UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 308

Contribution from the Forest Service
HENRY S. GRAVES, Forester

Washington, D. C. PROFESSIONAL PAPER November 22, 1915

SHORTLEAF PINE: ITS ECONOMIC IMPORTANCE AND FOREST MANAGEMENT

By

WILBUR R. MATTOON, Forest Examiner

CONTENTS

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By WILBUR R. MATTOON, *Forest Examiner.*

CONTENTS.

ADAPTABILITY FOR FOREST MANAGEMENT.[1]

Shortleaf pine possesses characteristics of growth which especially fit it for profitable forest management throughout a large part of the Eastern and Southern States. Over extensive areas from Maryland southward and westward to the Mississippi River it occurs as second growth, both in pure stands and mixed with hardwoods, and in the Gulf States and the central Mississippi Basin it forms a large proportion of the remaining virgin southern yellow pine. In a considerable portion of these regions shortleaf pine excels all other coniferous species in value and profitableness as a timber crop. It is one of the more important commercial pines and

[1] Frequent reference is hereafter made to Department Bulletin No. 244, "Life History of Shortleaf Pine," which treats in some detail of subjects of basic importance in the consideration of forest management such as size, age, soil, climatic demands, reproduction, and growth.

NOTE.—This bulletin is of value to those who are interested in the timber supply of the Eastern and Southern States, and in the management of tracts of shortleaf pine for their highest financial returns. It will be helpful to those in the regions covered desiring to restock denuded pine uplands by means of sowing and planting.

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because of the following qualities promises to supply much of the future timber crop: (1) Quick and persistent growth, (2) vigor of reproduction and high sprouting capacity during youth when most susceptible to serious injury, (3) quick response to increase of light secured by thinning, (4) characteristically tall, straight, and clean trunk, (5) intermediate quality of the wood, which fits it for a wide range of uses, and (6) the gregarious habit of the species in pure stands, resulting in large yields of high-grade timber per acre.

NAME.

Shortleaf pine (*Pinus echinata* Mill.) is one of the important southern yellow pines.[1] It is also known by various other names, such as "yellow," "old field," or "rosemary" pine in the Piedmont region from Virginia to the Mississippi River; "hill" pine in Arkansas and Louisiana; and "two-leaf" and "spruce" pine in other regions. In the lumber market the wood is known mostly as shortleaf or yellow pine. In the Central Atlantic States shortleaf and loblolly are marketed under the trade name of "North Carolina" pine. In other regions loblolly is usually classed, without qualification, as shortleaf lumber, while shortleaf and, to a lesser extent, loblolly are more or less frequently graded and sold as longleaf pine.

In the following discussion of the annual cut, standing timber, lumber prices, and market it will be necessary to refer to the total southern yellow-pine cut as a basis, since there is no complete separation of the different species by the trade either in lumbering operations or in the general lumber market.

PRESENT SUPPLY.

The Bureau of Corporations in its report on the standing timber in the United States, published January 20, 1913,[2] states that in 1909 there were 152,100,000,000 feet of shortleaf (throughout the report shortleaf is used to include both shortleaf and loblolly) and 232,300,000,000 feet of longleaf pine, or a total of 384,400,000,000 feet of southern yellow pine, distributed as shown in Table 1.

[1] The other important pines making up the southern pine lumber are longleaf pine (*Pinus palustris* Mill.) and loblolly pine (*Pinus tæda* Linn.). Other southern pines of relatively small importance are slash pine (*Pinus caribæa* Morelet), sold and classed as longleaf; pond pine (*Pinus serotina* Michx.); and spruce pine (*Pinus glabra* Walt.).

[2] The most complete timber census available.

TABLE 1.—*Standing timber of southern yellow pine in 1909 for 11 Southern States.*

[Publicly owned timber not included.] [1]

State.	Shortleaf and loblolly pine.		Longleaf.		Total quantity.
	Quantity.	Distribution.	Quantity.	Distribution.	
	Board feet.	*Per cent.*	*Board feet.*	*Per cent.*	*Board feet.*
Alabama	12,400,000,000	8.2	25,600,000,000	11.0	38,000,000,000
Arkansas	26,000,000,000	17.1			[2] 26,000,000,000
Florida	900,000,000	.6	58,200,000,000	25.1	59,100,000,000
Georgia (part)	13,200,000,000	8.7	18,500,000,000	8.0	31,700,000,000
Louisiana	15,200,000,000	10.0	52,500,000,000	22.6	67,700,000,000
Mississippi	14,800,000,000	9.7	47,600,000,000	20.5	62,400,000,000
Missouri (part)	1,100,000,000	.7			1,100,000,000
North Carolina (part)	22,700,000,000	14.9	2,900,000,000	1.2	25,600,000,000
South Carolina (part)	14,600,000,000	9.6	4,600,000,000	2.0	19,200,000,000
Texas	22,500,000,000	14.8	22,400,000,000	9.6	44,900,000,000
Virginia (part)	8,700,000,000	5.7			81,700,000,000
Total	152,100,000,000	100.0	232,300,000,000	100.0	384,400,000,000

[1] Bureau of Corporations, The Lumber Industry, Part I, p. 76.
[2] In 1880, Sargent estimated merchantable stand of shortleaf in Arkansas at 41,000,000,000 feet, Tenth U. S. Census.

