and flat-topped; the wide spreading branches become stout, irregularly distributed, and nearly horizontal, with tips slightly ascending. (Plate I.)

Root System.

The root of the one and two-year-old seedling pine is fibrous and diffuse; and, though the central slender taproot is very evident, it is essentially a fibrous root system. (Figure 3, *c*.) With age, the taproot, although it remains short, becomes proportionately more prominent, and many deeply seated lateral roots are developed. The taproot, which seldom descends to a depth of more than 4 or 5 feet, is often forked and blunted, and on hardpan and heavy clay soils, flattened or curved at the tip; it never assumes the proportion of that of the longleaf or shortleaf pines nor descends to such a depth as do the taproots of those trees. (Fig. 3, *a*. and *b*.) On loose, moist or sandy soils many of the lateral and central roots are deep-seated, descending 3 to 5 feet, but others lie near the surface of the ground. (Fig. 4, *a* and *b*.) On compact, and especially on dry, clay soils, the roots are much shallower and more spreading. On very wet soils where the water table is prevailingly close to the surface during the growing season there is in old trees no well developed tap root, but its place is taken by a number of central spreading roots. (Fig. 4, *c*.) The great development of the lateral roots probably explains the rapid growth of the pine in old fields, where the loose, easily penetrable top soils form an excellent bed for the spread of such roots. The early culmination of the growth in old fields on the red clays of the Piedmont, especially on the poorer soils, may be due in part to the check in the development of the lateral root system, as the roots fail to descend into the hard subsoil, as well as to the limited supply of soil moisture available for the stand. In old trees on loose, moist soils, the lateral roots spread for a distance of from 25 to 30 feet from the tree, though the taproot is rarely more than three feet long. The taproot is much shorter on compact clay soils and where there is a hard pan than on loose soils.

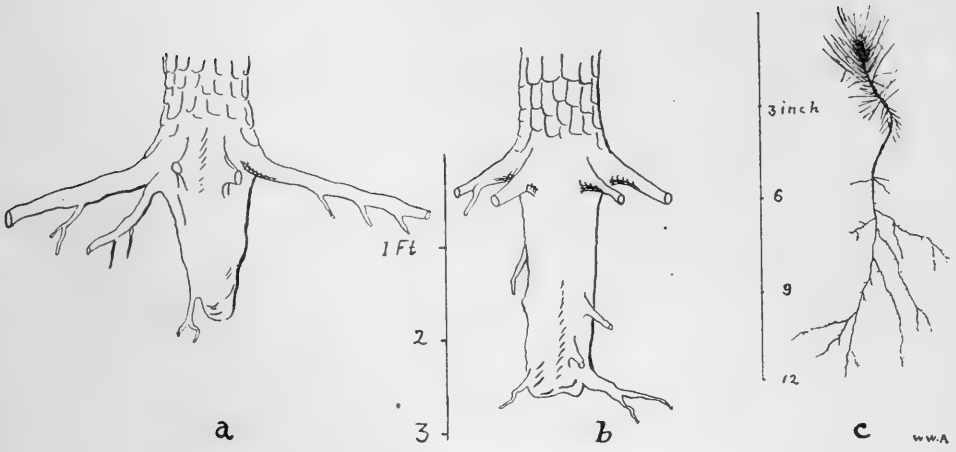


Fig. 3. *a* and *b*. Roots of mature loblolly pines on upland clays.
c. Two-year-old loblolly pine seedling.

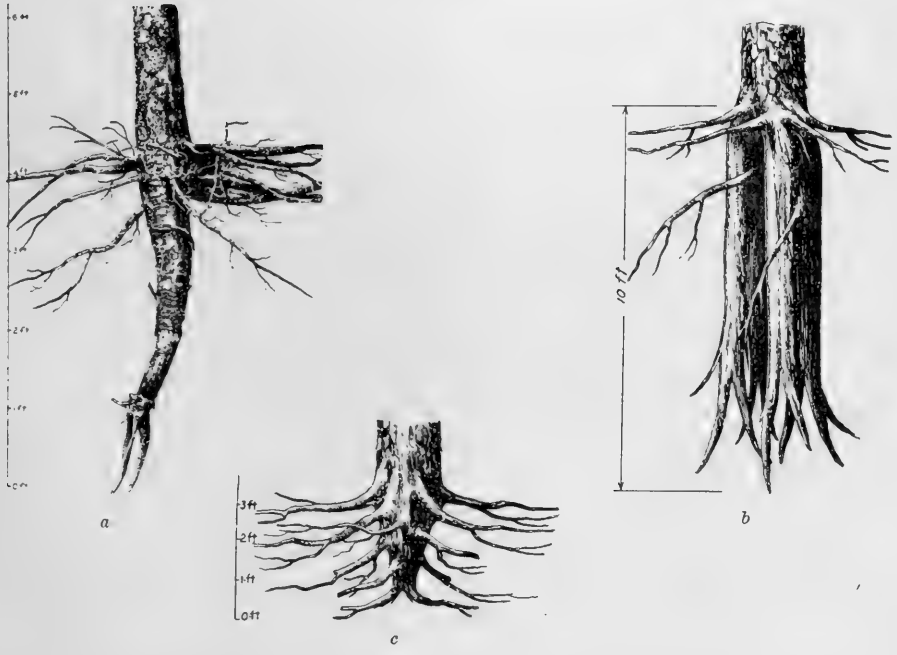


Fig. 4. *a*. Roots of loblolly pine saplings on dry sandy upland soils. (Adapted from photo. by J. S. Holmes.)
b. Roots of loblolly pine on moist but well drained sandy loam soils. Small deep-seated roots extending to water table. (Adapted by author from photo. by von Schrenk.)
c. Roots of loblolly pine on wet soils. No deep-seated roots, but a great mass of shallow roots. (From sketch made from nature.)

Bark.

The bark of small trees forms about 30 per cent of their volume; that of large trees about 15 per cent. In large trees the bark near the base of the tree is 3 to 6 inches thick and forms a great protection against fire. Above 2 or 3 feet from the ground it becomes thinner, seldom exceeding ½ inch in thickness at the base of the crown. The outer bark as it falls from the stem forms a mound of debris at the base of the trunk, at times 2 feet high and 5 or 6 feet wide. Unless this is removed, the stumps are apt to be cut high. The bark is much thicker on young thrifty trees than on slower growing older trees of the same diameter and height. Table 10 gives the thickness of bark at breast height for trees of different diameters and heights, and is an average of both young and old. Below breasthigh the bark is much thicker as shown in Table 11.

TABLE 10.—THICKNESS OF BARK AT BREASTHEIGHT AND DIAMETER OF STEM INSIDE OF BARK AT BREASTHEIGHT ON TREES OF LOBLOLLY PINE OF DIFFERENT DIAMETERS AND HEIGHTS. TREES WITH DIAMETERS BELOW 23 INCHES ARE LESS THAN 75 YEARS OLD.

Diameter breast-high	Trees 40 ft. high		Trees 70 ft. high		Trees 100 ft. high		Trees 140 ft. high	
	Diameter inside bark at 4.5 ft.	Double width of bark	Diameter inside bark at 4.5 ft.	Double width of bark	Diameter inside bark at 4.5 ft.	Double width of bark	Diameter inside bark at 4.5 ft.	Double width of bark
Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
4	2.8	1.2						
6	4.5+	1.5	4.9	1.1				
8	6.2	1.8	6.7	1.3				
10	7.8	2.2	8.4	1.6	8.7	1.3		
12	9.5—	2.5	10.2	1.8	10.5+	1.5		
14			12.0	2.0	12.4	1.6		
16			13.7	2.3	14.3	1.7		
18			15.5—	2.5	16.0	2.0		
20					17.8	2.2		
22					19.6	2.4		
24					21.1	2.9	22.1	1.9
26					22.9	3.1	23.8	2.2
28					24.7	3.3	25.5+	2.5
30					26.5—	3.5	27.2	2.8
32							28.9	3.1
34							30.7	3.3
36							32.3	3.7

Table 11 shows the comparative average thickness of the bark on the stump of trees of the loblolly, longleaf, and white pines of different sizes:

TABLE 11.—THICKNESS OF BARK ON STUMP.

Diameter breast-high	Loblolly pine	Longleaf pine	White pine
Inches	Measured on diameter—Inches		
2	.5	.2	.2
5	1.6	.4	.4
10	2.1	.6	1.0
15	3.3	.8	1.6
20	4.6	1.0	----------
25	5.5	1.1	----------

LONGEVITY AND SIZE.

The loblolly pine is comparatively a medium-lived tree. The oldest group which was measured, consisted of more than 20 trees that had an average age of 240 years. The oldest tree recorded was 245 years old; it was a perfectly sound tree, and one of the largest specimens seen, having a breasthigh diameter of 53 inches, a height of 150 feet, 88 feet of clear bole, and containing 4,109 board feet (Doyle-Scribner rule) of merchantable timber. The tallest tree measured was 164 feet high. The tree having the greatest diameter was 54 inches, and 139 feet in height.

The usual age on good soils is about 200 years, with a height of from 110 to 130 feet, and a diameter of from 2 to 3 feet. On poor or dry soils the sizes are smaller and the trees do not reach so great an age. On the very dry upland soils of old fields mature trees do not attain as a rule a greater height than 90 feet, a diameter above 20 inches, and an age of over 100 years.

SILVICAL REQUIREMENTS.

CLIMATE.

Although unfavorable soil conditions are the chief limiting factor to the western distribution of the loblolly pine in North Carolina, a minimum annual temperature of 55° F., a high atmospheric humidity and ample rainfall of 45 inches a year, or more, are essential conditions for its good development.

SOIL AND MOISTURE.

The loblolly pine is not exacting in regard to soil. It grows naturally on many soils, which differ widely in dryness, depth, compactness, and chemical composition. For its best development, however, it requires a uniform supply of moisture, and a deep, preferably porous, soil. On the light loams and the sandy loams of the coastal plain, with the water table seldom below 10 feet, it seems to be most thoroughly at home. On lower slopes bordering streams along the eastern edge of the Piedmont, loblolly pine grows especially well on the deep alluvial soils, which are uniformly moist throughout the growing season but are not subject to excessive flooding. In the large river swamps, subject to frequent and deep flooding by muddy water during the growing season,

loblolly pine is unable to maintain a foothold; on poorly drained soils it is capable of establishing itself, but the growth is slow. On the thoroughly drained rolling oak uplands, usually with clay soils, but sometimes with shallow or coarse gravelly soils, young pine growth is becoming common wherever the hardwoods have been cut. The light porous soils on fallow fields offer ideal conditions for the rapid development of the roots of the young pines, so that the rate of increment of young trees, even on dry, or sterile soils, if recently cultivated, is far more rapid than on any, except the best virgin forest soils. (Plate IV.) This is especially true of growth in diameter and of early growth in height. On the coarse, most siliceous, and extremely dry soils of the pine barrens, this pine occurs very rarely except on cultivated lands. The wet, peaty, and mossy soils of white cedar swamps (juniper bays), the fetter-bush swamps and peat bogs, the wet sour soils of briery bays and pocosons (raw, acid peat) and the wet savannas are unsuited to this tree. On such soils it seldom survives more than a few years.* On peaty soils, which are so well drained that the peat is decomposing and becoming humified, and so aërated that nitrification can take place, it reproduces freely and becomes a large tree. On the driest savannas and grassy flatwood lands, natural reproduction takes place very slowly, perhaps partly on account of the frequent fires.

Other factors being the same, a uniformly moist or damp soil is preferable to either a dry or wet one, or to one subject to great extremes of moisture or drought, while a porous loam or sandy loam is preferable to a clayey or compact soil or to a coarse siliceous one. (See Fig. 5.)

LIGHT.

The loblolly pine requires a full amount of direct sunlight for its best development. During the younger stages of growth, and until the period of rapid height-growth is passed, it will, however, endure much lateral compression of its crown, without being dwarfed or crowded out, but its capacity to endure shade and crowding is greatest on good sites and least on poor sites. Its greater tolerance of shade on good sites is due, at least in part, to the larger amount of available soil moisture. It will even bear overshading for several decades and still be able to make vigorous growth on the removal of the shade. This power of recovering from overshading, however, is limited to the early life of the tree, and to favorable sites, though this limit varies much with the site. On moist soils trees 40 to 60 years old can be found beneath a partial shade growing slowly but remaining healthy. On medium dry soils few small suppressed trees more than 50 or 60 years old can be found growing beneath a partial cover, so that it seems probable that if trees on medium soils are not offered light within that limit, they die. On dry uplands soils, such as the red clays of the Piedmont, intolerance of

*The symbiotic mycorrhiza, which occurs on the roots of the pocoson pine (*P. serotina*) and enables it to grow in the wet and unaerated soils of pocosons, briery bays, fetter-bush bays, reed swamps and peat bogs, does not occur on loblolly pine, which possibly explains the absence of this tree from such sites.

shade is acquired after the pole stage, and the most crowded trees in the intermediate crown class die rapidly after the thirty-fifth year. Young suppressed trees left in lumbering recover very slowly on medium sites, if the trees have passed the pole stage, and the crowding was of long duration. In fifty-two measurements made on 50-year-old suppressed trees which were growing on well-drained upland clay soils in the Piedmont, and which were left after lumbering seven years before, only nine showed any marked increase in the width of the last seven rings, as compared with the width of the preceding seven rings. They were selected as being typical suppressed trees, which were too small for saw logs at the time of the first cutting. The height growth of these same trees during the last seven years was only 22 inches, while that of the other trees which showed no signs of suppression was 39 inches during the same period. The revival of large overshaded trees, even if only moderately suppressed and growing on the drier soils, is slow or does not take place at all. The stem analyses fail to show that any large number of trees on such sites ever passed through any period of great or prolonged suppression, but rather that large old trees which were growing on drier quality sites invariably made good growth in their youth or that the period of suppression was short. On the other hand, the diameter growth of trees, which have not been subject to excessive overshading, is greatly accelerated when given growing space. This makes thinning by removing the smaller and crowded trees desirable, whenever it can be done without extra cost. Beneath a crown cover where about one-half of the light is excluded, young trees on the best sites will grow healthily till the high pole stage, though both the diameter and height growth are lessened, the diameter growth to a larger extent than the height growth; on the removal of the shade both make rapid response to the increased light. (Plate XIV.)

The trees exhibit with age a progressive increase in their demands upon light. About the period when the rate of height growth becomes lessened, the crown spreads rapidly, tending to become round and flat-topped, and the branches nearly horizontal. At the beginning of this stage there is a rapid decrease in the number of trees to the acre, from the dying off of the weaker crowded trees. The decrease in number of trees may be as great as 35 to 40 per cent in 10 years. (Table 42.) Eventually, except on the very best sites, each tree stands isolated with a band of light between it and its nearest neighbors. (Plate XXV.) On the poorer sites, especially on the drier soils, this isolation takes place at an earlier age than on good sites. Table 2 shows the small number of trees in the suppressed and intermediate crown classes. On the very best sites groups 120 to 130 years old can be found with almost unbroken cover. As the crowns become isolated under these conditions, young pines appear, while gallberry and similar shrubs always form an abundant ground cover. In the old-field groves on good sites, the period of isolation begins rather late, after the fiftieth year; while on poor sites it begins at the thirtieth or fortieth year. On the slow-draining savanna land it also begins early and young trees less than 40 years old are very intolerant of shade.

When loblolly pine grows on good sites associated with hardwoods, well-developed old pines overtop the hardwoods, spreading their crowns above them and securing full light in that way. The sweet gum and yellow poplar are the only associated trees which are not overtopped. In such hardwood forests the young pines appearing as single stems in openings, endure much lateral compression to an age of about 120 years, when they generally overtop the hardwoods. In spite of its intolerance of shade the pine succeeds in forming a considerable element in forests of the most shade-tolerant species, seizing by its abundant seeding openings caused from windfall, fire, or lumbering, and by its rapid growth outstripping competitors that would otherwise overtop and suppress it beneath their shade. (Plates XXIV to XXVII.)

REPRODUCTION.

Loblolly pine reproduces itself prolifically because of its high percentage of sound seed with excellent germinating power, the hardiness of the young seedling, and the varying degrees of light, moisture, and soil to which it is inured. Its ability to establish itself under adverse conditions is further aided by the early rapid development of a vigorous root system, accompanied by an extremely rapid height growth, which begins the second year and soon raises the crown above grass, weeds, and slower growing competitors, and by the thick bark which by the time it is a sapling affords excellent protection against fire. No other species can successfully compete with it, under existing conditions, over three-fourths of the coastal plain. Neglected by both cattle and hogs, it is subject neither to the browsings which suppress broadleaf species nor to the destruction to which the longleaf pine is exposed by having both its seed and roots eaten by hogs.

SEEDING.

Loblolly pine seeds abundantly nearly every year. From 60 to 70 per cent of the seed from large trees are viable. The seeds are light (about 17,000 to 20,000 cleaned seed to a pound) with large, tenacious wings, in consequence of which they are widely disseminated by the wind upon the maturing and opening of the cones after frost or late in autumn. The greater part of the seed is scattered during the months of November and December, but many cones do not open, or entirely open, until considerably later, so that some seed does not fall until spring. The distance to which the seed is scattered varies with the height of the trees and the velocity of the wind. As a rule in two seasons an area will be fairly thickly seeded by wind-sown seed to a distance of 200 yards from an adjoining forest of tall, seed-bearing trees, if the prevailing winds during the season, when the cones are opening, are favorable. (Plate IV.) Seeding is progressive, and the stocking will not be uniform but denser near the seed trees. Near the coast the prevailing winds during the winter are from the east and northeast; farther inland they are from the northwest.

A. Good example of heavy culling as practiced fifteen to twenty years ago. The large number of intermediate and suppressed trees which were left have now formed a basis for a remunerative second cutting. Pine reëstablishment fair but intermixed with oaks. (Author's illustration.)

B and C. Types of recently cut loblolly pine forest, five or six years after cutting; quality II, age about seventy years. Dense pine restocking, young stand being from six to ten feet high. Undesirable class of seed trees and no possibility of a remunerative second cutting. (Author's illustrations.)

Isolated trees begin to produce seed when about 15 years old. In crowded stands the age of cone production is later, between the twentieth and twenty-fifth year, and production is restricted to dominant trees. Seed production is relatively scant, however, until stands are 40 to 50 years old.

In the regularity and frequency of its seeding the loblolly pine is in strong contrast to the longleaf pine, which bears seed abundantly only at intervals of several years, and often no seed at all over extensive areas during the intervening period. The pocoson pine produces some seed nearly every year, but never any large amount. Its cones often remain on the trees unopened for several years, which interferes with the propagation of that species and the general distribution of its seed. The loblolly pine is more regular and prolific in its seeding than the shortleaf.

The loblolly pine produces its flowers about the tenth of April in the vicinity of Chapel Hill, N. C., near the western limits of its distribution, and the last of March in the vicinity of Wilmington, N. C. This is too late in the season to be injured by late spring frosts which at times interfere with the setting of seed of the longleaf pine in the western part of its range in North Carolina. The cones require two seasons in which to mature.

GERMINATION AND PLANT ESTABLISHMENT.

Most of the seed germinate the spring after maturing, generally between the first of March and middle of May, the time varying according to the warmth of the season, the distance from the coast and the amount of moisture in the seedbed. A few seed apparently lie over until midsummer. South of latitude 35 and near the coast, some seed apparently germinate in the fall. Germination takes place either in the shade of old trees, or in the direct sunlight, on barely moist to very wet soils. Naked earth makes the best seedbed, as the roots striking at once into the soil do not dry out. This accounts for the thorough stocking of old fields notwithstanding the exposure of the seed to the sun. Seed will germinate and the young plants take root in soil covered with a heavy sod of coarse grass, such as broom grass which often grows two or three feet high. Though the seed will germinate on damp leaf mould of broadleaf species and on damp pine leaves (straw) and litter, the young seedlings on account of their superficial root system are liable to dry out. The seed will seldom germinate on thick beds of dry leaves or pine needles, and it is generally necessary to destroy a thick layer of litter or to bring the mineral soil to the surface before restocking can be secured in such situations.* Occasionally a mossy log or rotten stump in the damp shade of a deep swamp has young seedlings on it, but during the first drought of summer most of them perish. For the same reason the young seedlings secure a permanent foothold with difficulty on the coarse and dry sands of the pine barrens which are so porous

*For full discussion of this see Proceedings Society American Foresters, 1910, page 90 and following.

and thoroughly drained that there is frequently insufficient moisture for sprouting, and if the seed germinate the young plants speedily succumb to drought. Fields which have been abandoned or left a few years to fallow, logged over areas, and burns all form suitable seedbeds.

FUNGOUS DISEASES AND INSECTS.

So far as known the older trees of loblolly pine are subject to few destructive fungous diseases. On some low, flat lands, especially where fires have burned around the collar of the trunk, the trees are attacked by a root rot caused by a species of *Hydnum,* which may gain entrance through fire scars. Only trees large enough to have heartwood are thus affected. The upper portions of the stems are also occasionally affected by redheart, produced by *Trametes pini,* which gains entrance chiefly at broken limbs and knot holes. Trees less than 75 years old are rarely affected by redheart, which is characteristically a disease of old age. Another fungus, *Polyporus Schweinitzii,* occasionally attacks the heartwood. Seedlings seem to be very free from diseases. They frequently turn an olive green or copper color in the spring, but this discoloration is not a disease.

While comparatively free from fungous diseases, loblolly pine is subject to the attacks of the pine bark beetle (*Dendroctonus frontalis, Zimm.*), which kills trees through girdling them by the galleries made beneath the bark chiefly in the middle part of the trunk. A few weeks after the attack the leaves begin to brown, generally at the top of the crown. Stands in which rapid natural thinning is taking place are particularly subject to attack. Not only are the dying and weakened intermediate and suppressed trees thus attacked, but sometimes also the large and healthy dominant trees are killed. During summer lumbering many young trees which are left become infested by the beetle, which breeds freely in the green slash, particularly that lying in the shade, and spreads from it to living trees. Trees which are bruised by falling timber or in skidding are first attacked. Several broods of the beetle are produced each season. The broods, which develop early in the spring, emerge and attack sound near-by trees, and as the different broods develop new centers of infection are established. In forests in which there is a large admixture of broadleaf species the damage to the pine by this insect is less than in pure stands, especially in the old-field stands. Many of the old-field stands are connected with farms and where the distance is not too great to permit fuel to be hauled, all trees which show by the discoloration of their foliage any signs of being affected by the bark beetles should be promptly removed. If infested trees are located during the winter and are cut and removed before spring the brood will be destroyed. This will check the propagation of the insects and prevent them from increasing in number and passing to other trees. Wherever it is possible to remove such attacked trees without great cost they should be promptly cut. It is more difficult to check an epidemic during the spring and summer after the broods have

begun to emerge. The Bureau of Entomology of the United States Department of Agriculture gives the following method of control in the summer when a group of trees is infested and begins to die. Trees which are infested should be promptly cut and the bark peeled and burned. In addition, "if felled and girdled trees are provided at the proper time, so that the beetles will be attracted to them at the period of their greatest flight, they will attack such trees in preference to the living, uninjured ones; then, after they have entered the inner bark and the broods are partially developed, that is, before they have entered the outer bark, it will only be necessary to remove the bark to effectually destroy them and thus protect the healthy timber. If, however, the removal of the bark is neglected until the broods have entered the outer dry portion, it will be necessary to burn it as soon as it is removed."

A weevil occasionally destroys the terminal shoot of the young tree, causing a forked or crooked stem.

The wood of trees which are blown down in storms or which are killed by fires is quickly attacked and tunneled by sawyers, the larvae of longicorn and other beetles. In order to save such timber, if it can not be promptly used, it should be cut and put in water, or if this is impossible, cut and peeled of the bark.

SENSITIVENESS TO FIRE.

During the first few years of its life the delicate tissues of the young pine are entirely consumed by even a light grass fire. After the young trees, however, attain a diameter of several inches, the bark around their base thickens so rapidly that they are seldom seriously injured by winter fires. The inner bark or growing tissue becomes active several weeks later in the spring in the loblolly pine than in the longleaf pine, and for this reason also large loblolly pines are less injured by early spring fires than are longleaf pines. It is an exceptional case, therefore, for old trees of loblolly pine to be severely injured by early spring fires unless they are crown fires. In winter or early spring before the sap is active, young trees may even have much of the foliage consumed without the fire killing the trees. Late spring and summer fires, after the growth of the tree has begun, are far more destructive.

The fact that loblolly pine generally grows on moister soils than the longleaf pine undoubtedly contributes to its greater freedom from fire injury; at times, however, even the wet lands and swamps, particularly those with peaty soils, are badly burned during dry periods in summer or in autumn. Such fires are extremely destructive when the humus is thick and undergrowth dense. To protect mature timber from the disastrous fires, it is customary to burn the underbrush during calm weather each winter, and in this way to prevent its accumulation. On loose, level, sandy soils having the water table near the surface, where the trees do not suffer from drought, the yearly destruction of a large portion of the litter probably affects but slightly the growth of the

trees. On drier, and especially on heavier soils, such as the Selma loams and Cecil loams and clays, the presence of the forest litter and humus is extremely desirable as a protection against excessive evaporation of soil moisture. The litter in pine forests on such soils, therefore, should never be burned. If such stands demand protection from fire it should be given by means of broad fire lanes, which can be annually cleaned, as discussed later.

An attempt was made to ascertain the effect of a severe fire upon the growth of loblolly pine when the land was foul with the accumulated leaves and undergrowth of several years. Nearly all large areas, even the shallower swamps, unless free from underwood, have been burned at some time, and often several times, and traces of fire on charred logs and stumps are in general evidence, except in some of the old fields and fenced areas. A grove which had been severely burned by having all the undergrowth of gallberries and other shrubs destroyed in the early part of the summer seven years before the examination, and which the owner asserted had not been burned before or since that year, furnished some conclusive data. The grove was on a well-drained heavy-loam soil near Kinston, and had an average age of about 50 years. The result of the fire upon the accretion is shown in Table 12.

TABLE 12.—THE EFFECT OF A SEVERE BRUSH FIRE UPON THE GROWTH IN DIAMETER OF LOBLOLLY PINE.

Diameter breasthigh Inches	Number of trees measured	Width of 7 rings preceding the fire Inches	Width of 7 rings after the fire Inches
7	2	.3	.2
8	2	.3	.15
9	4	.5	.3
10	3	.7	.3
11	5	1.1	.6
12	2	1.0	.6
13	3	1.1	.9

The trees without an exception show a sharp decrease in the width of the rings in the year following the burning, while their width gradually increased each succeeding year as the trees recovered from the effects of the fire.

CATTLE AND HOGS.

The chief injury by cattle to loblolly pine is by trampling the seedlings, although the shoot may be bitten off in grazing. Swine rarely dig up the seedling for its root. Just before restocking, the presence of swine in a stand is advantageous since they upturn the mineral soil.

Squirrels and wild turkeys do not destroy the seed of loblolly as they do the mast of longleaf pine.

SLEET AND SNOW.

The leaders of loblolly pine are sometimes broken by sleet or wet snow, particularly in the northeastern counties. On shallow soils the trees are in exceptional cases overturned by the weight of wet snow.

WIND-FIRMNESS.

On deep mellow soils in which the roots descend to a depth of three feet or more, the loblolly pine is comparatively wind-firm. On dry and shallow soils the roots are not so deeply seated or so firm, and the trees are more subject to windfall. The danger is greatest on heavy upland clays and on shallow sandy soils underlaid by hardpan. In the old fields on the red clays many of the roots often fail to penetrate below the layers loosened in plowing. Stands on such sites, if at all exposed, are particularly liable to suffer severely after a heavy thinning or after culling. The number of windfalls, three years after lumbering on 110 acres of cut-over land having a dry, compact clay soil amounted to 100 trees, 8 inches and over in diameter, or about 4.5 per cent of the trees left. On the deep sandy soils, the loss from windfall after lumbering is negligible.

THE WOOD AND ITS USES.

QUALITIES.

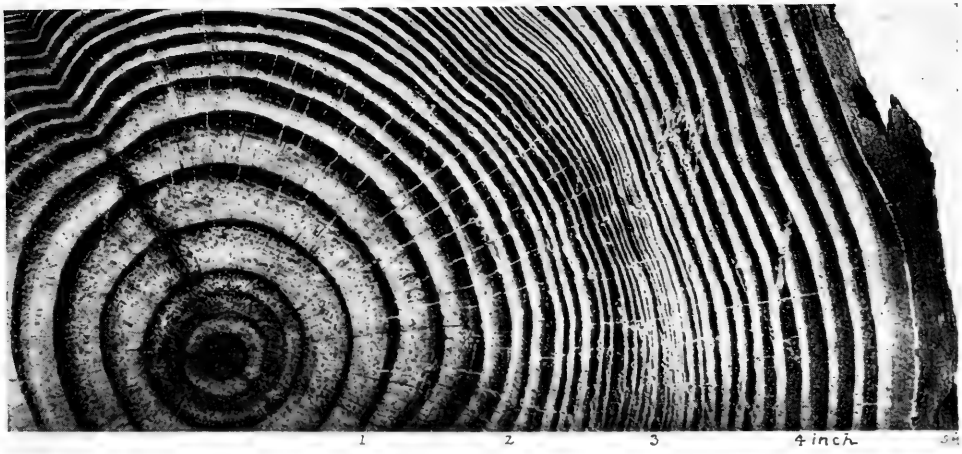
The wood of the loblolly or North Carolina pine is heavy, hard, strong, coarse grained, and decays rapidly in contact with the soil. It shrinks and checks considerably in drying. In kiln drying the shrinkage amounts to about 10 per cent of cross section (not length). From 3 to 4 per cent of the shrinkage is radial and 6 to 7 per cent is around the circumference. In air drying the shrinkage is less.* The shrinkage is greatest in the heavy sapwood from the base of young trees and least in the lighter heartwood from the tops of old trees. The wood, like that of all pine, swells again after commercial kiln-drying whenever exposed to dampness. The heartwood is yellowish to orange brown in color; the thick sapwood much paler. The soft spring wood in each annual layer is nearly white, while the very hard and tough summer band is dark brown, the contrast in color and hardness between these two layers being greatest near the stump and in the center of the log in young, thrifty trees which have formed no heartwood. Although the wood from the upper part of the stem is coarse grained, the summer band is very narrow. (Plate X, A.) Because of the great difference in density between the spring and summer wood coarse-grained boards, when planed, do not readily dress to a perfectly flat surface. On the other hand there is great adhesion between the two layers which reduces the tendency to split and sliver, so common in many coniferous woods.

*Bul. 99, U. S. Forest Service.

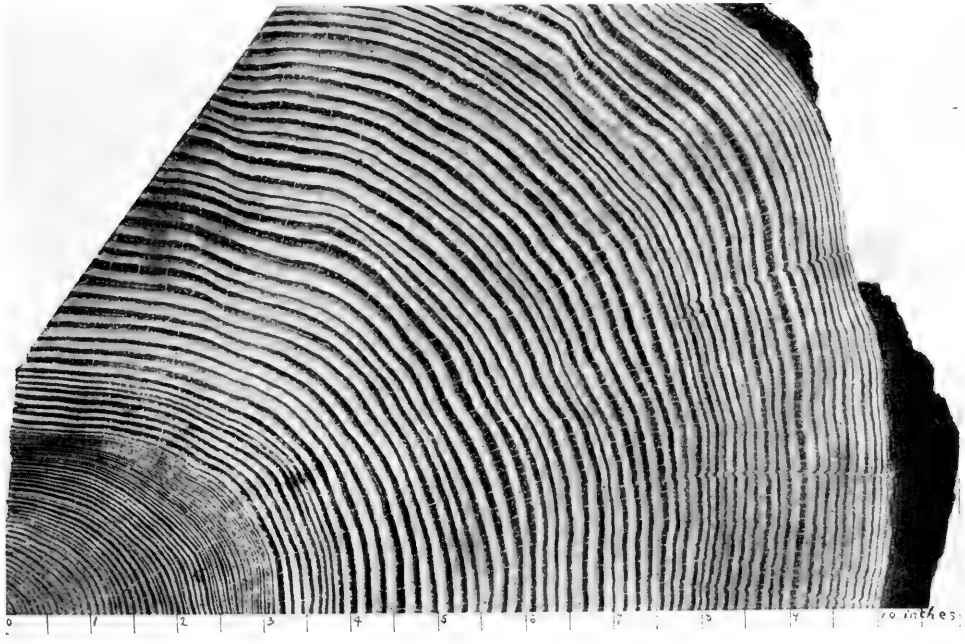
As would be expected from the rapid growth of the tree the wood is mostly coarse grained. Thrifty young trees frequently have as few as two rings to the inch near the center (Plate IX, A), while the sapwood of trees more than 100 years of age may exhibit less than ten rings to the inch. Lumber from second growth trees generally has from 5 to 8 rings of annual growth to the inch; that from large old trees from 7 to 10. Ten rings to the inch may be considered fine grained for this species. The green wood weighs about 45 pounds per cubic foot. The kiln-dried wood, average of the tree, weighs about 31 pounds to the cubic foot, the specific gravity being about .50. It is about five pounds per cubic foot lighter than that of the longleaf pine, five pounds heavier than that of white pine, and slightly heavier than that of the shortleaf pine of the Piedmont. But the wood varies considerably in weight. That from the lower part of the stem of trees which have hard, compact wood with wide summer wood in the annual ring (Plate IX, A) weighs more than 35 pounds per cubic foot; while that from the upper part of the stem of trees with narrow summer wood in the ring of annual growth weighs less than the average (Plate X, A), commercial wood being largely from the lower part of the stem averages about 33 pounds to the cubic foot for kiln-dried material. The green wood has a shipping weight of 4,200 pounds for 1,000 feet of inch boards, while the kiln-dried wood weighs about 3,100 pounds per 1,000 feet of inch boards. Moisture forms 50 per cent of the weight of fresh sapwood and about 25 per cent of the weight of the heartwood. While the wood is weaker (in proportion to its weight) in tensile, shearing, and bending strength than that of either longleaf pine or white pine, it is relatively stronger than that of the shortleaf pine. On account of its relative weakness it is not so desirable a wood as white pine for certain uses, such as doors and small packing boxes.

Heartwood begins to form between the twentieth and thirtieth years, earlier on good soils and in rapidly growing trees than on poor soils and in slowly growing intermediate or suppressed trees. The number of rings of sapwood does not remain the same throughout the life of the trees, but increases with age. A tree thirty years old is practically all sapwood, seldom having more than a small core of heartwood in the butt log. Trees one hundred years old have from 60 to 65 rings of sapwood, while trees 200 years old commonly have from 90 to 95 rings. Less than one-third of the volume of trees between seventy and one hundred years old is heartwood; and less than one-half of the volume of trees between 100 and 150 years old. Since the sapwood of this pine, on account of its clearness of knots, uniformly bright color, and freedom from pitch is esteemed for interior woodwork fully as highly as the heartwood, the large proportion of sapwood is considered advantageous rather than otherwise. (Plate XII, B.)

The wood is considerably less resinous than that of the longleaf pine, but more so than that of the shortleaf or white pine. Dr. Chas. H. Herty, the well-known authority on turpentine, says that the oleoresin



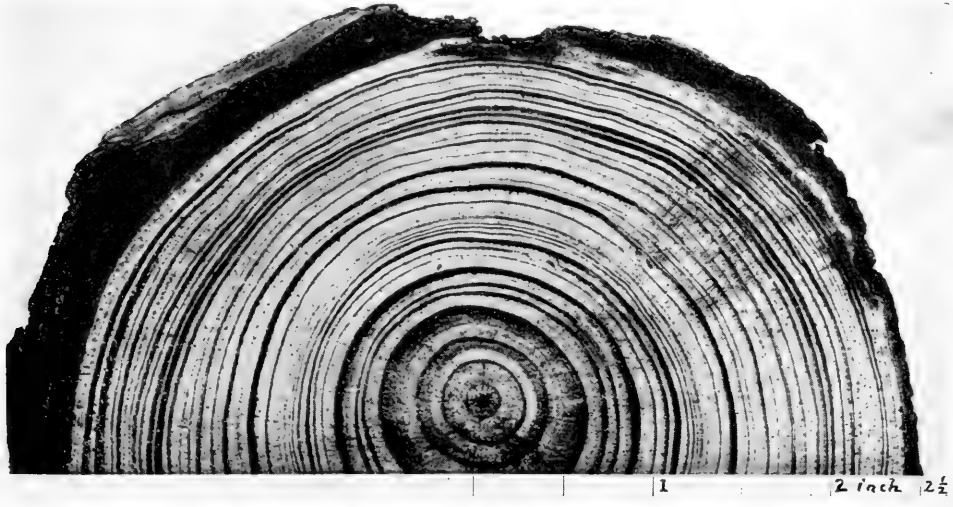
A. Type of wood from lower part of stem in old-field stand. The coarse-grained center indicates large knots. This tree became codominant or intermediate when about three inches on the radius. The diameter growth was slow on account of the crowding and the stem cleaned of branches. It was isolated by thinning when three and one-half inches on the radius. The stem at that time resembled that of one of the isolated trees shown on Plate XVI. As a result of this thinning the growth during the past ten years has been at the rate of one inch in diameter every three years. While the wood formed since thinning is coarse grained, it is clear and free from knots. The large amount of hard summerwood is characteristic for flatwoods soils. (Author's illustration.)



B. Characteristic wood from lower logs of trees in mixed stands, medium fine and even grained. The crown of this tree overtopped the hardwoods when it was about sixty years old (at 3.3 inches on the radius). Since this period the diameter growth has been at the rate of one inch every four years (seven and one-half rings to the inch of radius). This stem is practically free of knots for sixty feet and the wood is of high quality. Nearly the same result can be obtained by the method of cutting which is recommended for the best sites which seeks to develop the codominant and intermediate trees to form the mature stand, and by gradual cutting eventually to develop the best of the suppressed trees. Author's illustration.)

TYPES OF LOBLOLLY PINE WOOD.

A. Characteristic wood from middle and upper section of rapidly growing tree. The relatively small amount of hard summerwood in this portion of the stem is typical. (Author's illustration.)



B. Wood from tree growing on very wet soil, showing characteristic irregularity of grain. (Author's illustration.)

TYPES OF LOBLOLLY PINE WOOD.

(crude turpentine) of loblolly pine is closely allied in all of its properties to that of the longleaf pine, but the volatile oil evaporates from it very rapidly and consequently it is difficult to collect the material, as much of it remains in the solid condition on the scarified face of the tree. The relative proportions of volatile oil and resin are practically the same in this material as in that of the longleaf pine, but the total yield per season is much less from the loblolly or North Carolina pine. The commercial value of this tree for turpentine is discussed on page 53.

DEFECTS.

The most common defects in the wood are extreme coarseness of grain, lack of uniformity of texture, and large knots; pitch streaks and small pitch pockets, which, however, affect the grade of less than one-half of one per cent of the boards and are largely limited to butt logs; while in second growth trees, especially those from the open stands in old fields, there are large resinous, but tight knots. The wood is seldom affected by windshake or hollows. Redheart occurs in less than five per cent of the larger logs* and affects less than one per cent of the lumber which is sawed from second growth trees less than 50 years old. The proportion of redheart gradually increases with the age of the tree and is higher in trees grown on poor than on good quality sites.

The wood decays rapidly on exposure or in contact with the soil. When kiln-dried or even thoroughly air-dried, the coarse grained and more porous sapwood is readily impregnated with preservatives. The two most common methods are creosoting under pressure and impregnating with bichloride of zinc. The wood is attacked by several species of wood-destroying fungi when it is exposed to suitable moisture conditions, the sapwood being especially susceptible to such attacks. The most prevalent and destructive of these fungi are *Schizophyllum commune,* and the brown root, *Lenzites sepiaria,* which causes the rapid decay of damp undried wood and is particularly destructive to ties, piling, etc. *Merulius lacrimans* and *Coniophora cerebella* are reported as being destructive to large factory timbers, and *Polyporus vaporius* to sills and flooring near the ground. Various species of *Thelephoraceæ,* by attacking the sugar and starch in the cells of the sapwood, cause bluing of undried lumber. While bluing does not affect the strength of the wood, it lessens the value of sap lumber, which otherwise could be used for finish in natural grain. Immersion of the lumber in a solution of bicarbonate of soda in water prevent bluing, but it has been abandoned commercially where tried in favor of kiln drying.

*The large proportion of redheart logs which are cut in certain swamps is from the pocoson or black bark pine.

USES.

Loblolly pine lumber under the trade name of North Carolina pine is used for finishing, packing boxes and construction purposes. If sawn into boards the lumber is generally kiln dried and graded, a large part being reworked at the mills into finished products. The clearer grades are used for flooring, especially when rift sawn (6 to 12 annual layers to the inch particularly suitable) for which use it is especially adapted on account of the fact that it slivers less than most of the pines, for ceiling, interior woodwork, styles and panels of doors, for blinds, sashes, weather boarding and trimmings, and the lower grades for box stock, framing and scantling, bridge, factory,* and heavy construction work. It has extensively taken the place of white pine or has supplemented it for structural uses, being found in all markets from Pittsburg and North Tonawanda to Boston and certain ports in Maine. The exports have likewise been steadily increasing, going chiefly to English and German ports.

It enters extensively into car construction, particularly for siding and roofing, and into ship, boat and barge construction. A large amount of medium and low grade stock is used for box-making, slack cooperage, and headings, and it is now one of the best recognized woods in the box and slack cooperage trades. Slabs are resawn into lath and copper sticks for smelter use, and cut on a horizontal band saw into heading and crate stock. A small though constantly increasing amount is used both treated and untreated for mine timbers, chiefly in the anthracite fields of eastern Pennsylvania. Mine timber is sold by the ton, from 4 to 5 tons of green timber being required to produce 1,000 board feet log scale. The price per ton, green at Norfolk, depending upon the size of the timber, varies from $1.50 to $3. It is also cut into veneers, the lower grades being used for fruit and vegetable crates, barrel and keg stock, drawer bottoms, and the backs of cheap furniture. It is being used to a limited extent for chemical paper pulp stock, and this is doubtless one of the most important undeveloped uses for the wood. On account of the resin it cannot be used for ground fiber pulp and for this reason cannot compete successfully with spruce in the manufacture of newspaper and cheap book paper. On account of its great weight, however, unbleached papers can be successfully made. The wood fibers are very long, strong, thickwalled and tough which permits the manufacture of very superior wrapping, kraft and imitation Manila papers which are stronger than the real Manilas. The wood can be treated by

*Dense wood to meet the proposed yellow pine grading rules for factory structural timber must have between the third and fourth inches from the pith one-fourth of the volume summer wood if there are eight rings to the inch; one-third if there are six or seven rings to the inch; and one-half if the wood averages four rings to the inch. The wood shown in Plate VII, A and B meets these specifications. Such wood is produced on the best class of flatwoods soils. (See Loblolly pine on longleaf pine flat lands). The Panama Canal requires only six rings to the inch between the third and fourth inches. The Georgia-Florida Sawmill Association requires a minimum of six rings to the inch between the third and fourth inches and one-third summer wood.

the soda or sulphate processes to effect the destruction or partial destruction of the resin and disintegration of the fiber; or after being chipped the resin can be distilled off. There is a loss in weight by these processes of about 50 per cent; consequently a cord (128 feet) of peeled wood weighing about 3,000 pounds will make only about 1,500 pounds of paper. At present comparative prices of kraft paper and No. 4 lumber, low grade timber is more profitably converted into paper than into lumber since the very knotty tops can be utilized by the chemical pulp processes. A mill at Roanoke Rapids is now employing such a process in the manufacture of kraft paper for wrapping purposes.

While the wood of loblolly pine is less suitable than that of spruce for the manufacture of composition board on account of the great loss in weight resulting from the necessity of using a chemical process to disintegrate the fibers, it is, on account of its cheapness and great weight, being successfully employed for this purpose. A plant for the manufacture of composition board is also in operation at Roanoke Rapids.

It is also being used for the production of wood alcohol, the resin being first distilled after which the alcohol is produced. A large plant for the production of wood alcohol from sawdust and waste has recently been erected at Georgetown, S. C. The waste can also be used for the production of producer gas. This is a recent process the employment of which will enable a large amount of power to be obtained from mill waste in excess of the requirements of the sawmill plant.

North Carolina pine is extensively used for cross arms for electric wires, wire poles and for light railroad ties, being well suited for these uses after treatment with preservatives. On account of its softness and susceptibility of abrasion it can not be used as a tie for heavy traffic without a tie plate. Near the coast the timber is extensively used for piling; sticks of timber exceeding 100 feet in length being occasionally required for this use. Treated with preservatives it is being used for street paving blocks, the heavy types of wood with not less than 8 rings to the inch being required. It is very extensively used throughout the coastal plain for fuel for manufacturing as well as domestic use, and to some extent for charcoal. Near towns such mill waste as is otherwise unusable is converted into fuel billets and kindling wood.

COMMERCIAL VALUE FOR TURPENTINE.*

The loblolly pine exudes an oleoresin when wounded, which is occasionally in fairly remunerative quantities, but as a rule the yield of crude turpentine is so much less than from the longleaf and Cuban pines (the common commercial sources of crude turpentine) that no general tapping of this tree is practiced.

The oleoresin exudes from the wounded tree as clear limpid drops. However, crystallization of the dissolved acids takes place very rapidly, so that much of the material remains sticking upon the scarified surface

*This section has been prepared by Dr. Chas. H. Herty, of the University of North Carolina.

of the tree as "scrape." This unusually rapid crystallization of the mass leads to the consequent rapid evaporation of its content of spirits of turpentine. Analysis of the perfectly fresh oleoresin shows a normal amount of spirits of turpentine, but the collected gum, after standing several weeks in the receptacles, as in ordinary practice, shows a much lower per cent of volatile oil. For this reason it seems quite probable that if this pine is ever to be utilized on any large scale as a source of crude turpentine the usual methods employed in gathering must be materially modified.

An analysis of the crude turpentine from the first four weeks of chipping in July showed 17.58 per cent of spirits of turpentine, the collection at the end of four more weeks of chipping showed only 14.11 per cent. The spirits of turpentine thus obtained was found to have properties identical with those of commercial spirits of turpentine. The oleoresin is characterized by an unusually small amount, 4.2 per cent, of unsaponifiable matter. The rosin left after distillation of the spirits of turpentine resembles closely commercial rosin and has an acid number of 172.

GROWTH.

The growth of loblolly varies considerably with the character of soil. In accordance with the rapidity of growth there may be recognized three quality classes which are determined by the character of the soil or site. The maximum* figures of growth and yield are those for better conditions than Quality Site I, and the minimum for poorer conditions than Quality Site III. Both the maximum and minimum figures, however, are averages of stands both better and poorer than the figures indicate. The figures of growth which are given for any quality site are averages which embrace stands having a considerable range both above and below these figures, the limit of range being approximately one-half the interval between a given Quality class and those next to it.†

Quality Class I. This class includes stands of loblolly pine that make rapid growth and produce very heavy yields per acre. These are found on loams, sandy loams, and clay loams (particularly those desig-

*Details of several of the best stands are given below:

One-fourth acre had a stand 120 years old the yield of which was at the rate of 12,760 cubic feet of stem wood without bark, and 71,600 board feet mill cut $\frac{1}{7}$ inch kerf. The total number of trees per acre was at the rate of 216; basal area including bark, 284 square feet; average diameter of the trees 15.5 inch; and average height of dominant trees 115 feet. (Lenoir County.)

Another excellent stand which had an average age of not more than 60 years, had a cubic volume of 9,900 feet of stem wood without bark per acre, 54,200 board feet mill cut, $\frac{1}{7}$ inch kerf; basal area outside of bark of 233 square feet; and contained 180 trees 6 inches and over, which had an average diameter of 16.6 inches. The dominant trees were 120 feet high. (Washington County.)

The best young stand, 29 years old, was in an old field stand on a moist site in Pitt County. The total cubic volume per acre was 7,480 feet of stem wood without bark; the board measure volume $\frac{1}{7}$ inch kerf, 37,277 feet; and basal area outside of the bark 249 square feet. There were 320 trees per acre having an average diameter of 11.9 inches. The average height of dominant trees was nearly 80 feet.

†The figures which are given for number of trees per acre, height of stand of dominant trees, volume in board feet or cubic feet, and basal area per acre for stands on different quality sites at different ages, are averages which would embrace stands having a considerable range both above and be-

nated as the Portsmouth soil series of the Bureau of Soils of the U. S. Department of Agriculture) in which the water table seldom sinks more than 12 feet below the surface during the growing season, yet which on account of surface drainage or porosity are never flooded for prolonged periods; alluvial lands, particularly those with loamy soils

low this average. The wide limits of such variations are shown below in a list of stands of different ages, which were referred to Quality II. A (*) indicates stands which seemed to be under-stocked; a (‡) stands which seemed to be excessively crowded; stands which have been thinned are indicated by (†). Basal area refers to the area of the cross section (inside or outside of bark) at breasthigh of all trees on an acre.

Quality II Stands, Showing Range of Variation in Average Diameter, in Volume, Basal Area and Number of Trees Per Acre.

Age of stand Years	Height of dominant trees Feet	Average Diameter breasthigh of all trees 3″ and over Inches	Volume per acre		Number of trees 3″ and over Per acre	Basal area per acre Square fee
			Cubic feet, wood only	Board feet, 1-7″ kerf		
22	45	5.7	2,247	5,120	836	†146
22	50	4.4	2,437	2,536	1,364	146
23	50	4.9	2,367	2,526	1,076	142
26	50	4.9	2,568	6,211	1,173	156
30	54	6.3	3,128	10,600	800	172
30	63	6.4	2,893	12,362	559	*128
32	62	7.3	3,628	14,928	544	156
34	69	9.1	4,926	23,240	410	‡188
35	78	7.4	4,538	21,692	519	152
35	68	10.9	4,553	21,905	260	*168
35	72	10.0	5,310	26,344	348	‡188
35	74	8.7	4,554	24,432	400	166
37	70	9.1	4,241	20,330	360	161
38	74	9.4	5,918	29,550	440	‡212
38	71	7.7	4,299	19,680	480	154
43	85	9.0	4,619	24,730	319	*142
44	85	10.0	5,096	26,779	292	*156
44	85	10.4	5,732	27,374	310	182
45	87	11.2	6,610	34,100	290	200
51	90	15.7	6,575	33,813	140	187
52	87	9.5	6,544	32,290	410	‡202
55	85	10.3	5,617	28,774	285	176
60	89	10.7	6,348	32,400	306	193
60	90	12.8	6,277	32,203	203	†183
62	92	10.1	6,353	32,309	333	183
64	97	13.5	7,581	39,715	210	208
75	94	15.5	7,182	39,958	144	192
80	110	15.8	9,748	52,888	160	225
80	113	15.7	7,896	43,745	132	176
88	109	12.4	7,329	39,513	206	‡173
100	98	17.2	6,910	39,037	110	*177
110	105	15.5	7,633	41,181	151	197

The relation of number of trees, and average diameter to yield in board feet is shown by a comparison of the two 22-year old stands and the 60 and 62 year old stands. Some of the stands given as Quality II approach Quality I, others approach Quality III. The second 38-year old stand closely approaches Quality III. The 80-year old stands approach Quality 1.

which are subject to flooding for only a few days at a time; moist peaty soils, where the peat is in process of humification and along the margin of swamps.

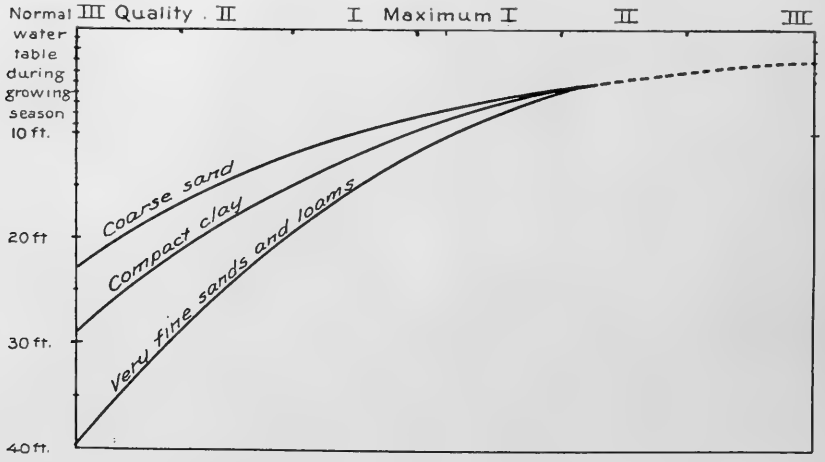


Fig. 5. Relation between loblolly pine quality sites and depth of water table in soils of different texture. (Author's illustration.)

Quality Class II. This class embraces the stands of medium growth on the great body of the upland soils of eastern North Carolina. The soils of this quality class include the greater portion of the flat woods (consisting of the more level tracts of Norfolk fine sands, loams, and silts, as designated by the Bureau of Soils) the Selma silt and Selma loam, with the water table usually about 20 feet below the surface, formerly largely occupied by the longleaf pine; compact clays occupied by hardwood swamps; the rolling loams and clay loams of the Norfolk series, largely north of the Roanoke River and in Chowan, Gates, and Northampton counties, formerly partly occupied by shortleaf pine. The usual depth of the water table in these soils is from 20 to 25 feet below the surface. It is lowest for this quality in the fine grained sands and loams.

Quality Class III. This includes loblolly pine stands of very slow growth. The soils characteristic of these are the better drained parts of the flat woods, particularly the areas with compact clay soils (characterized by roundleaf blackjack oak and post oak); the rolling piney lands and the Piedmont uplands; the savannas, edges of pocosons, sand hills, and swamps subject to prolonged overflow, or difficult to drain. The upland soils as a rule have the water table during the growing season from 20 to 45 feet below the surface. The soils of some of the poorly drained areas (very level clays, silts and peats are frequently saturated for long periods during the growing season, alternating in the case of clays with periods of semi-drought on account of the large

Fully-stocked stand thirty-five years old, Quality II, in old field on upland of good quality, following oak, hickory and shortleaf pine. The density is good; the growth, however, is beginning to decline, and the stand would be much benefited by a thinning. (Author's illustration.)

amount of hygroscopic water held by heavy clays which is not available for plant growth.

Old Field Stands. The old field stands on very sandy uplands and on clay uplands, particularly those on the Piedmont red clays (Cecil soil series) when young fall for the most part into Quality I or Quality II, but their rate of growth declines rapidly after a few decades, sometimes before the end of the second decade, and they eventually fall into Quality III. The chief cause for this is that the demands of the stand upon soil moisture soon reach the limits of available supply. Moreover, on the upland clays the top soil in the old cultivated fields is at first loose, permitting the roots freely to penetrate it, and has a high moisture carrying capacity. In a few years this soil becomes more compact and its water carrying capacity declines. This checks the growth of the lateral roots and as the taproot descends deeper into the unbroken layer which has never been disturbed by the plow, the rate of growth of the tree declines.

DETERMINATION OF QUALITY SITES.

The rate of height growth or the height of dominant trees at a given age in fully stocked groups is the most ready method of ascertaining the quality site when there is growing timber (Table 13). It is desirable in the case of middle-aged or old stands to correlate height with volume and basal area per acre (Table 35), relative height, relation of diameter to total height (Table 15). In the case of young stands especially on dry upland sites all of these are unreliable factors for predicting the capacity of the soil to sustain old stands and they should be supplemented by ascertaining the texture of the soil and depth of water table. The original forest type where indications of it remain should be examined to determine the undershrubs and to compare with Table 1. Abundance of particular undershrubs is a general guide to this extent; a rank growth of gallberry (*Ilex glabra*) indicates a site highly favorable for the rapid growth of the pine; wire grass (*Aristida stricta*) and low bush black huckleberry (*Vaccinium tenellum*) indicates sites which are becoming too dry; sphagnam mosses and evergreen fetter bush (*Andromeda* or *Pieris nitida*) sites which are becoming too wet. The approximate relation of the height of the water table in different kinds of soil to the quality site for loblolly pine is shown in Figure 3 which gives the results of a preliminary study of these important problems. The impossibility of depending solely upon height at younger ages for interpreting quality site is illustrated in the stand which is presented in Tables 14, 18 and 20, column 4. The rapid diameter and height growth of this stand during the early decades is followed during the fifth decade by an abrupt decline which is reflected by an equally abrupt culmination in the volume of the stand. On the other hand, the growth of the trees in column 1 in the same tables shows a slower but sustained rate of height growth, while the decline does not begin until a much later period.

Since loblolly pine normally grows in a large part of its range in pure even-aged stands or groups, there is given not only the rate of growth of trees as individual specimens but also the growth and development of the average tree in even-aged stands, and the growth of the average tree of each of the different crown classes, dominant, intermediate, and suppressed.*

GROWTH IN HEIGHT.

Loblolly pine attains on an average a height of about only two feet during the first two to four years. After that it at once begins to grow rapidly in height. The stage of rapid growth lasts until the thirtieth or fortieth year on best sites and until the fiftieth or even sixtieth year on inferior sites. Table 13 gives the heights of the different crown classes in fully stocked unthinned stands at different ages on different quality sites and the periodic annual growth. The periodic annual growth which is the annual growth during five-year periods shows that after the fiftieth year the growth in height is less than one foot a year.

*The dominant trees in a stand are such as overtop, even slightly, all others and whose large crowns are in full sunlight; intermediate trees are lower in height than the dominant and have slender stems and narrow, compressed crowns which receive only a scant amount of direct sunlight; suppressed trees are entirely overtopped and receive only such sunlight as filters through the foliage of the taller trees. Dominant trees are making most rapid growth both in height and diameter; intermediate trees are yet making rapid height growth, but their diameter growth has fallen behind; suppressed trees are making very little growth either in height or diameter.

TABLE 13.—HEIGHTS OF ALL DOMINANT, INTERMEDIATE, AND SUPPRESSED TREES SIX INCHES AND OVER IN DIAMETER IN FULLY STOCKED STANDS OF LOBLOLLY PINE ON DIFFERENT QUALITY SITES; AND PERIODIC ANNUAL GROWTH OF DOMINANT TREES.

Age of stand Years	Quality I			Quality II			Quality III			Periodic annual growth of dominant trees (for preceding interval)		
										Quality		
	Dominant	Intermediate	Suppressed	Dominant	Intermediate	Suppressed	Dominant	Intermediate	Suppressed	I	II	III
	Height—Feet											
20	56	51	43	44	39	34	32	29	26	2.8	2.2	1.6
25	66	59	51	53	47	41	40	36	32	2.0	1.8	1.6
30	75	68	58	61	54	48	47	43	38	1.8	1.6	1.4
35	82	75	64	68	61	54	53	49	43	1.4	1.4	1.2
40	89	81	70	74	67	59	59	54	48	1.4	1.2	1.2
45	94	87	75	79	72	63	65	59	52	1.0	1.0	1.2
50	99	91	78	84	76	67	70	63	55	1.0	1.0	1.0
55	103	94	80	88	80	70	74	67	58			
60	106	97	81	91	83	72	77	70	61			
65	108	98	84	94	85	74	81	72	63			
70	110	100	86	96	87	75	83	74	64			
75	112	101	87	97	89	76	85	76	65			
80	113	101	88	98	90	77	86	78	66			
85	114	102	89	99	91	78	87	79	67			
90	115	102	89	100	92	79	88	80	68			
95	116	103	90	101	92	79	89	81	69			
100	117	103	90	102	93	79	90	82	69			
105	118	104	91	103	94	80						
110	118	104	91	103	94	80						
115	119	105	91	104	95	80						
120	120	105	91	104	95	80						
125	121	105	91									
130	122	106	91									

Table 14 gives the height of trees in fully stocked stands for different diameters on different site classes.

On best sites in pure stands height growth reaches its maximum rate between the seventh and fifteenth years. Dominant trees in such groups during this period will often make a growth of four feet a year for several years, while the average rate of height growth during this period on all sites of the first quality is nearly three and one-half feet a year. During the second decade the growth averages three feet a year. On poorer sites the rate of height growth culminates later. On sites of Quality III, culmination does not take place until between the eighteenth and thirtieth years.

Single trees and small groups of trees growing among hardwoods on stiff clay soils attain the maximum rate of growth very late, between the thirtieth and fortieth years, and the same is true of some groups growing on the most unfavorable sites (Table 14, columns 1 and 6). The growth on old fields on the uplands is rapid at first but decreases after the fortieth year; such old field stands, therefore, if old, have an average rate of growth characteristic of slow growing stands. This is well illustrated by the growth of loblolly pine on cultivated soil on a very sandy, well drained knoll in the midst of a longleaf pine forest (Table 14, column 4). Thus, the average annual growth in height during the first decade was 2.1 feet, during the second decade 2.7 feet, the third decade 2.4 feet, the fourth decade 1.0 feet, and the fifth decade .3 feet.

The growth on very wet sites, as may be seen from the growth of the loblolly pine in mixture with cypress and black gum of the same age, is slow. (Table 14, column 6.) The pine, however, had slightly outgrown in height the black gum and the cypress. The soil is a loamy sand, covered with one or two feet of flowing water during most of the winter and spring and often for a few days at a time during the growing season.

The growth of the pine on the best alluvial soil in even-aged groups where the competition for the light is keen is very rapid (Table 14, column 2).

The growth given in Table 14 is the average growth of suppressed, intermediate and dominant trees. Single dominant trees therefore have a much better growth, while intermediate and suppressed trees have a much slower growth than that of the average tree.

Table 15 gives the relation of diameter to height, the merchantable length of trees of different diameters on different quality sites, and the per cent of merchantable length to total height. Top diameters of merchantable length are given in Tables 24 to 31.

TABLE 14.—HEIGHT GROWTH OF LOBLOLLY PINE ON DIFFERENT SITES.

Age of stand Years	Quality					
	I	I	III	II	III	II
	(1) Mixed with hardwoods. Moist, stiff clay soil. Stand crowded	(2) Best moist, loamy, alluvial soil. Stand fairly open	(3) Longleaf and pocoson pine flat lands. Stand fairly open	(4) Oldfield on a longleaf pine sandhill. Stand crowded	(5) Dry silt sand flats Stand fairly open	(6) Mixed with cypress in deep swamps. Stand crowded
	Feet					
10	7	20	11	21	7	9
20	20	47	26	48	11	29
30	38	68	45	72	17	43
40	60	85	62	82	25	56
50	75	99	71	85	32	67
60	85	109	77	----	37	78
70	93	116	82	----	----	88
80	101	----	85	----	----	95
90	107	----	87	----	----	101
100	111	----	90	----	----	----
120	119	----	95	----	----	----
140	126	----	99	----	----	----
160	131	----	102	----	----	----
180	134	----	106	----	----	----
200	137	----	108	----	----	----
240	140	----	----	----	----	----

TABLE 15.—RELATION BETWEEN THE TOTAL HEIGHT AND DIAMETER BREASTHIGH ON DIFFERENT QUALITY SITES. MERCHANTABLE LENGTH OF LOBLOLLY PINE.

Diameter breasthigh	Quality I				Quality II				Quality III			
	Total height of tree	Ratio of diameter to total height	Merchantable length	Per cent of merchantable length	Total height of tree	Ratio of diameter to total height	Merchantable length	Per cent of merchantable length	Total height of tree	Ratio of diameter to total height	Merchantable length	Per cent of merchantable length
Inches	Feet		Feet		Feet		Feet		Feet		Feet	
2	19	114			16	96			14	84		
3	27	108			24	96			21	84		
4	36	108			32	96			28	84		
5	45	108			40	96			35	84		
6	53	106	12	19	47	94	11	21	42	84	10	24
7	60	103	17	28	54	93	16	30	48	82	16	33
8	67	101	24	36	61	91	21	34	55	83	20	36
9	73	97	31	42	67	89	28	42	60	80	26	43
10	79	95	39	49	72	86	34	47	66	79	31	47
11	84	92	46	55	77	84	41	53	70	76	36	51
12	89	89	54	61	82	82	47	57	74	74	41	55
13	93	86	60	65	85	78	53	62	78	72	46	59
14	97	83	66	68	89	76	58	65	82	70	50	61
15	101	81	71	70	92	74	62	67	84	67	54	64
16	104	78	75	72	95	71	65	68	87	65	57	66
17	107	76	78	73	98	69	67	68	89	63	59	66
18	110	73	80	73	100	67	69	69	91	61	60	66
19	112	71	82	73	102	64	70	69	92	58	61	66
20	115	69	83	72	104	62	71	68	93	56	62	67
21	117	67	85	73	105	60	72	69	94	54	63	67
22	119	65	86	72	107	58	73	68	95	52	63	66
23	121	63	87	72	108	56	74	69	95	50	64	67
24	123	62	88	72	109	55	75	69	96	48	64	67
25	124	60	89	72	110	53	75	68	97	47	64	66
26	125	58	90	72	111	51	76	68	98	45	65	66
27	127	56	90	71	112	50	77	69	98	44	65	66
28	128	55	91	71	112	48	77	69	98	42	65	66

GROWTH IN DIAMETER.

Table 16 shows the average growth in diameter at breast height of all trees (6 inches and over), the diameter growth of dominant trees in fully stocked unthinned stands, the diameter growth of dominant trees in open stands, and the number of years required to grow one inch in diameter.

All the diameter measurements of standing trees, unless otherwise stated, were taken at a uniform height of 4 feet 6 inches from the ground called "breastheight." Breasthigh measurements made outside of the bark are a better guide for determining the growth in diameter than stump measurements, as in this way the variations due to the height of the stump and butt swellings are eliminated.

It is often desirable to convert diameter at stump height inside of bark to diameter at breastheight outside of bark. This relation is shown in Table 17. It can be used in obtaining the breasthigh diameter from stumps on cut-over land. (Also, see Table 8.)

The culmination of the diameter growth often takes place as early as during the first decade and seldom later than in the fourth decade.

Table 18 shows the diameter growth on stumps by decades for typical groups on different sites. Column 1 shows the diameter growth of a crowded group of loblolly pines mixed with hardwoods on moist stiff clay soil. The growth in diameter does not culminate until between the thirtieth and fortieth years; the growth is so persistent that at the age of 130 years it amounts to nearly 1.5 inches for the decade. The rate of diameter growth, however, is much less than that of the open stand given in column 2, which shows a group of trees on loose loamy soil on the edge of a pond, near Howard, Bertie County. It is an excellent example of persistent and rapid diameter growth, the increase between the eightieth and ninetieth years amounting to nearly 1.8 inches on the stump. Similar, if not better, results can probably be obtained from all stands of Quality I, provided they are properly thinned. (Plate IX, B.)

TABLE 16.—GROWTH IN DIAMETER, ON DIFFERENT QUALITY SITES, OF ALL TREES SIX INCHES AND OVER, AND OF DOMINANT TREES SIX INCHES AND OVER IN DIAMETER IN FULLY STOCKED STANDS; OF DOMINANT TREES IN OPEN STANDS; AND THE NUMBER OF YEARS REQUIRED TO GROW AN INCH.

Age of stand	Fully stocked stands				Open stands Dominant trees	
	All trees		Dominant trees			
Years	Diameter Inches	No. of years to grow an inch	Diameter Inches	No. of years to grow an inch	Diameter Inches	No. of years to grow an inch
			Quality I			
20	7.1		7.6		10.8	
25	8.2	4	9.1	3	12.7	3
30	9.3	5	10.4	4	14.2	3
40	11.4	5	13.2	4	16.9	4
50	13.2	6	15.7	5	19.2	4
60	14.8	6	17.4	6	21.0	5
70	16.1	7	18.8	6	22.6	6
80	17.3	8	20.0	7	24.0	6
90	18.3	10	21.2	8	25.3	7
100	19.1	11	22.3	9		
			Quality II			
20	6.4		6.5		8.2	
25	7.5	5	7.8	4	9.4	3
30	8.5	5	8.8	4	10.6	3
40	10.3	6	10.8	5	13.0	4
50	11.9	6	12.8	5	15.2	5
60	13.2	7	14.5	7	16.9	6
70	14.3	9	15.9	8	18.4	7
80	15.3	10	17.0	9	19.7	8
90	16.2	11	18.1	9	20.8	9
100	17.0	12	19.1	10		
			Quality III			
20	6.1		6.2		6.9	
25	6.8	6	7.2	5	8.0	4
30	7.6	6	8.2	5	9.1	5
40	9.1	7	10.0	6	11.1	5
50	10.5	8	11.7	6	12.8	5
60	11.7	9	13.1	7	14.3	7
70	12.7	10	14.3	8	15.7	7
80	13.6	11	15.4	9	17.0	8

TABLE 17.—DIAMETER BREASTHIGH OUTSIDE THE BARK OF LOBLOLLY PINE AND THE CORRESPONDING STUMP DIAMETER INSIDE THE BARK.

Diameter breasthigh outside bark	Average height of stump		Stump diameter inside of bark	Difference between the stump and breasthigh diameter
Inches	Feet	Inches	Inches	Inches
8	1	1	8.2	.2
9	1	1	9.0	.0
10	1	2	9.9	.1
11	1	3	10.9	.1
12	1	4	11.8	.2
13	1	5	12.7	.3
14	1	6	13.6	.4
15	1	7	14.4	.6
16	1	8	15.3	.7
17	1	9	16.2	.8
18	1	10	17.1	.9
19	1	11	18.0	1.0
20	2	0	18.9	1.1
21	2	1	19.8	1.2
22	2	2	20.7	1.3
23	2	3	21.6	1.4
24	2	4	22.4	1.6
25	2	5	23.3	1.7
26	2	6	24.2	1.8
27	2	7	25.1	1.9
28	2	8	26.0	2.0
29	2	9	26.9	2.1
30	2	10	27.9	2.1

Column 4, Table 18, shows the diameter growth of a pure stand in an old field on soil quite similar to that on which the group in column 3 was growing, except that the soil was previously cultivated. The culmination in diameter took place at the end of the first decade, with a growth for the decade of nearly 8 inches; but the subsequent decrease in growth is so rapid, that between the fifth and sixth decades it is only .4 of an inch. This manner of growth is characteristic of the dry old fields. The rate of diameter growth of trees on longleaf and pocoson pine flat lands (column 3), like the height growth of these species on the same site, is slow but persistent. As the trees stand well apart, the crowns are well developed and the diameter growth is at a maximum for this condition.

TABLE 18.—DIAMETER GROWTH OF LOBLOLLY PINE ON DIFFERENT SITES INSIDE THE BARK ON STUMPS ABOUT TWO FEET HIGH.

Age of stand on the stump Years	Quality I (1) In hardwoods on moist, stiff clay soils. Stand crowded	I (2) On loose moist, loamy soil on edge of pond. Stand fairly open	III (3) On longleaf and pocoson pine flat land. Stand fairly open	II (4) Old field on a longleaf pine sand hill. Stand crowded	III (5) On dry silt sand flats following longleaf pine. Stand open	II (6) Mixed with cypress in deep swamps. Stand crowded
	Inches					
10	1.8	5.2	2.8	7.8	1.4	----
20	4.3	10.7	4.9	10.9	3.0	----
30	8.0	15.2	6.6	12.6	4.5	----
40	11.4	19.1	8.6	13.6	5.9	10.0
50	14.3	22.0	10.2	14.2	7.2	11.3
60	16.8	24.4	11.0	14.6	8.2	13.0
70	19.3	26.5	13.2	----	9.0	14.4
80	21.5	28.3	14.6	----	----	16.2
90	23.7	30.0	16.0	----	----	17.5
100	25.7	----	17.2	----	----	----
120	28.9	----	19.2	----	----	----
140	31.5	----	20.7	----	----	----
160	33.7	----	22.0	----	----	----
180	35.0	----	23.3	----	----	----
200	36.1	----	24.0	----	----	----
240	37.0	----	----	----	----	----

GROWTH IN VOLUME.

Cubic Feet.

As both height and diameter growth of loblolly pine are most rapid in early youth, the greatest per cent of volume increment is made during this period. The contents in cubic feet of the stem of a tree without bark or branches, at different ages, is the best index of the rate of growth in total volume. The growth of the stem of the trees of loblolly pine in cubic feet in different quality classes is given in Table 19. The growth in cubic feet of trees in stands on different sites is given in Table 20.

Board Feet.

The volume in board feet increases at a more rapid rate than the volume in cubic feet on account of the greater proportion of convertible material in timber of large diameter than in small. The volume in board feet of the dominant trees in stands at different ages is given in Table 21 by Doyle-Scribner rule, and on the basis of actual mill cut 1-7 inch saw kerf band-sawed. The volume of trees on different sites at given ages is given in Table 22. It is probable that the rapid increase

in merchantable volume shown by the fairly open stand on the best, moist, alluvial soil can be secured from a large portion of stands of Quality I by proper thinning.

TABLE 19.—GROWTH OF LOBLOLLY PINE IN CUBIC FEET (MERCHANTABLE STEMWOOD PEELED) AND IN CORDS (STEMWOOD PEELED AND SPLIT) AVERAGE OF ALL TREES SIX INCHES AND OVER IN DIAMETER IN FULLY STOCKED STANDS ON DIFFERENT QUALITY SITES.

Age of stand Years	Height Feet	Diameter breast-high Inches	Volume Cubic feet	Volume Long cords
		Quality I		
20	56	7.1	5.0	.05
25	66	8.2	8.8	.08
30	75	9.3	13.2	.12
40	90	11.4	23.7	.21
50	99	13.2	34.8	.31
60	106	14.8	46.7	.41
70	110	16.1	57.8	.51
80	112	17.3	68.2	.60
90	114	18.3	77.4	.69
100	115	19.1	85.0	.75
		Quality II		
20	44	6.4	3.1	.03
25	53	7.5	5.3	.05
30	61	8.5	8.3	.075
40	74	10.3	16.1	.14
50	84	11.9	24.2	.21
60	90	13.2	32.0	.29
70	95	14.3	39.6	.35
80	98	15.3	47.2	.42
90	100	16.2	54.4	.48
100	101	17.0	60.5	.54
		Quality III		
20	32	6.1	2.0	.02
25	39	6.8	3.0	.03
30	46	7.6	4.5	.04
40	59	9.1	9.1	.083
50	69	10.5	15.5	.14
60	76	11.7	21.9	.19
70	82	12.7	27.3	.24
80	85	13.6	32.2	.29

TABLE 20.—GROWTH OF LOBLOLLY PINE ON DIFFERENT SITES IN VOLUME (CUBIC FEET) EXCLUSIVE OF STUMP, TOP, AND BARK.

Age of stand Years	Quality					
	I	I	III	II	III	III
	(1) Groups of trees in hardwoods on moist stiff clay soil. Stand crowded	(2) On loose moist, loamy soil on edge of pond. Stand open	(3) On long-leaf and pocoson pine flat lands. Stand fairly open	(4) Old field on long leaf pine sand hill. Stand crowded	(5) On dry sandy flats following longleaf pine. Stand fairly open	(6) Mixed with cypress in deep swamps, always wet. Stand fairly open
	Cubic feet					
10	2.0	3.0	----------	----------	----------	----------
20	2.8	16.0	3.5	8.0	----------	1.0
30	5.2	42.0	6.0	22.0	1.7	3.0
40	11.5	68.0	12.0	33.0	2.5	8.0
50	23.0	96.0	20.0	40.0	5.3	16.0
60	44.0	133.0	29.0	45.0	11.0	29.0
70	69.0	177.0	40.0	----------	17.4	44.0
80	97.0	217.0	51.0	----------	----------	59.0
90	126.0	257.0	62.0	----------	----------	76.0
100	157.0	----------	74.0	----------	----------	----------
120	218.0	----------	96.0	----------	----------	----------
140	277.0	----------	120.0	----------	----------	----------
160	338.0	----------	145.0	----------	----------	----------
180	383.0	----------	168.0	----------	----------	----------
200	427.0	----------	190.0	----------	----------	----------

TABLE 21.—GROWTH IN BOARD FOOT VOLUME, BASED ON ACTUAL MILL CUT WITH 1-7 INCH KERF AND ON DOYLE-SCRIBNER RULE, OF DOMINANT TREES SIX INCHES AND OVER IN CROWDED STANDS; OF DOMINANT TREES IN OPEN STANDS, AND AVERAGE OF ALL TREES IN OPEN STANDS ON DIFFERENT QUALITY SITES. NO ALLOWANCE FOR DEFECT, WASTE OR BREAKAGE IN LOGGING.

Age of Stand	Height of Dominant Trees	Dominant Trees—Crowded Stands			Dominant Trees—Open Stands			All Trees—Open Stands		
		Diameter	Volume		Diameter	Volume		Diameter	Volume	
			1-7″ kerf	Doyle-Scribner		1-7″ kerf	Doyle-Scribner		1-7″ kerf	Doyle-Scribner
Years	Feet	Inches	Board Feet		Inches	Board Feet		Inches	Board Feet	
Quality I										
20	56	7.6	27	2	10.8	60	18	7.1	22	1
25	66	9.1	55	12	12.7	104	50	8.2	45	7
30	75	10.4	89	30	14.2	159	90	9.3	73	18
40	90	13.2	166	90	16.9	296	208	11.4	128	53
50	99	15.7	275	180	19.2	436	342	13.2	184	100
60	106	17.4	368	270	21.0	564	478	14.8	254	157
70	110	18.8	450	350	22.6	714	595	16.1	315	215
80	112	20.0	562	465	24.0	846	760	17.3	406	310
90	114	21.2	640	555	25.3	977	890	18.3	472	370
100	115	22.3	748	645				19.1	526	420

TABLE 21—*Continued.*

Age of Stand Years	Height of Dominant Trees Feet	Dominant Trees—Crowded Stands			Dominant Trees—Open Stands			All Trees—Open Stands		
		Diameter Inches	Volume		Diameter Inches	Volume		Diameter Inches	Volume	
			1-7″ kerf	Doyle-Scribner		1-7″ kerf	Doyle-Scribner		1-7″ kerf	Doyle-Scribner
			Board Feet			Board Feet			Board Feet	
Quality II										
20	44	6.5	9	----------	8.2	18	3	6.4	8	----------
25	53	7.8	25	3	9.4	40	9	7.5	23	2
30	61	8.8	43	8	10.6	67	20	8.5	41	7
40	74	10.8	94	33	13.0	128	65	10.3	86	27
50	84	12.8	144	74	15.2	209	136	11.9	127	56
60	90	14.5	205	125	16.9	296	208	13.2	166	90
70	95	15.9	271	179	18.4	380	307	14.3	211	125
80	98	17.0	332	245	19.7	471	385	15.3	265	180
90	100	18.1	395	305	20.8	548	460	16.2	308	220
100	101	19.1	451	360	----------	----------	----------	17.0	344	255
Quality III										
20	32	6.2	3	----------	6.9	5	----------	6.1	3	----------
25	39	7.2	9	----------	8.0	12	2	6.8	7	----------
30	46	8.2	21	3	9.1	28	5	7.6	16	2
40	59	10.0	56	14	11.1	69	23	9.1	43	10
50	69	11.7	95	39	12.8	113	55	10.5	80	26
60	76	13.1	135	70	14.3	164	95	11.7	109	47
70	82	14.3	181	105	15.7	218	145	12.7	138	70
80	85	15.4	222	145	17.0	280	200	13.6	171	93

TABLE 22.—BOARD-FOOT VOLUME, 1-7″ KERF, AND SCALED BY DOYLE-SCRIBNER RULE, OF SINGLE TREES IN GROUPS OR STANDS OF LOBLOLLY PINE ON DIFFERENT SITES—FOR TYPICAL CONDITIONS AT DIFFERENT AGES. NO ALLOWANCE FOR DEFECT, WASTE OR BREAKAGE IN LOGGING.

Age of stand	Quality I (1) Groups of trees in hardwoods on moist, stiff clay soil. Stand crowded		Quality I (2) Stand on the best moist, loamy alluvial soil. Stand open		Quality III (3) Stand on longleaf and pocoson pine flat land. Stand fairly open		Quality II (4) Stand in old field on a longleaf pine sand hill. Stand crowded		Quality III (5) Groups on dry silt sand flats following longleaf pine. Stand fairly open		Quality II (6) Groups mixed with cypress in deep swamp, always wet, often flowing water. Stand fairly open	
Years	1-7″ kerf	Doyle-Scribner	1-7″ kerf	Doyle-Scribner	1-7″ kerf	Doyle-Scribner	1-7″ kerf	Doyle-Scribner	1-7″ kerf	Doyle-Scribner	1-7″ kerf	Doyle-Scribner
	Board feet											
20	----------	----------	42	12	----------	----------	45	19	----------	----------	----------	----------
30	11	2	158	97	----------	----------	116	57	----------	----------	----------	----------
40	74	27	390	285	42	8	162	88	----------	----------	57	13
50	161	93	595	515	79	24	185	107	----------	----------	91	32
60	272	192	859	780	104	37	----------	----------	12	2	139	71
70	417	327	1,197	1,025	150	80	----------	----------	19	12	197	120
80	595	510	1,287	1,230	200	120	----------	----------	----------	----------	280	205
90	796	705	----------	----------	248	170	----------	----------	----------	----------	369	280
100	985	910	----------	----------	310	230	----------	----------	----------	----------	----------	----------
120	1,358	1,300	----------	----------	426	345	----------	----------	----------	----------	----------	----------
140	1,740	1,680	----------	----------	537	450	----------	----------	----------	----------	----------	----------
160	----------	2,020	----------	----------	632	550	----------	----------	----------	----------	----------	----------

*Heights and diameters of groups as given in Tables 14 and 18.

VOLUME TABLES.

Table 23 gives the volumes of both upper and lower logs of different diameters, measured inside the bark at the small end of the log, in (1) cubic feet; (2) by Doyle-Scribner rule; (3) band-sawed 1-7 inch kerf; (4) circular-sawed 1-4 inch kerf; and (5) the number of board feet obtainable per cubic foot of solid wood, mill factor.

The saw gain of logs from the upper part of the tree over logs from the lower part of the tree is noteworthy. This is due to the greater actual volume in cubic feet of the top logs on account of their taper, the volume being calculated on the basis of the average diameter at the small end. The number of board feet per cubic foot shows that even in converting a tree 14 inches in diameter breasthigh with a band saw 1-7 inch kerf, more than one-half of the volume of wood in the logs is lost in kerf, shrinkage, and slabs. Even in a tree with a diameter of 30 inches, the average diameter of logs being 18 inches, this loss exceeds one-third of the volume of the cubic contents of the logs.

Tables 24 to 31 give the merchantable volumes in board feet of trees of different diameters and heights in actual mill tallies and in Scribner Decimal C, Doyle-Scribner, and Tiemann log rules. The volume tables based on the actual mill cut are both for logs band-sawed with seven cuts to the inch and for logs sawed with a circular saw with four cuts to the inch. Trees less than 50 years old will yield less than the volumes given in Tables 24, 26, 28 and 30; in stands 40 to 45 years old about 10 per cent less; in stands 30 to 40 years old about 15 per cent less. The actual volume of trees in a 45 year old stand is shown in a footnote to Table 26. This is the actual cut at the mill.

The volume as given in Tables 24 to 31, inclusive of Table 30*a*, is based on straight logs or crooked logs in which the crook amounts to less than 2 inches in a 16-foot log. The rule is to scale down into an inch lower diameter class logs which have about this degree of crookedness. In about 30 per cent of the logs cut, the crook amounts to more than 2 inches. There is little loss in the cut from crook, however, until the crook amounts to more than one-fourth of the diameter of the log, which will seldom occur in trees more than 12 inches in diameter. No allowance is made in these tables, or in the tables based thereon, for crooks which exceed 2 inches, for waste, which is often 5 per cent (see footnote to Table 26), or for breakage. In ordinary calculation of volume, estimating, or of yield a deduction, which will vary with the class of timber and the locality, should be made for losses from these sources. On poor sites the deduction for crook may amount to 6 per cent (Plate XII); on good sites it may not exceed 2 per cent. With careful felling and cutting the loss from breakage should be less than one-half of one per cent. A comparison of Table 26 with the table in the footnote shows that in an average operation a deduction of 25 per cent should be allowed from the mill cut volumes given for 6, 7, and 8-

inch trees, 15 per cent for 9, 10 and 11-inch trees, and 5 per cent for 12-inch trees to cover excessive crook, waste and breakage. No allowance is required for trees of larger diameters. An average deduction of 10 per cent consequently is sufficient for all except very young stands. In practice this loss is covered by the deductions made in the woods' scale for crook and breakage. It should be allowed however in estimating and volume appraisal.

Table 32 gives the number of logs 16 feet long, and the diameter at the small end of the top log for trees of different diameters and heights on which the volume tables of the trees are based.

Table 33 gives the volume in cubic feet of merchantable stemwood (without bark) in trees of different diameters and heights, less than 75 years old.

Table 34 gives the comparative volumes with and without bark, in cubic feet and cords, number of trees to a cord and per cent of bark, in trees of different diameters and heights in stands 35 to 45 years old, Quality II, which may be assumed to be an average site and average age for cordwood stock. The volumes would be less for younger stands in which the trees have the same diameters and heights.

TABLE 23.—VOLUMES IN BOARD FEET AND CUBIC FEET OF LOGS OF LOBLOLLY PINE SIXTEEN FEET LONG OF DIFFERENT DIAMETERS.