True shortleaf pine occurs in eight States besides those represented in the table, though in relatively smaller quantity. There are no accurate figures available of the relative proportion of loblolly and shortleaf. The best available estimate, based upon the distribution and the lumber production, places the amount of standing shortleaf at about 55 per cent of the combined amount of both species. On this basis there were in 1909 about 83,700,000,000 board feet in the States shown in Table 1. The report of the Bureau of Corporations for the same year showed that 4.1 per cent of the southern yellow pine was being cut annually.[1] This gives for the major part of the 11 most important States a remaining stand in 1913 of about 73,400,000,000 feet. To this must be added (1) the stand of shortleaf in the other eight States and the parts of Virginia, North Carolina, South Carolina, and Georgia not included in the above computation, (2) National Forest timber in Arkansas, and (3) the total increment or growth during the period, which may conservatively be placed at 1 per cent annually, after allowing for loss by fire and other causes. This gives a total of 80 billion board feet (Table 2), which is believed to be a conservative estimate of the present shortleaf-pine supply.

[1] There is reason to believe, however, that both longleaf and loblolly have been cut at a faster rate than shortleaf, because of their location over lowlands near the coast.

For the botanical and commercial range of shortleaf pine, see figure 1.

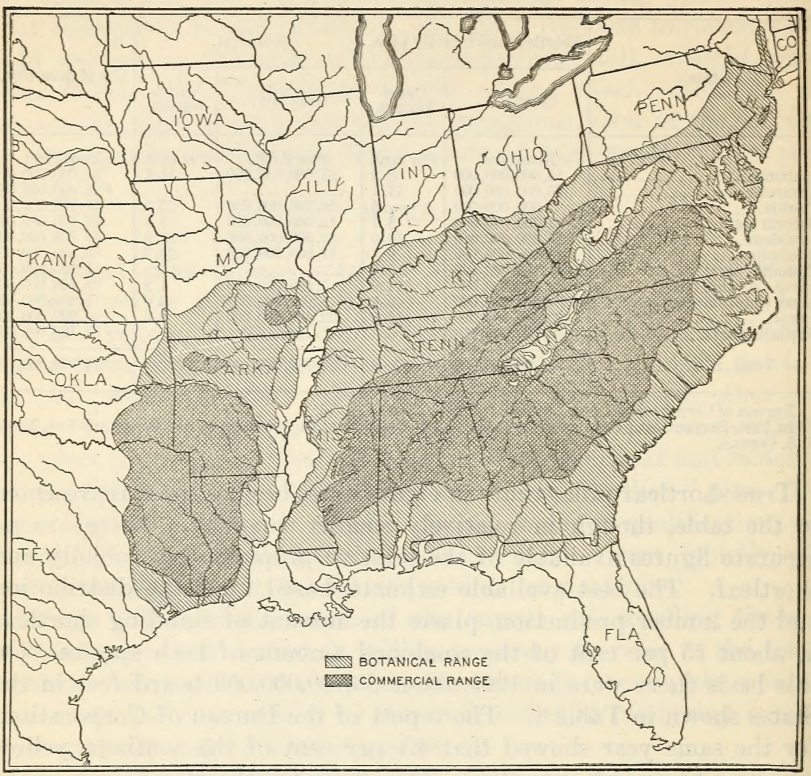

FIG. 1.—Botanical and commercial range of shortleaf pine.

TABLE 2.—*Estimated total stand of shortleaf pine timber in the United States for 1913.*

Region.	Standing shortleaf.	Region.	Standing shortleaf.
	Board feet.		*Board feet.*
Eleven Southern States (6 States and parts of 5 States) [1]	73,400,000,000	Kentucky, Tennessee, and West Virginia [5]	455,000,000
Virginia, North Carolina, South Carolina, and Georgia (parts) [2]	1,144,000,000	New Jersey, Pennsylvania, Delaware, and Maryland [6]	16,100,000
National Forests of Arkansas [3]	1,608,900,000	Growth, 1910 to 1913, inclusive [7]	3,000,000,000
Oklahoma [4]	1,200,000,000		
		Total	80,824,000,000

[1] Based on Bureau of Corporations report "The Lumber Industry, Part I, Standing Timber." (Alabama, Arkansas, Florida, Louisiana, Mississippi, and Texas; parts of Georgia, Missouri, North Carolina, South Carolina, and Virginia) and annual cut at rate of 4.1 per cent.