Average diameter of logs at small end	Volume of lower logs	Volume by Doyle-Scribner rule	Lower logs*		Upper logs†		Number of board feet per cubic foot¶ (mill factor)		Gain upper logs over lower logs 1-7″ kerf	Proportion of wood not utilized in lower logs††	Gain or loss of lower logs, circular saw, over Doyle-Scribner scale
			Band saw 1-7″ kerf, boards 1 1-16″ thick	Circular saw 1-4″ kerf, boards 1 1-8″ thick‡	Band saw 1-7″ kerf, boards 1 1-16″ thick	Circular saw 1-4″ kerf, boards 1 1-8″ thick	Lower logs 1-7″ kerf	Upper logs 1-7″ kerf			
Inches	Cu. ft.**	Feet	Board feet						Per cent		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
5	3.40	----------	10	9	13	11	3.5	4.0	30	71	Gain
6	4.30	4	18	16	21	17	4.1	4.6	17	64	+300
7	5.40	9	24	21	32	28	4.7	5.3	33	59	+130
8	6.70	16	34	30	41	38	5.2	5.8	21	54	+95
9	8.10	25	45	39	52	45	5.6	6.2	16	51	+56
10	9.80	36	60	53	64	56	6.0	6.6	7	48	+47
11	11.70	49	74	65	79	69	6.3	6.8	7	46	+33
12	13.80	64	91	80	96	84	6.5	7.0	5	44	+25
13	16.20	81	110	96	114	100	6.7	7.2	4	43	+18
14	18.85	100	131	115	135	118	6.9	7.3	3	41	+15
15	21.90	121	152	133	158	138	7.0	7.4	4	40	+10
16	25.15	144	177	155	181	159	7.1	7.4	2	40	+8
17	28.55	169	202	177	207	181	7.2	7.4	2	39	+5
18	32.20	196	230	201	234	205	7.3	7.5	2	39	+2
19	35.90	225	262	228	262	230	7.3	7.5	0	38	+1
20	39.95	256	292	256	292	256	7.4	7.5	0	38	loss
21	43.85	289	327	286	324	286	7.4	7.6	—1	37	—1
22	47.75	324	364	319	357	315	7.5	7.6	—2	37	—2
23	52.80	359	400	350	391	345	7.5	7.6	—2	36	—3
24	----------	400	438	384	428	378	----------	----------	----------	----------	—4
25	----------	441	475	416	465	409	----------	----------	----------	----------	—5
26	----------	484	513	449	504	442	----------	----------	----------	----------	—7
27	----------	530	550	482	----------	----------	----------	----------	----------	----------	----------
28	----------	582	589	516	----------	----------	----------	----------	----------	----------	----------

29	----------	609	627	549	----------	----------	----------	----------	----------	----------	----------
30	----------	657	668	585	----------	----------	----------	----------	----------	----------	----------

*Taper in diameter of logs less than 19 inches usually less than 2 inches per log. Gain by squaring on the saw, small.

†Taper of smaller logs more than 2 inches per log. Gain by squaring on the saw, large.

‡The factor for conversion from circular-sawed lumber, 1-4 inch kerf boards 1 1-8 inch thick, to band-sawed lumber 1-7 inch kerf, the boards 1 1-16 inch thick, is 1.1442.

¶With shorter logs there is a slightly larger yield of sawed lumber per cubic foot of wood, especially for small diameters (4 to 6 inches). In 4-foot bolts the increase may amount to 15 per cent above that given for 16-foot logs; for large diameters above 10 inches there is little or no overrun.

**Volumes in cubic feet of upper logs of the same diameter are from 5 to 8 per cent larger for the smaller logs.

††Lost in saw kerf, slabs and shrinkage. The allowance for shrinkage is 1-16 inch in thickness for 1-inch boards with 1-7 inch kerf, and 1-8 inch with 1-4 inch kerf.

TABLE 23*a*—LOG RULE FOR LOBLOLLY PINE. ACTUAL MILL CUT, CIRCULAR SAW, ¼-INCH KERF, LOGS WITH LESS THAN TWO INCHES CROOK.

Average diameter inside bark at small end	Length of log—Feet				
	8	10	12	14	16
Inches	Volume in board feet				
5	5	6	7	8	10
6	8	10	12	14	16
7	12	15	18	21	25
8	18	22	26	30	35
9	22	27	32	38	44
10	28	35	42	49	56
11	34	42	51	59	68
12	40	50	61	71	82
13	48	60	72	85	98
14	58	72	86	101	116
15	68	85	102	119	136
16	78	98	118	138	158
17	90	112	134	157	180
18	100	125	151	176	202
19	114	142	171	199	228
20	128	160	192	224	256
21	142	178	214	250	286
22	158	197	236	274	316
23	174	217	261	304	348
24	190	237	285	332	380
25	206	257	309	360	412
26	222	277	333	389	445
27	240	300	361	421	482
28	258	322	387	451	516
29	274	342	411	480	549
30	292	365	439	511	585

Table 23*a* gives a proposed log rule for loblolly pine. It is based on actual mill cut, circular saw, ¼ inch saw kerf. This may be used for calculating the amount of lumber which may be cut from logs of different diameters and lengths.

Tables 24 to 31, inclusive, were made from taper curves by scaling the merchantable length in log lengths to the top diameters shown. Logs were 16.3 feet long whenever possible, with some 14.3 feet, 12.3 feet, and 10.3 feet long to avoid waste. The assumed stump height was 1 foot for trees 6 to 16 inches in diameter breasthigh, and 1.5 feet for trees 17 to 25 inches.

TABLE 24.—VOLUME IN BOARD FEET, BAND-SAWED 1-7 INCH KERF, OF TREES OF LOBLOLLY PINE OF DIFFERENT DIAMETERS AND HEIGHTS. NO ALLOWANCE FOR BREAKAGE, EXCESSIVE CROOK OR WASTE, WHICH AMOUNT TO 25 PER CENT FOR 7 AND 8 INCH TREES; 15 PER CENT FOR 9 AND 10 INCH TREES; AND 5 PER CENT FOR 12 INCH TREES.

TREES LESS THAN 75 YEARS OLD.

Diameter breast-high	Height of tree—Feet									Diameter inside bark of top
Inches	40	50	60	70	80	90	100	110	120	Inches
	Volume—Board feet									
7	8	16	25	34						5
8	13	23	35	48	60					5
9	19	33	42	61	75	83				6
10	25	41	58	74	90	100	110			6
11	30	50	70	89	110	120	130	130		6
12	38	58	80	100	120	140	150	160	170	7
13		67	93	120	140	160	180	190	200	7
14		78	120	140	170	190	210	230	240	7
15			130	160	190	220	250	270	280	8
16			140	180	220	260	290	310	330	8
17				210	260	300	330	360	380	9
18				240	290	340	380	410	440	9
19					330	390	430	460	500	9
20					380	440	480	520	560	10
21						490	540	580	620	10
22						550	600	640	680	11

TABLE 25.—VOLUME IN BOARD FEET, BAND-SAWED 1-7 INCH KERF, OF TREES OF LOBLOLLY PINE OF DIFFERENT DIAMETERS AND HEIGHTS. NO ALLOWANCE FOR BREAKAGE, EXCESSIVE CROOK OR WASTE.

TREES OVER 75 YEARS OLD.

Diameter breast-high	Height of tree—Feet						Diameter inside bark of top
Inches	90	100	110	120	130	140	Inches
	Volume—Board feet in tens						
14	20	22	24	27	----	----	7
15	23	26	29	32	----	----	8
16	26	30	33	37	----	----	8
17	30	34	38	43	----	----	8
18	35	39	43	49	----	----	9
19	39	44	49	55	----	----	9
20	44	50	55	61	----	----	9
21	51	56	60	66	72	----	10
22	56	62	68	74	81	----	10
23	63	69	75	82	90	----	10
24	69	76	83	91	102	114	11
25	----	84	92	100	110	123	11
26	----	91	100	109	120	131	11
27	----	99	108	118	130	142	12
28	----	106	117	128	140	152	12
29	----	114	126	138	151	163	13
30	----	122	136	150	162	174	13
31	----	----	146	161	173	185	13
32	----	----	157	172	185	195	14
33	----	----	169	183	196	208	14
34	----	----	181	195	208	221	15
35	----	----	----	207	221	235	15
36	----	----	----	218	235	250	15

TABLE 26.—*VOLUME IN BOARD FEET (CIRCULAR-SAWED 1-4 INCH KERF) OF TREES OF LOBLOLLY PINE OF DIFFERENT DIAMETERS AND HEIGHTS. NO ALLOWANCE FOR BREAKAGE, EXCESSIVE CROOK OR WASTE WHICH AMOUNT TO 25 PER CENT FOR 7 AND 8 INCH TREES; 15 PER CENT FOR 9 AND 10 INCH; AND 5 PER CENT FOR 12 INCH.

TREES UNDER 75 YEARS OLD.

Diameter breast-high	Height of tree—Feet									Diameter inside bark of top
Inches	40	50	60	70	80	90	100	110	120	Inches
	Volume—Board feet									
7	7	14	22	30	----	----	----	----	----	5
8	11	20	31	42	53	----	----	----	----	5
9	17	29	37	54	66	71	----	----	----	6
10	22	36	51	65	79	88	97	----	----	6
11	26	44	62	79	97	106	114	114	----	6
12	33	51	70	88	106	123	132	141	150	7
13	----	59	82	106	121	141	158	167	176	7
14	----	69	106	123	148	167	185	202	211	7
15	----	----	114	139	167	194	220	238	264	8
16	----	----	123	157	194	220	255	273	290	8
17	----	----	----	185	229	264	290	317	334	9
18	----	----	----	210	255	299	334	361	387	9
19	----	----	----	----	290	343	378	405	440	9
20	----	----	----	----	334	387	422	458	493	10
21	----	----	----	----	----	431	493	510	548	10
22	----	----	----	----	----	484	528	563	598	11

*An operation in Gates County, North Carolina, yielded at the mill from two stands, one averaging 45 years old (Quality site I), and one averaging 60 years old (Quality site II to III), the following volumes in board feet (circular saw 1-4 inch kerf). As was to be expected, the younger trees, although taller, gave the lower yield.

Diameter breast-high	Top diameter	Age 45 years				Age 60 years			
Inches	Inches	Height of tree Feet	Used length Feet	Actual mill cut Board feet	Basis	Height of tree Feet	Used length Feet	Actual mill cut Board feet	Basis
8	4.9	77	40	27	1	----	----	----	----
9	5.5	79	43	43	7	----	----	----	----
10	5.9	81	46	49	23	77	57	54	15
11	6.3	82	48	64	39	78	60	71	27
12	6.7	83	50	83	27	79	62	92	27
13	7.1	84	53	112	38	80	64	116	29
14	7.5	85	55	145	20	82	66	155	25
15	7.9	86	57	180	7	84	68	188	21
16	8.2	86	59	216	7	86	70	224	22
17	8.5	88	60	256	2	88	71	247	8
18	8.8	89	61	290	3	90	72	330	3

The mill loss in this case could have been considerably lessened by a better disposition of log lengths. Logs were chiefly cut in 16 foot lengths. By cutting more shorter logs fewer crooks would have been left in the middle of the logs and the loss in slabbing reduced. In this operation there was an average of 11 linear feet of sound stem, 5 inches and over in diameter at the small end left in the tops. This additional volume, entirely box and cull, amounted to about 7 board feet (circular-sawed) per tree.

TABLE 27.—VOLUME IN BOARD FEET (CIRCULAR-SAWED 1-4 INCH KERF) OF TREES OF LOBLOLLY PINE OF DIFFERENT DIAMETERS AND HEIGHTS. NO ALLOWANCE FOR EXCESSIVE CROOK, WASTE OR BREAKAGE.

TREES OVER 75 YEARS OLD.

Diameter breast-high	Height of tree—Feet						Diameter inside bark of top
	90	100	110	120	130	140	
Inches	Volume—Board feet						Inches
14	176	194	211	238	----------	----------	7
15	202	229	255	282	----------	----------	8
16	229	264	290	326	----------	----------	8
17	264	299	334	373	----------	----------	8
18	308	343	378	431	----------	----------	9
19	343	387	431	484	----------	----------	9
20	387	440	484	537	----------	----------	9
21	449	493	528	581	634	----------	10
22	493	548	598	651	713	----------	10
23	554	607	660	722	792	----------	10
24	607	669	730	810	898	1,003	11
25	----------	739	820	880	968	1,082	11
26	----------	801	880	959	1,056	1,153	11
27	----------	870	950	1,038	1,144	1,250	12
28	----------	933	1,030	1,126	1,232	1,338	12
29	----------	1,003	1,109	1,214	1,329	1,434	13
30	----------	1,074	1,197	1,320	1,426	1,531	13
31	----------	----------	1,285	1,417	1,522	1,628	13
32	----------	----------	1,382	1,514	1,628	1,716	14
33	----------	----------	1,482	1,610	1,725	1,830	14
34	----------	----------	1,583	1,716	1,830	1,944	15
35	----------	----------	----------	1,822	1,944	2,068	15
36	----------	----------	----------	1,918	2,068	2,200	15

TABLE 28.—VOLUME SCALED BY DOYLE-SCRIBNER RULE OF TREES OF LOBLOLLY PINE OF DIFFERENT DIAMETERS AND HEIGHTS. NO ALLOWANCE FOR EXCESSIVE CROOK.

TREES LESS THAN 75 YEARS OLD.

Diameter breast-high	Height of tree—Feet									Diameter inside bark of top
Inches	40	50	60	70	80	90	100	110	120	Inches
	Volume—Board feet									
8	2	3	4	6	8	----	----	----	----	5
9	3	7	9	13	16	----	----	----	----	6
10	5	9	15	21	27	32	35	----	----	6
11	8	15	23	32	39	45	51	----	----	6
12	12	23	34	45	55	63	71	79	88	7
13	----	30	45	60	73	84	95	110	120	7
14	----	40	59	77	94	110	120	130	150	7
15	----	----	69	98	120	140	150	170	180	8
16	----	----	83	120	150	170	190	210	220	8
17	----	----	----	150	180	210	240	260	270	9
18	----	----	----	170	220	250	280	310	330	9
19	----	----	----	----	260	300	330	360	390	9
20	----	----	----	----	300	350	390	420	450	10
21	----	----	----	----	----	410	450	490	520	10
22	----	----	----	----	----	470	520	560	600	11

TABLE 29.—VOLUME SCALED BY DOYLE-SCRIBNER RULE OF TREES OF LOBLOLLY PINE OF DIFFERENT DIAMETERS AND HEIGHTS. NO ALLOWANCE FOR EXCESSIVE CROOK.

TREES OVER 75 YEARS OLD.

Diameter breast-high	Height of tree—Feet						Approximate diameter inside bark of top
Inches	90	100	110	120	130	140	Inches
	Volume—Board feet in tens						
14	11	13	15	17	----	----	8
15	14	17	20	22	----	----	8
16	18	21	24	26	----	----	8
17	22	25	29	32	----	----	8
18	26	30	34	37	----	----	9
19	31	35	39	43	----	----	9
20	36	41	46	49	52	----	9
21	42	47	52	57	61	----	10
22	47	54	60	64	69	----	10
23	53	60	67	73	77	----	10
24	58	67	75	81	87	93	11
25	----	75	83	91	98	104	11
26	----	83	92	101	108	115	11
27	----	91	101	111	119	127	12
28	----	99	111	121	131	141	12
29	----	108	121	132	143	154	13
30	----	116	131	143	155	166	13
31	----	----	141	155	167	178	13
32	----	----	153	167	179	190	14
33	----	----	164	179	192	203	14
34	----	----	175	191	204	215	15
35	----	----	----	204	217	228	15
36	----	----	----	216	229	241	15

TABLE 30.—VOLUME SCALED BY SCRIBNER DECIMAL C RULE OF TREES OF LOBLOLLY PINE OF DIFFERENT DIAMETERS AND HEIGHTS. NO ALLOWANCE FOR EXCESSIVE CROOK.

TREES LESS THAN 75 YEARS OLD.

Diameter breast-high	Height of tree—Feet									Diameter inside bark of top
Inches	40	50	60	70	80	90	100	110	120	Inches
	Volume—Board feet									
8	5	13	21	27						5
9	12	22	32	42	52					6
10	15	30	42	55	65					6
11	25	40	54	68	81	93				6
12	32	50	66	83	99	110	130	140	150	7
13	40	60	81	100	120	140	160	170	180	7
14		70	97	120	150	170	190	200	220	7
15			110	140	170	200	220	240	260	8
16			120	160	200	230	260	280	300	8
17				190	230	270	300	330	350	9
18				220	270	310	350	380	410	9
19					300	350	400	430	460	9
20					330	400	460	490	520	10
21						460	510	550	590	10
22						520	570	620	660	11

TABLE 30*a*.—VOLUME SCALED BY SCRIBNER DECIMAL C RULE OF TREES OF LOBLOLLY PINE OF DIFFERENT DIAMETERS AND HEIGHTS. NO ALLOWANCE FOR EXCESSIVE CROOK.

TREES OVER 75 YEARS OLD.

Diameter breast-high	Height of tree—Feet						Diameter inside bark of top
Inches	90	100	110	120	130	140	Inches
	Volume—Board feet in tens						
14	18	20	22	24			8
15	21	23	26	29			8
16	24	27	30	33			8
17	27	31	35	38			8
18	31	36	40	44			9
19	36	41	46	50	53		9
20	41	47	52	57	61		9
21	46	53	59	64	69		10
22	51	60	66	72	78		10
23	57	66	74	81	87		10
24	62	73	82	90	96	102	11
25		81	91	99	106	113	11
26		89	99	109	117	124	11
27		97	109	119	128	135	12
28		106	118	129	139	147	12
29		115	128	140	150	159	13
30		124	138	151	162	171	13
31			150	163	175	186	13
32			161	175	188	198	14
33			172	187	201	213	14
34			184	200	214	225	15
35				213	227	238	15
36				227	240	251	15

TABLE 31.—VOLUME SCALED BY TIEMANN LOG RULE (1-8 INCH SAW KERF) OF TREES OF LOBLOLLY PINE OF DIFFERENT DIAMETERS AND HEIGHTS. NO ALLOWANCE FOR EXCESSIVE CRGOK.

TREES LESS THAN 75 YEARS OLD.

Diameter breast-high	Height of tree—Feet									Approximate diameter inside bark of top
Inches	40	50	60	70	80	90	100	110	120	Inches
	Volume—Board feet in tens									
7	.5	1	1	2						5
8	1	2	2	3	4					5
9	2	3	4	5	6					6
10	2	4	5	6	8	9				6
11	3	5	7	8	10	11				6
12	4	6	8	10	12	13	14	15		7
13		8	10	13	15	17	18	19	20	7
14		9	12	15	18	20	22	23	25	7
15			14	18	21	24	26	28	30	8
16				21	25	28	31	33	35	8
17				24	29	32	35	38	40	9
18				28	33	37	40	44	46	9
19					37	42	46	50	53	9
20					42	48	53	57	60	10
21							60	64	67	10
22							67	72	76	11

TABLE 31a.—VOLUME SCALED BY TIEMANN LOG RULE (1-8 INCH SAW KERF) OF TREES OF LOBLOLLY PINE OF DIFFERENT DIAMETERS AND HEIGHTS. NO ALLOWANCE FOR EXCESSIVE CROOK.

TREES OVER 75 YEARS OLD.

Diameter breast-high	Height of tree—Feet						Approximate diameter inside bark of top
Inches	90	100	110	120	130	140	Inches
	Volume—Board feet in tens						
14	18	23	26				8
15	23	27	31				8
16	27	32	35				8
17	32	37	41				8
18	37	43	47	50			9
19	43	49	53	57			9
20	48	54	60	65	69		9
21	54	61	68	73	79		10
22	59	68	76	82	88		10
23	66	75	83	91	98		10
24	72	83	92	100	107	115	11
25		91	101	109	118	126	11
26		99	109	119	128	137	11
27		108	118	129	139	148	12
28		117	129	140	150	159	12
29		125	138	150	161	171	13
30		134	147	161	173	185	13
31			157	171	185	198	13
32			168	183	197	210	14
33			179	195	210	222	14
34			190	208	222	235	15
35				221	235	248	15
36				233	249	261	15

TABLE 32.—NUMBER OF LOGS 16.3 FEET LONG IN TREES OF LOBLOLLY PINE OF DIFFERENT DIAMETERS AND HEIGHTS, AND TOP DIAMETER OF THE TOP LOG.

UNDER 75 YEARS OLD.

Diameter breastHigh—Inches	Height of trees—Feet																					
	40		50		60		70		80		90		100		110		120		130		140	
	No. of logs 16.3 feet long	Diameter in-side bark at top	No. of logs 16.3 feet long	Diameter in-side bark at top	No. of logs 16.3 feet long	Diameter in-side bark at top	No. of logs 16.3 feet long	Diameter in-side bark at top	No. of logs 16.3 feet long	Diameter in-side bark at top	No. of logs 16.3 feet long	Diameter in-side bark at top	No. of logs 16.3 feet long	Diameter in-side bark at top	No. of logs 16.3 feet long	Diameter in-side bark at top	No. of logs 16.3 feet long	Diameter in-side bark at top	No. of logs 16.3 feet long	Diameter in-side bark at top	No. of logs 16.3 feet long	Diameter in-side bark at top
7	½	4.8	¾	4.8	1¼	4.7	2	4.7	----	----	----	----	----	----	----	----	----	----	----	----	----	----
8	¾	5.1	1	5.4	1½	5.1	2	5.2	2¾	5.2	----	----	----	----	----	----	----	----	----	----	----	----
9	¾	5.8	1¼	5.7	1¾	5.6	2¼	5.5	2¾	5.6	----	----	----	----	----	----	----	----	----	----	----	----
10	1	6.0	1½	5.9	2	5.9	2½	5.9	3	6.0	3	5.9	3	6.0	----	----	----	----	----	----	----	----
11	1	6.6	1½	6.5	2	6.2	2½	6.2	3	6.3	3	6.3	3¼	6.2	----	----	----	----	----	----	----	----
12	1	7.2	1¾	6.7	2	6.7	2½	6.8	3	6.9	3	7.1	3½	6.7	3¾	6.7	4	6.7	----	----	----	----
13	----	----	1¾	7.4	2	7.3	2¾	7.1	3	7.3	3¼	7.2	3½	7.1	4	7.0	4	7.2	----	----	----	----
14	----	----	1¾	7.4	2	8.0	2¾	7.7	3	7.9	3½	7.5	3¾	7.6	4	7.5	4¼	7.4	----	----	----	----
15	----	----	----	----	2	8.4	2¾	7.9	3	8.4	3½	7.8	3¾	7.9	4	8.1	4½	7.9	----	----	----	----
16	----	----	----	----	2	9.1	2¾	8.4	3	8.9	3½	8.5	4	8.3	4	8.7	4½	8.2	----	----	----	----
17	----	----	----	----	----	----	2¾	8.8	3	9.4	3½	9.0	4	8.8	4¼	8.7	4½	8.8	----	----	----	----
18	----	----	----	----	----	----	2¾	9.3	3¼	9.0	3¾	9.3	4	9.1	4¼	9.2	4¾	9.1	----	----	----	----
19	----	----	----	----	----	----	----	----	3¼	9.4	3¾	9.8	4	9.7	4½	9.5	4¾	9.6	----	----	----	----
20	----	----	----	----	----	----	----	----	3¼	10.0	3¾	10.3	4	10.3	4½	10.0	4¾	9.8	----	----	----	----
21	----	----	----	----	----	----	----	----	3½	10.0	3¾	10.5	4	10.9	4½	10.3	4¾	10.3	----	----	----	----
22	----	----	----	----	----	----	----	----	3½	10.0	3¾	11.0	4¼	10.6	4½	10.8	4¾	10.8	----	----	----	----

TABLE 32—*Continued.*

OVER 75 YEARS OLD.

Diameter breasthigh—Inches	Height of trees—Feet																											
	40		50		60		70		80		90		100		110		120		130		140	
	No. of logs 16.3 feet long	Diameter in-side bark at top	No. of logs 16.3 feet long	Diameter in-side bark at top	No. of logs 16.3 feet long	Diameter in-side bark at top	No. of logs 16.3 feet long	Diameter in-side bark at top	No. of logs 16.3 feet long	Diameter in-side bark at top	No. of logs 16.3 feet long	Diameter in-side bark at top	No. of logs 16.3 feet long	Diameter in-side bark at top	No. of logs 16.3 feet long	Diameter in-side bark at top	No. of logs 16.3 feet long	Diameter in-side bark at top	No. of logs 16.3 feet long	Diameter in-side bark at top	No. of logs 16.3 feet long	Diameter in-side bark at top
14	----	----	----	----	----	----	----	----	----	----	3½	7.6	4	7.5	4	7.9	4¼	7.7	----	----	----	----
15	----	----	----	----	----	----	----	----	----	----	3½	8.1	4	8.0	4¼	8.0	4½	8.0	----	----	----	----
16	----	----	----	----	----	----	----	----	----	----	3½	8.4	4	8.4	4½	8.4	4¾	8.2	----	----	----	----
17	----	----	----	----	----	----	----	----	----	----	3¾	8.5	4	8.9	4½	8.6	4¾	8.5	----	----	----	----
18	----	----	----	----	----	----	----	----	----	----	3¾	9.1	4	9.4	4½	9.0	5	8.7	----	----	----	----
19	----	----	----	----	----	----	----	----	----	----	3¾	9.1	4¼	9.2	4¾	9.3	5	9.0	----	----	----	----
20	----	----	----	----	----	----	----	----	----	----	3¾	9.7	4¼	9.8	4¾	9.3	5	9.7	5½	9.6	----	----
21	----	----	----	----	----	----	----	----	----	----	4	9.6	4½	10.2	4¾	9.9	5	10.2	5¾	9.8	----	----
22	----	----	----	----	----	----	----	----	----	----	4	10.1	4½	10.3	4¾	10.3	5	10.8	5¾	10.4	----	----
23	----	----	----	----	----	----	----	----	----	----	4	10.6	4½	10.8	5	10.4	5	11.3	5¾	10.4	----	----
24	----	----	----	----	----	----	----	----	----	----	4	11.1	4½	10.7	5	10.8	5¼	10.9	5¾	10.9	6½	10.8
25	----	----	----	----	----	----	----	----	----	----	----	----	4½	11.1	5	11.4	5¼	11.6	5¾	11.4	6½	11.2
26	----	----	----	----	----	----	----	----	----	----	----	----	4½	11.6	5	11.6	5¼	11.9	5¾	11.7	6½	11.4
27	----	----	----	----	----	----	----	----	----	----	----	----	4½	12.0	5	12.2	5¼	12.4	5¾	12.2	6¼	12.2
28	----	----	----	----	----	----	----	----	----	----	----	----	4½	12.6	5	12.5	5½	12.4	6	12.3	6¼	12.6
29	----	----	----	----	----	----	----	----	----	----	----	----	4½	13.0	5	13.1	5½	12.9	6	12.8	6¼	12.9
30	----	----	----	----	----	----	----	----	----	----	----	----	4½	13.5	5	13.6	5½	13.5	6	13.3	6¼	13.3
31	----	----	----	----	----	----	----	----	----	----	----	----	----	----	5	14.0	5½	13.8	6	13.7	6¼	13.7
32	----	----	----	----	----	----	----	----	----	----	----	----	----	----	5	14.4	5½	14.4	6	14.3	6¼	14.1
33	----	----	----	----	----	----	----	----	----	----	----	----	----	----	5	15.0	5½	14.9	6	14.7	6¼	14.4
34	----	----	----	----	----	----	----	----	----	----	----	----	----	----	5	14.7	5½	14.6	6	15.2	6¼	14.8
35	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	5½	15.0	6	15.6	6¼	15.1
36	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	5½	15.6	6	15.4	6¼	15.5

TABLE 33.—VOLUME IN CUBIC FEET OF MERCHANTABLE STEM WOOD* WITHOUT STUMP OR BARK OF TREES OF LOBLOLLY PINE OF DIFFERENT DIAMETERS AND HEIGHTS.

AGE LESS THAN 75 YEARS.

Diameter breast-high	Height—Feet										
	20	30	40	50	60	70	80	90	100	110	120
Inches	Merchantable cubic feet										
6	1.3	1.8	2.4	3.2	4.2	5.3	6.3				
7	1.7	2.4	3.3	4.2	5.2	7.2	8.7	9.7	10.7		
8	2.0	3.0	4.2	5.6	7.1	9.1	11.1	12.1	13.6		
9			5.3	7.0	9.0	11.5	13.0	15.0	16.5		
10			6.9	9.4	11.9	14.4	16.4	18.4	19.9	20.9	
11			8.2	11.2	14.2	17.2	20.2	22.2	23.7	25.2	
12			9.5	13.5	17.0	20.5	23.5	26.0	28.5	31.0	33.0
13				16.0	20.0	24.0	28.0	31.0	34.0	36.5	39.0
14				18.0	23.0	27.5	32.0	36.0	39.5	42.5	45.5
15					26.0	31.5	36.5	41.5	46.0	49.5	53.0
16					29.0	36.5	42.5	48.0	53.0	57.0	61.0
17						41.0	48.0	54.5	60.0	65.0	69.0
18						45.5	54.0	61.0	68.0	73.0	77.5
19						50.5	59.5	68.5	75.5	81.5	86.5
20						55.5	66.5	76.0	83.5	90.5	96.5
21						60.5	72.5	83.5	92.5	100.0	106.5
22						66.0	79.0	91.0	101.5	110.5	117.5
23							85.5	100.0	113.5	125.0	135.5
24							91.5	109.0	123.0	137.0	150.0
25							98.0	118.5	134.0	148.5	162.0
26								127.5	145.0	160.5	175.0
27									156.0	172.0	188.0
28									167.5	184.5	201.0
29									179.5	197.5	214.5
30									193.0	211.0	229.0

* Tops included to a diameter of 3 inches in small trees, and about 5 inches in trees 14 inches and over. If no knotty top-wood is to be included, a deduction, increasing with the diameter, of from 5 to 10 per cent should be made.

TABLE 34.—VOLUME OF TREES OF LOBLOLLY PINE OF DIFFERENT DIAMETERS AND HEIGHTS, QUALITY II, AGE 35 TO 45, IN CUBIC FEET, AND IN CORDS, WITH AND WITHOUT BARK; NUMBER OF TREES TO A CORD, AND PROPORTION OF BARK, WITHOUT STUMP OR TOP BELOW 3 INCHES. (FOR RANGE OF HEIGHTS SEE TABLE 13.)

Diameter breast-high	Without bark				With bark				
	Volume per tree		Number of trees to a cord of 160 ft.	Per cent of bark	Volume per tree		Number of trees to a cord of 128 ft.	Volume—Cords of 160 ft.	Number of trees to a cord of 160 ft.
Inches	Cu. ft.	Cords of 160 ft.			Cu. ft.	Cords of 128 ft.			
6	3.6	.031	33	31	5.2	.064	15.5	.051	19.5
7	5.1	.048	21	30	7.0	.086	11.6	.069	14.5
8	7.9	.08	12	29	11.1	.133	7.5	.106	9.4
9	11.0	.11	9	28	15.3	.172	5.8	.138	7.4
10	14.8	.14	7	27	20.3	.227	4.4	.182	5.5
11	19.0	.18	5.3	26	25.7	.281	3.6	.225	4.5
12	23.2	.21	5	25	30.9	.336	3.	.269	3.8
13	28.3	.26	4	24	37.2	.406	2.5	.325	3.1
14	33.2	.3	3.3	23	43.1	.469	2.1	.375	2.6
15	38.5	.35	2.9	22	49.3	.531	1.9	.425	2.4
16	45.3	.41	2.5	21	57.3	.625	1.6	.50	2
17	51.3	.46	2.1	20	64.1	.695	1.4	.556	1.8
18	57.5	.52	1.9	19	71.0	.773	1.3	.618	1.6

The per cent of solid wood to a cubic foot of piled cordwood varies with the diameter of the tree when the wood is cut in 4 or 5 foot lengths. With trees below 7 inches in diameter it is 63 per cent; trees 7 to 9 inches, it is 69 per cent; trees 10 inches and over, if the larger pieces are split, is is 72 per cent. By combining this with columns 8 and 9, Table 23, a factor is obtained showing the number of board feet per long cord of bolts. This gives a yield of 616 board feet from a cord of peeled wood from 7-inch trees cut in 4-foot bolts; and about 750 board feet per cord of wood from trees 10 inches in diameter. When wood is in pieces longer than 5 feet the per cent of solid wood is somewhat less than is given and the number of board feet per cord somewhat smaller.

YIELD OF PURE EVEN-AGED STANDS.

Loblolly pine characteristically forms over large areas pure stands which are to a great extent even-aged. While it also grows in mixed stands and pure uneven-aged stands, its occurrence in pure even-aged stands is of chief importance on account of their large yield, the ease with which they are logged, and the simplicity of their management.

On the basis of 90 plots laid off in stands of different ages and under different conditions of growth yield tables were constructed for even-aged stands of loblolly pine. The plots were fully stocked with normally developed crowns and stems. Yield tables have a two-fold value. They show the approximate yield per acre which can be expected at any given age when the quality site is known or can be determined. They also show the time at which a stand produces the largest amount of wood, and by determining its quality or grade yield, the time when it has the greatest value.

In Cubic Feet and Cords.

Table 35 gives the yield in cubic feet of all trees 3 inches and over in diameter in fully stocked unthinned stands of loblolly pine on different quality sites at different ages. This embraces only the volume of stem wood without bark to a diameter of 3 inches (see foot note to Table 33). The average annual increment for the entire period and for five year periods is given. The basal area, showing in square feet the sum of the cross sections of all trees inside the bark at breast height, is also given. The basal area of stands on very dry soils often declines after 30 years; and if the basal area is measured outside the bark it declines in all stands after they are 40 or 50 years old except those on the best sites.* Table 36 gives the yield of stem wood of trees 6 inches and over without bark. Table 37 gives the yield in cubic feet and cords of all merchantable trees 6 inches and over in diameter without stump, bark and top.

*While the basal area af the wood only inside of bark increases in stands up to 100 years of age and more, the basal area measured outside of the bark soon begins to decline. This is due to the proportional greater thickness of the bark in small trees than in large ones.

TABLE 35.—YIELD PER ACRE IN CUBIC FEET OF STEM WOOD INCLUDING STUMP AND TOP OF ALL TREES THREE INCHES AND OVER IN DIAMETER BREASTHIGH IN FULLY STOCKED UNTHINNED STANDS OF LOBLOLLY PINE AT DIFFERENT AGES ON DIFFERENT QUALITY SITES; ANNUAL INCREMENT, AND BASAL AREA.

Age of stand	Quality										
	Maximum	I			II			III			Minimum
	Total yield	Total yield	Average annual increment		Total yield	Average annual increment		Total yield	Average annual increment		Total yield
			Entire period	Past 5 years		Entire period	Past 5 years		Entire period	Past 5 years	
Years	Cubic feet per acre										
15	1,700	1,300			850						
20	3,000	2,550			1,680			920			400
25	4,800	4,000	160	290	2,680	107	200	1,580	63	132	850
30	6,050	4,950	165	190	3,650	122	194	2,290	76	142	1,360
35	6,800	5,840	166	178	4,470	128	164	2,860	77	114	1,900
40	7,350	6,550	163	142	5,010	125	108	3,350	88	98	2,450
45	7,780	7,000			5,450	121	88	3,780	84	86	2,900
50	8,200	7,350	147	70	5,780	116	66	4,090	82	62	3,220
55					6,050			4,350	79	52	3,450
60	Older ages same as for 6 inches and over (table 36)										3,620
	Basal area, wood only, at breasthigh—Square feet per acre										
20			114			98			81		
25			126			110			93		
30			134			118			102		
35			141			124			108		
40			145			129			113		
50			152			134			118		
60			157			137			121		
70			160			140			123		
80			162			141			124		

TABLE 36.—YIELD PER ACRE IN CUBIC FEET OF STEM WOOD, WITHOUT BARK, BUT INCLUDING STUMPS AND TOPS OF ALL TREES SIX INCHES AND OVER BREASTHIGH IN FULLY STOCKED UNTHINNED STANDS OF LOBLOLLY PINE AT DIFFERENT AGES ON DIFFERENT QUALITY SITES.

Age Years	Maximum Cu. ft. per acre	Quality I		Quality II		Quality III		Minimum Cu. ft. per acre
		Cu. ft. per acre	Annual Per cent of increase in volume preceding 5 years	Cu. ft. per acre	Annual Per cent of increase in volume preceding 5 years	Cu. ft. per acre	Annual Per cent of increase in volume preceding 5 years	
15	1,400	1,050		600				
20	2,560	2,200		1,430		600		
25	4,350	3,600	8.3	2,400	8.9	1,270	12.7	650
30	5,790	4,900	2.8	3,360	3.7	1,980	5.1	1,100
35	6,650	5,790	1.3	4,160	1.7	2,700	2.2	1,700
40	7,300	6,430	.7	4,830	.9	3,260	1.1	2,260
45	7,750	6,940	.5	5,330	.55	3,700	.6	2,750
50	8,150	7,300		5,700		4,070		3,100
55	8,470	7,600		6,000		4,350		2,360
60	8,730	7,850		6,230		4,550		3,560
65	8,940	8,040		6,410		4,720		3,730
70	9,110	8,240		6,540		4,850		3,850
75	9,250	8,400		6,650		4,940		3,950
80	9,380	8,520		6,740		4,990		4,000
85	9,480	8,600		6,810		5,050		4,050
90	9,570	8,650		6,870		5,070		4,100
95	9,660	8,700		6,920		5,100		4,860
100	9,730	8,730		6,950		5,120		4,910

Table 37 gives practically the material which would be available for conversion into bolts, heading, staves, box boards, or for paper pulp stock. The yield is given both in long cords of 160 cubic feet without bark and in standard cords of 128 cubic feet with bark. The greatest average annual yield in standard cords on Quality I is obtained by cutting the stand at about the age of 30 years; or Quality II at about 40 years; or Quality III at about 50 years. In old field stands on dry sites there is an actual decline in the volume of the stand between 40 and 60 years of age, according to site. This is due to the rapid natural thinning as the trees become intolerant of shade or when the demands on soil moisture increase above the available supply. Plate XVI shows Quality II stand at the age of greatest average annual yield.

In Board Feet.

Table 38 gives the yield in board feet, 1-7 inch saw kerf, of all trees 6 inches and over in diameter breasthigh in fully stocked unthinned stands of loblolly pine on different quality sites at different ages, on the basis of three to four logs to the large trees and of top diameters given in Table 32. No allowance is made in this and following tables for crooked logs in which the crookedness exceeds 2 inches for waste or

TABLE 37.—YIELD PER ACRE IN CUBIC FEET, AND IN CORDS WITH AND WITHOUT BARK OF STEM WOOD WITHOUT STUMP AND WITHOUT TOP BELOW THREE INCHES OF ALL TREES SIX INCHES AND OVER IN DIAMETER IN FULLY STOCKED, UNTHINNED STANDS OF LOBLOLLY PINE AT DIFFERENT AGES ON DIFFERENT QUALITY SITES.

Age of stand, Years	Quality I	Quality II	Quality III
	Cubic feet merchantable wood without stump, or bark, and top to 3 inches		
20	2,100	1,330	-----
25	3,500	2,300	1,200
30	4,775	2,260	1,900
40	6,385	4,700	3,160
50	7,125	5,550	3,950
60	-----	-----	4,410

Total yield	Average annual yield: Entire period	Average annual yield: Past 10 years	Total yield	Average annual yield: Entire period	Average annual yield: Past 10 years	Total yield	Average annual yield: Entire period	Average annual yield: Past 10 years
Standard cords, 128 cubic feet, with bark								
37	1.8	--	24	1.2	--	--	--	--
58	2.3	--	40	1.6	--	22	.9	--
75	2.5	3.8	53	1.8	2.9	33	1.1	2.2
96	2.4	1.9	72	1.8	1.9	50	1.3	1.7
105	2.1	.8	83	1.7	1.1	60	1.2	1.
--	--	--	--	--	--	66	1.1	.6
Long cords, 160 cubic feet, without bark								
21	1.	--	13	.7	--	--	--	--
33	1.5	--	22	.9	--	1.2	.5	--
43	1.45	2.3	30	1.	1.7	18	.6	1.2
57	1.4	1.4	42	1.1	1.2	28	.7	.1
64	1.3	.7	49	1.	.8	35	.7	.6
--	--	--	--	--	--	39	.65	.5

for breakage. Table 39 is the same as Table 38 except that the yield is given circular sawed, ¼ inch kerf. Table 40 gives the yield of all trees 6 inches and over in diameter scaled by Doyle-Scribner rule and also the average annual increment. The largest average annual increment in board feet is obtained on Quality I by cutting the stand when 50 years old; on Quality II when between 50 and 60 years old; on Quality III when between 60 and 70 years old.

Tables 41 and 41*a* give the yield in board feet band-sawed with 1-7 inch kerf by cutting to 9 and 11 inches in diameter, respectively. Cutting to 9 inches in diameter gives the yield of all trees which make

standard 7x7 inch ties. The greatest average annual yield of tie timber is obtained on Quality I when the stand is about 40 years old; on Quality II when about 50 years old; and on Quality III when about 55 years old. Cutting to 11 inches in diameter gives the yield of all trees large enough for crate veneer stock. (Plate XIV shows a Quality II stand, culled, 60 years old, yielding about 30,000 feet per acre; Plate XV an unthinned stand about 80 years old, yielding about 40,000 feet per acre.)

Table 42 gives the total number of trees 6 inches and over, the average diameter of all trees and the annual rate of decrease in the number of trees with the increase in the age of the stand. This table is of value in showing which portion of the yield is contributed by the trees in the dominant crown class. It shows the approximate number of trees which would be removed in thinning unthinned stands by deducting the number of dominant trees from the total number of trees. (See page 159.)

Tables 43 and 44 show the number of trees 9 inches and over and 11 inches and over per acre respectively and their average diameters at different ages in fully stocked stands. By combining Table 42 with Tables 43 and 44 the number of trees over 6 inches in diameter left per acre after cutting to 9 and 11 inches in diameter breasthigh can be obtained.

TABLE 38.—YIELD PER ACRE IN BOARD FEET OF ALL TREES SIX INCHES AND OVER IN DIAMETER BREASTHIGH TO TOP DIAMETER GIVEN IN TABLE 32, IN FULLY STOCKED UNTHINNED STANDS OF LOBLOLLY PINE AT DIFFERENT AGES ON DIFFERENT QUALITY SITES. NO ALLOWANCE FOR EXCESSIVE CROOK, WASTE OR BREAKAGE.

BOARDS 1 1-16 INCH THICK, BAND-SAWED, KERF 1-7 INCH.

Age Years	Maximum Bd. ft. per acre	Quality I		Quality II		Quality III		Minimum Bd. ft. per acre
		Bd. ft. per acre	Annual Per cent of increase in volume preceding decade	Bd. ft. per acre	Annual Per cent of increase in volume preceding decade	Bd. ft. per acre	Annual Per cent of increase in volume preceding decade	
20	19,700	14,500						
25	28,600	22,300		8,800				
30	35,100	28,850	7.1	16,000		7,170		
35	40,100	34,000		21,850		12,700		2,600
40	44,200	38,150	2.8	26,850	5.3	17,000	9.0	12,050
45	47,500	41,600		30,850		20,400		15,400
50	50,300	44,500	1.6	33,900	2.4	23,000	3.1	18,050
55	52,650	46,850		36,300		25,200		20,150
60	54,600	48,750	.9	38,200	1.2	26,850	1.6	21,900
65	56,250	50,300		39,700		28,200		23,200
70	57,650	51,550	.6	40,900	.7	29,250	.9	24,250
75	58,900	52,650		41,850		30,150		25,000
80	60,000	53,600	.4	42,650	.4	30,750	.5	25,650
85	61,000	54,400		43,200		31,000		26,100
90	62,000	55,200	.3	43,700	.2	31,650	.3	26,500
95	62,900	56,000		44,100				
100	63,750	56,700	.3	44,500	.2			

TABLE 39.—YIELD PER ACRE IN BOARD FEET OF ALL TREES OF LOBLOLLY PINE, SIX INCHES AND OVER IN DIAMETER BREASTHIGH TO TOP DIAMETER GIVEN IN TABLE 32 IN FULLY STOCKED UNTHINNED STANDS AT DIFFERENT AGES ON DIFFERENT QUALITY SITES. NO ALLOWANCE FOR EXCESSIVE CROOK, WASTE OR BREAKAGE. BOARDS 1 1-8 INCHES THICK, CIRCULAR SAWED, KERF ¼ INCH.

Age of stand Years	Quality		
	I	II	III
	Board feet per acre		
20	12,700		
30	25,200	14,000	6,300
40	33,300	23,500	14,900
50	38,900	30,000	20,100
60	42,600	33,400	23,500
70	45,100	35,800	25,600
80	46,900	37,300	26,900

TABLE 40.—YIELD PER ACRE IN BOARD FEET (DOYLE-SCRIBNER) OF ALL TREES SIX INCHES AND OVER IN DIAMETER IN FULLY STOCKED STANDS OF LOBLOLLY PINE AT DIFFERENT AGES ON DIFFERENT QUALITY SITES. TOP DIAMETERS AS IN TABLE 32. NO ALLOWANCE FOR EXCESSIVE CROOK, WASTE OR BREAKAGE.

Age Years	Quality					
	I		II		III	
	Volume	Average annual increment	Volume	Average annual increment	Volume	Average annual increment
	Board feet per acre					
25	7,368	295	1,310	52		
30	16,143	535	6,824	227	652	22
40	28,365	709	16,419	410	6,024	150
50	36,689	734	23,716	474	12,391	247
60	41,811	697	28,130	469	16,228	270
70	43,601		30,568	436	18,939	270
80	44,868		32,201		20,149	252
90	45,180		33,205		20,827	

TABLE 41.—YIELD PER ACRE IN BOARD FEET OF ALL TREES NINE INCHES AND OVER IN DIAMETER BREASTHIGH IN FULLY STOCKED STANDS OF LOBLOLLY PINE AT DIFFERENT AGES AND ON DIFFERENT QUALITY SITES. NO ALLOWANCE FOR EXCESSIVE CROOK, WASTE OR BREAKAGE.

BOARDS 1 1-16 INCH THICK, BAND-SAWED, 1-7 INCH KERF.

(To reduce to circular-sawed 1-4 inch kerf, divide by 1.144.)

Age Years	Maximum	Quality			Minimum
		I	II	III	
	Volume—Board feet				
20	10,500	----------	----------	----------	----------
25	25,200	16,200	----------	----------	----------
30	34,500	26,600	12,700	----------	----------
35	40,000	32,200	20,650	7,700	1,500
40	44,100	37,800	25,900	13,800	8,000
45	47,500	41,400	29,800	18,250	12,500
50	50,300	44,500	32,800	21,350	15,600
55	----------	----------	35,200	23,700	17,750
60	----------	----------	37,000	25,400	19,400
65	----------	----------	38,700	26,850	20,800
70	----------	----------	----------	28,150	22,000
75	----------	----------	----------	29,200	23,000
80	----------	----------	----------	30,100	23,800
85	----------	----------	----------	30,800	24,650

TABLE 41*a*.—YIELD PER ACRE IN BOARD FEET OF ALL TREES 11 INCHES AND OVER IN DIAMETER BREASTHIGH IN FULLY STOCKED STANDS OF LOBLOLLY PINE AT DIFFERENT AGES AND ON DIFFERENT QUALITY SITES. NO ALLOWANCE FOR EXCESSIVE CROOK, WASTE OR BREAKAGE.

BOARDS 1 1-16 INCHES THICK, BAND-SAWED, 1-7 INCH KERF.

(To reduce to circular-sawed, 1-4 inch kerf, divide by 1.144.)

Age Years	Quality		
	I	II	III
	Volume—Board feet		
25	5,450	----------	----------
30	16,500	2,200	----------
35	25,300	12,250	1,400
40	31,800	19,400	7,750
45	36,650	24,400	12,700
50	40,350	28,300	16,650
55	43,500	31,400	19,800
60	46,200	34,150	22,300
65	48,600	36,450	24,650
70	50,500	38,500	26,650
75	52,100	40,200	28,350
80	53,350	41,600	29,800
85	54,350	42,700	30,900
90	55,200	43,500	31,700
95	56,000	44,200	----------
100	56,700	44,700	----------

TABLE 42.—TOTAL NUMBER OF LOBLOLLY PINE TREES OF ALL CROWN CLASSES PER ACRE SIX INCHES AND OVER IN DIAMETER, THEIR AVERAGE DIAMETER AND PER CENT OF DECREASE IN NUMBER, TOTAL NUMBER OF DOMINANT TREES SIX INCHES AND OVER, AND THEIR AVERAGE DIAMETER AT DIFFERENT AGES ON DIFFERENT QUALITY SITES.

Age Years	Trees of all crown classes 6 inches and over			Dominant trees 6 inches and over	
	Number of trees per acre	Per cent of decrease in number of trees	Average diameter Inches	Number of trees per acre	Average diameter Inches
Quality I					
25	486	----------	8.2	230	9.1
30	449	7.6	9.3	248	10.4
40	273	39.2	11.4	179	13.2
50	199	27.1	13.2	125	15.7
60	169	15.1	14.8	100	17.4
70	150	10.6	16.1	89	18.8
80	134	----------	17.3	77	20.0
90	120	----------	18.3	71	21.2
100	108	----------	19.1	64	22.3
Quality II					
25	476	----------	7.5	262	7.8
30	469	1.5	8.5	273	8.8
40	342	27.8	10.3	217	10.8
50	244	28.3	11.9	151	12.8
60	187	21.8	13.2	118	14.5
70	160	12.4	14.3	101	15.7
80	142	----------	15.3	86	17.0
90	129	----------	16.2	77	18.1
100	118	----------	17.0	70	19.1
Quality III					
30	482	----------	7.6	263	8.2
40	357	17.9	9.1	204	10.0
50	256	28.3	10.5	157	11.7
60	199	17.0	11.7	121	13.1
70	167	12.6	12.7	102	14.3
80	150	----------	13.6	88	15.4

TABLE 43.—TOTAL NUMBER OF TREES PER ACRE NINE INCHES AND OVER IN DIAMETER BREAST-HIGH AND THEIR AVERAGE DIAMETER IN DENSE, UNTHINNED STANDS OF LOBLOLLY PINE AT DIFFERENT AGES ON DIFFERENT QUALITY SITES.

Age of stand Years	Number of trees 9 inches in diameter and over	Average diameter
	Quality I	
25	234	10.3
30	254	11.4
40	204	13.2
50	173	14.6
60	154	15.6
70	140	16.4
80	130	17.1
90	121	17.6
100	115	18.0
110	109	18.4
120	105	18.6
	Quality II	
25	68	9.4
30	153	9.9
40	197	11.2
50	179	12.6
60	161	13.9
70	145	14.9
80	135	15.6
90	126	16.2
100	118	16.7
110	112	17.0
120	108	17.4
	Quality III	
30	46	9.1
40	234	9.7
50	173	11.0
60	146	12.5
70	126	13.6
80	113	14.4
90	102	15.1
100	94	15.6

TABLE 44.—TOTAL NUMBER OF TREES PER ACRE ELEVEN INCHES AND OVER IN DIAMETER BREASTHIGH AND THEIR AVERAGE DIAMETER IN DENSE, UNTHINNED STANDS OF LOBLOLLY PINE AT DIFFERENT AGES ON DIFFERENT QUALITY SITES.

Age of stand Years	Number of trees 11 inches in diameter and over	Average diameter
	Quality I	
25	156	11.8
30	173	12.6
40	163	14.2
50	150	15.4
60	135	16.4
70	125	17.2
80	117	17.8
90	109	18.3
100	104	18.7
110	101	18.9
120	98	19.1
	Quality II	
30	50	11.5
40	120	12.8
50	131	14.1
60	127	15.2
70	120	16.0
80	114	16.7
90	107	17.3
100	102	17.7
110	98	18.0
120	95	18.3
	Quality III	
40	80	11.7
50	96	13.0
60	94	14.2
70	90	15.1
80	85	15.8
90	81	16.3
100	78	16.7

GRADED VOLUME TABLES.

Tables 45 to 54 give the actual amounts, values, and percentages of the different grades of lumber sawed from logs of different grades and from logs from different parts of the stem.

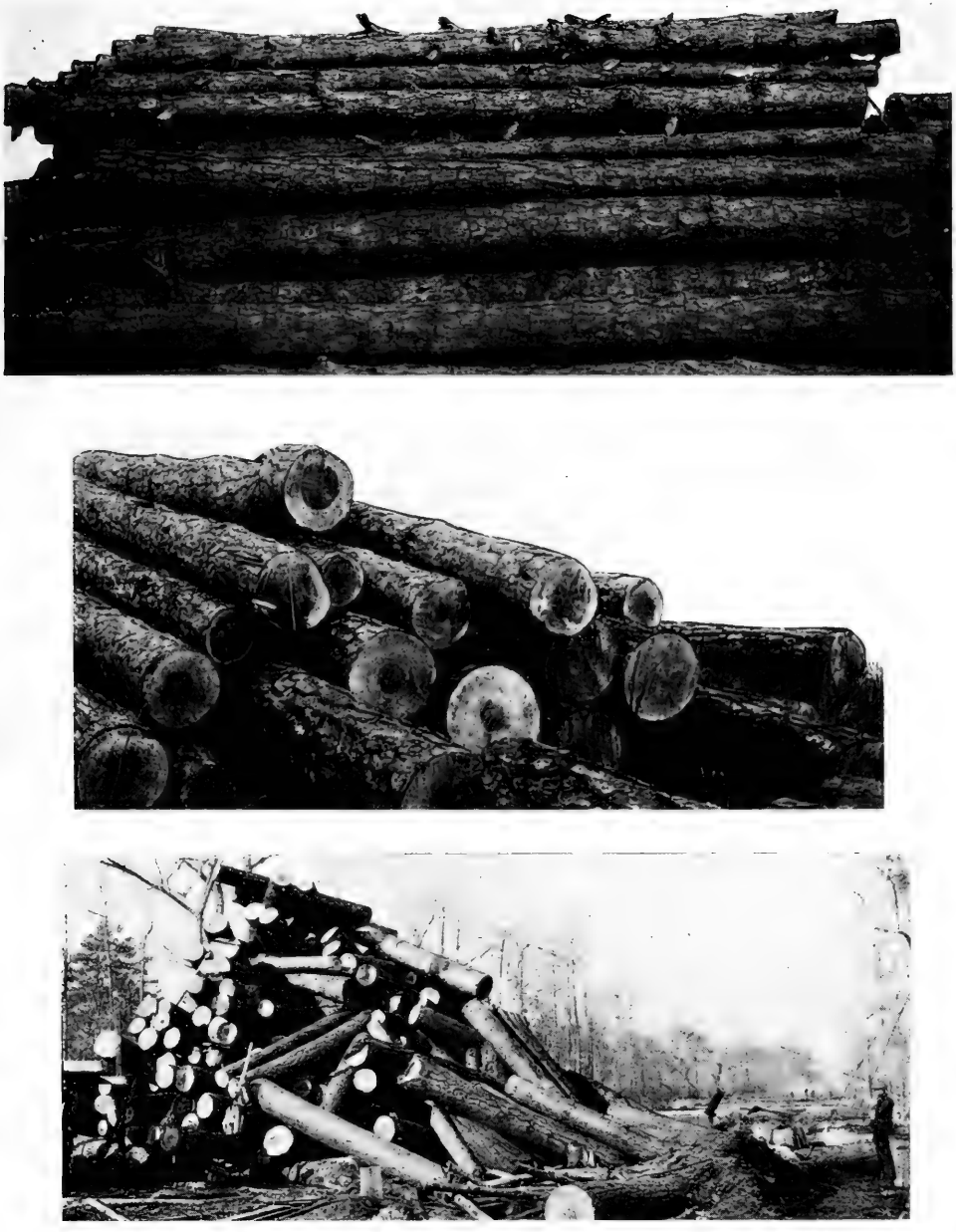
The results were secured by a large number of measurements of the logs in the woods and their cut at the mill. The logs were carefully measured as to diameter and length, and marked, those in each tree being given a specific designation, which showed not only that they were from the same tree, but indicated the relative position of each log in the trunk of the tree, whether butt, second, third, or top. About 1,000 logs were sawed at a mill with a daily cut of 30,000 board feet by a circular saw taking a ¼-inch kerf. An exact tally was kept not only of the number of feet but of the grade of each board which was sawed from each log. These logs ranging in diameter at the small end from 5 inches to 20 inches were largely from second-growth stands between 40 and 70 years old. The utilization was close and the amount of mill waste small; somewhat closer utilization would have been possible in the tops, but at the expense of reducing the grades. About 1,000 other logs ranging in diameter at the small end from 7 to 30 inches were marked and numbered in the woods and were carefully graded. These were sawed at three different mills and, with the exception of a small number, were band-sawed. An exact tally was kept of the number of board feet and the amount of each grade of lumber which was sawed from the logs of different diameters in each grade of logs. These logs were from trees in stands which varied in age between 45 and 250 years. The cut of all logs was brought to a uniform basis as regards saw thickness and allowance for shrinkage by the use of converting factors (see note to table 23).

GRADING OF LOGS.

Six grades of logs were recognized as follows:

Grade 1. Logs smooth-barked, the centers not coarse-grained, and entirely free from such surface indications of defects as knot signs or red heart. While they are chiefly butt logs, second and even third logs from large 5 and 6-logged trees, particularly those from intermediate and suppressed trees, were included in this grade. Even butt logs of this grade if less than 10 inches in diameter must as a rule come from intermediate and suppressed trees. They have less taper than any other grade of logs and consequently saw out less lumber above the log scale. The f. o. b. value (first quarter 1913) of the lumber which is sawed from Grade 1 logs at points which have the Norfolk, Virginia, price basis is from $22.46 per 1,000 board feet for lumber from 7-inch logs to $30 per 1,000 board feet for lumber from 30-inch logs. (Plate XII, C.)

Grade 2. Logs free from indications of red heart, smooth barked, but showing slight signs of knots on one side or quarter of the log.



LOGS OF DIFFERENT GRADES.

A. Logs chiefly of Grades 3 and 4, diameters 5 to 16 inches. These are the prevailing grades and sizes now coming to the mills. Average log about 38 feet, D.-S. (Author's illustration.)

B. Logs chiefly of Grades 2 and 3, diameters 10 to 24 inches. These are the prevailing grades and sizes which were cut by the mills between 1895 and 1910. Average log about 90 feet, D.-S. The small size of the heartwood is noteworthy. (Author's illustration.)

C. Logs chiefly of Grades 1 and 2, diameters 12 to 36 inches. These were the prevailing grades and sizes which were sawed until 1895. Average log about 200 feet, D.-S.

GRADING OF LUMBER.

All lumber was graded according to the 1911 standard for the inspection of North Carolina pine. The basis of inspection is the best or face side. Stock sizes below 12-inch are 6-inch, 8-inch and 10-inch widths. Other widths are grouped as edge. A pin knot is not over ½ inch; a standard knot not over 1½ inches; a large knot is over 1½ inches. Standard lengths of lumber are 8 to 16 feet, not to exceed 5 per cent 8 feet lengths; widths, other than bark strips 3 inches and over. The following is a brief description of the grades of kiln-dried lumber. Air dried lumber admits more stain than kiln-dried; 25 per cent in No. 2; 50 per cent in No. 3; 75 per cent in No. 4. By stain is meant blued sap wood. This does not affect the strength of the wood.

No. 1 Grade. This grade includes boards 8 inches and under in width having one side clear of all defects, except 2 small defects such as pitch streaks, and the other side grading up to a No. 2 board. Lumber over 8 inches wide may have in addition one small pitch pocket, sound pin knot, or other slight defect for each additional 2 inches of width. (Plate XIII, A.)

No. 2 Grade.—This grade consists of boards with small tight knots on the best side and less than one-sixth of the area of pitch streaks; the other side grades up to No. 3 or better. Pieces 8 inches in width or under may have 3 pin knots, or 3 small pitch pockets; pieces over 8 inches wide may have for each additional 2 inches of width one standard knot, 3 pin knots or 3 pitch pockets or small pitch streaks. (Plate XIII, B.)

No. 3 Grade.—This grade consists of tight knotted boards below No. 2, one edge No. 2 or better on the best face, and not to exceed 15 per cent of stain. Pieces 6 inches and over admit sound knots to a diameter of not over ¼ of the width of the piece, or other defects such as pin knots, pitch pockets, or pitch streaks; pitchy boards which would otherwise grade No. 1 or No. 2. No. 1 and No. 2 boards which are pitchy, No. 2, allowing 33 per cent. No. 1, 50 per cent of pitch; No. 1 and No. 2 boards having 50 per cent stained surface or firm redheart not to exceed 20 per cent are admitted to this grade. (Plate XIII, C.)

No. 4 Grade (Box).—Box consists of sound lumber below the grade of No. 3, containing pin, standard, and large reasonably sound knots, and will admit other knots which do not seriously affect the strength of the pieces; a larger amount of pitchy, stained, or redheart surface than No. 3, or a greater aggregate of knots or pitch pockets than is admissible in No. 3 boards. (Plate XIII, D.)

No. 5 Grade (Culls).—Culls consist of lumber lower than No. 4 (excepting redheart or box strips), either knottier or with more pitch, which can be used without a waste exceeding 25 per cent and may contain 50 per cent of firm redheart.

Firm redheart admits pieces containing any amount of firm redheart which can not be classed as No. 1, 2, 3, or 4. (Plate XIII, E.)

Nos. 1 and 2 bark strips consist of edging lumber faced with bark on one side and shall not show less than ½ inch of wood on both edges from end to end of piece, and shall otherwise equal the grades of Nos. 1 and 2 lumber.

Box bark strip. This grade consists of bark strips falling below No. 1 and No. 2 bark strip. (Plate XIII, F.)

TABLE 45.—PER CENT OF DIFFERENT GRADES OF NORTH CAROLINA PINE LUMBER SAWED FROM GRADE ONE LOGS OF LOBLOLLY PINE OF DIFFERENT DIAMETERS.

Logs 16.3 feet long, perfect, sound, usually from the lower part of stem, free from knot signs, with smooth bark and fine-grained centers. Boards 1 1-16 inch thick, band-sawed, kerf 1-7 inch.

Diameter inside bark at small end of log Inches	Per cent of each grade						
	No. 1	No. 2	No. 3	Box	Red heart and cull	Bark strips Nos. 1 and 2	Total
7	25.0	25.0	20.8	16.7	----------	12.5	100
8	23.5	32.4	23.5	11.8	----------	8.8	100
9	24.4	37.8	22.2	8.9	----------	6.7	100
10	28.3	38.3	21.7	6.7	----------	5.0	100
11	28.4	40.5	21.6	5.4	----------	4.1	100
12	31.9	39.6	20.8	4.4	----------	3.3	100
13	33.6	39.1	20.1	3.6	----------	3.6	100
14	35.9	38.2	19.1	3.0	.8	3.0	100
15	37.5	36.8	19.1	2.6	.7	3.3	100
16	40.1	35.6	18.0	2.3	.6	3.4	100
17	41.6	34.7	17.7	2.0	.5	3.5	100
18	43.0	34.3	17.6	1.7	.4	3.0	100
19	43.8	33.8	17.4	1.5	.4	3.1	100
20	44.2	33.2	17.5	1.7	.3	3.1	100
21	44.0	33.0	17.8	1.8	.3	3.1	100
22	43.7	32.7	18.1	2.2	.3	3.0	100
23	43.6	32.7	18.6	2.2	.2	2.7	100
24	43.2	32.2	18.9	2.5	.5	2.7	100
25	42.9	32.2	19.5	2.5	.4	2.5	100
26	42.9	32.2	19.7	2.5	.4	2.3	100
27	42.7	32.2	20.1	2.4	.4	2.2	100
28	42.6	32.1	20.6	2.4	.3	2.0	100
29	42.4	32.2	20.8	2.4	.3	1.9	100
30	42.2	32.2	21.0	2.5	.3	1.8	100

TABLE 46.—PER CENT OF DIFFERENT GRADES OF NORTH CAROLINA PINE LUMBER SAWED FROM GRADE TWO LOGS OF LOBLOLLY PINE OF DIFFERENT DIAMETERS.

Logs 16.3 feet long, slightly knotty, sound, usually from the lower part of stem, with smooth bark, and moderately fine-grained centers. Boards 1 1-16 inch thick, band-sawed, kerf 1-7 inch.

Diameter inside bark at small end of log Inches	Per cent of each grade						
	No. 1	No. 2	No. 3	Box	Red heart and cull	Bark strips Nos. 1 and 2	Total
7	16.6	25.0	29.3	16.6	----------	12.5	100
8	17.6	32.4	29.4	11.8	----------	8.8	100
9	20.0	37.8	26.6	8.9	----------	6.7	100
10	21.7	39.9	26.7	6.7	----------	5.0	100
11	23.0	40.5	27.0	5.4	----------	4.1	100
12	25.3	39.6	25.2	5.5	1.1	3.3	100
13	27.3	38.2	24.5	5.5	.9	3.6	100
14	29.8	37.4	24.3	4.6	.8	3.1	100
15	32.2	35.5	23.7	4.6	.7	3.3	100
16	34.5	33.9	23.1	4.5	.6	3.4	100
17	36.1	33.2	22.2	4.0	1.0	3.5	100
18	37.4	32.2	22.2	3.9	1.3	3.0	100
19	38.5	31.5	21.5	4.2	1.2	3.1	100
20	39.7	30.8	21.3	4.1	1.0	3.1	100
21	40.4	30.6	20.7	4.3	.9	3.1	100
22	40.9	30.2	20.7	4.4	.8	3.0	100
23	41.4	30.4	20.3	4.5	.7	2.7	100
24	42.0	30.1	20.2	4.3	.7	2.7	100
25	42.5	30.1	19.9	4.4	.6	2.5	100
26	42.9	30.0	19.7	4.5	.6	2.3	100
27	43.3	30.0	19.6	4.4	.5	2.2	100
28	43.3	30.1	19.5	4.4	.7	2.0	100
29	43.7	30.0	19.5	4.3	.6	1.9	100
30	43.7	29.9	19.6	4.3	.7	1.8	100

TABLE 47.—PER CENT OF DIFFERENT GRADES OF NORTH CAROLINA PINE LUMBER SAWED FROM GRADE THREE LOGS OF LOBLOLLY PINE OF DIFFERENT DIAMETERS.

Logs 16.3 feet long, slightly knotty, chiefly from the middle part of the stem. Boards 1 1-16 inch thick, band-sawed, kerf 1-7 inch.

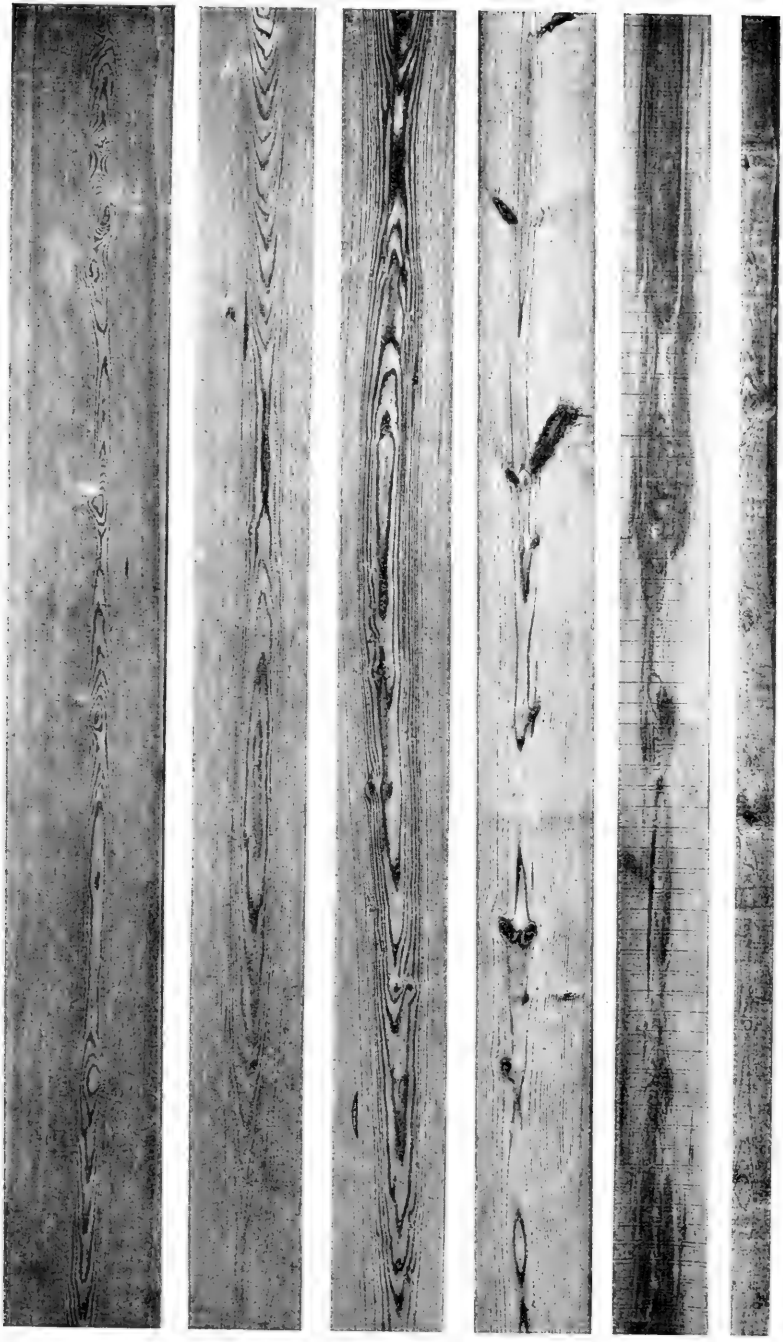
Diameter inside bark at small end of log Inches	Per cent of each grade						
	No. 1	No. 2	No. 3	Box	Red heart and cull	Bark strips Nos. 1 and 2	Total
5	----------	----------	----------	77.0	----------	23.0	100
6	----------	----------	33.3	52.4	----------	14.3	100
7	----------	6.3	31.2	50.0	3.1	9.4	100
8	----------	9.8	31.7	48.8	2.4	7.3	100
9	3.8	11.5	30.8	46.2	1.9	5.8	100
10	4.7	12.5	29.7	45.3	3.1	4.7	100
11	7.6	12.7	27.8	44.3	3.8	3.8	100
12	9.4	13.5	27.1	42.7	4.2	3.1	100
13	11.4	14.0	25.4	40.4	5.3	3.5	100
14	12.6	14.1	25.2	39.2	5.9	3.0	100
15	13.9	14.6	24.0	37.3	7.0	3.2	100
16	15.5	14.9	23.8	35.4	7.7	2.7	100
17	16.9	15.5	23.2	33.8	8.2	2.4	100
18	18.0	15.8	23.1	32.0	9.0	2.1	100
19	19.5	16.0	22.9	30.2	9.5	1.9	100
20	20.5	16.4	22.6	28.5	10.3	1.7	100
21	21.9	16.7	22.2	26.5	11.1	1.6	100
22	23.2	16.5	22.4	25.0	11.5	1.4	100
23	24.8	16.4	22.2	23.3	12.0	1.3	100
24	25.9	16.3	22.0	22.0	12.6	1.2	100
25	27.6	16.1	21.7	20.6	12.9	1.1	100
26	29.0	15.9	21.5	19.3	13.3	1.0	100
27	30.5	15.4	21.4	18.0	13.8	.9	100
28	31.9	15.2	21.2	16.9	13.9	.9	100
29	33.1	14.9	21.0	16.0	14.2	.8	100
30	34.3	14.4	20.9	15.2	14.4	.8	100

TABLE 48.—PER CENT OF DIFFERENT GRADES OF NORTH CAROLINA PINE LUMBER SAWED FROM GRADE 4 LOGS OF LOBLOLLY PINE OF DIFFERENT DIAMETERS. THESE ARE LOGS FROM BELOW THE TOP LOG.

Diameter inside bark at small end of Log Inches	No. 1	No. 2	No. 3	Box or No. 4	Cull	Box bark strip	Total
4	----------	----------	----------	74	----------	26	100
5	----------	----------	2	82	----------	16	100
6	----------	----------	5	85	----------	10	100
7	----------	----------	5	88	----------	7	100
8	----------	2	5	88	----------	5	100
9	----------	2	5	89	----------	4	100
10	----------	2	5	88	2	3	100
11	----------	2	5	88	2	3	100
12	1	2	5	87	2	3	100
13	2	2	6	86	2	2	100
14	2	2	6	86	2	2	100
15	2	3	6	85	2	2	100
16	2	3	6	85	2	2	100
17	3	3	6	84	3	1	100
18	3	4	6	82	4	1	100
19	3	4	7	81	4	1	100
20	4	4	7	80	4	1	100
21	5	5	7	77	5	1	.100
22	5	5	7	77	5	1	100

Grade 5 logs, which are knotty top logs, yield at least 95 per cent of No. 4 lumber and cull.

Cull logs, which are very knotty top logs from large trees and have coarse knots, yield at least 50 per cent cull lumber. (Note the log within the crown of tree in Plate VII.)



A B C D E F

PLATE XIII. Typical boards of important grades of North Carolina pine lumber 12 feet long. A to D, inclusive, are dressed boards; E and F are rough. (Photographs made under direction of author.)

A. No. 1 grade board, 16 inches wide, from a large, old, fine-grained heart tree of the quality known as "slash pine." A narrow margin of sapwood is shown on either edge of the board.

B. No. 2 grade board, 12 inches wide. The defects are a small pin knot and a narrow pitch streak in the upper one-half of the board. Board from an old growth, fine-grained tree, very largely heartwood.

C. No. 3 grade board, 12 inches wide. The defects are a pitch pocket in the lower one-fourth, two pin knots near the middle of the board, a pitch streak at the upper end of the board, and a sliver in the coarse flat grain of its center. Board is from a second-growth forest tree, coarse-grained in the center and medium-grained on the edges.

D. Box or No. 4 grade board, 12 inches wide. Very knotty and coarse-grained. This board is from a rapid growth tree of the old-field type and is all sapwood except a narrow ribbon of heart down the center.

E. Merchantable red heart grade board, 10 inches wide. This board would have graded as a No. 3 but for the red heart which shows as the dark streaks in the heartwood.

F. Box bark strip. The bark edge shows along the upper right-hand edge of the strip; the bark has been trimmed from the lower portion of the piece.

TABLE 49.—PER CENT OF DIFFERENT GRADES OF NORTH CAROLINA PINE LUMBER SAWED FROM RED HEART LOGS OF LOBLOLLY PINE OF DIFFERENT DIAMETERS.

Diameter inside bark at small end of log	No. 1	No. 2	No. 3	Box	Red heart and cull	Box bark strip	Total
Inches	Per cent of each grade						
7	6.2	9.4	31.3	37.5	6.2	9.4	100
8	4.9	7.3	24.4	41.5	14.6	7.3	100
9	3.8	7.7	19.2	46.2	17.3	5.8	100
10	3.1	6.3	17.2	48.4	18.7	6.3	100
11	3.8	6.3	13.9	48.1	22.8	5.1	100
12	4.2	5.2	12.5	48.9	24.0	5.2	100
13	5.3	5.3	11.4	48.2	25.4	4.4	100
14	5.2	5.2	10.4	47.4	28.1	3.7	100
15	5.7	5.1	9.5	46.2	30.3	3.2	100
16	6.0	5.0	9.4	44.8	32.0	2.8	100
17	6.3	4.8	9.2	43.5	33.8	2.4	100
18	6.9	4.7	9.4	41.9	35.0	2.1	100
19	6.9	4.6	9.5	40.5	36.6	1.9	100
20	7.2	4.5	9.6	39.0	38.0	1.7	100
21	7.1	4.3	9.9	38.0	39.2	1.5	100
22	7.0	4.2	10.4	37.2	39.8	1.4	100
23	6.6	4.1	10.5	36.8	40.7	1.3	100
24	6.5	3.7	10.8	36.7	41.1	1.2	100
25	6.2	3.7	10.7	36.6	41.7	1.1	100
26	6.0	3.4	10.5	36.7	42.4	1.0	100
27	5.9	3.1	10.3	37.2	42.6	.9	100
28	5.5	2.9	10.0	37.8	42.9	.9	100
29	5.2	2.7	9.5	38.5	43.3	.8	100
30	5.0	2.6	9.3	39.1	43.2	.8	100

TABLE 50.—AMOUNTS AND F. O. B. VALUES (1ST QUARTER, 1913) AT POINTS WHICH HAVE THE NORFOLK, VA., PRICE BASIS OF THE DIFFERENT GRADES OF NORTH CAROLINA PINE LUMBER SAWED FROM GRADE 1 LOGS OF LOBLOLLY PINE TREES OF DIFFERENT DIAMETERS.

Diameter inside bark at small end of log	No. 1		No. 2		No. 3		Box		Red heart and cull		Bark strips 1 and 2		Total Volume	Total value
Inches	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	
5	----------	$--------	1	$ 0.01	3	$ 0.06	4	$ 0.06	----------	$--------	3	$ 0.06	11	$ 0.19
6	3	.08	4	.07	4	.08	4	.06	----------	----------	4	.08	19	.37
7	6	.17	6	.15	5	.10	4	.06	----------	----------	3	.06	24	.54
8	8	.23	11	.28	8	.15	4	.06	----------	----------	3	.06	34	.78
9	11	.32	17	.43	10	.20	4	.06	----------	----------	3	.06	45	1.07
10	17	.51	23	.59	13	.26	4	.06	----------	----------	3	.06	60	1.48
11	21	.64	30	.78	16	.32	4	.07	----------	----------	3	.06	74	1.87
12	29	.90	36	.96	19	.39	4	.07	----------	----------	3	.06	91	2.38
13	37	1.16	43	1.14	22	.46	4	.07	----------	----------	4	.08	110	2.91
14	47	1.52	50	1.35	25	.52	4	.07	1	.02	4	.08	131	3.56
15	57	1.86	56	1.52	29	.60	4	.07	1	.02	5	.10	152	4.17
16	71	2.38	63	1.74	32	.67	4	.07	1	.02	6	.11	177	4.99
17	84	2.86	70	1.95	36	.75	4	.07	1	.02	7	.13	202	5.78
18	99	3.37	79	2.20	40	.84	4	.07	1	.02	7	.13	230	6.63
19	114	3.88	88	2.46	45	.94	4	.07	1	.02	8	.15	260	7.52
20	129	4.41	97	2.72	51	1.07	5	.09	1	.02	9	.17	292	8.48
21	144	4.92	108	3.03	58	1.21	6	.11	1	.02	10	.19	327	9.48
22	159	5.44	119	3.34	66	1.38	8	.14	1	.02	11	.21	364	10.53
23	175	5.99	131	3.68	74	1.55	9	.16	1	.02	11	.21	401	11.61
24	189	6.48	141	3.96	83	1.73	11	.19	2	.03	12	.23	438	12.62
25	204	7.00	153	4.30	92	1.92	12	.21	2	.03	12	.23	475	13.69
26	220	7.55	165	4.64	101	2.11	13	.23	2	.03	12	.23	513	14.79
27	235	8.06	177	4.97	111	2.32	13	.23	2	.03	12	.23	550	15.84
28	251	8.61	189	5.31	121	2.53	14	.25	2	.03	12	.23	589	16.96
29	266	9.12	202	5.68	130	2.72	15	.26	2	.03	12	.23	627	18.04
30	282	9.67	215	6.04	140	2.93	17	.29	2	.03	12	.23	668	19.19

TABLE 51.—AMOUNTS AND F. O. B. VALUES (1ST QUARTER, 1913) AT POINTS WHICH HAVE THE NORFOLK, VA., PRICE BASIS OF THE DIFFERENT GRADES OF NORTH CAROLINA PINE LUMBER SAWED FROM GRADE 2 LOGS OF LOBLOLLY PINE TREES OF DIFFERENT DIAMETERS.

Diameter inside bark at small end of log	No. 1		No. 2		No. 3		Box		Red heart and cull		Bark strips 1 and 2		Total volume	Total value
Inches	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	
7	4	$ 0.12	6	$ 0.15	7	$ 0.13	4	$ 0.06	----------	$--------	3	$ 0.06	24	$ 0.52
8	6	.17	11	.28	10	.19	4	.06	----------	----------	3	.06	34	.76
9	9	.26	17	.43	12	.23	4	.06	----------	----------	3	.06	45	1.04
10	13	.39	24	.61	16	.32	4	.06	----------	----------	3	.06	60	1.44
11	17	.52	30	.78	20	.40	4	.07	----------	----------	3	.06	74	1.83
12	23	.71	36	.96	23	.47	5	.09	1	.02	3	.06	91	2.31
13	30	.94	42	1.12	27	.56	6	.10	1	.02	4	.08	110	2.82
14	39	1.26	49	1.32	32	.67	6	.10	1	.02	4	.08	131	3.45
15	49	1.60	54	1.47	36	.75	7	.12	1	.02	5	.10	152	4.06
16	61	2.04	60	1.66	41	.85	8	.14	1	.02	6	.11	177	4.82
17	73	2.48	67	1.86	45	.94	8	.14	2	.03	7	.13	202	5.58
18	86	2.92	74	2.06	51	1.07	9	.16	3	.05	7	.13	230	6.39
19	100	3.40	82	2.30	56	1.17	11	.19	3	.05	8	.15	260	7.26
20	116	3.97	90	2.52	62	1.30	12	.21	3	.05	9	.17	292	8.22
21	132	4.51	100	2.81	68	1.42	14	.25	3	.05	10	.19	327	9.23
22	149	5.10	110	3.09	75	1.57	16	.28	3	.05	11	.21	364	10.30
23	166	5.68	122	3.43	81	1.69	18	.32	3	.05	11	.21	401	11.38
24	184	6.31	132	3.71	88	1.84	19	.33	3	.05	12	.23	438	12.47
25	202	6.93	143	4.02	94	1.96	21	.37	3	.05	12	.23	475	13.56
26	220	7.55	154	4.33	101	2.11	23	.40	3	.05	12	.23	513	14.67
27	238	8.16	165	4.64	108	2.26	24	.42	3	.05	12	.23	550	15.76

TABLE 52.—AMOUNTS AND F. O. B. VALUES (1ST QUARTER, 1913) AT POINTS WHICH HAVE THE NORFOLK, VA., PRICE BASIS, OF DIFFERENT GRADES OF NORTH CAROLINA PINE LUMBER SAWED FROM GRADE 3 LOGS OF LOBLOLLY PINE TREES OF DIFFERENT DIAMETERS.

Diameter inside bark at small end of log	No. 1		No. 2		No. 3		Box		Red heart and cull		Bark strips 1 and 2		Total volume	Total value
Inches	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	
4		$		$		$		$		$		$		$
5							10	.15			3	.06	13	.21
6					7	.13	11	.17			3	.06	21	.36
7			2	.05	10	.19	16	.25	1	.01	3	.06	32	.56
8			4	.10	13	.26	20	.31	1	.01	3	.06	41	.74
9	2	.06	6	.15	16	.32	24	.38	1	.01	3	.06	52	.98
10	3	.09	8	.21	19	.38	29	.47	2	.03	3	.06	64	1.24
11	6	.18	10	.26	22	.58	35	.58	3	.05	3	.06	79	1.71
12	9	.28	13	.34	26	.54	41	.70	4	.06	3	.06	96	1.98
13	13	.41	16	.43	29	.60	46	.79	6	.10	4	.08	114	2.41
14	17	.54	19	.51	34	.71	53	.92	8	.13	4	.08	135	2.89
15	22	.71	23	.62	38	.79	59	1.03	11	.18	5	.10	158	3.43
16	28	.92	27	.74	43	.90	64	1.12	14	.23	5	.10	181	4.01
17	35	1.17	32	.89	48	1.00	70	1.23	17	.28	5	.10	207	4.67
18	42	1.43	37	1.04	54	1.13	75	1.32	21	.35	5	.10	234	5.37
19	51	1.73	42	1.18	60	1.25	79	1.39	25	.42	5	.10	262	6.07
20	60	2.04	48	1.34	66	1.38	83	1.46	30	.50	5	.10	292	6.82
21	71	2.41	54	1.51	72	1.50	86	1.51	36	.60	5	.10	324	7.63
22	83	2.82	59	1.65	80	1.67	89	1.57	41	.68	5	.10	357	8.49
23	97	3.30	64	1.79	87	1.82	91	1.60	47	.78	5	.10	391	9.39
24	111	3.77	70	1.96	94	1.96	94	1.65	54	.91	5	.10	428	10.35
25	128	4.35	75	2.10	101	2.11	96	1.69	60	1.01	5	.10	465	11.36
26	146	4.96	80	2.24	109	2.28	97	1.71	67	1.13	5	.10	504	12.42
27	166	5.64	84	2.36	117	2.45	98	1.72	75	1.26	5	.10	545	13.53
28	185	6.29	88	2.47	123	2.57	98	1.72	81	1.36	5	.10	580	14.51
29	205	6.97	92	2.59	130	2.72	99	1.74	88	1.48	5	.10	619	15.60
30	226	7.68	95	2.67	138	2.88	100	1.76	95	1.60	5	.10	659	16.69

TABLE 53.—AMOUNTS AND F. O. B. VALUES (1ST QUARTER, 1913), AT POINTS WHICH HAVE THE NORFOLK, VA., PRICE BASIS, OF DIFFERENT GRADES OF NORTH CAROLINA PINE LUMBER SAWED FROM GRADE 4 LOGS OF LOBLOLLY PINE TREES OF DIFFERENT DIAMETERS.

Diameter inside bark at small end of log	No. 1		No. 2		No. 3		Box		Red heart and cull		Bark strips 1 and 2		Total Volume	Total value
Inches	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	
4	----	$----	----	$----	----	$----	5	$ 0.08	----	$----	2	$ 0.02	7	$ 0.10
5	----	----	----	----	1	.02	10	.15	----	----	2	.02	13	.19
6	----	----	----	----	1	.02	18	.27	----	----	2	.02	21	.31
7	----	----	----	----	2	.04	28	.43	----	----	2	.02	32	.49
8	----	----	1	.03	2	.04	36	.57	----	----	2	.02	41	.66
9	----	----	1	.03	3	.06	45	.72	1	.01	2	.02	52	.84
10	----	----	1	.03	3	.08	57	.92	1	.01	2	.02	64	1.06
11	----	----	2	.05	4	.09	69	1.14	2	.03	2	.02	79	1.33
12	1	.03	2	.05	5	.10	83	1.41	2	.03	3	.03	96	1.65
13	2	.06	2	.05	5	.10	100	1.72	2	.03	3	.03	114	1.99
14	3	.09	3	.08	8	.17	115	1.98	3	.05	3	.03	135	2.40
15	3	.10	5	.14	9	.19	135	2.35	3	.05	3	.03	158	2.86
16	4	.13	6	.17	11	.23	153	2.68	4	.06	3	.03	181	3.30
17	6	.20	6	.17	12	.26	175	3.08	6	.10	2	.02	207	3.83
18	7	.24	9	.25	15	.31	192	3.37	9	.15	2	.02	234	4.34
19	8	.27	10	.28	18	.37	213	3.75	10	.17	3	.03	262	4.87
20	11	.37	12	.34	20	.42	235	4.14	11	.18	3	.03	292	5.48
21	16	.54	16	.45	23	.45	250	4.43	16	.26	3	.03	324	6.16
22	18	.57	18	.51	28	.48	272	4.79	18	.29	3	.03	357	6.67

TABLE 54.—AMOUNTS AND F. O. B. VALUES (1ST QUARTER, 1913), AT POINTS WHICH HAVE THE NORFOLK, VA., PRICE BASIS, OF DIFFERENT GRADES OF NORTH CAROLINA PINE LUMBER SAWED FROM RED HEART LOGS OF LOBLOLLY PINE TREES OF DIFFERENT DIAMETERS.

Diameter inside bark at small end of log	No. 1		No. 2		No. 3		Box		Red heart and cull		Bark strips 1 and 2		Total volume	Total value
Inches	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	
7	2	$ .06	3	$ 0.08	10	$ 0.19	12	$ 0.18	2	$ 0.03	3	$ 0.03	32	$ 0.57
8	2	.06	3	.08	10	.20	17	.27	6	.08	3	.03	41	.72
9	2	.06	4	.10	10	.20	24	.38	9	.13	3	.03	52	.90
10	2	.06	4	.10	11	.22	31	.50	12	.18	4	.04	64	1.10
11	3	.09	5	.13	11	.29	38	.63	18	.28	4	.04	79	1.46
12	4	.13	5	.14	12	.25	47	.80	23	.37	5	.06	96	1.75
13	6	.19	6	.16	13	.27	55	.95	29	.47	5	.06	114	2.10
14	7	.22	7	.19	14	.24	64	1.11	38	.62	5	.06	135	2.49
15	9	.29	8	.22	15	.31	73	1.27	48	.79	5	.06	158	2.94
16	11	.36	9	.25	17	.36	81	1.43	58	.96	5	.06	181	3.42
17	13	.44	10	.28	19	.40	90	1.59	70	1.16	5	.06	207	3.93
18	16	.54	11	.31	22	.46	98	1.72	82	1.37	5	.06	234	4.46
19	18	.61	12	.34	25	.52	106	1.87	96	1.60	5	.06	262	5.00
20	21	.71	13	.36	28	.59	114	2.01	111	1.85	5	.06	292	5.58
21	23	.78	14	.39	32	.67	123	2.16	127	2.12	5	.06	324	6.18
22	25	.85	15	.42	37	.77	133	2.34	142	2.37	5	.06	357	6.81
23	26	.88	16	.45	41	.86	144	2.53	159	2.66	5	.06	391	7.44
24	28	.95	16	.45	46	.96	157	2.76	176	2.96	5	.06	428	8.14
25	29	.99	17	.48	50	1.05	170	2.99	194	3.26	5	.06	465	8.83
26	30	1.02	17	.48	53	1.11	185	3.26	214	3.60	5	.06	504	9.53
27	32	1.09	17	.48	56	1.17	203	3.57	232	3.90	5	.06	545	11.27
28	32	1.09	17	.48	59	1.21	222	3.85	251	4.18	5	.06	586	10.87
29	32	1.09	17	.48	59	1.23	238	4.19	267	4.50	5	.06	618	11.55
30	33	1.12	17	.48	61	1.27	256	4.54	283	4.79	5	.06	655	12.26

Tables 55 and 55*a* give the per cent and amounts of the different grades of lumber sawed with a circular saw with ¼-inch kerf in logs from different parts of the trunk of trees in fully stocked stands of loblolly pine 45 years old, Quality I, and 65 years old between Qualities II and III, respectively. These measurements were made at a mill in Gates County, N. C. They show the small per cent of upper grades in top logs and indicate the necessity of forcing the length of clear stem of trees in young stands since, at a given age, with equal diameters, the longer the stem the greater is the proportion of upper grades. (Plates III, XIV and XVII, also I and VII.) The larger proportion of upper grades of lumber in the logs of the older stand is noteworthy as well as the rapid increase in the amounts of these grades with diameter. This also applies to Tables 56 and 57.

Table 56 gives the per cent of different grades of lumber in trees of different diameters in fully stocked stands 40 to 50 years old on different quality sites, and Table 57, the same for stands 60 to 70 years old. These tables show the per cent of grades which trees in stands on different quality sites can be expected to yield at 45 and 65 years.* By interpolation the proportion can be ascertained for trees in stands of intermediate ages, and the proportion can be approximated for trees in younger and older stands. Few commercial stands will be produced, however, beyond the age of 60 years. This table used in connection with value table (Table 58) enables the probable future value of a stand

*The average tree which was being cut in the 60-70 years old stand in Gates County had a mill volume of 142 board feet, and a corresponding breast-high diameter of 13.6 inches. The grade yield of such a tree (between quality classes II and III) is obtained from Table 57 as consisting of:

Grade	Per cent of grade	Price per 1000 ft. of grade 1912–13	Value
No. 1	13	$ 29.80	$ 3.87
No. 2	10	25.50	2.55
No. 3	20	19.20	3.84
No. 4	50	15.00	7.50
1 and 2 Bark Strip	4	19.00	.76
Box Bark Strip	2	11.00	.22
Cull	1	13.00	.13
Value per 1,000 feet of lumber in average tree			$ 18.87

This gives an f. o. b. Norfolk value of $18.87 per 1,000 bd. ft., which is within a few cents of the figure obtainable from Tables 63 and 64. Since cutting in this stand was only to 8 inches in diameter breasthigh, the average diameter is .6 inch larger than that obtained from Table 16.

The 45 year old stand, Quality I, also in Gates County, has an average diameter of 12.8 inches, a volume of 106 board feet, and an average value per 1,000 board feet of its lumber of $16.72.

The average of these figures, $17.80, corresponds very closely to the Norfolk price that the output of this operation brought when cut in the winter of 1912. The average tree cut in this operation was 13.7 inches in diameter breasthigh.

to be determined and the financial results of thinnings to be forecast. The values of trees in these stands are given in Tables 59 to 64. For a discussion of the factors influencing grades see pages 119 and following.

Tables 55, 56, and 57 apply only to fully stocked stands on forest soils. They will not apply to younger or open stands, formed of short-bodied trees or to stands on dry upland old fields, in which the wood is coarse grained and knotty and which will largely yield No. 4 lumber.

TABLE 55.—AMOUNTS AND PER CENTS OF GRADES CUT FROM BUTT, MIDDLE, AND TOP LOGS OF LOBLOLLY PINE (CROOK LESS THAN TWO INCHES) STANDS 45 YEARS OLD, QUALITY I.

CIRCULAR-SAWED 1-4 INCH KERF.

Diameter inside bark at top of log	No. 1		No. 2		No. 3		No. 4 or Box		1 and 2 bark strips		Box bark strips		Cull and red heart		Total volume of log
Inches	Bd. ft.	Per cent	Bd. ft.	Per cent	Bd. ft.	Per cent	Bd. ft.	Per cent	Bd. ft.	Per cent	Bd. ft.	Per cent	Bd. ft.	Per cent	Bd. ft.
Butt logs															
6	----------	----------	0.5	2	3	15	11	64	2	15	0.5	3	----------	1	17
7	----------	2	1	4	5	18	15	60	3	12	1	3	----------	1	25
8	1	4	2	6	7	20	20	56	3	10	1	3	----------	1	34
9	3	6	4	8	9	20	25	55	2	8	1	2	1	1	45
10	5	8	6	10	12	21	31	54	3	5	1	2	----------	----------	58
11	7	10	8	11	16	22	37	52	3	4	1	1	----------	----------	72
12	10	12	11	13	19	22	43	50	3	3	----------	----------	----------	----------	86
13	14	14	14	14	23	22	48	47	3	3	----------	----------	----------	----------	102
14	17	15	19	16	26	22	52	44	4	3	----------	----------	----------	----------	118
15	23	17	23	17	32	23	56	41	3	2	----------	----------	----------	----------	137
Second log															
5	----------	----------	----------	----------	----------	2	9	82	0.5	4	1.5	12	----------	----------	11
6	----------	----------	----------	1	5	4	15	82	0.5	3	1.5	10	----------	----------	18
7	----------	1	0.5	2	1	5	22	81	0.5	2	3	9	----------	----------	27
8	1	2	1	3	2	6	30	81	1	2	2	6	----------	----------	37
9	1	3	2	3	3	7	40	81	1	2	2	4	----------	----------	48
10	2	4	3	4	4	7	48	81	1	2	1	2	----------	----------	59
11	3	4	4	5	6	8	57	80	1	2	1	1	----------	----------	72
12	3	4	4	5	9	10	69	79	2	2	----------	----------	----------	----------	87
13	6	6	6	6	11	10	78	76	2	2	----------	----------	----------	----------	103

TABLE 55—*Continued.*

Diameter inside bark at top of log	No. 1		No. 2		No. 3		No. 4 or Box		1 and 2 bark strips		Box bark strips		Cull and red heart		Total volume of log
Inches	Bd. ft.	Per cent	Bd. ft.	Per cent	Bd. ft.	Per cent	Bd. ft.	Per cent	Bd. ft.	Per cent	Bd. ft.	Per cent	Bd. ft.	Per cent	Bd. ft.
Logs below the top log in 4 and 5 logged trees															
6	----------	----------	----------	----------	----------	----------	19	87	1	3	2	10	----------	----------	22
7	----------	----------	----------	----------	----------	----------	28	91	1	2	2	7	----------	----------	31
8	----------	----------	----------	----------	1	2	37	91	1	2	2	5	----------	----------	41
9	----------	----------	----------	----------	2	4	48	91	1	1	2	4	----------	----------	53
10	----------	----------	----------	----------	4	6	61	90	1	1	2	3	----------	----------	68
11	----------	----------	----------	----------	7	9	72	88	----------	----------	3	3	----------	----------	82
12	----------	----------	----------	----------	11	11	83	86	----------	----------	3	3	----------	----------	97
13	----------	----------	----------	----------	14	13	98	85	----------	----------	2	2	----------	----------	114

Top logs in 3, 4, and 5 logged trees entirely No. 4 grade, except about 2 per cent of box bark strip in diameters below 8 inches, and about 3 per cent of red heart and cull.

TABLE 55*a*.—AMOUNTS AND PER CENTS OF GRADES CUT FROM BUTT, MIDDLE, AND TOP LOGS OF LOBLOLLY PINE (CROOK LESS THAN TWO INCHES), STANDS 60 TO 70 YEARS OLD, BETWEEN QUALITIES II AND III.

CIRCULAR-SAWED 1-4 INCH KERF.

Diameter inside bark at top of log	No. 1		No. 2		No. 3		No. 4 or Box		1 and 2 bark strips		Box bark strips		Cull and red heart		Total volume of log
Inches	Bd. ft.	Per cent	Bd. ft.	Per cent	Bd. ft.	Per cent	Bd. ft.	Per cent	Bd. ft.	Per cent	Bd. ft.	Per cent	Bd. ft.	Per cent	Bd. ft.
Butt logs															
6	0.5	3	0.5	3	7	40	6	37	2	13	1	4	----	----	17
7	2	7	2	7	10	39	7	32	3	12	1	3	----	----	25
8	3	11	3	10	14	38	10	29	3	10	1	2	----	----	34
9	7	15	6	13	16	36	12	26	3	8	1	2	----	----	45
10	10	17	9	15	21	37	14	24	3	6	1	1	----	----	58
11	14	20	13	18	26	36	15	21	3	4	1	1	----	----	72
12	19	22	17	20	31	36	16	18	3	4	----	----	----	----	86
13	25	24	21	21	37	36	16	16	3	3	----	----	----	----	102
14	30	25	27	23	44	37	15	13	2	2	----	----	----	----	118
15	37	27	34	24	49	37	14	10	3	2	----	----	----	----	137
16	43	28	38	25	57	37	12	8	3	2	----	----	----	----	153
Second log															
5	----	1	----	2	2	15	7	65	1	12	1	5	----	----	11
6	----	2	1	4	2	16	12	65	2	9	1	4	----	----	18
7	1	4	2	7	4	15	17	65	2	6	1	3	----	----	27
8	2	6	3	8	5	15	24	64	2	5	1	2	----	----	37
9	3	7	5	10	7	15	30	62	2	4	1	2	----	----	48
10	5	8	6	11	9	15	36	61	2	4	1	1	----	----	59
11	6	9	8	12	12	15	42	59	3	4	1	1	----	----	72
12	9	10	11	13	14	16	50	58	3	3	----	----	----	----	87
13	11	11	13	13	18	17	58	56	3	3	----	----	----	----	103
14	14	12	17	14	20	17	65	54	4	3	----	----	----	----	120

TABLE 55a—*Continued.*

Diameter inside bark at top of log	No. 1		No. 2		No. 3		No. 4 or Box		1 and 2 bark strips		Box bark strips		Cull and red heart		Total volume of log
Inches	Bd. ft.	Per cent	Bd. ft.	Per cent	Bd. ft.	Per cent	Bd. ft.	Per cent	Bd. ft.	Per cent	Bd. ft.	Per cent	Bd. ft.	Per cent	Bd. ft.
Logs below the top log in 4 and 5 logged trees															
5	----------	----------	----------	----------	----------	1	12	85	----------	3	1	11	----------	----------	13
6	----------	----------	----------	----------	0.5	2	19	88	.5	2	2	8	----------	----------	22
7	----------	----------	0.5	1	0.5	2	28	90	.5	1	1.5	6	----------	----------	31
8	0.5	1	0.5	1	0.5	2	38	92	----------	----------	1.5	4	----------	----------	41
9	0.5	1	0.5	1	1.5	3	49	92	----------	----------	1.5	3	----------	----------	53
10	1	1	1	1	2	4	62	92	----------	----------	1	2	----------	----------	68
11	1	1	2	2	3	4	74	91	----------	----------	2	2	----------	----------	82

Top logs in 3, 4, and 5 logged trees entirely No. 4 grade, except about 2 per cent of box bark strip in diameters below 7 inches, and about 3 per cent of red heart and cull, chiefly in diameters above 7 inches.

TABLE 56.—PER CENT OF GRADES OF LUMBER IN TREES OF DIFFERENT DIAMETERS GROWING IN FULLY STOCKED STANDS OF DIFFERENT AGES AND ON DIFFERENT QUALITY SITES.

STANDS 40 TO 50 YEARS OLD.

Quality I

Diameter breast-high	Height of tree	No. 1	No. 2	No. 3	No. 4 or box	Bark strips		Cull and red heart	Total
						1 and 2	Box		
Inches	Feet	Per cent							
7	70	----	----	5	76	11	8	----	100
8	75	----	----	8	75	10	7	----	100
9	80	1	1	9	74	9	6	----	100
10	84	2	3	8	73	7	6	1	100
11	88	3	4	9	73	5	5	1	100
12	91	3	5	10	74	4	3	1	100
13	93	4	6	11	73	3	2	1	100
14	94	5	7	11	72	2	2	1	100
15	95	6	7	12	71	2	1	1	100
16	96	7	8	12	69	2	1	1	100
17	97	8	9	12	68	2	----	1	100
18	98	9	9	12	67	2	----	1	100
19	99	10	10	12	65	2	----	1	100
20	99	11	11	12	63	2	----	1	100

Quality II

7	59	----	----	2	79	10	9	----	100
8	64	----	----	6	78	9	7	----	100
9	68	----	----	7	78	8	6	1	100
10	72	----	1	8	78	6	6	1	100
11	76	----	2	8	79	5	5	1	100
12	79	1	3	8	79	4	4	1	100
13	81	2	4	9	79	3	2	1	100
14	83	3	5	9	78	2	2	1	100
15	84	4	6	10	76	2	1	1	100
16	85	5	7	10	74	2	1	1	100
17	85	6	8	10	72	2	1	1	100
18	85	7	8	10	72	2	----	1	100
19	84	8	9	10	70	2	----	1	100

Quality III

7	52	----	----	----	82	9	9	----	100
8	57	----	----	3	81	8	8	----	100
9	61	----	----	6	80	7	7	----	100
10	64	----	----	8	80	5	6	1	100
11	67	----	2	8	80	4	5	1	100
12	69	1	2	8	81	3	4	1	100
13	70	1	3	8	82	2	3	1	100
14	71	2	5	8	79	2	3	1	100
15	71	3	5	9	78	2	2	1	100
16	71	4	5	9	78	2	1	1	100
17	71	4	6	9	77	2	1	1	100
18	70	5	6	9	76	2	1	1	100

TABLE 57.—PER CENT OF GRADES OF LUMBER IN TREES OF DIFFERENT DIAMETERS, IN FULLY STOCKED STANDS OF DIFFERENT AGES AND ON DIFFERENT QUALITY SITES.

STANDS 60 TO 70 YEARS OLD.

Quality I

Diameter breast-high	Height of tree	No. 1	No. 2	No. 3	No. 4 or box	Bark strips		Cull and red heart	Total
						1 and 2	Box		
Inches	Feet	Per cent							
11	87	11	9	25	45	7	3	----------	100
12	92	15	12	26	38	6	2	1	100
13	96	18	13	26	36	5	1	1	100
14	100	20	13	27	34	4	1	1	100
15	103	21	14	28	31	4	1	1	100
16	105	22	14	28	31	3	1	1	100
17	106	23	15	28	30	3	----------	1	100
18	107	23	16	28	29	3	----------	1	100
19	108	24	16	29	28	2	----------	1	100
20	109	24	17	29	27	2	----------	1	100
21	110	25	17	29	26	2	----------	1	100
22	110	25	19	29	25	1	----------	1	100
23	110	26	20	30	22	1	----------	1	100
24	111	26	21	30	21	1	----------	1	100
25	111	26	21	30	21	1	----------	1	100

Quality II

9	----------	1	6	22	56	8	7	----------	100
10	74	5	6	21	54	7	6	1	100
11	78	9	8	21	51	6	4	1	100
12	82	12	9	21	49	5	3	1	100
13	85	14	10	21	48	4	2	1	100
14	86	15	11	21	47	4	1	1	100
15	90	16	13	21	44	4	1	1	100
16	92	18	13	21	43	3	1	1	100
17	93	19	14	21	41	3	1	1	100
18	94	20	14	21	41	3	----------	1	100
19	95	21	14	21	40	3	----------	1	100
20	95	21	15	21	39	3	----------	1	100
21	95	22	15	21	38	3	----------	1	100
22	95	22	15	22	38	2	----------	1	100

Quality III

9	63	--------	5	20	58	7	9	1	100
10	67	3	4	20	58	6	8	1	100
11	71	6	5	19	59	5	5	1	100
12	74	9	7	18	57	4	4	1	100
13	76	11	8	18	55	4	3	1	100
14	78	12	9	18	55	3	2	1	100
15	80	13	10	18	53	3	2	1	100
16	81	14	11	18	51	3	2	1	100
17	81	16	12	18	49	3	1	1	100
18	81	17	12	18	48	3	1	1	100
19	82	18	12	18	48	2	1	1	100
20	82	18	13	17	48	2	1	1	100
21	82	19	13	17	47	2	1	1	100

INCREASE IN VALUE OF TREES.

A tree increases in value by: (1) Increase in volume; (2) increase in the width of the boards which are cut from the tree, since the wider the board the greater its price even in the same grade; (3) increase in the proportion of the higher priced grades, which are free from knots and other defects; (4) increase in the price of stumpage; and (5) closer utilization or lowering the specifications of grades of lumber. In a fully stocked stand the effects of these factors progressively increase with the age of the stand and the size of the trees except in the case of price change in specifications and utilization, which increase irregularly.

Increase in volume (page 66) and increase in the proportion of the higher priced grades (page 101) have already been discussed. The other factors which influence value will be considered below.

INCREASE IN QUALITY OF SAW TIMBER.

The prices which have been used for the different grades and widths of lumber are figures based on actual sales (Weekly Sales Reports, N. C. Pine Association), f. o. b. Norfolk, Virginia, during the first quarter of 1913. They are shown in the following table:

Width of boards Inches	Grades of rough, kiln-dried lumber and price per 1,000 board feet, 4–4 stock				
	No. 1	No. 2	No. 3	No. 4 or Box	Red heart and mill cull
Edge*	$ 29.00	$ 25.00	$ 19.00	$ 15.00	$ 13.25
6	29.50	25.50	20.00	16.00	14.25
8	31.00	26.00	20.25	16.50	15.75
10	32.00	27.00	21.00	17.50	16.75
12	36.00	29.00	21.00	18.00	17.25
Over 12	41.00	35.00			

Bark strips Nos. 1 and 2 ..... $19.00 per 1,000 board feet.
Box bark strips ..... 11.00 per 1,000 board feet.

*See page 100.

The average price of North Carolina pine lumber f. o. b. Norfolk, Va., for first quarter 1913 was about $18 per 1,000 board feet. In June, 1914, this average price had declined to about $16.50 per 1,000 board feet as shown by the following record of weekly sales, issued June 19, 1914:

Width of boards Inches	Grades of rough lumber and price per 1,000 board feet, kiln dried, 4–4 stock, f. o. b. Norfolk, Va.				
	No. 1	No. 2	No. 3	No. 4 or box	Red heart and mill cull
Edge*	$ 25.81	$ 23.23	$ 16.06	$ 13.30	$ 11.55
6	----------	----------	----------	14.10	----------
8	31.00	----------	18.13	14.99	13.47
10	----------	----------	----------	16.31	14.13
12	34.00	----------	20.93	16.99	14.00

Bark strips Nos. 1 and 2	$18.07
Box bark strips	10.10

This decline, which is probably only temporary, should be considered in connection with all tables of average lumber prices or stumpage values based thereon.

Table 58 shows the increase in value of boards of the same grade with the increase in the diameter of the log from which they were cut. This is due to a wide board having a higher price than a narrow board of the same grade. These data were computed for upper as well as for lower logs, and as the greatest difference in the value of any one grade was found to be less than two per cent, the two sets of figures were combined. By multiplying the amounts of different grades obtained from logs and trees of different diameters (Tables 55, 56 and 57) by the respective values of these grades (Table 58) the values of trees of different diameters were obtained (Tables 59 to 64). It is possible to obtain from this the value per 1,000 board feet of logs of different diameters of each grade. Table 56 was obtained from data in Table 55, which is derived from the mill cut.

The stands of the future, which will be managed for the production of sawtimber, will as a rule be cut between the ages of 40 and 70 years. On some of the best sites where thinnings are possible cutting may be as early as 25 years. It is consequently necessary to give full information in regard to composition, volume and value of such stands only. This is contained in Tables 55, 56, 57 which have already been given and in Tables 59 to 64.

Tables 59 to 61 give the comparative volumes on different quality sites of trees of different diameters in 40 to 50-year old stands, band-

*See page 100.

sawed 1-7-inch kerf, circular sawed ¼-inch kerf and scaled by Doyle-Scribner rule; the value f. o. b. Norfolk, Virginia, of lumber sawed from trees, and the stumpage value per tree under different costs of operation calculated on the basis of actual contents and Doyle-Scribner rule. Tables 62 to 64 give the same data for trees in stands 60 to 70 years old. The salient feature in these tables is the value per 1,000 board feet of the lumber from different sized trees and the value of their stumpage as derived from the value of the lumber. Under a high cost of operation the stumpage value per 1,000 board feet more than doubles when the diameter doubles. For a discussion of the three costs of operation ($11, $13, and $15), and the import of stumpage value under Doyle-Scribner scale and mill cut see page 137.

TABLE 58.—THE F. O. B. VALUE (1ST QUARTER, 1913) PER 1,000 BOARD FEET, AT POINTS WHICH HAVE THE NORFOLK PRICE BASIS, OF DIFFERENT GRADES OF LUMBER SAWED FROM LOGS OF DIFFERENT DIAMETERS.

Diameter inside of bark at small end of log	No. 1	No. 2	No. 3	Box	Red heart and cull
Inches	Value per 1,000 board feet				
5	$ 29.00	$ 25.00	$ 19.00	$ 15.00	$ 13.00
6	29.00	25.00	19.00	15.00	13.00
7	29.00	25.00	19.00	15.00	13.00
8	29.10	25.10	19.20	15.20	13.20
9	29.40	25.30	19.50	15.50	13.60
10	29.80	25.50	19.80	15.80	14.20
11	30.50	25.90	20.20	16.30	15.00
12	31.00	26.60	20.50	17.00	16.00
13	31.40	26.60	20.80	17.10	16.20
14	32.30	27.00	20.80	17.20	16.20
15	32.70	27.20	20.80	17.30	16.40
16	33.50	27.60	20.80	17.40	16.60
17	34.00	27.80	20.80	17.50	16.70
18	34.00	27.90	20.90	17.50	16.70
19	34.00	28.00	20.90	17.50	16.70
20	34.20	28.00	20.90	17.60	16.80
21	34.20	28.10	20.90	17.60	16.80
22	34.20	28.10	20.90	17.60	16.80
23	34.20	28.10	20.90	17.60	16.80
24	34.30	28.10	20.90	17.60	16.80
25	34.30	28.10	20.90	17.60	16.80
26	34.30	28.10	20.90	17.60	16.80
27	34.30	28.10	20.90	17.60	16.80

TABLE 59.—STUMPAGE VALUE OF TREES OF DIFFERENT DIAMETERS UNDER DIFFERENT COSTS OF OPERATION—STAND 40 TO 50 YEARS OLD.

Quality I

Diameter breast-high	Total height	Actual volume per tree (Full allowance for breakage, crook and defect)		Volume Doyle-Scribner rule	Value of lumber per 1,000 board feet f. o. b. Norfolk, Va.	Stumpage value under operating cost of											
						$11 per 1,000 feet				$13 per 1,000 feet				$15 per 1,000 feet			
							Per tree				Per tree				Per tree		
Inches	Feet	Band sawed 1-7″ kerf Bd. ft.	Circular sawed 1-4″ kerf Bd. ft.	Bd. ft.		Per 1,000 ft.	Band sawed 1-7″ kerf	Circular sawed 1-4″ kerf	Doyle-Scribner rule	Per 1,000 ft.	Band sawed 1-7″ kerf	Circular sawed 1-4″ kerf	Doyle-Scribner rule	Per 1,000 ft.	Band sawed 1-7″ kerf	Circular sawed 1-4″ kerf	Doyle-Scribner rule
6	65	13	11	----------	$15.64	$4.64	$0.06	$0.05	$--------	$2.64	$0.03	$0.03	$--------	$0.64	$0.01	$0.01	$--------
7	70	20	18	----------	15.72	4.72	.09	.08	----------	2.72	.05	.05	----------	.72	.01	.01	----------
8	75	30	26	7	15.82	4.82	.14	.13	.03	2.82	.08	.07	.02	.82	.02	.02	.01
9	80	43	38	17	15.97	4.97	.21	.19	.08	2.97	.13	.11	.05	.97	.04	.04	.02
10	84	62	55	28	16.15	5.15	.32	.28	.14	3.15	.20	.17	.09	1.15	.07	.06	.03
11	88	91	80	43	16.40	5.40	.49	.43	.23	3.40	.31	.27	.15	1.40	.13	.11	.06
12	91	127	112	61	16.70	5.70	.72	.64	.35	3.70	.47	.41	.23	1.70	.22	.19	.10
13	93	166	146	84	17.07	6.07	1.01	.89	.51	4.07	.68	.59	.34	2.07	.34	.30	.17
14	94	209	184	110	17.54	6.54	1.37	1.20	.72	4.54	.95	.83	.50	2.54	.53	.47	.28
15	95	256	225	140	18.08	7.08	1.81	1.59	.99	5.08	1.30	1.14	.71	3.08	.79	.69	.43
16	96	302	266	180	18.70	7.70	2.33	2.05	1.39	5.70	1.72	1.51	1.03	3.70	1.12	.98	.67
17	97	352	310	230	19.42	8.42	2.96	2.61	1.94	6.42	2.26	1.99	1.48	4.42	1.56	1.37	1.02
18	98	404	356	280	20.15	9.15	3.70	3.25	2.56	7.15	2.89	2.54	2.00	5.15	2.08	1.83	1.44
19	99	460	405	330	20.85	9.85	4.53	3.99	3.25	7.85	3.61	3.18	2.59	5.85	2.69	2.37	1.93
20	99	519	455	380	21.47	10.47	5.43	4.78	3.98	8.47	4.40	3.87	3.22	6.47	3.36	2.95	2.46
21	99	582	512	450	22.00	11.00	6.40	5.63	4.95	9.00	5.24	4.61	4.05	7.00	4.07	3.59	3.15
22	98	652	574	510	22.40	11.40	7.43	6.54	5.81	9.40	6.13	5.39	4.79	7.40	4.82	4.25	3.77
23	98	734	646	580	22.85	11.85	8.70	7.65	6.87	9.85	7.23	6.36	5.71	7.85	5.76	5.07	4.55

TABLE 60.—STUMPAGE VALUE OF TREES OF DIFFERENT DIAMETERS UNDER DIFFERENT COSTS OF OPERATION—STAND 40 TO 50 YEARS OLD.

Quality II

Diameter breast-high	Total height	Actual volume per tree (Full allowance for breakage, crook and defect)		Volume Doyle-Scribner rule	Value of lumber per 1,000 board feet f. o. b. Norfolk, Va.	Stumpage value under operating cost of											
						$11 per 1,000 feet				$13 per 1,000 feet				$15 per 1,000 feet			
							Per tree				Per tree				Per tree		
		Band sawed 1-7″ kerf	Circular sawed 1-4″ kerf			Per 1,000 ft.	Band sawed 1-7″ kerf	Circular sawed 1-4″ kerf	Doyle-Scribner rule	Per 1,000 ft.	Band sawed 1-7″ kerf	Circular sawed 1-4″ kerf	Doyle-Scribner rule	Per 1,000 ft.	Band sawed 1-7″ kerf	Circular sawed 1-4″ kerf	Doyle-Scribner rule
Inches	Feet	Bd. ft.	Bd. ft.	Bd. ft.													
6	54	10	9	----------	$15.52	$4.52	$0.05	$0.04	$----------	$2.52	$0.03	$0.02	$----------	$0.52	$0.01	$------	$----------
7	59	18	16	----------	15.58	4.58	.08	.07	----------	2.58	.05	.04	----------	.58	.01	.01	----------
8	64	27	24	6	15.67	4.67	.13	.11	.03	2.67	.07	.06	.02	.67	.02	.02	----------
9	68	39	34	13	15.78	4.78	.19	.16	.06	2.78	.11	.10	.04	.78	.03	.03	.01
10	72	57	50	22	15.95	4.93	.28	.25	.11	2.95	.17	.15	.06	.95	.05	.05	.02
11	76	80	70	34	16.17	5.17	.41	.36	.18	3.17	.25	.22	.11	1.17	.09	.08	.04
12	79	109	96	51	16.44	5.44	.59	.52	.28	3.44	.37	.33	.18	1.44	.16	.14	.07
13	81	143	126	71	16.76	5.76	.82	.72	.41	3.76	.54	.47	.27	1.76	.25	.22	.12
14	83	180	158	96	17.14	6.14	1.11	.97	.59	4.14	.75	.66	.40	2.14	.39	.34	.21
15	84	220	194	130	17.60	6.60	1.45	1.28	.86	4.60	1.01	.89	.60	2.60	.57	.50	.34
16	85	260	229	160	18.16	7.16	1.86	1.64	1.15	5.16	1.34	1.18	.83	3.16	.82	.72	.51
17	85	305	268	200	18.82	7.82	2.39	2.10	1.56	5.82	1.78	1.56	1.16	3.82	1.17	1.03	.76
18	85	351	309	240	19.50	8.50	2.98	2.63	2.04	6.50	2.28	2.01	1.56	4.50	1.58	1.39	1.08
19	85	400	352	280	20.21	9.21	3.68	3.24	2.58	7.21	2.88	2.54	2.02	5.21	2.08	1.83	1.46
20	84	453	399	330	20.60	9.60	4.35	3.83	3.17	7.60	3.44	3.03	2.51	5.60	2.54	2.33	1.85

TABLE 61.—STUMPAGE VALUE OF TREES OF DIFFERENT DIAMETERS UNDER DIFFERENT COSTS OF OPERATION—STAND 40 TO 50 YEARS OLD.

Quality III

Diameter breast-high	Total height	Actual volume per tree (Full allowance for breakage, crook and defect)		Volume Doyle-Scribner rule	Value of lumber per 1,000 board feet f. o. b. Norfolk, Va.	Stumpage value under operating cost of											
						$11 per 1,000 feet				$13 per 1,000 feet				$15 per 1,000 feet			
							Per tree				Per tree				Per tree		
Inches	Feet	Band sawed 1-7″ kerf	Circular sawed 1-4″ kerf	Bd. ft.		Per 1,000 ft.	Band sawed 1-7″ kerf	Circular sawed 1-4″ kerf	Doyle-Scribner rule	Per 1,000 ft.	Band sawed 1-7″ kerf	Circular sawed 1-4″ kerf	Doyle-Scribner rule	Per 1,000 ft.	Band sawed 1-7″ kerf	Circular sawed 1-4″ kerf	Doyle-Scribner rule
		Bd. ft.	Bd. ft.														
6	47	8	7	----------	$15.42	$4.42	$0.04	$0.03	$--------	$2.42	$0.02	$0.02	$--------	$0.42	$------	$------	$--------
7	52	15	13	----------	15.47	4.47	.07	.06	----------	2.47	.04	.03	----------	.47	.01	.01	----------
8	57	23	20	5	15.56	4.56	.10	.09	.02	2.56	.06	.05	.01	.56	.01	.01	----------
9	61	34	30	9	15.67	4.67	.16	.14	.04	2.67	.09	.08	.02	.67	.02	.02	.01
10	64	49	34	16	15.81	4.81	.19	.17	.08	2.81	.11	.10	.04	.81	.03	.03	.01
11	67	68	60	26	15.99	4.99	.34	.30	.13	2.99	.20	.18	.08	.99	.07	.06	.03
12	69	91	80	41	16.22	5.22	.48	.42	.21	3.22	.29	.26	.13	1.22	.11	.10	.05
13	70	117	103	59	16.50	5.50	.64	.57	.32	3.50	.41	.36	.21	1.50	.18	.15	.09
14	71	145	128	80	16.85	5.85	.85	.75	.47	3.85	.56	.49	.31	1.85	.27	.24	.15
15	71	175	154	100	17.25	6.25	1.09	.96	.63	4.25	.74	.65	.43	2.25	.39	.35	.23
16	71	207	182	120	17.74	6.74	1.40	1.23	.81	4.74	.98	.86	.57	2.74	.57	.50	.33
17	71	239	210	150	18.27	7.27	1.74	1.53	1.09	5.27	1.26	1.11	.79	3.27	.78	.69	.49
18	70	277	242	170	18.45	7.45	2.06	1.82	1.27	5.45	1.51	1.33	.93	3.45	.96	.84	.59

TABLE 62.—STUMPAGE VALUE OF TREES OF DIFFERENT DIAMETERS UNDER DIFFERENT COSTS OF OPERATION—STAND 60 TO 70 YEARS OLD.

Quality I

Diameter breast-high	Total height	Actual volume per tree (Full allowance for breakage, crook and defect)		Volume Doyle-Scribner rule	Value of lumber per 1,000 board feet f. o. b. Norfolk, Va.	Stumpage value per tree under operating cost of											
						$11 per 1,000 feet				$13 per 1,000 feet				$15 per 1,000 feet			
							Per tree				Per tree				Per tree		
Inches	Feet	Band sawed 1-7″ kerf Bd. ft.	Circular sawed 1-4″ kerf Bd. ft.	Bd. ft.		Per 1,000 ft.	Band sawed 1-7″ kerf	Circular sawed 1-4″ kerf	Doyle-Scribner rule	Per 1,000 ft.	Band sawed 1-7″ kerf	Circular sawed 1-4″ kerf	Doyle-Scribner rule	Per 1,000 ft.	Band sawed 1-7″ kerf	Circular sawed 1-4″ kerf	Doyle-Scribner rule
8	70	33	29	7	$16.96	$5.96	$0.20	$0.17	$0.04	$3.96	$0.13	$0.11	$0.03	$1.96	$0.06	$0.06	$0.01
9	78	45	40	17	17.26	6.26	.28	.25	.11	4.26	.19	.18	.07	2.26	.10	.10	.04
10	84	64	56	28	17.66	6.60	.42	.37	.18	4.60	.29	.26	.13	2.60	.17	.15	.07
11	87	93	82	42	17.96	6.96	.65	.57	.29	4.96	.46	.41	.21	2.96	.28	.24	.12
12	92	130	114	61	18.38	7.38	.96	.84	.45	5.38	.70	.62	.33	3.38	.44	.39	.21
13	96	172	151	85	18.87	7.87	1.35	1.19	.67	5.87	1.01	.89	.50	3.87	.67	.59	.33
14	100	217	191	120	19.47	8.47	1.84	1.62	1.02	6.47	1.40	1.24	.78	4.47	.97	.85	.54
15	103	264	232	160	20.18	9.18	2.42	2.13	1.47	7.18	1.90	1.67	1.15	5.18	1.37	1.20	.83
16	105	311	274	200	20.73	9.73	3.03	2.66	1.95	7.73	2.40	2.12	1.55	5.73	1.78	1.57	1.15
17	106	360	317	250	21.32	10.32	3.72	3.27	2.58	8.32	3.00	2.64	2.08	6.32	2.28	2.00	1.58
18	107	412	363	300	22.15	11.15	4.59	4.04	3.35	9.15	3.77	3.32	2.75	7.15	2.95	2.59	2.15
19	108	467	411	350	22.58	11.58	5.41	4.76	4.05	9.58	4.47	3.94	3.35	7.58	3.54	3.12	2.65
20	109	527	464	420	22.95	11.95	6.30	5.54	5.02	9.95	5.24	4.61	4.18	7.95	4.19	3.69	3.34
21	110	592	521	480	23.29	12.29	7.28	6.40	5.90	10.29	6.09	5.36	4.94	8.29	4.91	4.32	3.98
22	110	662	583	560	23.60	12.60	8.34	7.34	7.06	10.60	7.02	6.18	5.94	8.60	5.69	5.01	4.82
23	110	742	653	630	23.87	12.87	9.55	8.40	8.11	10.87	8.07	7.10	6.85	8.87	6.58	5.79	5.59
24	111	840	739	710	24.15	13.15	11.05	9.72	9.34	11.15	9.37	8.24	7.92	9.15	7.69	6.76	6.50
25	111	945	832	790	24.40	13.40	12.66	11.14	10.59	11.40	10.77	9.48	9.01	9.40	8.88	7.82	7.43
26	111	1,064	936	870	24.67	13.67	14.54	12.80	11.89	11.67	12.42	10.93	10.15	9.67	10.29	9.05	8.41
27	111	1,200	1,056	950	24.95	13.95	16.74	14.73	13.25	11.95	14.34	12.62	11.35	9.95	11.95	10.51	9.45
28	111	1,357	1,194	1,030	25.15	14.15	19.20	16.90	14.57	12.15	16.49	14.51	12.51	10.15	13.77	12.12	10.45
29	111	1,512	1,331	1,110	25.35	14.35	21.70	19.09	15.93	12.35	18.67	16.43	13.71	10.35	15.65	13.77	11.49
30	111	1,650	1,452	1,190	25.55	14.55	24.01	21.13	17.31	12.55	20.71	18.22	14.93	10.55	17.41	15.32	12.55

TABLE 63.—STUMPAGE VALUE OF TREES OF DIFFERENT DIAMETERS UNDER DIFFERENT COSTS OF OPERATION—STAND 60 TO 70 YEARS OLD.

Quality II

Diameter breast-high	Total height	Actual volume per tree (Full allowance for breakage, crook and defect)		Volume Doyle-Scribner rule	Value of lumber per 1,000 board feet f. o. b. Norfolk, Va.	Stumpage value under operating cost of											
						$11 per 1,000 feet				$13 per 1,000 feet				$15 per 1,000 feet			
							Per tree				Per tree				Per tree		
Inches	Feet	Band sawed 1-7″ kerf Bd. ft.	Circular sawed 1-4″ kerf Bd. ft.	Bd. ft.		Per 1,000 ft.	Band sawed 1-7″ kerf	Circular sawed 1-4″ kerf	Doyle-Scribner rule	Per 1,000 ft.	Band sawed 1-7″ kerf	Circular sawed 1-4″ kerf	Doyle-Scribner rule	Per 1,000 ft.	Band sawed 1-7″ kerf	Circular sawed 1-4″ kerf	Doyle-Scribner rule
7	59	23	20	----------	$16.50	$5.50	$0.13	$0.11	$----------	$3.50	$0.08	$0.07	$----------	$1.50	$0.03	$0.03	$----------
8	65	28	25	6	16.75	5.75	.16	.14	.03	3.75	.11	.09	.02	1.75	.05	.04	.01
9	69	40	35	13	17.03	6.03	.24	.21	.07	4.03	.16	.14	.05	2.03	.08	.07	.03
10	74	58	51	22	17.34	6.34	.37	.32	.14	4.34	.25	.22	.10	2.34	.14	.12	.05
11	78	82	72	37	17.67	6.67	.55	.48	.25	4.67	.38	.34	.17	2.67	.22	.19	.10
12	82	113	99	55	18.05	7.05	.80	.70	.39	5.05	.57	.50	.28	3.05	.34	.30	.17
13	85	146	128	77	18.50	7.50	1.10	.96	.58	5.50	.80	.71	.42	3.50	.51	.45	.27
14	88	184	162	100	19.02	8.02	1.48	1.30	.80	6.02	1.11	.97	.60	4.02	.74	.65	.40
15	90	225	198	140	19.63	8.63	1.94	1.71	1.21	6.63	1.49	1.31	.93	4.63	1.04	.92	.65
16	92	264	232	170	20.25	9.25	2.44	2.15	1.57	7.25	1.91	1.68	1.23	5.25	1.39	1.22	.89
17	93	312	275	210	20.86	9.86	3.08	2.71	2.07	7.86	2.45	2.16	1.65	5.86	1.83	1.61	1.23
18	94	358	315	260	21.30	10.30	3.69	3.24	2.68	8.30	2.97	2.61	2.16	6.30	2.26	1.98	1.64
19	95	407	358	310	21.85	10.85	4.42	3.89	3.36	8.85	3.60	3.17	2.74	6.85	2.79	2.45	2.12
20	95	460	405	370	22.15	11.15	5.13	4.51	4.13	9.15	4.21	3.70	3.39	7.15	3.29	2.89	2.65
21	95	515	453	430	22.44	11.44	5.89	5.18	4.92	9.44	4.86	4.28	4.06	7.44	3.83	3.37	3.20
22	95	574	505	490	22.85	11.85	6.80	5.99	5.81	9.85	5.65	4.98	4.83	7.85	4.51	3.97	3.85
23	95	635	559	560	23.18	12.18	7.73	6.81	6.82	10.18	6.46	5.69	5.70	8.18	5.19	4.57	4.58
24	95	704	620	630	23.45	12.45	8.76	7.71	7.84	10.45	7.36	6.47	6.58	8.45	5.95	5.23	5.32
25	95	780	686	700	23.70	12.70	9.91	8.72	8.89	10.70	8.35	7.34	7.49	8.70	6.79	5.97	6.09
26	95	860	757	760	23.95	12.95	11.14	9.80	9.84	10.95	9.42	8.28	8.32	8.95	7.70	6.77	6.80

TABLE 64.—STUMPAGE VALUE OF TREES OF DIFFERENT DIAMETERS UNDER DIFFERENT COSTS OF OPERATION—STAND 60 TO 70 YEARS OLD.

Quality III

Diameter breast-high	Total height	Actual volume per tree (Full allowance for breakage, crook and defect)		Volume Doyle-Scribner rule	Value of lumber per 1,000 board feet f. o. b. Norfolk, Va.	Stumpage value under operating cost of											
						$11 per 1,000 feet				$13 per 1,000 feet				$15 per 1,000 feet			
							Per tree				Per tree				Per tree		
Inches	Feet	Band sawed 1-7″ kerf Bd. ft.	Circular sawed 1-4″ kerf Bd. ft.	Bd. ft.		Per 1,000 ft.	Band sawed 1-7″ kerf	Circular sawed 1-4″ kerf	Doyle-Scribner rule	Per 1,000 ft.	Band sawed 1-7″ kerf	Circular sawed 1-4″ kerf	Doyle-Scribner rule	Per 1,000 ft.	Band sawed 1-7″ kerf	Circular sawed 1-4″ kerf	Doyle-Scribner rule
7	51	19	17	----------	$16.40	$5.40	$0.10	$ 0.09	$--------	$3.40	$0.06	$0.06	$--------	$1.40	$0.03	$0.02	$--------
8	57	24	21	5	16.62	5.62	.13	.12	.03	3.62	.09	.08	.02	1.62	.04	.03	.01
9	63	35	31	10	16.87	5.87	.21	.18	.06	3.87	.14	.12	.04	1.87	.07	.06	.02
10	67	50	44	18	17.14	6.14	.30	.27	.11	4.14	.21	.18	.07	2.14	.11	.09	.04
11	71	69	61	30	17.44	6.44	.44	.39	.19	4.44	.31	.27	.13	2.44	.17	.15	.07
12	74	92	81	45	17.87	6.87	.63	.56	.31	4.87	.45	.39	.22	2.87	.26	.23	.13
13	76	119	105	65	18.17	7.17	.85	.75	.47	5.17	.62	.54	.34	3.17	.38	.33	.21
14	78	148	130	88	18.64	7.64	1.13	1.00	.67	5.64	.83	.73	.50	3.64	.54	.47	.32
15	80	171	150	120	19.15	8.15	1.39	1.23	.98	6.15	1.05	.93	.74	4.15	.71	.62	.50
16	81	212	187	150	19.68	8.68	1.84	1.62	1.30	6.68	1.42	1.25	1.00	4.68	.99	.87	.70
17	81	245	216	180	20.23	9.23	2.26	1.99	1.66	7.23	1.77	1.56	1.30	5.23	1.28	1.13	.94
18	81	277	244	220	20.63	9.63	2.67	2.35	2.12	7.63	2.11	1.86	1.68	5.63	1.56	1.37	1.24
19	82	311	274	270	21.15	10.15	3.16	2.78	2.74	8.15	2.53	2.23	2.20	6.15	1.91	1.68	1.66
20	82	353	311	310	21.45	10.45	3.69	3.25	3.24	8.45	2.98	2.62	2.62	6.45	2.28	2.00	2.00
21	82	392	345	360	21.60	10.60	4.16	3.66	3.82	8.60	3.37	2.97	3.10	6.60	2.59	2.28	2.38
22	82	420	370	400	21.80	10.80	4.54	3.99	4.32	8.80	3.70	3.25	3.52	6.80	2.86	2.51	2.72
23	82	475	418	450	23.00	12.00	5.70	5.02	5.40	10.00	4.75	4.18	4.50	8.00	3.80	3.34	3.60
24	82	523	460	500	23.20	12.20	6.38	5.61	6.10	10.20	5.33	4.69	5.10	8.20	4.29	3.77	4.10
25	82	576	507	540	23.40	12.40	7.14	6.29	6.70	10.40	5.99	5.27	5.62	8.40	4.84	4.26	4.54

The increase in the proportion of the higher grades in the tree with increased diameter is influenced by several conditions, the most important of which are (1) the density of the stand, (2) the quality site, and (3) the rate of growth and the age of stand.

Influence of Density of Stand.

The proportion of different grades in trees of different diameters as given in Tables 55, 56 and 57 applies only to fully stocked stands on forest soils or at least not to upland old fields. As the stands become more open, more limbs and larger knots develop on the trees with consequent increase in the proportion of lower grades in them. (Plates III and IV.)

Influence of Quality Site.

The wood of trees of loblolly pine grown on poorer quality sites generally is worth more per 1,000 board feet than that from younger dominant trees of the same diameter and height on a good quality site. This is due to the more thorough cleaning of the stem, the smaller size of the knots, and less taper; knots, however, are more numerous in the upper logs and there are fewer clear logs in the tree, since the length of merchantable stem is shorter. This is shown by Table 65, which gives the value per 1,000 board feet of the stumpage of trees growing on different quality sites at different ages. By referring to Table 16 it is seen that at the age of the same average diameter the stumpage of the stand on the poorer quality site is more valuable. With a marked difference in the heights of the trees of the same diameter, however, the shorter bodied tree will have a larger proportion of crown and consequently a higher proportion of the common grades and a lower average value for the lumber. (Plates X, A and X, B.)

Influence of Rate of Growth and Age of Stand.

The clean bodied and slow growing intermediate and suppressed trees of a given diameter in an old stand yield a larger proportion of the higher grades of lumber than dominant trees of the same diameter and height in younger stands on this same site. (Plates IX, A, and IX, B, also Plates XVI and XVII.) Tables 59 to 64 show the value of lumber sawed from trees of the same diameter and approximately the same height on an average in 45 and 65-year old stands. The trees above 14 inches in diameter in the 45-year old age stand (Quality I) are dominant. Trees from 14 to 18 inches in diameter in the 65-year old age stand (Quality I) are intermediate. There is a difference of about $2 per 1,000 board feet in the value of the lumber at Norfolk. Since the cost of operation is the same for producing lumber from trees of the same size, this difference results in a higher stumpage for the older

stand (Tables 62, 63, and 64). These tables also show a greater value of the wood from old trees, the diameters and heights of the trees being the same.

In old field stands on dry soils the trees are of very rapid growth, contain coarse knots, and most of them are dominant. (Plate III.) For these reasons the yield of lower grades of lumber is also larger than in the more crowded and usually somewhat slower growing stands on forest soils. Eighty-five per cent of the lumber which is cut from stands 35 to 50 years old growing on the poorer old field sites is of box grade; ten per cent, No. 3; and the balance, largely bark strips, cull, and No. 2. This does not apply, however, to dense old field stands on moist sites.

TABLE 65.—APPROXIMATE VALUE PER 1,000 BOARD FEET F. O. B. NORFOLK, VA., OF KILN-DRIED* LUMBER SAWED FROM WELL STOCKED STANDS OF LOBLOLLY PINE OF DIFFERENT AGES GROWING ON DIFFERENT QUALITY SITES; BAND-SAWED 1-7 INCH KERF; FIRST QUARTER, 1913, PRICES.†

Age of stand	Value per 1,000 board feet, f. o. b., Norfolk, Va., of lumber from quality site		
Years	I	II	III
20	$ 15.50	$----------	$----------
30	15.60	15.50	----------
40	16.05	15.85	15.50
50	17.30	16.55	15.90
60	18.80	17.85	17.00
70	20.70	19.75	18.45
80	22.05	21.10	19.80

The average tree being cut in the Norfolk district is about 14 inches in diameter, Quality Site II, cutting to 7-inch breasthigh diameter. Such a tree (in the present open stands) would be about 55 years old and in first quarter 1913 would have had a stumpage value under an operating cost of $14 per 1,000 board feet, of about $3.05 per 1,000 board feet mill cut or allowing for over run of 30 per cent above log scale, a stumpage value of $3.85 based on the Doyle-Scribner scale, which was close to the general price for average stumpage in the Norfolk district in the latter part of 1912 and first half of 1913.

*Air dried circular-sawed lumber would be about $1.00 per 1,000 board feet lower.
†July 1914 prices are about $1.50 per 1,000 board feet lower.

TABLE 66.—APPROXIMATE VALUE PER 1,000 BOARD FEET OF STUMPAGE OF LOBLOLLY PINE IN STANDS OF DIFFERENT AGES AND ON DIFFERENT QUALITY SITES, BASED ON THE F. O. B., NORFOLK, VA., VALUES OF LUMBER GIVEN IN TABLE 65 AND VALUED ON MILL CUT BAND-SAWED 1-7 INCH SAW KERF (FIRST QUARTER, 1913).

Age of stand	Quality site I			Quality site II			Quality site III		
	Value of stumpage per 1,000 board feet under operating costs of								
Years	$11	$13	$15	$11	$13	$15	$11	$13	$15
20	$ 4.50	$ 2.50	$ 0.50	$	$	$	$	$	$
30	4.60	2.60	.60	4.50	2.50	.50	4.50	2.50	.50
40	5.05	3.05	1.05	4.85	2.85	.85	4.50	2.50	.50
50	6.30	4.30	2.30	5.55	3.55	1.55	4.90	2.90	.90
60	7.80	5.80	3.80	6.85	4.85	2.85	6.00	4.00	2.00
70	9.70	7.70	5.70	8.75	6.75	4.75	7.45	5.45	3.45
80	11.05	9.05	7.05	10.10	8.10	6.10	8.80	6.80	4.80

While the stumpage values given in Table 66 for stands above 60 years old, especially those on Quality Site I seem high, it is to be remembered that they are for timber in fully stocked stands which at such ages contain many long-bodied trees more than 25 inches in diameter, and which yield a much larger proportion of upper grades than average stands now being operated.

These stumpage values are based on mill-cut, band-sawed 1-7-inch kerf. Stumpage is bought, however, on the basis of Doyle-Scribner log scale. Consequently the value of commercial stumpage for any one age class would be greater than that given by the amount of the mill overrun above the Doyle-Scribner scale for the average tree in this age class. The mill overrun declines from about 40 per cent for stands in which the average tree has a breasthigh diameter of 8 inches to 10 per cent when the average tree becomes 17 inches in diameter breasthigh. Since there has been a decline of more than $1.50 per 1,000 board feet, mill run, in the value of lumber (July 1, 1914) after these computations were made in the first quarter of 1913, their stumpage values must be correspondingly reduced to adapt them to current lumber prices.

With the same cost of operation if lumber is cut with a circular saw ¼-inch kerf the value of stumpage would be 15 per cent less than that given in Table 66 if the cost of operation and the selling price of the land were the same.

The figures in Table 66 show that at a certain stage in the development of a stand there is a very rapid increase in the value of its stumpage, preceded by a period of slow increase and followed by a period of slow increase. So long as a number of sound trees in the stand continue to pass from nonmerchantable to merchantable diameters (Table 42) the rate of increase in price of stumpage is retarded. As soon, however, as all the trees have entered merchantable size, rapid increase in average diameter begins to take place through the elimination of the

smallest trees by overcrowding, and this is accompanied by a rapid increase in price which continues until all widths of boards and all grades of lumber are represented in the stand, after which the rate of increase in price rapidly declines, although some increase in price continues so long as diameter growth takes place and the trees remain sound.

Table 67 gives the value per cubic foot of the wood of trees of loblolly pine of different diameters under different costs of operation in stands 45 to 65 years old. By the time the tree has attained a diameter of 21 inches the period of most rapid increase in value has been passed.

TABLE 67.—STUMPAGE VALUE PER CUBIC FOOT OF STEMWOOD OF TREES OF LOBLOLLY PINE OF DIFFERENT DIAMETERS IN STANDS 45 TO 65 YEARS OLD BASED ON VALUE FOR SAWTIMBER

Diameter Breast-high	Operating expenses per 1,000 board feet		
	$11	$13	$15
Inches	Quality II*		
8	$0.015	$0.01	$0.003
9	.02	.011	.003
10	.021	.012	.004
11	.022	.013	.005
12	.024	.016	.007
13	.026	.017	.008
14	.031	.021	.012
15	.038	.027	.016
18	.056	.045	.031
21	.07	.058	.054
25	.079	.068	.055

*The wood of trees of Quality I except of small diameters has a slightly higher value than that of Quality II, and that of trees of Quality III a slightly lower value.

The subsequent rate of increase in value is much slower. Younger stands have less values per cubic foot than those given. In stands 20 years old, an 8-inch tree under a $13 cost of operation, would have a value of about $.002 per cubic foot; in a 30-year old stand a value of about $.005 per cubic foot. Larger trees would increase in value proportionately with the value given.

INCREASE IN STUMPAGE PRICE.

Increase in volume and grade take place in a uniform manner with growth. Increase in utilization is dependent upon trade demand. The lowering of grades likewise meets trade conditions and can not be used as an investment factor. The increase in price of stumpage while fixed by supply and demand and subject to temporary fluctuations, is generally constant although at a progressively declining rate. Table 74 shows the rate of increase in the value of stumpage as purchased by mills during the past two decades, and the probable increase in value during the

next two decades. While the table shows the actual increase in the value of commercial stumpage, it by no means shows the increase in the value of stumpage held as an investment, for the reason that the logging standards have decreased.

In 1893 lumber from the present commercial tree was worth $11.45 per 1,000 board feet. In 1913, on the basis of the same utilization, it was worth $20.81 per 1,000 board feet. With an operating cost of $11 in 1893, stumpage was worth 45 cents; with an operating cost of $13.75 in 1913, stumpage of the same kind is worth $7.06 per 1,000 board feet.

The following list prices of the North Carolina Pine Association for 1899 to 1911 inclusive, and actual reported sales to the Association for April and May, 1912, June, 1913, and June, 1914, of different grades 4/4 edge below 12 inches, f.o.b. Norfolk, Va., show the general tendency towards higher prices of North Carolina Pine lumber during the past 25 years:

Year	Prices f. o. b., Norfolk, Va., of			
	No. 1	No. 2	No. 3	No. 4 or box
1889	$ 15.00	$ 13.00	$ 9.50	$ 7.50
1890	15.00	13.00	9.50	7.50
1891	15.25	13.00	9.50	7.75
1892	15.75	13.25	9.50	8.25
1893	15.50	13.50	9.50	8.50
1894	14.50	13.00	9.50	8.50
1895	13.75	12.25	9.25	8.25
1896	13.75	12.00	9.00	7.75
1897	13.65	11.75	9.00	7.75
1898	14.60	13.00	10.00	8.25
1899	18.00	16.25	12.75	11.00
1900	20.00	18.00	14.00	12.00
1901	20.00	18.00	13.25	11.25
1902	20.00	18.00	13.00	11.50
1903	20.00	18.00	13.50	12.25
1904	22.00	18.50	14.50	12.50
1905	27.50	24.00	19.50	14.75
1906	30.00	28.00	21.50	16.50
1907	27.50	25.50	17.50	14.75
1908	27.00	24.00	17.50	13.50
1909	27.00	24.00	17.50	13.50
1910	27.00	24.00	17.50	13.50
1911	27.00	24.00	17.50	14.00
1912	25.99	23.57	17.67	15.75
1913	28.45	25.60	19.17	15.89
1914	25.81	23.23	16.06	13.30

Price list prices generally were from $0.50 to $1.50 higher than actual sales, consequently the increase has actually been greater than the upward trend of the figures would seem to indicate.

TABLE 68.—PER CENT OF INCREASE IN UTILIZATION AND PER CENT OF INCREASE IN THE VALUE OF STUMPAGE BY DECADES 1893 TO 1903 AND 1913, OF LOBLOLLY PINE TIMBER, NORFOLK DISTRICT.*

(South of the Roanoke River the average log and tree are larger but freight rates are higher.)

Grades—Kiln-dried	Norfolk, Va., prices					
	1891–1893		1901–1903		1911–1913	
	Price per 1,000 bd. ft.	Per cent of grades	Price per 1,000 bd. ft.	Per cent of grades	Price per 1,000 bd. ft.	Per cent of grades
No. 1 Edge under 12 inches	$ 15.25	29	$ 20.00	18	$ 26.00	7.5
No. 2 Edge under 12 inches	13.15	26	18.00	18	23.00	7.5
No. 3 Edge under 12 inches	9.00	19	13.25	21	17.50	17.0
No. 4 Edge under 12 inches	8.00	17	11.75	33	16.50	61.0
Nos. 1 and 2 bark strips	9.00†	2	11.00†	3	19.00	3.0
Box bark strips‡	3.00†	1	5.00†	3	11.00	3.0
Cull and red heart§	6.00	6	8.50†	4	14.50	1.0
(a) Value mill run f. o. b. Norfolk, per 1,000 board feet	$ 11.45		$ 14.32		$ 17.77	
(b) Diameter of average tree	20 inches		18 inches		14 inches	
(c) Volume Doyle-Scribner according to present utilization	420 bd. ft.		250 bd. ft.		100 bd. ft.	
(d) Volume as actually utilized (common logs not utilized)	360 bd. ft.		230 bd. ft.		100 bd. ft.	
(e) Per cent of past utilization on basis of present utilization (d÷c)	85.7 per cent		90.4 per cent		100 per cent	
(f) Per cent of length of tree utilized	50 per cent		54 per cent		58 per cent	
(g) Volume of average log	110 bd. ft.		70 bd. ft.		32 bd. ft.	
(a) Value f. o. b., Norfolk, per 1,000 board feet	$11.45		$14.32		$17.77	
(h) Per cent of increase in operating costs over 1892			10		25	
(i) Operating costs per 1,000 board feet, including profits and freight to establish Norfolk price parity	$11.00		$12.10		$13.75	
(j) Stumpage value of utilized timber per 1,000 board feet (a—i)	45		2.22		4.02	
(k) Stumpage value based on total content of tree (j×e)	.39		2.03		4.02	
(l) Annual rate increase in stumpage value based on used portion of tree (j)	1892 to 1902 17 per cent; 1902 to 1912 6.3 per cent					
(m) Annual rate of increase in stumpage value based on total content of tree (l)	1892 to 1902 18.4 per cent; 1902 to 1912 7 per cent					
(n) Decline in rate of increase between 1902 and 1912 (total content)	260 per cent					
(o) Probable rate of increase in stumpage value for the next 20 years	2.7 per cent a year.					
(p) Stumpage value 14-inch trees in 1923 based on this rate of increase	$5.19 per 1,000 board feet					
(q) Stumpage value 14-inch trees in 1933 based on this rate of increase	$6.78 per 1,000 board feet					

However, if the current rate of increase during the past decade (7 per cent) shall continue for the next 10 years, the price of stumpage in 1923 will be $7.65 per 1,000 board feet.

*Groups of three years taken to avoid abnormal fluctuations in prices.

†Approximate prices furnished by Mr. W. B. Roper, Secretary North Carolina Pine Association.

‡Bark strips were rarely saved prior to 1900.

§There was a large proportion of red heart and cull in the early period on account of many of the very large trees being very defective. Small trees now being cut are seldom old enough to have a large proportion of red heart, and have few large knots. A large proportion of the red heart output of some mills comes from the pocoson pine.

INCREASE IN UTILIZATION.

Table 68 shows (e) the per cent of increase in the utilization of the tree during the past twenty years. There is still some additional utilization possible, but largely at the expense of further reduction in grade. Small trees are used very closely in the tops. The heavy limbed top log of large trees is seldom used, however, on account of the numerous and very large knots more than 2 inches in diameter and the high cost of cutting off the large limbs. The use of clear slabs at the mills for laths is general. There is the possibility of using knotty slabs by resawing on a horizontal band saw and cutting out between the knots for heading or crate stock and such uses. There is also the possibility of using very knotty tops and limbs for chemical wood pulp, but this can be effected only at large, expensive and centrally located plants. Since 1906, when Mr. George W. Roper called the attention of the North Carolina Pine Association to the waste in cutting all lumber in even lengths 12 feet or over, there has been a beneficial change in this respect, even lengths of 8 feet or more now being cut. It will be necessary, however, both to take odd lengths and to use pieces shorter than 8 feet in order to secure complete woods' utilization of the stem and to further reduce the mill waste.

MANAGEMENT.

So long as there was an unlimited supply of virgin forests, the protection of young or old timber and close utilization of forest were not essential. At present, when approximately three-fourths of the annual cut of loblolly pine is obtained from cut-over land and is either the product of young growth or of small trees which were left at the previous cutting, there is need for a change in the methods of handling the forest.

In its present condition a great portion of the timberland is producing less than one-half of the amount of timber that it should, and much less than one-half of the net income of which it is capable. The stands are not fully stocked. Much of the timber, moreover, is short-bodied and knotty, and yields inferior grades of logs. With a lower yield per acre, the cost of logging is increased. If railroad construction amounts to 50 cents per thousand board feet with a stand of 3,000 feet per acre, its cost will be only 25 cents per thousand by doubling the cut per acre, while the costs of milling, felling, and loading decrease progressively as the contents of the logs increase.

Well stocked loblolly pine stands are capable of producing annually more than 300 board feet per acre. On the best soils the production on large tracts should be 500 board feet per acre a year, and on the poorest soils, not less than 150 feet. The maintenance costs, taxes, and interest are practically as high on half-stocked woodland as on fully stocked, while the net earning capacity is more than twice as great in the

case of the fully stocked land. Moreover, the earning capacity of the soil can be largely increased, though not to the full possibilities, with slight additional cost. It is largely a question of (1) regulating cutting, (2) adequate protection for young growth from fires for fifteen years after lumbering, and (3) closer utilization.

Few eastern American trees offer better and quicker returns under management and protection than the loblolly pine. It has the following advantages:

(a) It is a tree of rapid growth, especially in its youth.

(b) It attains merchantable dimensions at an early age, making possible the realization of early financial returns.

(c) It seeds abundantly and at an early age; with proper protection there is no difficulty in securing on most soils thorough regeneration after logging.

(d) On account of the large use of small timber for fuel and for cross ties, when logging with steam railroads, there is an excellent opportunity on large tracts for occasional improvement cutting at no cost, for bettering the condition of the forest and placing it on a higher earning basis. It is also possible in many places and in many types of forest to make thinnings economically, since logs even of the smallest sizes, from 5 to 6 inches in diameter at the small end, can be profitably used when the cost of operation is not too high.

(e) This pine forms in many places pure even-aged forests, which make logging and administration inexpensive.

Under this caption the management of loblolly will be discussed as to the most profitable age and size at which to cut, the reduction of waste in logging, the methods of cutting to secure natural restocking and thinning.

MOST PROFITABLE AGE AND SIZE AT WHICH TO CUT.

Mixed Stands.

In mixed stands of loblolly pine and hardwoods, in which culling or cutting to a diameter limit can be practiced, the most profitable trees to cut can be determined by the rate with which they increase in value. When the rate of increase in value declines to six per cent, the tree can be considered financially mature. This is not, however, a six per cent investment as the rate is not reckoned on the investment value of the property as a whole but merely on the current value of the tree. Since the rate of increase in value during the earlier part of its life is much higher than six per cent, and since in addition there is a constant appreciation in the value of stumpage through the increase in the price of lumber, the average rate of increase in value during the two decades preceding cutting is higher than six per cent. From this rate, however, are to be deducted taxes, the cost of protection and administration charges. Table 69 gives the rate per cent of increase in value of trees of loblolly pine on Quality I sites in culled hardwood swamps.

TABLE 69.—RATE PER CENT OF INCREASE IN VALUE OF DOMINANT AND INTERMEDIATE TREES OF LOBLOLLY PINE IN MIXED CULLED STANDS ON GOOD SITES. (VALUE BASED ON LUMBER BAND-SAWED.)

Diameter breast-high Inches	Approximate time required to grow an inch in diameter, breasthigh—Years	Approximate stumpage value per tree under a cost of operation of $13 per 1,000 board feet	Rate of increase in value in growing to next inch diameter class—Per cent
10	4	$ 0.22	11.5
11	4	.34	11.2
12	5	.52	7.9
13	5	.76	7.1
14	5	1.09	6.9
15	6	1.49	4.8
16	6	1.92	4.5
17	8	2.57	3.2
18	10	3.30	2.4
19		4.37	

Trees should be cut, therefore, when they are between 14 and 15 inches in diameter breasthigh, at which size their rate of increase in value (neglecting increase in price) becomes equal to the current interest rate. If held to a large diameter, the rate of increase declines below the current rate at which the money invested in the tree could be loaned. If the value is based on the contents by the Doyle-Scribner rule, the rate of increase in value declines to six per cent at the same size. By cutting at this diameter there will be about 14 logs to 1,000 board feet by Doyle-Scribner rule and the average f. o. b. Norfolk value of the log run output will be about $20.50 per 1,000 board feet.

Pure Even-aged Stands for Saw Timber.

From the standpoint of the landowner the age at which loblolly pine stands yield annually the highest net profits, or the largest average per cent of profit on the investment is the most important consideration. The determination of the net profits must take into consideration the value of the soil, the interest on it for the period of the investment, and the annual expenditures for taxes, supervision and protection of the property, and the yearly compounded interest on these various items. The sum of these expenses determines the cost of production.

In determining the value of standing timber at a given age it is assumed that the present grades of lumber will remain the same and the prices will not decline. However, since stumpage values are not absolute, but vary with the cost of logging and the freight rates to the nearest general market, it is necessary to base calculations on a reasonable range of stumpage values. In applying the figures it is necessary, therefore, to select the table in which the elements of cost are nearest to the actual conditions. Since Norfolk, Virginia, is the chief distributing market for North Carolina pine lumber, all costs of operation are figured in relation to the Norfolk prices, with a sufficient allowance to

Stand 50 to 60 years old, Quality II, on permanent loblolly pine site, which was culled of the dominant trees fifteen years ago. This stand, consequently, is formed of the intermediate and suppressed trees of the original stand, which accounts for the very clean and slender stems. Under a better method of cutting, this stand would have produced at this time 35,000 board feet to the acre, the average log being 45 feet D.-S. and yielding more than 60 per cent No. 3 grade lumber and better. Desirable type of seed trees marked "S." (Author's illustration.)

Unthinned stand 80 years old, Quality II, on permanent loblolly pine site, in process of lumbering. Although of good size, the upper logs are prevailingly knotty. This stand would have been benefited by the removal of the dominant trees 25 to 30 years ago. Scale of average log about 50 feet, D.-S. Such a stand will yield 30 per cent of lumber of Grades No. 1 and No. 2. Desirable type of seed trees marked "S." (Author's illustration.)

cover the freight differential to establish Norfolk parity in price. The elements of costs per 1,000 board feet in an actual operation are as follows:

Logging, felling, bucking and swamping	$3.55
Railroad construction	.40
Hauling to mill on railroad or towage	.60
Milling, drying, stacking, and grading	1.95
Selling and discount	.35
Overhead charges (interest, insurance, salaries, taxes, sinking fund, and profits)	3.60
Freight differential to establish Norfolk price parity	2.40
Total cost of operation per 1,000 feet	$12.85

Some of these items are paid for on the basis of the wood's scale and this must be converted to the mill cut; while there is a credit in the excess of the mill cut above the Doyle-Scribner wood's scale which in the case of very small timber may materially affect the apparent cost of the operations. When all woods' work is paid for by the day the stumpage and other costs are based on the direct output of the mill using the band saw or circular saw table as the case may require.

The cost of operation in this case would be regarded, in round figures, as $13 and stumpage values figured accordingly.

To provide for a wide range of conditions three costs of operation have been used: a low cost at $11 per 1,000 feet; a medium cost at $13; and a high cost at $15. The one must be selected which most nearly suits the conditions of each individual case.

Since some of the important factors of expense which enter into the cost of growing timber are variable, it is impossible to make any one set of calculations which will accurately determine the cost and profit in producing loblolly pine timber on cut-over lands, at all places within North Carolina where there is no cost of stocking. Consequently the calculations are made on the basis of what are assumed to be average conditions. A soil value of $5 an acre is used, and a rate of interest of six per cent compounded is allowed on the soil value. The increase in the soil value and the increase in stumpage price will in part cover the cost of protection and taxes. A deduction of one per cent from the rate of profit added to the increase in stumpage and soil values will undoubtedly more than cover taxes, protection, and administration charges within a growing period of fifty years. Since there is no cost of stocking other than protection and leaving seed trees, the initial investment is practically limited to the soil value. The growth of the seed trees, if they are carefully selected, should approximately cover the interest on their initial value.

Table 70 shows on the basis of Doyle-Scribner rule the rate of interest yielded by fully stocked unthinned stands of loblolly pine with a soil value of $5 an acre, at different ages on different quality sites, and

TABLE 70.—VALUE OF FULLY STOCKED STANDS OF LOBLOLLY PINE, AS SCALED BY DOYLE-SCRIBNER RULE, AT DIFFERENT AGES ON DIFFERENT QUALITY SITES AND UNDER DIFFERENT COSTS OF OPERATION; AND THE PER CENT OF INTEREST ON AN INITIAL INVESTMENT OF $5 AN ACRE REPRESENTED BY THIS VALUE.

Age of stand Years	Operating expenses $11	Rate of compound interest on an investment of $5 an acre Per cent	Operating expenses $13	Rate of compound interest on an investment of $5 an acre Per cent	Operating expenses $15	Rate of compound interest on an investment of $5 an acre Per cent
Quality I						
25	$ 33	8	$ 18	6.1	$ 4	----
30	74	9	42	7.0	10	4.0
40	143	8	87	8.0	30	5.0
50	231	7	158	7.0	84	6.0
60	326	7	243	6.5	159	6.0
70	423	----	336	6.1	249	4.5
80	496	----	406	----	316	----
Quality II						
25	$ 6	0.8	$ 3	----	$ 1	----
30	31	6.0	17	5.0	3	----
40	80	7.0	47	6.0	14	3.0
50	132	6.5	84	6.0	37	4.5
60	193	6.3	136	5.5	80	5.0
70	267	----	206	----	145	5.0
80	325	----	261	----	196	4.5
Quality III						
25	----	----	----	----	----	----
30	----	----	----	----	----	----
40	$ 27	4.0	$ 15	----	$ 3	----
50	61	5.0	36	4.0	11	----
60	97	4.5	65	4.5	32	3.5
70	141	----	103	4.5	65	4.0
80	177	----	137	4.0	97	4.0

with different costs of operation. The less favorable the quality site, the later is the age at which the maximum interest rate is attained. Likewise, as the cost of operating increases and stumpage value decreases, the period at which the stand attains its maximum interest rate is postponed and the rate of interest yielded is lower.

On Quality I site with operating costs of $11 per 1,000 feet, the maximum rate, 9 per cent, is obtained on the soil value of $5 an acre when the stand is 30 years old; with costs of $13 per 1,000 feet, a maximum rate of 8 per cent is obtained when the stand is 40 years old; with costs of $15 per 1,000 feet, the maximum rate is 6 per cent and is attained when the stand is 50 years old.

On Quality II site the maximum interest rate on the soil value of $5

TABLE 71.—STUMPAGE VALUE PER ACRE OF FULLY STOCKED STANDS OF LOBLOLLY PINE AT DIFFERENT AGES ON DIFFERENT QUALITY SITES AND UNDER VARIOUS COSTS OF OPERATION; AND THE RATES OF COMPOUND INTEREST YIELDED ON AN INITIAL SOIL VALUE OF $5 AN ACRE. BASED ON MILL CUT 1-7 INCH SAW KERF.

Quality I

Age Years	Operating expenses per 1,000 board feet at $11		Operating expenses per 1,000 board feet at $13		Operating expenses per 1,000 board feet at $15	
	Value of stand	Gross rate of compound inetrest yielded on $5 Per cent	Value of stand	Gross rate of compound interest yielded on $5 Per cent	Value of stand	Gross rate of compound interest yielded on $5 Per cent
20	$ 65	14	$ 36	11	$ 7	4.5
30	133	11	75	9	17	4.0
40	193	8	116	8	40	4.0
50	280	7	191	7	102	4.0
60	380	6	283	6	185	4.0
70	500	5	397	5	294	4.0
80	592	5	485	4	378	5.0
Quality II						
30	72	9	40	8	8	3
40	130	8	77	7	23	3
50	188	7	120	6	53	3
60	262	6	185	5	109	3
70	358	6	276	5	194	3
80	431	5	345	5	260	4
Quality III						
30	32	7	18	5	4	2
40	76	7	42	6	8	2
50	113	5	67	5	21	2
60	161	4	107	4	54	2
70	218	4	159	4	101	3
80	271	4	209	4	148	3

an acre is 7 per cent obtained from a stand 40 years old with operating expenses of $11 per 1,000 feet; 6 per cent from a stand 50 years old with operating expenses of $13 per 1,000 feet; and 5 per cent from a stand 60 years old when the operating expenses are $15 per 1,000 feet.

On Quality III site the maximum interest rate on the soil value of $5 an acre is 5 per cent obtained from a stand 50 years old when the operating expenses are $11 per 1,000 feet; 4.5 per cent from a stand 60 years old when the operating expenses are $13 per 1,000 feet; and 4 per cent from a stand 70 years old when the operating expenses are $15 per 1,000 feet. Table 71 is similar to Table 70, but is on the basis of actual mill cut (1-7-inch saw kerf).

Pure Even-aged Stands for Cordwood.

Cordwood either with or without bark is chiefly used for fuel, pulpwood, crate, stave and heading stock. There is little, if any, increase in price with increase in size, if small trees less than 6 inches in diameter breasthigh are excluded. In fixing, therefore, the most profitable age for cutting cordwood only the volume of the stands and the cost of producing it need be considered. Table 72 gives the age at which cordwood is most cheaply produced, assuming the value of the land at $5 an acre and an interest rate of six per cent with no expense for restocking or protection. The cheapest cost of production on all quality sites is when the stand is between 25 and 30 years old. The yields at this age are given in Table 37. If cutting is done to a larger diameter in the top or if knotty tops are excluded, as shown in discussing this table, a deduction must be made from the volume given in Table 37 and a corresponding increase made in the cost of growing.

TABLE 72.—COST OF GROWING CORDWOOD IN FULLY STOCKED STANDS OF LOBLOLLY PINE AT DIFFERENT AGES ON DIFFERENT QUALITY SITES ON LAND VALUED AT $5 AN ACRE AND INTEREST AT SIX PER CENT.

STEM WOOD ONLY FROM TREES SIX INCHES AND OVER IN DIAMETER.

Age of stand Years	Value of $5 compounded at 6% for the period, less the initial investment	Cost of growing a cord of 160 cubic feet, peeled			Cost of growing a standard cord of 128 cubic feet, bark included		
		Quality			Quality		
		I	II	III	I	II	III
25	$ 16.45	$ 0.50	$ 0.74	$ 1.37	$ 0.26	$ 0.41	$ .75
30	23.65	.55	.79	1.31	.31	.44	.71
40	56.40	.97	1.34	2.02	.59	.78	1.13
50	87.10	----------	----------	2.49	.83	1.05	1.45

If reasonably clear wood only is used the yields of the stands would be reduced about 15 per cent and there would be an increase of about 15 per cent in the cost of growing the wood.

TABLE 73.—TIME REQUIRED TO GROW AN INCH, AND THE RATE PER CENT OF INCREASE IN VALUE OF DOMINANT TREES IN OPEN STANDS OF UNEVEN-AGED GROUPS.

Diameter breast-high	Quality											
	I				II				III			
Inches	Age Years	Time required to grow one inch in diameter Years	Stumpage value per tree under an operating cost of $13 1,000 bd. ft.	Rate per cent of increase in value a year	Age Years	Time required to grow one inch in diameter Years	Stumpage value per tree under an operating cost of $13 1,000 bd. ft.	Rate per cent of increase in value a year	Age Years	Time required to grow one inch in diameter Years	Stumpage value per tree under an operating cost of $13 1,000 bd. ft.	Rate per cent of increase in value a year
11	22	----------	$0.09	----------	31	----------	$0.08	----------	39	----------	$0.07	----------
12	25	3	.15	19	35	4	.14	15	44	5	.13	13
13	28	3	.23	15	39	4	.23	13	49	5	.23	12
14	31	3	.35	15	44	5	.39	11	56	7	.41	9
15	35	4	.57	13	49	5	.66	11	63	7	.70	8
16	39	4	.89	12	55	6	1.03	8	70	7	1.09	7
17	43	4	1.40	12	61	6	1.56	7	78	8	1.63	5
18	48	5	2.14	9	68	7	2.18	5	86	8	2.28	4

Open Pure Uneven-aged Stands.

The per cent of increase in the value of the individual tree can also be applied in fixing a diameter limit for cutting in open pure or slightly mixed uneven-aged stands or groups in which the openness is caused by fires and unregulated cutting. Table 73 gives the rate per cent of increase in value for one inch increase in diameter of the dominant trees in irregular open stands on different quality sites. The diameters which correspond to a six per cent rate of increase are 18 inches on Quality I, 17 inches on Quality II, and 16 inches on Quality III.

DETERMINATION OF YIELD.

One of the most important problems in connection with the proper management of loblolly pine lands is the determination of the yield which could be secured from a tract within a definite period; or in the case of larger tracts, it might be desirable to know the amount of timber which could be felled yearly to supply a mill without lessening the producing capacity of the forest during a subsequent period.

In the case of small tracts which are fully stocked, the quality site can be ascertained and the yield determined from the yield tables for the class of timber desired, and the age at which it would be necessary to fell.

In the case of large tracts, not only will it be necessary to map and determine the areas of the different forest types and quality sites, but to indicate the age and condition of each stand. Waste and unproductive land and young stands from which no yield can be expected within the period to be considered should be eliminated. The productive lands should be grouped according to their growing capacity, and the quantity of the material into:

1. Very open, pure, even-aged stands in which the trees are somewhat short-bodied. The yield of these stands can be obtained by means of Table 73.

2. Pure, even-aged sapling and pole stands of good density. The yields of these can be secured direct from the yield tables. (Tables 35 to 41.)

3. Pure and mixed old stands. Growth is practically stationary in such stands, such increment as takes place in young trees being balanced by the death or decay of old ones.

4. Mixed young and middle-aged stands; and pure, uneven-aged stands, which usually have been culled, but the trees in which have stems of nearly normal length. By means of Table 73 it is possible to determine approximately the smallest sized dominant trees of loblolly pine which will attain merchantable diameter by a designated year. Trees of this diameter and larger can be tallied on a known percentage

of the area by means of strips. After obtaining the average number of trees of each diameter per acre the proportion of the total area which is occupied by these trees can be ascertained by means of Table 74, which which gives the crown space in per cent of an area required for the growth of trees of different diameters. If these trees are separated into diameter groups and the diameter of the average tree in each group determined, the average age of the trees in each diameter group can be calculated by means of Tables 42, 43, and 44. Knowing the quality site, and the approximate age of the groups, and the proportion each group contributes to the stocking, it is possible, by means of the yield tables to obtain the approximate yield from the subordinate as well as the dominant crown classes at the period desired.

TABLE 74.—CROWN SPACE IN PER CENT OF ACRE REQUIRED BY DOMINANT TREES OF LOBLOLLY PINE OF DIFFERENT DIAMETERS ON DIFFERENT QUALITY SITES.

Diameter Breasthigh Inches	Quality I	Quality II	Quality III
8	.0019	.0027	.0026
9	.0024	.0037	.0035
10	.0031	.0048	.0045
11	.0038	.0058	.0055
12	.0046	.0070	.0065
13	.0054	.0083	.0080
14	.0064	.0096	.0096
15	.0073	.0109	.0109
16	.0084	.0122	.0122
17	.0094	.0135	.0135
18	.0104	.0149	.0149
19	.0115	.0163	.0163
20	.0127	.0179	.0179
21	.0139	.0195	----------
22	.0151	.0212	----------
23	.0168	----------	----------
24	.0211	----------	----------

INCREASING THE REVENUE FROM TIMBERLAND.

Reducing Waste in Logging.

A considerable source of loss of timber is the cutting of extra long logs. The usual length of allowance is four inches above the scale length of the log. Logs are frequently cut, however, with 6 or 8 inches extra length. If cutting is carefully done a 3-inch allowance is sufficient for logs less than 14 inches in diameter and 4 inches for logs of larger diameter.

Another source of loss is in cutting extra high stumps. This is seldom done now, however, except by contractors, small mill men, or unskilled farm laborers, hired during the winter months. As a rule, stumps are cut as low in loblolly pine logging as is possible. One rea-

son for this is that the trees often grow on small hillocks or mounds, which enables the sawyer to cut low without too much discomfort in stooping. Some loggers require stumps of all trees less than 16 inches in diameter to be less than a foot high. A reasonable height for stumps is one equal to the diameter of the tree up to 18 inches. There is no necessity, however, for increasing the height of the stump above 18 inches; even large trees can be sawn as low as that without making the sawyer stoop. (Plate XXIII.)

TABLE 75.—VALUE OF LUMBER, F. O. B., NORFOLK, VA., CONTAINED IN ONE FOOT OF SOUND STUMP.

Diameter breast-high of tree Inches	Value of lumber f. o. b. Norfolk	Diameter breasthigh of tree Inches	Value of lumber f. o. b. Norfolk
8	$ 0.05	15	$ 0.27
9	.06	16	.31
10	.08	17	.36
11	.11	18	.41
12	.15	19	.46
13	.18	20	.53
14	.22	21	.59

The loss from high stumps, as from long logs, although trifling for each tree, in the aggregate amounts to a great deal at the end of a year in large cuttings. The stump contains the very best quality of timber in the tree, and every inch of it should be taken when possible.

Table 75 shows the loss in lumber in every linear foot of sound stump which is left unused. These values are based on the No. 1 grade butt logs.

If an additional linear foot could be utilized from only one-fourth of the trees cut in a year's operation, it would add to the Norfolk value of the output $360 for every million feet sawed. This is on the basis of a 13-inch tree, scaling 125 board feet Doyle-Scribner. By lowering the height of the stumps and cutting the logs as short as possible, not only an additional 2 feet of height may be obtained but the scale yield from the tree may often be increased by throwing the logs in a larger diameter class. By shortening the upper logs large knots will often be thrown into the log above, which is usually of lower grade, and in this way raise the grades of several boards sawed from the log below. (Page 106.)

Another source of loss in cutting is the injury done to small trees by breaking them down. This loss is not reflected in immediate operations but it lessens the future yield, since it destroys trees which would probably have yielded several saw logs by the time of the second cut. (Plate XXI.)

One of the greatest wastes in logging and one which can be greatly reduced, is using vigorous young trees of pine and other valuable spe-

cies for cross-ties in trams and logging roads. A tree large enough to make such a cross-tie is from 8 to 12 inches in diameter on the stump, and there are about 500 such trees used in laying one mile of tramway. If the increment on these trees amounts to 2,850 feet, board measure, a year until the time of the second cutting in ten years, there has been a loss of 28,000 feet of timber from the 320 acres which was logged by means of this spur road. This loss amounts to 85 board feet per acre. Some loggers, especially where the mill men own the timber, take up the cross-ties and relay them several times. Others, however, never use a tie the second time, after the spikes are drawn. The loss of this young timber is an immense drain on the future yield of the forest and goes far toward keeping it in its depleted condition, as it destroys so many trees which would be the largest trees at the time of the next cutting. Over the greater portion of the pine land there is sufficient scrubby hardwood to be used for ties. Where the track is temporary and there is an abundant supply of small hardwood, owners of timberland should specify in their sale contracts, or in logging contracts, that all cross-ties and bridge timbers are to be cut from the cheaper class of hardwoods; black gum, oaks, and maples. Where there is an insufficient supply of hardwood timber, the best portion of the tops of medium grade pines which are cut for saw logs should be used, or short bodied or defective pines which will not make good milling trees by the next cutting, or trees thinned from dense groups of pine.

There is also some waste of timber in skidding, a considerable portion of which should be avoided, by using for skidways and loading tables, logs of a poor class of hardwoods, defective pines or trees from thick groups of pines which need thinning. The same applies to the use of timber for the construction of corduroy roads, small bridges, cribbing, and trusses.

Another item in which there is great waste of young timber is fuel for logging locomotives. The contractors or cutters, who supply fuel, generally take out the clearest and straightest young trees on account of the ease with which they can be split. Defective trees, whenever possible, should be used for such fuel, and where the locomotive boiler furnace is large enough to take round wood, the knotty part of the tops which can not be split, should be utilized in that way, together with the limbs. Where all the fuel for the logging locomotives can not be supplied in this way, the rest of it should be cut from groups of young trees which require thinning. In fact this offers, together with the use of young trees for cross-ties, the best means of making, at no expense, thinnings which will be of great benefit to the forest and largely improve its condition, and increase, instead of decreasing, the yield at the time of the next cutting. In logging over a large tract 20,000 to 50,000 acres, nearly one cord of fuel is required for moving 10,000 feet of logs from the forest to the sawmill. If even one-half of this is young timber, it means the removal of four 8-inch trees, or their equivalent, per acre for

locomotive fuel. If these trees are 8 inches in diameter, there is a loss at the next cutting in ten years of 160 feet, board measure, per acre. Large numbers of small trees are also needlessly broken down by sawyers; by careless felling, or are cut for bed trees.

Rules to Govern Logging.

Owners of timberland who wish to (1) prevent waste of their timber and (2) cut to the most advantageous size for securing the greatest present yields from the forest and maintain it on a producing basis should require of loggers the observance of the following regulations:

(1) Rigid protection from fires must be afforded all cut-over lands during re-stocking, since probably one-fifth of all the young timber, except on wet soil, is destroyed or injured by fires.

(2) Sound young pines unless suppressed, must not be used for tramroad cross-ties, for fuel for locomotives, corduroy roads, skidways, etc., unless it is impossible to obtain other timber.

(3) When no other timber is available for the above uses young pines in dense groups and crooked, limby, short-bodied, or oppressed trees which will not make clear merchantable logs of good size by the next cutting must be used in preference to other trees.

(4) Large trees must not be thrown in clumps of young trees.

(5) No dominant or codominant trees less than 16 inches in diameter breasthigh must be cut unless taken from a dense group.

(6) In case of clean cutting seed trees must be left.

(7) Stumps must not be higher than the diameter in the case of trees under 18 inches in diameter on the stump, and not more than 18 inches in larger trees.

(8) Sound merchantable logs 6 inches or more in diameter used for skidways and loading platforms must not be left in the woods.

Increase in Cost of Handling Small Timber.

The increase in the cost of handling and converting was found to be about 3.3 per cent for each decrease of 10 board feet in the Doyle-Scribner scale of the log in the smaller diameters. The size of the mill-run log between the years 1895 and 1900 was more than 80 feet. It is now between 30 and 40 feet, Doyle-Scribner, in many of the larger mills operating in the Norfolk district. If the cost of logging and milling a 13-inch log, scaling 81 feet by the Doyle-Scribner rule, is regarded as 100 per cent, then the increase in the cost of logging and milling smaller logs can be shown by the per cent of increase over the cost for this size log. Table 76 shows the cost of logging and manufacture of logs of different sizes allowing a 3.3 per cent increase in cost for every decrease of 10 feet in the scale of the log.

TABLE 76.—INCREASE IN THE COST OF MANUFACTURING LUMBER WITH DECREASE IN THE SIZE OF THE LOG.

Diameter of log Inches	Scale of log Feet b. m.	Cost of logging and milling Per cent
13	81	100
12	64	105
11	49	110
10	36	115
9	25	120

It would cost 15 per cent more to manufacture lumber from 10-inch logs than from 13-inch logs, consequently, disregarding the overrun, the larger logs might be regarded as 15 per cent more valuable than the small ones even if the value of the lumber per 1,000 feet were the same from logs of both sizes.

RELATIVE VALUE OF TREES FOR DIFFERENT USES.

The wood of loblolly pine is commonly measured either as logs, scaled by Doyle-Scribner rule, or as cords of 128 cubic feet with the bark on, or as cords of 160 cubic feet with the bark peeled. Piling is now usually purchased on the same basis as logs for lumber—the diameter of the log being taken in the middle (the average of the two ends) and the volume of the log scaled by a log rule. Since only the straightest and longest bodied trees are used for piling, the stumpage value of timber selected for this use should be higher than that of the same size sold for milling purposes. Veneer is generally cut from logs 16 inches and over in diameter. In smaller logs there is too large a proportion of waste in the wood which is left in the core. Small coarse grained and somewhat knotty stock can be used for crate veneers, but for panel veneer fine grained timber, either free from knots or with only a few knots, is desired. Pine veneer stock is purchased entirely by log scale, and its value, consequently, is that of the appropriate grades and sizes of logs which are purchased. (Tables 50 to 54.) (Plate XII, C shows excellent veneer logs.)

Only small timber is purchased by the cord. Bolts for boxes and crates, staves and headings are purchased by the cord with the bark on. Pulpwood stock is purchased by the cord generally with the bark removed or rossed. (For proportion of bark see Table 34.) The relative value of small trees of different sizes for cordwood, both rossed and with the bark on and for sawtimber is shown in Table 77. Stumpage values in the table are placed at $1.00 per thousand feet for lumber; at $1.00 a long cord for wood measured after it is rossed, dried and racked; and at $1.00 a cord for wood measured with the bark on. 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 $1.00 to the

actual stumpage price which is offered, using as a basal diameter the diameter breasthigh of the average sized tree on the tract. For example: If board measure stumpage were worth $1.50 per thousand 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. Cords of 128 cubic feet with bark on can be converted to cords of 160 cubic feet with bark on by deducting one-fifth from the value per cord of 128 feet. The table is based on all trees in stands 6 inches and over in diameter breasthigh. Cordwood is cut to 3 inches inside the bark at the top for small trees and 6 inches for large trees. If knotty tops are not used the values of the trees must be reduced about one-tenth.

TABLE 77.—COMPARATIVE VALUE OF TREES OF DIFFERENT SIZES FOR CORDWOOD WITH THE BARK ON, CORDWOOD PEELED, AND FOR LUMBER (SCALED BY DOYLE-SCRIBNER RULE).

(Based on the average tree, Quality II)

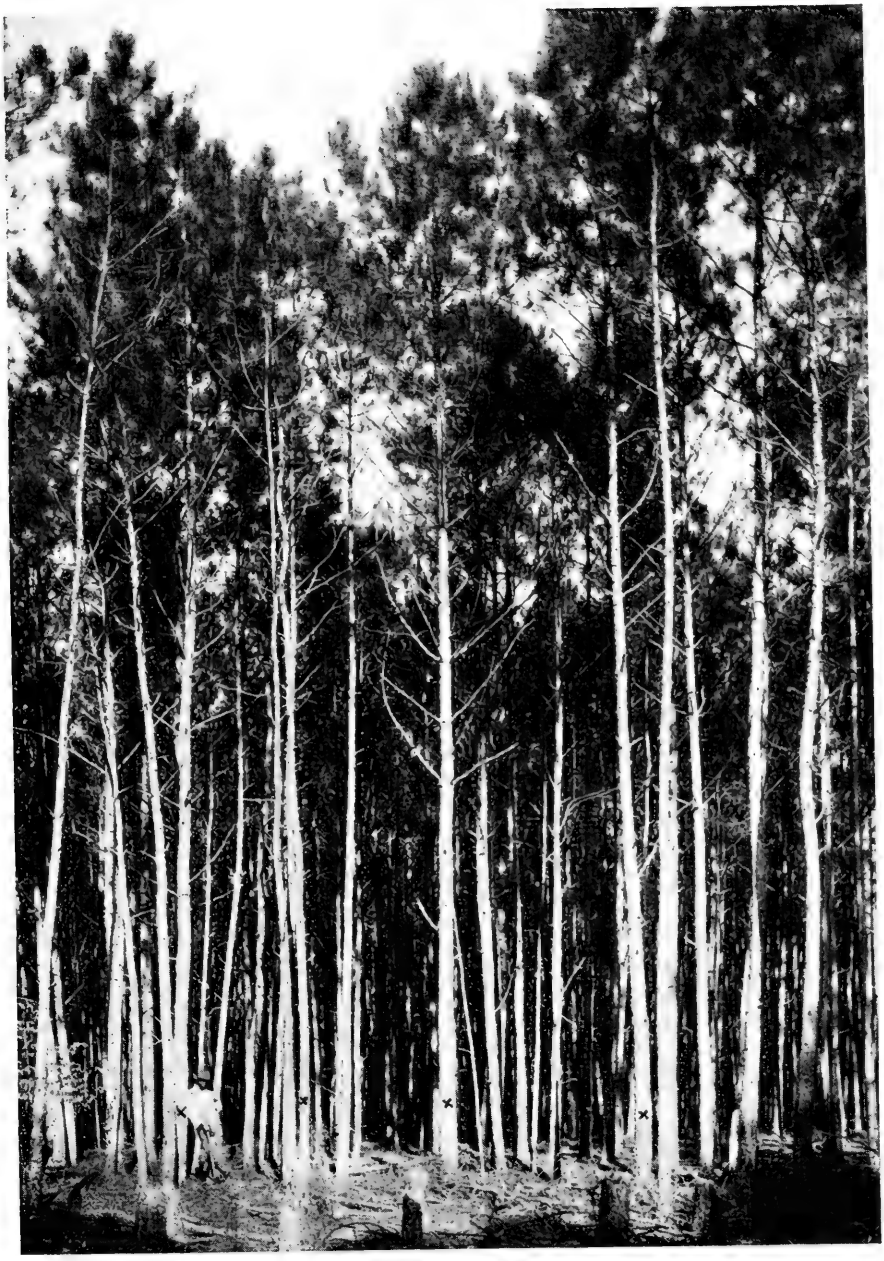
Diameter Breasthigh Inches	Cordwood, 128 cubic feet, with the bark on at $1 a cord	Cordwood, 160 cubic feet, measured after peeling, at $1 a cord	Saw logs scaled by Doyle-Scribner rule, at $1 a 1,000 board feet
6	$ .065	$ .036	$ .01
7	.08	.045	.013
8	.126	.07	.023
9	.174	.95	.04
10	.225	.12	.056
11	.28	.17	.076
12	.325	.205	.10
13	.40	.25	.122
14	.475	.29	.156
15	.54	.34	.18
16	.625	.40	.22
17	.71	.46	.25
18	.79	.51	.29

SILVICULTURAL SYSTEMS OF CUTTING IN DIFFERENT TYPES.

The widely different conditions under which loblolly pine grows require different methods of cutting in order to obtain the most thorough restocking. At times, however, it is not possible to adopt what is regarded as the most suitable system of restocking on account of the method of logging which is employed, and there must be a compromise in order to meet the logging requirements.

There are in common use three different methods of logging loblolly pine. On wet land logging railroads are used with cable skidding, generally with overhead cable; or sometimes skidding is done by cable direct from the streams or canals dug for the purpose. On uplands logging railroads are used, particularly on large tracts in extensive operations with slack cable skidding or drag skidding. This is frequently

Stand shown in Plate XVI after a combined first cutting and improvement thinning. Most of the knotty dominant trees have been cut, leaving the stand formed entirely of slender, clean-stemmed codominant and intermediate trees. These, with increased diameters, will yield from 3 to 3½ nearly clear logs, which will saw out approximately the same type of wood as that shown in Plate IX-B. More than 3,000 feet D.-S. per acre were removed from the stand in this cutting. The average log, however, scaled less than 12 feet. (Author's illustration.)



Stand 25 to 30 years old, Quality II, before being thinned. The large knots on the dominant trees are noteworthy. Trees to be removed in first improvement thinning marked "X." (Author's illustration.)

supplemented with wheel logging. Wheels alone are used by farmers in logging woodlots. They are also often used exclusively in logging such tracts as are near floating water, in which case the timber is logged by wheels to the water and then rafted to the mill.

Logging with railroad and overhead cable on wet land necessitates either clear cutting or cutting in strips since the breakage of small trees is very large. The cost of construction is comparatively heavy. Management consequently can not be intensive since relatively long intervals must elapse between cutting periods. Logging with railroad on upland with ground cable skidding is not so expensive as swamp logging and the breakage of small timber is not so great; consequently it can be repeated at more frequent intervals. (Plate XXI.) Logging with wheels permits cutting at short intervals in very intensive operations. (Plates XIV and XX.) In deciding on the method of cutting it is necessary to take into consideration the method of logging. The object is to afford the most frequent cutting periods, which are consistent with high earning power.

The following methods of cutting on different types of forests are recommended.

(1) Upland Old Fields.

On dry soils loblolly pine forms pure stands only on old fields or on longleaf pine or shortleaf pine land, which have been cut clean and burned, and where the naked soil conditions resemble those of old fields. The small intermediate and suppressed trees in such stands recuperate slowly after logging. Since the suppressed trees are invariably short-bodied, a second cutting must be deferred for a long time. This results in the crowns of these trees becoming large and interfering with the growth of the young stand which appears in the openings after the first cut. For this reason clean cutting is preferable on all such sites. (Plate III.) The mature stand should be removed in one or two cuttings. In case two cuttings are made, the smaller and less promising trees, as well as the knottiest trees, should be removed at the first cutting. The scattered seed tree system of reproduction should be used; from 3 to 6 trees should be left per acre, unless there are near-by dominant trees in mature stands which can be relied upon. The best formed trees should be reserved for seed trees. If the trees are wind-firm, isolated seed trees of the dominant class may be left. If, as is frequently the case, on dry, heavy clays of the Piedmont, or when sand in the Coastal Plain is underlain by hardpan, the trees are not wind-firm (Fig. 3, *a* and *b*), seed trees should be left only in groups. If these seed trees have slender, clean stems, they can be carried over until the succeeding stand is cut, when their large diameters and clear timber will render them extremely valuable.

On the dry sandhills or Piedmont uplands loblolly pine reproduces thoroughly only when its seed come in direct contact with mineral soil. Stands on very sandy soil are frequently destitute of undergrowth, and the leaf litter is extremely thin. (Plate III.) When 50 years old the cover in such stands will often be so open that if the mineral soil is exposed, dense mats of seedlings appear during wet periods. In the Piedmont, where the undergrowth is heavy it may be necessary to cut the small broadleaf trees which have appeared. (Plate VIII, A.) In open stands the undergrowth is desirable for lessening the evaporation of soil moisture both by sun and wind. When logging is carried on during wet weather, particularly during the winter, enough mineral soil may be brought to the surface to make a suitable mineral seedbed. On small tracts, a proper seedbed may be prepared by raking up the leaf litter and using it for farm purposes, such as compost, stable absorbent or mulch. This is frequently done, and while it is not intended for securing restocking, the latter follows as a natural consequence. On such sites, where a suitable mineral seedbed is found, reproduction of loblolly pine begins to take place by the time the stands are forty or fifty years old, although most of the seedlings die after a few years, since the shade of the old trees is still too dense. On the other hand, where the leaf litter is deep and has not been disturbed, young growth comes in slowly. This is well shown by stands at Grimesland, Pitt County, North Carolina, examined in the spring of 1909. Loblolly pine had partially replaced longleaf pine on sandy-loam upland (Norfolk loam). The tract, which was near a dwelling, had been protected from fire, and hogs had been excluded from it for more than twenty years. The leaf litter had accumulated to a depth of from six to eight inches. Although there were large openings, and the surrounding loblolly pines bore seed abundantly, the stocking was not complete on account of the dryness of the thick leaf litter. On the other hand near-by open lands, on which the deep humus and litter had been destroyed by fire and hogs, were well stocked. It may be desirable in the case of farm forests to cut clean, cultivate the soil a few years until the humus is partially exhausted, and then restock. In such a case if there are no near-by seed trees it will be necessary to plant.

While the destruction of litter on this type is desirable for securing restocking, it is not necessary as a protective measure for old timber. The ground cover rarely becomes sufficiently dense for a spring fire to endanger the stand. It is undesirable to destroy the humus on the clay soils of the Piedmont region for the reason that the water table is 30 to 45 feet from the surface during dry periods. During the autumn the amount of available soil moisture in the fine-grained clay soils is small on account of their high hygroscopicity. The humus covering, therefore, acts as a protection against evaporation of soil moisture and should never be destroyed except when necessary to obtain natural reproduction.

(2) Permanent or "Natural" Loblolly Pine Type.

On the so-called "natural" or permanent loblolly soils which occupy Quality I sites and some of the best Quality II sites, loblolly pine forms pure even-aged groups or stands. On such sites the pine is very tolerant of shade (Plate IV) and has a greater power of recuperation from suppression (Plate VIII, B), and a thrifty young stand is easily obtained in the partial shade resulting from the successive removal of trees in the old stand. The stand, therefore, lends itself to a diameter limit cutting. By such cutting the waste in cutting the slender intermediate trees (Plate XVII) is prevented and a greater profit in holding them for additional diameter growth is assured. On "natural" sites the mature stand may be removed by gradual cutting in two or more successive fellings. The first removes the larger trees to a minimum diameter of from 14 to 16 inches, according to the quality site. The second, made from 10 to 20 years later, should remove the remaining timber, unless the small trees will still show sufficient increment to justify holding them for a third cut, which will often be the case. If the stand is more than 45 years old when the first felling is made, the intermediate and suppressed trees, since by that time they have passed the stage of most rapid height growth, can gain very little in height after lumbering.

With logging operations costing $13 per 1,000 feet the maximum rate of interest (8 per cent) is obtained on Quality I site by clean cutting when the stand is 40 years old. The number of trees per acre 6 inches and over in diameter breasthigh in a stand at this age is 273, the average diameter 11.4 inches, the average volume 98 board feet, and total yield 26,754 feet per acre by Doyle-Scribner rule; the average stumpage value per tree, 35 cents, or the total stumpage value per acre $94.05. In a normal stand at this age the average number of dominant trees is about 123, having an average diameter breasthigh of 13.2 inches, an average volume of 191 board feet, and an average log scale of 59 feet.

If instead of cutting clean only the dominant trees are cut, the yield would be 23,400 board feet, having a Norfolk, Va., value of $17.16 per 1,000 feet, or a stumpage value of $77.49 per acre, under an operating cost of $13 per 1,000 feet. The remaining portion of the stand above six inches in diameter, including the intermediate and suppressed trees, have an approximate stumpage value of $18.06 per acre. This value is made up of 150 trees, with an average volume of 54 board feet, an average diameter breasthigh of 9.1 inches, and a stumpage value of about 12 cents per tree. The examination of old cuttings indicates that in stands of Quality I the intermediate and suppressed trees, because of the improved light conditions and greater amount of soil moisture, made available by the removal of the dominant trees, will make almost as rapid growth in diameter as dominant trees of the same diameters. In 15 years they may, therefore, attain an average diameter breasthigh

of 12.5 inches, an average volume of 128 board feet, or a total yield per acre of 19,200 board feet. Since, however, the value of the timber of the intermediate trees will be greater than that of the dominant trees of the same diameter, they will have an approximate value of $17.50 or $18.00 per 1,000 board feet at Norfolk, and a stumpage value of 55 cents each, under an operating cost of $13, or a total stumpage value of $82.50 per acre. This amount represents the accumulated compound interest for 15 years on the trees left for growth, plus the original investment in these trees of $18.06. The original investment has thus yielded 10.7 per cent compound interest as against 8.6 which would have been obtained by cutting clear at 40 years. Moreover, the average size log under gradual felling is much larger. By cutting clean at 40 years the average log is 34 feet. By making two fellings the average log of the first cutting is 89 feet; that of the second felling 40 feet. The average annual yield per acre by clean felling at 40 years is 669 board feet; by removing the timber in two cuts it is 775 board feet. In this calculation only the trees which were 6 inches and over in diameter at the time of the first cutting are considered. In addition there are many suppressed trees, which were less than 6 inches in diameter at the time of the first cutting. Many of these will have diameters of from 7 to 9 inches at the time of the second cut and will be merchantable in a third cutting. Since the crown cover of the stand will be only about one-half complete, even up to the time when the second felling is made, a thorough restocking will have taken place. Within 15 years after the felling the young stand which will have appeared should be from 30 to 50 feet in height, the two age-classes resembling a two-storied stand. In the second felling it is often possible to remove some of the largest trees in the young stand—those with coarse knots. The second felling in the old stand will have the same effect upon the young growth as that of a heavy irregular thinning and improvement cutting.

The successive removal of the larger trees was in vogue in cutting loblolly pine in eastern Virginia and North Carolina until after 1900. It was customary up to that date to cut to a stump diameter of from 14 to 16 inches, which removed in the first cutting chiefly the dominant trees. After 1900 this method was superseded either by clean cutting, where the conditions justified it, or by reducing the diameter limit to 8 or 10 inch on the stump. Gradual felling under present market conditions and methods of logging, seems best suited to pure stands of loblolly pine on good sites. In place, however, of merely cutting to a diameter limit or of removing only the dominant trees as was the custom and as was the method used in the example, only large trees, whose increment has begun to decline, should be removed in the first cutting. The amount of the first cut should be so adjusted as to equalize the two cuts, either in volume or in value, taking interest into consideration. It should be possible to obtain at the second cutting a large

number of trees of relatively high grade. By uniform spacing to secure the fullest individual growth, trees of large diameters and yielding a valuable product could be obtained. (Table 78.) While not without drawbacks, this method of cutting has many advantages in its favor. The advantages and disadvantages of this method are as follows:

1. The cut per acre which can be made at one time by a logging crew is less with two cuttings than with clean cutting. This, however, is fully compensated for by the larger size of the logs, resulting in cheaper logging and cheaper millwork.

2. Logging the old trees in young stands is somewhat more costly than clean cutting. This, however, is again compensated for by the cleaning and thinning of the young growth.

3. Some of the young trees are broken down by felling the larger trees. With careful felling the damage is small, since the old suppressed and intermediate trees have very long, rather than wide-spreading, heavy crowns.

4. The reduction in the volume which is cut per acre also increases the cost of railroad construction per 1,000 feet cut. This, however, is far more than met by the enhanced value of the product. In practice it should be easy to determine whether the increased value per 1,000 feet of the stand will be greater or less than the increased cost of production per 1,000 feet.

Since too many trees in the old stand will retard the height growth of near-by groups of young trees, the first cutting must be moderately heavy. The retarding of the dominant trees in the young stand, however, is desirable since the trunk is freer of knots, the knots are smaller, and the proportion of high grade lumber is greater in dominant trees, particularly in the lower logs, when they are crowded. This system of cutting is one which has been satisfactory to the lumbermen for many years, and which helped to maintain the supply of loblolly pine in the Norfolk (Va.), Albemarle Sound, Plymouth (N. C.), and Washington (N. C.) sections. It has further the advantage of affording heavy cuttings at intervals of not more than twenty years and, therefore, should be practiced in place of clear cutting, which makes logging possible only at from 40 to 50 year intervals, and yields a lower grade of logs. In following gradual felling, however, the suppressed trees which are left for additional growth should not be relied upon for seed trees, but these should be reserved from the dominant part of the stand. These should be trees with the choicest stems and should be carried to large diameters, if their rate of growth is satisfactory, to furnish high grade veneer stock, or large size piling, or choice sawlogs which will yield 70 per cent of No. 1 and No. 2 lumber.

The form of forest sought should be large even-aged blocks. In logging with railroad it is possible to thin one block when the adjoining block is being cut for larger timber. This makes thinnings possible and yet maintains the cut.

(3) Longleaf Pine Flat Lands.

The first step in connection with the management of these lands should be to increase the density of the stands by protection against fire. (Plate VI, A.) At present on account of the irregularity of the stands only selection culling or cutting clean in small groups is possible. The diameter for cutting should be controlled as indicated in the discussion of the method of cutting in open pure uneven-aged stands. The method of cutting in large even-aged groups should be governed by the quality site. On best sites cutting to a diameter limit may be followed. On the dry sites the stands should be thinned in the manner described under thinnings, provided thinnings can be conducted without loss, the object of thinning being to develop the best formed dominant and the codominant trees, and the stands should be cut clean in one cutting or in two cuttings at intervals of 10 to 15 years. Some of the best developed dominant trees should be left for seeding, unless mature and heavy groups are near enough to assure thorough stocking. The ultimate form of forest which should be sought should be large even-aged groups or blocks, varying in age by 15 to 20 years, conforming to the interval between cuttings. In many places there is already an excellent basis for this form and the present distribution of age classes enables it to be readily obtained. Seeding would take place from near-by mature groups or seed trees could be left. Under good management these lands are capable of yielding between 450 and 500 board feet a year. At present the yield is much less, probably not over 300 feet a year.

On some of the medium dry sites with compact loamy, clayey, or silty soils having a low humifying or oxidizing capacity, the pine straw and leaf litter accumulates under heavy stands of timber to a depth of six to eight inches. This litter dries out so thoroughly during the autumn that seedlings, which were established on it during the damp spring, die. Consequently, it is necessary when the mineral soil has not been brought to the surface during lumbering or by hogs, to destroy the leaf litter immediately after or during lumbering, in order to expose the mineral soil sufficiently to secure restocking.

(4) Mixed With Hardwoods in Flat Swamps.

The present manner of cutting this type removes all of the pine and the best trees of the more valuable hardwoods and leaves a large number of old defective and small trees, chiefly water gum, sweet gum, and red maples. Many of these are suppressed trees which fail to recuperate and make additional height growth. They serve, however, largely as seed trees. The resultant forest is a young, even-aged stand formed chiefly of red maple, water gum, and sweet gum, but containing some pine overtopped by the trees which were left at the first cutting. It is an undesirable mixture on the whole, but a convenient form which permits con-

version either into even-aged mixed stands or into group selection stands. Either of these is desirable. In the event of conversion into even-aged stands, the next cutting would be deferred until the young age class was large enough to be cut, at which time all trees except select seed trees would be cut. These seed trees, three to four to the acre, could remain uncut until the next felling period, when, if well selected, they would have attained large diameters and be extremely valuable. Large areas of even-aged stands, however, do not admit of thinnings, under present conditions, and consequently the best individual development of the tree is not obtained.

A group selection form can be developed by felling the oldest age class before the younger class reaches merchantable size, by the removal of only a portion of the young growth, and cutting clean in groups as much as possible in order to establish even-aged groups. In this manner three or four age classes can be established, each occupying groups which might consist of only a few trees or might be an acre in extent. This is a very desirable form, since at the same time that the oldest age class is felled thinnings and cleanings could be conducted in the younger groups. This would enable the trees in each group to obtain the maximum growth, and at the same time by means of cleanings to eradicate gradually the inferior species. The forest should be managed for the production of large sized oak, poplar, ash, and pine.

Since the soil conditions are not perfectly uniform in these swamps, certain areas, often less than one-fourth of an acre in extent, are better adapted to the growth of some species than of others. So far as is economically possible an attempt should be made to localize the species on the sites on which they make the heaviest yield, by leaving near-by seed trees of these species. The present complex mixture should also be converted into a more simple one by eliminating those species which are of least value, such as water gum, red maple, and beech. (Plate I.) The following species are the most valuable both silviculturally and for lumber, and preference should be given them in forming mixed stands on appropriate sites—loblolly pine, swamp chestnut oak, yellow poplar, ash, sweet gum, water oak, and elm. Except sweet gum and elm, these species are all rather intolerant of shade and require plenty of light for seedling establishment.

(5) Loblolly Pine With Cypress in Deep Swamps.

These stands of mixed cypress, pine, and black gum (Plate V, B) are logged either from canals, from streams, or from logging railroads by means of steam skidders and overhead cable ways. Since there is a large breakage of small timber with this system of logging, it is recommended that clear cutting be practiced and that seed trees be left both of cypress and of pine. (Plate XXI.) The establishment of both species,

however, takes place only during the drier seasons, consequently there is no assurance that they will form a large part of the stand. Their yield and value is so much greater than that of the gum and water ash with which they are associated that management should look to eradicating or reducing these species and supplanting them with cypress and pine.

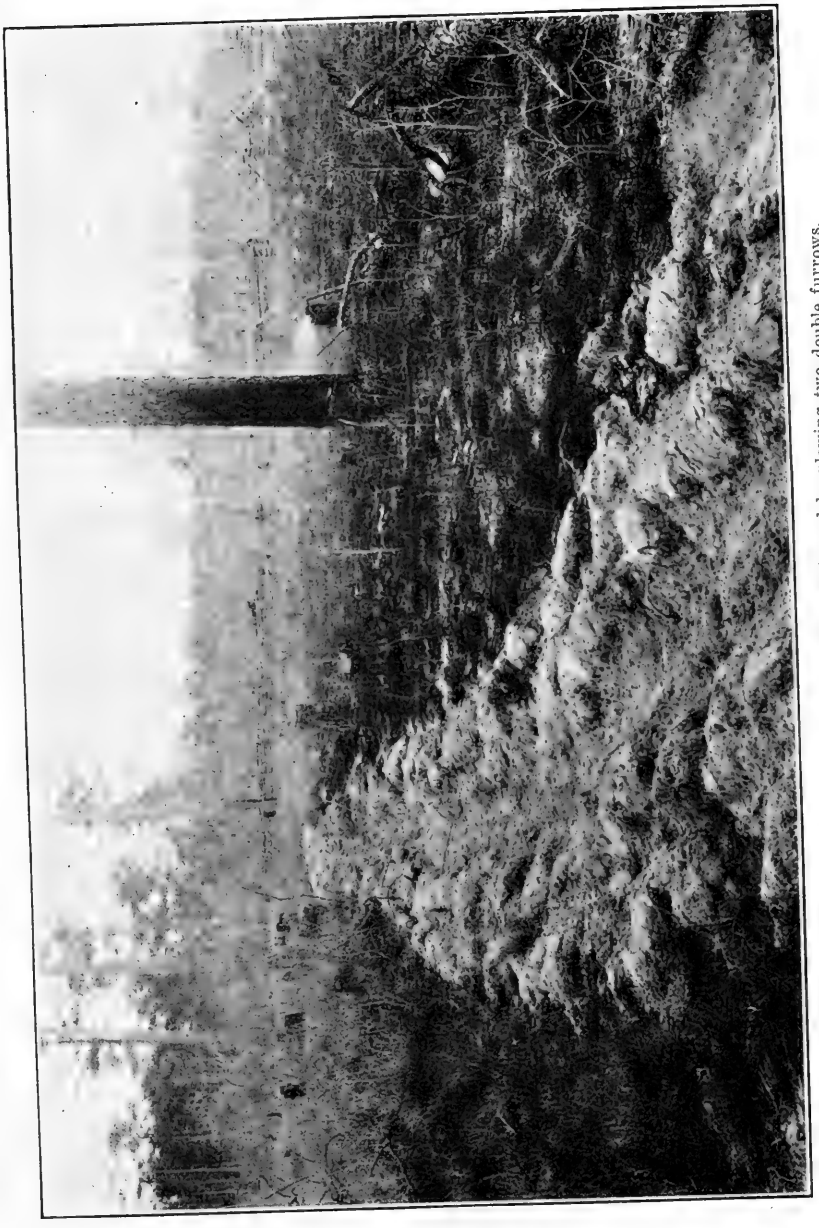
(6) Loblolly Pine With Pocoson Pine on Savannas.

The open stands of this type, which consists of scattered trees, require that the density be increased in order to utilize fully the soil. (Plate V, A.) Where the stands are open and the age classes are very irregular, selection cutting (culling) must continue at present. The diameter for cutting should be controlled as indicated in selection cutting in open stands in Qualities II and III. Old even-aged groups should be cut clean, leaving seed trees. There are numerous, though scattered, even-aged groups of young trees, and with these as nuclei a group selection form of forest should be developed. If the cutting interval is 20 years, these can eventually be merged into definite even-aged blocks, the age interval between them being 20 to 30 years. As these even-aged blocks mature they should be cut clean, the immature blocks being thinned during each cutting.

It is necessary to destroy moss during dry seasons since its accumulation retards aëration and renders the soil more acid, thus rendering it less suitable for loblolly pine which has no visible mycorrhiza on its roots. It also prevents the establishment of loblolly pine seedlings on thick carpets of living sphagnum or on its raw humus, although the pocoson pine can establish itself. Likewise the heavy sod of grasses and herbaceous plants materially interferes at times with the establishment of seedlings, although the presence of water on these lands during the spring germinating period tends to limit their occupancy by loblolly pine. The mixture on these sites should consist of longleaf, pocoson, and loblolly pines. These lands are capable of yielding from 300 to 350 board feet a year in a rotation of 60 to 80 years, with cutting intervals of 20 to 25 years. At present the annual yield is less than 200 feet.

(7) Loblolly Pine With Shortleaf Pine and Hardwoods on Uplands.

The forests of this type should be managed as selection, preferably as group selection stands. (Plate VII.) The loblolly pine should be cut when it is about 16 inches in diameter breasthigh and when not more than 70 years old. The trees will yield about 3 logs, the average log scaling about 55 feet. Although loblolly pine makes more rapid growth than shortleaf in this type it is not so desirable a tree as the latter on account of its coarse, knotty wood, except on lower slopes, where the moist soils are suited to its growth. The ideal mixture which should be



Fire protection. Surface fire in pine forest stopped by plowing two double furrows.

Unused top containing a sound 16-foot log, 10 inches in diameter at large end and 5 inches at small end, but yielding only cull lumber on account of large knots. Such a top is forming a serious fire menace. (Author's illustration.)

Loblolly pine stand, Quality II, cut to a 12-inch diameter, a large number of slender, cleaned-stemmed, intermediate trees being uncut. Characteristic condition in which such a stand was left after it was logged by means of wheels in the decade preceding 1905. Compare Plates VI-B and VIII. The lumber from these small trees at the date of the cutting would have had a Norfolk value of $13.60 per M, with a high cost of operation on account of the small size of the logs, less than 15 feet b.m., D.-S., and a stumpage value of only a few cents per M. After holding 15 years, these trees have a stumpage value of about $2.40 per M, while the average log scales between 40 and 50 board feet. This is an increase in value of practically 1,000 per cent. (Photo. U. S. Forest Service.)

Condition in which loblolly pine and hardwood swamp forest was left after being logged by steam skidder in the manner of cutting which prevailed to 1905. In the present operations cutting is closer and less small timber is left. Note the large amount of inflammable slash. (Poto. U. S. Forest Service.)

Open mature stand of loblolly pine, Quality II. Establishment of pine seedlings prevented by fires. Heavy underwood of oak and other broad-leaf trees growing beneath the pine, but periodically top-killed by fire. (Photo. U. S. Forest Service.)

Stand similar to that in Plate XXII, but unburned for 15 years. Tendency of scrubby hardwoods to replace pine. Note unnecessarily high stumps; and old fire scar on butt of log on right. (Photo. by U. S. Forest Serice.)

sought should be loblolly pine, shortleaf pine, yellow poplar, and southern red oak. In order to obtain restocking, it is necessary to bring the mineral soil to the surface, to cut heavily, and afford plenty of light.

PROTECTION FROM FIRES.

The greatest destruction of young timber in the loblolly pineries is caused by forest fires. The tendency of the pine is to seek open places where it secures full sunlight; these places are generally grassy, and if a ground fire occurs before the pine is large enough to withstand it the young growth is injured or destroyed. The frequent fires on the heavy sod on the longleaf pine flat land and the pocoson pine savannas are responsible to a large extent for the open stands on such lands. (Plates V, A; V, B; VI, A; XX and XXII.) The same is true of the grassy, peaty lands, and the logged-over swamp lands in which grass and short-lived shrubs have secured a foothold and which dry out sufficiently to burn.

The difficulties of checking a forest fire in this region during a dry season, when it is under headway before a wind, are evident. The available force for fighting fire is limited; the areas are large and often difficult of access on account of undergrowth in the swamps. The most satisfactory way of reducing loss from forest fire is to prevent the fires from starting or from getting under headway.

While some fires undoubtedly originate from lightning, which can not be prevented, the greater number start from one or another of the following sources:

(1) Locomotives, especially logging locomotives.

(2) Logging crews or from logging camps.

(3) Farm laborers, especially in the spring when new ground is being cleared, brush burned, or fence lines cleaned.

(4) Burning dead grass on grazing land, from which the fire spreads to woodland, or burning the woodland for pasturage.

(5) Hunters and fishermen.

(6) Carelessness on the part of other persons.

The fires from all these causes can be prevented or reduced in number through using greater care in handling fire in the forest, posting notices, and general education of the people to the losses from fires.

The law of North Carolina in regard to setting fire to woodland, brush land or grass land, reads as follows:

Section 8 of Chapter 243, Public Laws of 1915.—If any person shall intentionally set fire to any grass land, brush land, or woodland, except it be his own property, or in that case without first giving notice to all persons owning or in charge of lands adjoining the land intended to be fired, and also taking care to watch such fire while burning and taking effectual care to extinguish such fire before it shall reach any lands near to or adjoining the lands so fired, he shall for every such offense be guilty of a misdemeanor and shall be fined not less than ten dollars, nor more than fifty dollars, or imprisoned not exceeding thirty days. This shall not prevent action for damages sustained by the owner of any property from such fires.

In the portions of the State where this law has been publicly posted and arrests and prosecutions made under its provisions, it has had the effect of greatly lessening the number of fires from carelessness.

(7) In addition, owners should require persons wishing to hunt, especially to hunt at night with torch, to obtain a permit, with the understanding that the services of the holder of the permit shall be available for fighting fire without pay.

(8) No grazing should be permitted on land which was burned that season.

The most satisfactory way to protect forest land from outside fires is to burn in the fall, as soon as the leaves have fallen and are sufficiently dry, a strip 100 feet wide around the area to be protected. Sometimes it is sufficient to plow only several furrows around the area or two furrows 100 feet apart and burn the intervening strip. (Plate XVIII.)

It is essential to protect all young pine trees from fire until they are from 20 to 30 feet high and their stems are well cleaned for 10 or 15 feet. (Plate IV.) This means a period of from 10 to 15 years after lumbering and restocking. Areas containing young growth should be surrounded by fire lines, kept clear by annual burning during damp weather. During very dry weather it is advisable to patrol large bodies of well established young growth, if at all exposed to fire. Neighborhood associations should be formed in sections of counties where the damage from fire is great, and these associations assume the responsibility of protection. The members can issue permits for grazing and night hunting on their lands, prohibiting during the year the use of areas which have been burned for these purposes, appoint patrols during dry, windy seasons and organize forces for fighting fires in case one starts.

BRUSH LOPPING.

Wherever clean cutting is practiced and seed trees left, or where cutting is done to a diameter limit and only small trees are left, it is desirable that the branches be lopped from the tops in order to reduce the danger from fire. The lopped branches lie close to the earth and soon decay. Tops which are unlopped may remain a fire menace for many years. (Plate XIX.) Lopping is not necessary on very wet lands or where pine is mixed with hardwoods, unless cutting is clean and the amount of slash is large. Lopping without burning is generally sufficient; only in exceptional cases is it necessary to burn the slash. Whether it should be piled before burning depends upon the conditions, but piling is generally advisable. No slash should be left touching seed trees or groups of young trees. Damp weather without wind should be selected for burning. There should always be an ample force on hand to look after the fire.

Crown cover of loblolly pine. Quality I stand, 70 years old. Its density is noteworthy. (Author's illustration.)

Crown cover of loblolly pine. Quality III stand in old field, age 50 years. The complete isolation of the crowns is characteristic. Groups of seedlings are beginning to establish themselves under such a canopy. (Author's illustration.)

THINNINGS.

Thinnings are made in crowded even-aged stands in order to concentrate the productive power of the soil in a few best trees, accelerate their growth, and in this way shorten the time necessary for them to reach maturity. Since only the smaller or defective large trees are removed, the mature stand eventually consists of large well-developed trees. In the natural process of thinning the elimination of the weaker specimens takes place too slowly for the best development of the stand. (Plates IV; XVII; XXVII.) In the struggle for light and food both the suppressed and dominant trees suffer. A certain amount of crowding, however, is necessary, particularly during the period of rapid height growth, to develop long straight stems reasonably free from knots in the lower logs. (Plate XVII.) Thinnings, therefore, should be light during the period of rapid growth in height, and should be largely limited to removing the knottiest trees. After the clear length of stem, however, has been developed (see Table 15) thinnings should be heavy in order to favor the rapid development in diameter of individual stems, the diameter of the tree has an important influence; not only on the amount of material in it but also on the high value of the lumber which is obtained from it. (See page 120, and Tables 59 to 64, and 71.) It is commonly held that when the larger trees are removed as they come to merchantable size, the smaller trees left will begin to grow fast. Such a thinning may be of benefit to the stand, but not to the same extent as thinnings of the small trees; by thinning the small trees not only a larger amount, but a higher quality is secured.

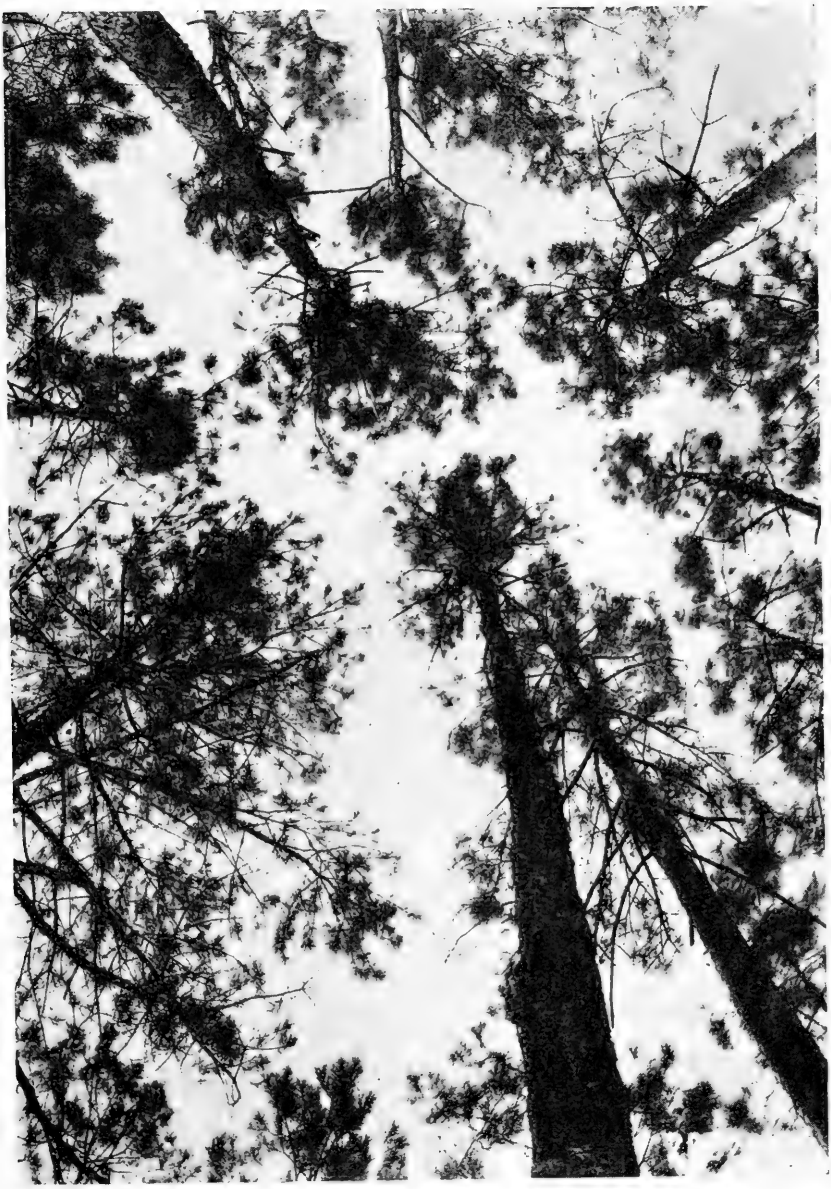
It has already been noted (page 42) that loblolly pine exhibits with age a progressive increase in its light requirements and a corresponding decline in its capacity to endure crown compression. (Plates IV; XI.) This decline is especially marked on the dryer sites. (Plates III, and XXV.) On good sites one effect of this characteristic is that in middle-aged stands, 50 to 75 years, the suppressed and intermediate trees and even such codominant trees as have endured prolonged crown compression lose their capacity to recover rapidly or even at all after their crowns are freed; on dry sites this inertness of the dominated classes extends to much younger trees. The relative tolerance which the dominant trees of different diameters and on different quality sites exhibit as expressed by the demands of the crown for light, is shown numerically by the index of tolerance (Table 78) which is the ratio of the surface of the crown space to the area of the surface of the stem of the tree inside the bark. (Plates XXIV; XXV; XXVI; XXVII.)

On account of its comparative intolerance of shade the natural thin-

ning which takes place in stands is rapid as is shown by the decrease in the number of trees per acre (Table 42). (Plates IV; XI; XV.) Stands of loblolly pine consequently are less benefited by artificial thinning than those of such species as endure more crowding and in which the struggle of the individual trees for supremacy is more prolonged. Stands of this species on good sites (moist soil) are most responsive to thinning (Plate IV); those on dry sites are less responsive (Plate III). On very wet soils thinnings increase but little the growth of the remaining trees and for this reason are hardly justifiable.

Since the power of recuperation of the intermediate and suppressed trees decreases with the age of the stands and with the length of the period of overcrowding, thinnings in old stands which have never been previously thinned, must be entirely limited to the subordinate classes. In young stands which are thinned when not more than 25 or 30 years old, many dominant trees can be removed, since the codominant and intermediate trees of these ages still retain great recuperative power (Plate IX, A), have approximately the same height as dominant trees, and straighter, clearer, and better formed stems (Plate XVII). Such a thinning constitutes a combined thinning and improvement cutting. A thinning of the dominant trees at this age will remove stems with coarse knots which would saw out a large amount of low grade lumber, even after they attained large diameters. (Plate XVI.) It also has the advantage of yielding some sawlog timber, thus making cutting at an early age remunerative. On the poorer, and particularly, on the drier, sites, subsequent thinnings should be made only with the object of forcing the development in diameter of the largest and choicest of the trees in the stand. The smaller trees which are crowding the better trees, which are to form the final stand, should be removed. Thinnings should be repeated, dependent upon their severity, at intervals of from 5 to 15 years. Frequent and light thinnings are preferable to heavy ones made at long intervals. The number of trees per acre on the different quality sites decreases in natural stands at different rates in accordance with the age of the stand (Table 42). This rate may serve as a guide in making thinnings at any age. Thinnings are less effective when the first one is deferred until the stand is 40 or more years old.

Artificial thinnings should be heavier than natural thinnings, but never so heavy as to leave large openings on all sides of the best trees selected for the final stand. The trees which are removed in older stands should be in the intermediate and codominant crown classes. The openings which are made by removals should be closed before the time of the next thinning in order to secure some lateral crowding and the clearing of the stems of branches before they become too stout and horizontal. Since the development of knots $1\frac{1}{4}$ inches in diameter causes a reduction in grade,



Crown cover of loblolly pine, Quality II, age 35 years. Crowns small but stems clean. Stand crowded, in urgent need of thinning to develop larger crowns. (Author's illustration.)

Crown cover of loblolly pine, Quality II, age 35 years. Crowns well developed and symmetrical. Excellent condition for rapid individual growth. (Author's illustration.)

sufficient density should be maintained to prevent the development of limbs which would make knots of this size on the lower three logs on Quality I and the lower two logs on Qualities II and III. The suppressed trees need not be removed. They make small demand upon soil moisture, yet serve a very useful purpose on account of their low crowns in shading the soil and lessening drying winds. This is particularly applicable to very dry clay sites; less so to very sandy sites. When the mature stand is fully developed, it can be removed in one cutting or in several cuttings made at short intervals.

Notwithstanding that the pure even-aged stands of loblolly pine offer unexcelled inducements for thinnings made for the purpose of accelerating the growth of the individual tree, no adequate data are available, either as the result of experience in commercial forests or in experimental plots which show the preferable manner in which thinnings should be executed, their cost or their effects upon the yield of the stand. It is believed that by proper thinning the rate of diameter growth of all trees in a stand can be stimulated well beyond that given in Table 71 for dominant trees. There would not be as many trees per acre on such thinned stands as there are in the dominant class of crowded stands (Table 42), but the larger volume per tree and the larger amount of saw timber would more than compensate for the smaller number of trees. A stand containing 6,000 cubic feet per acre in 60 trees, each of which will yield 560 board feet (Tables 19 and 21) or 36,000 feet per acre is far more valuable than one containing 6,000 cubic feet formed of 100 trees, each containing 300 board feet and yielding 31,000 feet per acre. Not only is the cost of operation less, there being 50 per cent more logs to handle in the stand containing the larger number of trees, but in addition to the larger yield per acre the stumpage of the larger trees is intrinsically more valuable per unit on account of the larger proportion of wide stock and high grades it will yield. (Pages 119 to 127.)

It is possible however to determine approximately the results upon yield of very intensive thinnings by means of data obtained from fully stocked unthinned stands. Certain trees in such stands on account of the fact that they are less crowded and have more growing space have outstripped all others both in height and diameter. These are the predominant trees which constitute in the normal unthinned fully stocked stand from one-fifth to one-fourth of the number of dominant trees. Not only have they larger diameters than the other dominant trees but they are also taller. The wide range of diameters of trees in intermediate and dominant crown classes which enter into the crown cover is shown in Table 1. Had the density of the more crowded portions of the stand been reduced so that the spacing of all the trees equaled that of those of the favored predominant class there would have been fewer

trees in the stand but their individual growth should have equaled that of the predominant trees. Careful measurements have been made to determine the area of the optimum crown space required for the growth of dominant trees of different diameters (at different ages) on different quality sites. Table 78 gives the crown space of dominant trees and the distance between trees, while in Table 79 is given the number of such trees of different diameters which would occupy an acre without retarding accretion.

TABLE 78.—CROWN SPACE, DISTANCE BETWEEN TREES AND INDEX OF TOLERANCE OF DOMINANT TREES OF LOBLOLLY PINE OF DIFFERENT DIAMETERS ON DIFFERENT QUALITY SITES.

Diameter breast-high Inches	Quality								
	I			II			III		
	Crown space Sq. feet	Distance between trees Feet	Index of tolerance	Crown space Sq. feet	Distance between trees Feet	Index of tolerance	Crown space Sq. feet	Distance between trees Feet	Index of tolerance
8	82	10	7.2	102	11	8.6	115	12	11.1
9	108	12	7.2	137	13	8.7	152	14	11.3
10	137	13	7.3	170	15	8.9	194	16	11.4
11	167	15	7.4	210	16	9.1	242	18	11.7
12	200	16	7.5	240	17	9.3	296	19	11.9
13	235	17	7.6	296	19	9.5	355	21	12.2
14	279	19	7.8	345	21	9.8	415	23	12.6
15	329	20	7.9	396	22	10.2	474	25	13.0
16	366	22	8.1	450	24	10.6	532	26	13.4
17	409	23	8.4	506	25	11.1	590	27	13.9
18	453	24	8.7	563	27	11.6	648	29	14.4
19	501	25	9.0	622	28	12.1	710	30	15.0
20	553	27	9.4	680	29	12.7	780	32	15.6
21	605	28	9.9	742	31	13.3	----	----	----
22	659	29	10.4	802	32	13.9	----	----	----
23	733	31	11.0	----	----	----	----	----	----
24	920	34	11.5	----	----	----	----	----	----

The trees which enter into the crown cover can be so thinned as to give each tree the optimum crown space required for that diameter: if the crown space is less than the optimum (Plate XXVII), although there are more trees per acre, the accretion of the individual tree is retarded; if it exceeds the optimum the stand is understocked. (Plate VI, A.)

Table 79, to show yield of thinned stand and yield of thinnings, gives the average diameter of the predominant trees in stands of different ages on different quality sites; the number of such trees which could occupy an acre as determined by the areas of their crown spaces; the total yield of such stands, and the yield of the trees removed in thinning; the full value of the entire stand at different ages, and the value of

the trees removed in thinnings. In fixing stumpage values for the trees in the younger stands a deduction has been made from the values given in Tables 59 to 64 to allow for the difference in age. It is believed, however, that the stumpage in thinned stands at all ages after the first thinning will be more valuable than that in unthinned stands of the same age if, as recommended, the roughest dominant trees are removed in the preliminary thinning and improvement cutting leaving as the basis for the ultimate mature stand the clean stemmed intermediate and codominant trees. (Plates XVI; XVII.) On account of the high cost of making thinnings the stumpage value of the trees removed in making them has been placed at $2 per 1,000 board feet less than the stumpage value of the timber in the entire stand.

TABLE 79.—YIELD AND VALUE OF THINNED STANDS OF LOBLOLLY PINE AT DIFFERENT AGES AND THE AMOUNT AND VALUE OF TIMBER REMOVED IN THINNINGS(a).

Age of stand	Average diameter of predominant trees (b)	Number of trees per acre	Volume per tree (c)	Yield per acre of stand before each thinning	Stumpage value per 1000 bd. ft., operating expenses $13	Stumpage value per acre of entire stand (d)	Thinnings made at age of stand given		Aggregate value of stand and thinnings
							Amount	Value each (c)	
Years	Inches		Board feet				Bd. ft.		
Quality I									
25	10.5	280	80	22,400	$ 2.75	$ 62.00	5,000	$ 4.00	$ 62.00
30	12.0	217	118	25,000	3.50	87.00	9,600	14.00	91.00
40	15.0	136	230	31,200	5.00	156.00	8,300	25.00	174.00
50	17.6	100	372	37,200	6.75	251.00	7,400	35.00	294.00
60	19.8	80	508	40,600	9.25	375.00	10,200	76.00	453.00
80	23.0	60	740	44,400	11.00	488.00	10,400	94.00	642.00
100	25.3	46	940	43,200	11.50	497.00	----------	----------	745.00
Quality II									
30	10.4	238	68	16,200	2.50	40.00	5,000	2.00	40.00
40	12.6	162	126	20,400	3.60	73.00	5,800	9.00	82.00
50	14.7	115	202	23,400	4.50	105.00	4,800	12.00	116.00
60	16.5	92	295	27,100	7.50	203.00	5,900	32.00	226.00
80	18.8	72	426	30,700	8.75	268.00	7,200	49.00	323.00
100	21.8	55	650	35,700	10.00	357.00	----------	----------	461.00
Quality III									
30	9.6	250	38	9,500	2.00	19.00	3,400	----------	19.00
40	11.5	160	79	12,900	3.00	39.00	3,500	3.00	39.00
50	13.4	116	134	14,500	3.70	54.00	3,200	5.00	57.00
60	15.0	92	190	17,500	5.75	101.00	4,500	17.00	109.00
80	17.7	68	328	22,300	7.75	173.00	----------	----------	198.00

(a)The first thinnings presuppose a preliminary improvement cutting and thinning and possibly two such.
(b)The heights of predominant trees slightly exceed the average of the dominant (Table 13).
(c)By interpolation in table.
(d)Assumed stumpage value $2.00 per thousand feet less than that of stand at same age. The 30-year old stand, Quality III, is consequently thinned without profit.
(e)Values per acre are rounded off to the nearest dollar.

By comparing the values of the thinned stands in Table 79 with those given for unthinned stands in Table 71 it is seen that thinnings increase the value of the stands on Qualities I and II. The values of Quality III stands, however, are reduced. This shows as has been pointed out in a previous paper* that "the chief value of the thinnings in the older stands on dry soils is to save the tree which would be lost by dying. There would be comparatively little accelerated growth on this quality for natural thinning takes place so rapidly that there is no prolonged crowding to retard the diameter increment of the dominant trees." Thinnings, however, add greatly to the value of the stands on good sites, and if the value of the material saved in the thinnings is taken into consideration they are probably profitable on all sites except the very wet. (Table 79, last column.)

It should be understood, however, that the theoretical yields for thinned stands which are given in Table 79 are obtainable only under ideal conditions of equal spacing which could not be realized in practice. The crown space for each tree can not be progressively increased to meet its requirements; some trees or some sides of certain trees will at times invariably be crowded; while on account of the removal of large intervening crowns some other trees will have too much space. In practice it is possible to be guided only in a general way by the distance between adjacent trees, or by the number of trees per acre. The real guide at all times of what trees to remove and how heavily to thin must be the interference of crowns (Plates XI, XIV, XV, XVI, XXVII) and the less promising trees must be removed here and there where the conditions allow it to be done without making extremely large openings in the crown cover. (Plate XXII.)

Mere thinnings can seldom be made on large tracts which are managed for the production of sawmill timber and require the building of railroads for profitable logging. (Page 137.) Loblolly pine occupies, however, in pure, even-aged stands a large area of farm forest in thickly settled communities, either near towns or near factories which assure a continuous market for cordwood. Such conditions not only render thinnings possible and profitable for their influence upon the development of the mature stand, but in many cases will be financially profitable by themselves. The farmer, however, can profitably apply intensive methods of management, which are impossible on large tracts. Under certain conditions thinnings can undoubtedly also be made in stands managed for the production of timber for pulp, stave, crate, and heading stock; or for the production of timber for these uses in connection with the production of large sized timber for saw logs.

The gradual felling of the larger trees in the even aged loblolly pine stands which has been recommended (pages 151 and following) as a

*Management of Loblolly and Shortleaf Pines, Proc. Soc. Am. Foresters, 1910, Page 97.

tentative method of cutting, that will result in larger yields than clean cutting, is not thinning. It has the effect of freeing the smaller trees which on certain sites are stimulated into accelerated growth, but the ultimate results are very different from those obtained by thinning. Under gradual felling the merchantable trees are removed while yet of medium diameter in order to obtain early cuttings. The object of thinnings is to obtain timber of large diameters; the removal of the main stand consequently is deferred.

ARTIFICIAL RESTOCKING.

Gathering of Seed.

Seed should be collected in September or early in October before heavy frosts have opened the cones. (Plate II.) The cones are frequently still green in September but if the seed are firm they will germinate. Cones can be secured from trees which are being cut where lumbering is in progress, and should be taken from dominant, thrifty, middle-aged, or older trees rather than from young trees or from codominant or suppressed ones, since not only is the percentage of sound seed higher from such trees but it is genetically undesirable that the specimens of poorest growth should be the source of seed. Not less than 50 per cent of fresh seed from such trees should be germinable. The cones after sunning until they begin to open should be placed in sacks or loose barrels in a dry but well ventilated building until they are fully open, when the seed can be flailed out. To prevent the seed from mildewing, the sacks or barrels should be occasionally turned, or the cones can be stored in shallow trays with bottoms of slats or wire netting, the trays being on racks in an airy chamber so as to secure ventilation.

The seed are flattened, about ¼ inch long, nearly black, and are attached to a shining brown wing ¾ inch long. There are about 20,000 cleaned seed to a pound. The price per pound usually varies from $1.50 when bought directly from collectors, to $2.50 if bought from dealers. The collection of seed should be profitable. It is estimated that two bushels of unopened cones will yield a pound of seed.

Seedbeds.

Seedbeds should be prepared in fertile, loamy, or mellow soil, preferably on a rather moist site. The soil is best prepared by cultivating several times during the year preceding planting. The weed seed can be killed by burning the soil as is done in preparing tobacco beds. Beds are usually made 4 or 5 feet wide, the rows being located across the bed. The seed should be planted in February or March, or, near the coast, early in autumn, about ¼ inch deep in thin rows about 8 inches

apart. A pound of seed is sufficient to plant 300 feet of drill. The seeds sprout in a few weeks and the seedlings should be from 8 to 12 inches high by the end of the first season, when they should be permanently planted. If the bed is located on moist soil or where it receives partial shade, as in a small clearing in the forest, no shading will be required. On very dry soil it will be desirable to shade lightly by a screen made of slats or boughs on a frame 2 or 3 feet above the seedbed. If the bed is located in the forest a deep trench should be dug around it to prevent the roots of nearby trees from draining it of moisture. A liberal application of ashes to the seedbed two or three weeks before planting and well worked in makes the plants more thrifty and stockier and gives a more compact and better developed root system. The soil of the seedbed must not be wet, since this may lead to "damping off" of the plants when very young. This is a disease caused by a fungus which may attack and destroy the stem if plants are over-crowded in seedbeds although so far it has not been known to attack loblolly pine.

Planting.

Loblolly pine reproduces only from seed. Plantations can be started either by young plants or by direct seeding. Direct seeding is cheaper and under most conditions is more satisfactory on account of the difficulty of transplanting the young pines. It is desirable to use plants only on land which is very foul and on which young seedlings might be smothered. One-year-old wild seedling plants can be used in place of nursery grown stock. Planting should be done during late winter or early in the spring. Fall planting, except on wet soils, is not advisable. Planting is most quickly done by two persons, one making the holes with a mattock, the other carrying the plants in a box strapped over the left shoulder. The plant is held upright in the hole with one hand; the roots are spread out with the other; the earth is drawn up to the plant with the foot and firmly pressed around it on both sides with the feet. Every precaution must be taken to prevent the roots of the plants in the box from drying out; they should, therefore, be kept all the time covered with a thick wet cloth. It is preferable to puddle the roots on lifting the plants from the seedbed by dipping them in a thick mud, so as to coat them thoroughly. On the better soils planting can well be made 6 by 6 feet; on the poorer, 5 by 5 feet. When the condition of the surface will permit it, furrows can be laid off with a plow the desired distance apart, and one man can plant in these furrows without assistance. On account of the rapidity of its growth it would seldom be necessary to cultivate a plantation unless on dry and heavy clay soils.

Direct Seeding.

On account of the large proportion of sound seed, the ease of germination and the hardiness and rapidity of growth of the young plant, direct seeding succeeds remarkably well. This can be either broadcast sowing or by seed spot planting.

Broadcast sowing should be made early in March. If the surface is very foul with weeds or brush, the larger brush should be cut with axes or brush hooks in strips early in winter and piled in windrows against living brush. In early spring, when thoroughly dry, it should be burned clean and the seed sown after the first rain. From three to four pounds of seed per acre are required for direct seeding without covering. If there is a heavy sod, it can be burnt and the ground harrowed with a disk or tooth harrow before seeding and the seed covered with a weeder after seeding two or three pounds of seed per acre. On plowed ground seed should be broadcast at the rate of 1½ to 2 pounds to the acre and covered with a weeder. It is desirable to mix the seed with one-half bushel of slacked ashes or earth, as is done with turnip seed, in order to secure a uniform distribution.

Seed spot sowing requires less seed than broadcast. Droppings can be done either like corn or peas at places 4 by 4 feet, or furrows can be laid off four feet apart, the seed dropped at distances of 4 feet in the furrows and lightly covered ¼ to ½ inch with earth. The soil can be either plowed or unplowed. Plowing is seldom justified. On smooth, clean, sandy land where there are few bushes, stumps, or little sod, it is possible to plant with a horse corn or pea-planter, such as the Cole combination planter. A plate with one small hole can be used which will drop several seed every 4 feet. The seed should be thoroughly mixed with dry ashes. It is necessary to adjust plow point and coverer so that the seed are covered the necessary depth. On rough soil a hand corn-planter can be used, adjusted for the small pine seed. If planting is done by hand the soil should be loosened with a mattock for 6 inches square and to a depth of 3 to 5 inches and from 10 to 15 seed should be dropped in each spot and covered not more than one-half inch. From one to two pounds of seed is ample for seed spot planting. On most portions of the sandy longleaf pine lands the conditions permit the use of a planter. Since from 3 to 6 acres of land can be planted in a day by this means, the planting of these lands in loblolly pine, at a total cost of planting of $2 to $3 an acre, would be, with adequate protection from fire, advisable from an investment standpoint. It is necessary in all plantations to furnish absolute protection against fire.

Advisability of Loblolly Pine Planting.

At the present prices of pine stumpage it is possible to grow loblolly pine in plantations profitably in places where land of good growing capacity can be purchased cheaply. Plantations should never be made on land which naturally stocks in pine, since in such a case the cost of planting adds unnecessary expense. Neither should it be undertaken on land which has a value greater than $10 an acre. If the land has a value of $10 an acre and a producing capacity equal to that of upland old fields of good quality, about Quality Site II, and the cost of seed spot

planting, including seed and labor, does not exceed $3 an acre, the cost of growing 1,000 board feet of timber under an interest rate of 6 per cent a year, in an unthinned stand, is as shown in Table 80.

TABLE 80.—COST PER 1,000 BOARD FEET OF GROWING LOBLOLLY PINE IN PLANTATIONS.

QUALITY II.

Age of stand Years	Accumulated costs on an initial investment of $13 an acre, interest at 6 per cent a year, less the value of the land	Yield of stand in board feet	Cost of growing stumpage per 1,000 board feet	Value (Jan. 1913) per 1,000 feet B. M., of stumpage based on Quality II, operating cost $13 per 1,000
30	$ 64.62	16,000	$ 4.04	$ 2.50
35	89.84	21,850	4.10	2.60
40	123.77	26,850	4.58	2.85
45	168.88	30,850	5.45	3.20

Plantations can be made consequently with an initial investment of $13 an acre with the expectation of netting at least 5 per cent, compounded, provided there is an increase of $1.50 per 1,000 feet in the price of stumpage in a stand at 35 years; an increase of $1.75 in a stand at 40 years old, and an increase of $2.25 in a stand at 45 years. The increase of $1.50 in 35 years is less than ¾ of one per cent a year on the present value of stumpage per 1,000 feet. The cost of growing on other quality sites can be easily calculated by means of Table 38. The present value of stumpage can be approximated from Tables 59 to 64. In case stands are thinned the cost of growing is affected as shown in Table 79.

PUBLICATIONS

OF THE

NORTH CAROLINA GEOLOGICAL AND ECONOMIC SURVEY

BULLETINS.

1. Iron Ores of North Carolina, by Henry B. C. Nitze, 1893. 8°, 239 pp., 20 pl., and map. *Out of print.*

2. Building and Ornamental Stones in North Carolina, by T. L. Watson and F. B. Laney in collaboration with George P. Merrill, 1906. 8°, 283 pp., 32 pl., 2 figs. *Postage 25 cents. Cloth-bound copy 30 cents extra.*

3. Gold Deposits in North Carolina, by Henry B. C. Nitze and George B. Hanna, 1896. 8°, 196 pp., 14 pl., and map. *Out of print.*

4. Road Material and Road Construction in North Carolina, by J. A. Holmes and William Cain, 1893. 8°, 88 pp. *Out of print.*

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11. Corundum and the Basic Magnesian Rocks of Western North Carolina, by J. Volney Lewis, 1895. 8°, 107 pp., 6 pl. *Out of print.*

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24. Loblolly or North Carolina Pine, by W. W. Ashe, Forest Inspector, U. S. Forest Service (and former Forester of the North Carolina Geological and Economic Survey). Prepared in Coöperation with the Forest Service, U. S. Department of Agriculture, 1914. 8°, 176 pp., 27 plates, 5 figs. *Postage 10 cents.*

ECONOMIC PAPERS.

1. The Maple sugar Industry in Western North Carolina, by W. W. Ashe, 1897. 8°, 34 pp. *Postage 2 cents.*

2. Recent Road Legislation in North Carolina, by J. A. Holmes. *Out of print.*

3. Talc and Pyrophyllite Deposits in North Carolina, by Joseph Hyde Pratt, 1900. 8°, 29 pp., 2 maps. *Postage 2 cents.*

4. The Mining Industry in North Carolina During 1900, by Joseph Hyde Pratt, 1901. 8°, 36 pp., and map. *Postage 2 cents.*

Takes up in some detail Occurrences of Gold, Silver, Lead and Zinc, Copper, Iron Manganese, Corundum, Granite, Mica, Talc, Pyrophyllite, Graphite, Kaolin, Gem Minerals, Monazite, Tungsten, Building Stones, and Coal in North Carolina.

5. Road Laws of North Carolina, by J. A. Holmes. *Out of print.*

6. The Mining Industry in North Carolina During 1901, by Joseph Hyde Pratt, 1902. 8°, 102 pp. *Postage 4 cents.*

Gives a List of Minerals found in North Carolina; describes the Treatment of Sulphuret Gold Ores, giving localities; takes up the Occurrence of Copper in the Virgilina, Gold Hill, and Ore Knob districts; gives Occurrence and Uses of Corundum; a List of Garnets, describing Localities; the Occurrence, Associated Minerals, Uses and Localities of Mica; the Occurrence of North Carolina Feldspar, with Analyses; an extended description of North Carolina Gems and Gem Minerals; Occurrences of Monazite, Barytes, Ocher; describes and gives Occurrences of Graphite and Coal; describes and gives Occurrences of Building Stones, including Limestone; describes and gives Uses for the various forms of Clay; and under the head of "Other Economic Minerals," describes and gives Occurrences of Chromite, Asbestos and Zircon.

7. Mining Industry in North Carolina During 1902, by Joseph Hyde Pratt, 1903. 8°, 27 pp. *Out of print.*

8. The Mining Industry in North Carolina During 1903, by Joseph Hyde Pratt, 1904. 8°, 74 pp. *Postage 4 cents.*

Gives descriptions of Mines worked for Gold in 1903; descriptions of Properties worked for Copper during 1903, together with assay of ore from Twin-Edwards Mine; Analyses of Limonite ore from Wilson Mine; the Occurrence of Tin; in some detail the Occurrences of Abrasives; Occurrences of Monazite and Zircon; Occurrences and Varieties of Graphite, giving Methods of Cleaning; Occurrences of Marble and other forms of Limestone; Analyses of Kaolin from Barber Creek, Jackson County, North Carolina.

9. The Mining Industry in North Carolina During 1904, by Joseph Hyde Pratt, 1905. 8°, 95 pp. *Postage 4 cents.*

Gives Mines Producing Gold and Silver during 1903 and 1904 and Sources of the Gold Produced during 1904; describes the mineral Chromite, giving Analyses of Selected Samples of Chromite from Mines in Yancey County; describes Commercial Varieties of Mica, giving the manner in which it occurs in North Carolina, Percentage of Mica in the Dikes, Methods of Mining, Associated Minerals, Localities, Uses; describes the mineral Barytes, giving Method of Cleaning and Preparing Barytes for Market; describes the use of Monazite as used in connection with the Preparation of the Bunsen Burner, and goes into the use of Zircon in connection with the Nernst Lamp, giving a List of the Principal Yttrium Minerals; describes the minerals containing Corundum Gems, Hiddenite and Other Gem Minerals, and gives New Occurrences of these Gems; describes the mineral Graphite and gives new Uses for same.

10. Oyster Culture in North Carolina, by Robert E. Coker, 1905. 8°, 39 pp. *Out of print.*

11. The Mining Industry in North Carolina During 1905, by Joseph Hyde Pratt, 1906. 8°, 95 pp. *Postage 4 cents.*

Describes the mineral Cobalt and the principal minerals that contain Cobalt; Corundum Localities; Monazite and Zircon in considerable detail, giving Analyses of Thorianite; describes Tantalum Minerals and gives description of the Tantalum Lamp; gives brief description of Peat Deposits; the manufacture of Sand-lime Brick; Operations of Concentrating Plant in Black Sand Investigations; gives Laws Relating to Mines, Coal Mines, Mining, Mineral Interest in Land, Phosphate Rock, Marl Beds.

12. Investigations Relative to the Shad Fisheries of North Carolina, by John N. Cobb, 1906. 8°, 74 pp., 8 maps. *Postage 6 cents.*

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Under the head of "Recent Changes in Gold Mining in North Carolina," gives methods of mining, describing Log Washers, Square Sets, Cyanide Plants, etc., and detailed descriptions

of Gold Deposits and Mines are given; Copper Deposits of Swain County are described; Mica Deposits of western North Carolina are described, giving distribution and General Character, General Geology, Occurrence, Associated Minerals, Mining and Treatment of Mica, Origin, together with a description of many of the mines; Monazite is taken up in considerable detail as to Location and Occurrence, Geology, including classes of Rocks, Age, Associations, Weathering, method of Mining and Cleaning, description of Monazite in Original Matrix.

15. The Mining Industry in North Carolina During 1907, by Joseph Hyde Pratt, 1908. 8°, 176 pp., 13 pl., and 4 figs. *Postage 15 cents.*

Takes up in detail the Copper of the Gold Hill Copper District; a description of the Uses of Monazite and its Associated Minerals; descriptions of Ruby, Emerald, Beryl, Hiddenite, and Amethyst Localities; a detailed description with Analyses of the Principal Mineral Springs of North Carolina; a description of the Peat Formations in North Carolina, together with a detailed account of the Uses of Peat and the Results of an Experiment Conducted by the United States Geological Survey on Peat from Elizabeth City, North Carolina.

16. Report of Convention called by Governor R. B. Glenn to Investigate the Fishing Industries in North Carolina, compiled by Joseph Hyde Pratt, State Geologist, 1908. 8°, 45 pp. *Out of print.*

17. Proceedings of Drainage Convention held at New Bern, North Carolina, September 9, 1908. Compiled by Joseph Hyde Pratt, 1908. 8°, 94 pp. *Out of print.*

18. Proceedings of Second Annual Drainage Convention held at New Bern, North Carolina, November 11 and 12, 1909, compiled by Joseph Hyde Pratt, and containing North Carolina Drainage Law, 1909. 8°, 50 pp. *Out of print.*

19. Forest Fires in North Carolina During 1909, by J. S. Holmes, Forester, 1910. 8°, 52 pp., 9 pl. *Out of print.*

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21. Proceedings of the Third Annual Drainage Convention, held under Auspices of the North Carolina Drainage Association; and the North Carolina Drainage Law (codified). Compiled by Joseph Hyde Pratt, 1911. 8°, 67 pp., 3 pl. *Out of print.*

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23. Mining Industry in North Carolina During 1908, '09, and '10, by Joseph Hyde Pratt and Miss H. M. Berry, 1911. 8°, 134 pp., 1 pl., 27 figs. *Postage 10 cents.*

Gives report on Virgilina Copper District of North Carolina and Virginia, by F. B. Laney; Detailed report on Mica Deposits of North Carolina, by Douglas B. Sterrett; Detailed report on Monazite, by Douglas B. Sterrett; Reports on various Gem Minerals, by Douglas B. Sterrett; Information and Analyses concerning certain Mineral Springs; Extract from Chance Report of the Dan River and Deep River Coal Fields; Some notes on the Peat Industry, by Professor Charles A. Davis; Extract from report of Arthur Keith on the Nantahala Marble; Description of the manufacture of Sand-lime Brick.

24. Fishing Industry of North Carolina, by Joseph Hyde Pratt, 1911. 8°, 44 pp. *Out of print.*

25. Proceedings of Second Annual Convention of the North Carolina Forestry Association, held at Raleigh, North Carolina, February 21, 1912. Forest Fires in North Carolina During 1911. Suggested Forestry Legislation. Compiled by J. S. Holmes, Forester, 1912. 8°, 71 pp. *Postage 5 cents.*

26. Proceedings of Fourth Annual Drainage Convention, held at Elizabeth City, North Carolina, November 15 and 16, 1911, compiled by Joseph Hyde Pratt, State Geologist, 1912. 8°, 45 pp. *Postage 3 cents.*

27. Highway Work in North Carolina, containing a Statistical Report of Road Work during 1911 by Joseph Hyde Pratt, State Geologist, and Miss H. M. Berry, Secretary, 1912. 8°, 145 pp., 11 figs. *Postage 10 cents.*

28. Culverts and Small Bridges for Country Roads in North Carolina, by C. R. Thomas and T. F. Hickerson, 1912. 8°, 56 pp., 14 figs., 20 pl. *Postage 10 cents.*

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sembly of 1909, and the Legislation Recommended by this Committee, 1912. 8°, 302 pp. *Postage 15 cents.*

30. Proceedings of the Annual Convention of the North Carolina Good Roads Association held at Charlotte, N. C., August 1 and 2, 1912, in Coöperation with the North Carolina Geological and Economic Survey. Compiled by Joseph Hyde Pratt, State Geologist, and Miss H. M. Berry, Secretary, 1912. 8°, 109 pp. *Postage 10 cents.*

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34. Mining Industry in North Carolina during 1911-12, by Joseph Hyde Pratt, State Geologist, 1914. 8°, 314 pp., 23 pl., 12 figs. *Postage 30 cents.*

Gives detailed report on Gold Mining in various counties with special report on Metallurgical Processes used at the Iola Mine, by Claud Hafer; description of a Cyanide Mill, by Percy Barbour; The new Milling Process for treating North Carolina Siliceous Gold Ores at the Montgomery Mine, including a description of the Uwarrie Mining Company's Plant; notes on the Carter Mine, Montgomery County, by Claud Hafer; also a description of the Howie Mine and its mill; a detailed report on the Coggins (Appalachian) Gold Mine, by Joseph Hyde Pratt; a list of gems and gem minerals occurring in the United States; special descriptions of Localities where the Amethyst, Beryl, Emerald, and Quartz Gems Occur as taken from United States Geological Survey Report by Douglas B. Sterrett; a report on the Dan River Coal Field, by R. W. Stone, as reprinted from Bulletin 471-B of the United States Geological Survey; a special report on Graphite, by Edson S. Bastin and reprinted from Mineral Resources of United States for 1912; a special report on Asbestos describing both the Amphibole and Chrysotile varieties; a report on the Mount Airy Granite Quarry; special report on Sand and Gravel, giving Uses, Definitions of Various Sands, etc.; the portion of a Bulletin on Feldspar and Kaolin of the United States Bureau of Mines, which relates to North Carolina, and which takes up in detail Occurrences, Methods of Mining, and Descriptions of Localities of Feldspar and Kaolin mines in North Carolina, prepared by Mr. A. S. Watts. In this Economic Paper are also given the names and addresses of Producers of the various minerals during the years covered by the report.

35. Good Roads Days, November 5th and 6th, 1913, compiled by Joseph Hyde Pratt, State Geologist, and Miss H. M. Berry, Secretary. 8°, 102 pp., 11 pl. *Postage 10 cents.*

36. Proceedings of the North Carolina Good Roads Association, held at Morehead City, N. C., July 31st and August 1st, 1913. In Coöperation with the North Carolina Geological and Economic Survey.—Statistical Report of Highway Work in North Carolina during 1912. Compiled by Joseph Hyde Pratt, State Geologist, and Miss H. M. Berry, Secretary. 8°, 127 pp., 7 figs. *Postage 10 cents.*

37. Forest Fires in North Carolina During 1913 and a Summary of State Forest Fire Prevention in the United States, by J. S. Holmes, Forester, 1914. 8°, 82 pp. *Postage 8 cents.*

38. Forms covering the Organization of Drainage Districts under the North Carolina Drainage Law, Chapter 442, Public Laws of 1909, and Amendments. And Forms for Minutes of Board of Drainage Commissioners covering the Organization of the Board up to and Including the Issuing of the Drainage Bonds. Compiled by Geo. R. Boyd, Drainage Engineer, 1914. 8°, 133 pp. *Postage 10 cents.*

39. Proceedings of the Good Roads Institute held at the University of North Carolina, March 17-19, 1914. Held under the auspices of the Departments of Civil and Highway Engineering of the University of North Carolina and The North Carolina Geological and Economic Survey, 1914. 8°, 117 pp., 15 figs., 4 pl. *Postage 10 cents.*

VOLUMES.

Vol. I. Corundum and the Basic Magnesian Rocks in Western North Carolina, by Joseph Hyde Pratt and J. Volney Lewis, 1905. 8°, 464 pp., 44 pl., 35 figs. *Postage 32 cents. Cloth-bound copy 30 cents extra.*

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Pt. I.—The Physiography and Geology of the Coastal Plain of North Carolina, by Wm. Bullock Clark, Benjamin L. Miller, and L. W. Stephenson.
Pt. II.—The Water Resources of the Coastal Plain of North Carolina, by L. W. Stephenson and B. L. Johnson.

Vol. IV. Birds of North Carolina. *In press.*

BIENNIAL REPORTS.

First Biennial Report, 1891-1892, J. A. Holmes, State Geologist, 1893. 8°, 111 pp., 12 pl., 2 figs. *Postage 6 cents.*

Administrative report, giving Object and Organization of the Survey; Investigations of Iron Ores, Building Stone, Geological Work in Coastal Plain Region, including supplies of drinking waters in eastern counties, Report on Forests and Forest Products, Coal and Marble, Investigations of Diamond Drill

Biennial Report 1893-1894, J. A. Holmes, State Geologist, 1894. 8° 15 pp. *Postage 1 cent.*

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Biennial Report, 1895-1896, J. A. Holmes, State Geologist, 1896. 8°, 17 pp. *Postage 1 cent.*

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Biennial Report, 1905-1906, Joseph Hyde Pratt, State Geologist, 1907. 8°, 60 pp. *Postage 3 cents.*

Administrative report; report on certain swamp lands belonging to the State, by W. W. Ashe; it also gives certain magnetic observations at North Carolina stations.

Biennial Report, 1907-1908, Joseph Hyde Pratt, State Geologist, 1908. 8°, 60 pp., 2 pl. *Postage 5 cents.*

Administrative report. Contains Special Report on an examination of the Sand Banks along the North Carolina Coast, by Jay F. Bond, Forest Assistant, United States Forest Service; certain magnetic observations at North Carolina stations; Results of an Investigation Relating to Clam Cultivation, by Howard E. Enders of Purdue University.

Biennial Report 1909-1910, Joseph Hyde Pratt, State Geologist, 1911. 8°, 152 pp. *Postage 10 cents.*

Administrative report, and contains Agreements for Coöperation in Statistical Work, and Topographical and Traverse Mapping Work with the United States Geological Survey; Forest Work with the United States Department of Agriculture (Forest Service); List of Topographic maps of North Carolina and counties partly or wholly topographically mapped; description of special Highways in North Carolina; suggested Road Legislation; list of Drainage Districts and Results of Third Annual Drainage Convention; Forestry reports relating to Connolly Tract, Buncombe County and Transylvania County State Farms; certain Watersheds; Reforestation of Cut-over and Abandoned Farm Lands on the Woodlands of the Salem Academy and College; Recommendations for the Artificial Regeneration of Longleaf Pine at Pinehurst; Act regulating the use of and for the Protection of Meridian Monuments and Standards of Measure at the several county seats of North Carolina; list of Magnetic Declinations at the county seats, January 1, 1910; letter of Fish Commissioner of the United States Bureau of Fisheries relating to the conditions of the North Carolina fish industries; report of the Survey for the North Carolina Fish Commission referring to dutch or pound-net fishing in Albemarle and Croatan sounds and Chowan River, by Gilbert T. Rude, of the United States Coast and Geodetic Survey; Historical Sketch of the several North Carolina Geological Surveys, with list of publications of each.

Biennial Report, 1911-1912, Joseph Hyde Pratt, State Geologist, 1913. 8°, 118 pp. *Postage 7 cents.*

Administrative report, and contains reports on method of construction and estimate of cost of road improvement in Stantonsburg Township, Wilson County; report on road conditions in Lee County; report on preliminary location of section of Spartanburg-Hendersonville Highway

between Tryon and Tuxedo; report of road work done by U. S. Office of Public Roads during biennial period; experiments with glutrin on the sand-clay road; report on Central Highway, giving Act establishing and report of trip over this Highway; suggested road legislation; report on the Asheville City watershed; report on the Struan property at Arden, Buncombe County; report on the woodlands on the farm of Dr. J. W. Kilgore, Iredell County; report on examination of the woodlands on the Berry place, Orange County; report on the forest property of Miss Julia A. Thorne, Asheboro, Randolph County; report on the examination of the forest lands of the Butters Lumber Company, Columbus County; proposed forestry legislation; swamp lands and drainage, giving drainage districts; suggested drainage legislation; proposed Fisheries Commission bill.

Biennial Report, 1913-1914, Joseph Hyde Pratt, State Geologist, 1915. 8°, 190 pp. *Postage 14 cents.*

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