[2] Reports of North Carolina Geological Survey; other States estimated on basis of comparative area with North Carolina and known character of stand.

[3] Forest Service estimates for Arkansas (1,500,000,000 feet) and Ozark (108,900,000 feet) National Forests.

[4] Rough estimate from general knowledge of area and character of distribution.

[5] State report of Kentucky (195,000,000 feet) and two other States estimated on basis of comparison with Kentucky.

[6] Rough estimates by States, based upon general character of distribution and regional studies by States or Forest Service.

[7] Growth at rate of 1 per cent annually, after allowing for loss by fire, etc.

ANNUAL CUT OF SOUTHERN YELLOW PINE.

The annual cut of southern yellow pine has for many years far exceeded in total amount that of any other species or group of species in the United States. Of the seven leading groups shown in Table 3, yellow pine furnishes annually nearly as much as the combined output of all the other groups.

TABLE 3.—*Lumber cut of the seven leading woods in the United States, in the order of rank in production for 1913.*[1]

Kind of wood.	Rank in production.	Lumber sawed.									
		Quantity (M feet b. m.).					Proportion of total cut of all species (per cent).				
	1913	*1913*	*1912*	*1911*	*1910*	*1909*	*1913*	*1912*	*1911*	*1910*	*1909*
Yellow pine[2]	1	14,839,363	14,737,052	12,896,706	14,143,471	16,277,185	38.7	37.6	34.9	35.3	36.6
Douglas fir	2	5,556,096	5,175,123	5,054,243	5,203,644	4,856,378	14.5	13.2	13.7	13.0	10.9
Oak	3	3,211,718	3,318,952	3,098,444	3,522,098	4,414,457	8.4	8.5	8.4	8.8	9.9
White pine	4	2,568,636	3,138,227	3,230,584	3,352,183	3,900,034	6.7	8.0	8.7	8.4	8.8
Hemlock	5	2,319,982	2,426,554	2,555,308	2,836,129	3,051,399	6.0	6.2	6.9	7.1	6.9
Western pine	6	1,258,528	1,219,444	1,330,700	1,562,106	1,499,985	3.3	3.1	3.6	3.9	3.4
Cypress	7	1,097,247	997,227	981,527	935,659	955,635	2.9	2.5	2.7	2.3	2.1
Total[3]	.....	38,387,009	39,158,414	37,003,207	40,018,282	44,509,761	100.0	100.0	100.0	100.0	100.0

[1] Bureau of Census reports in cooperation with Forest Service, 1909–1912; Bureau of Crop Estimates in cooperation with Forest Service, 1913.
[2] All southern yellow pine except a very small amount of pitch pine and scrub pine in the Middle and North Atlantic States.
[3] Total of all woods (about 40 species).

The cut of yellow pine ranged from 36.6 per cent of the entire cut of the country in 1909 to 38.7 per cent in 1913, when it amounted to 14,839,363,000 board feet. Of the eight States holding highest rank in 1913 in timber production, five owe their importance chiefly to their output of yellow pine, of which a large proportion is shortleaf. The production of yellow pine by States in 1913 is shown in Table 4.

TABLE 4.—*Production of yellow-pine lumber in 1913 by States.*[1]

State.	Quantity.	Percentage of total cut.	Number of active mills reporting.	State.	Quantity.	Percentage of total cut.	Number of active mills reporting.
	Board feet.	*Per ct.*			*Board feet.*	*Per ct.*	
United States.	14,839,363,000	100.00	7,639	Virginia	810,362,000	5.5	1,023
				Georgia	662,043,000	4.5	671
Louisiana	3,092,375,000	20.8	299	South Carolina	635,426,000	4.3	492
Mississippi	2,224,711,000	15.0	540	Oklahoma	120,860,000	.8	55
Texas	2,024,231,000	13.7	317	Maryland	65,143,000	.4	165
North Carolina	1,515,102,000	10.2	1,522	Tennessee	60,137,000	.4	343
Alabama	1,395,059,000	9.4	744	Missouri	57,023,000	.4	130
Arkansas	1,174,498,000	7.9	467	All others[2]	78,520,000	.5	678
Florida	923,873,000	6.2	193				

[1] Bureau of Crop Estimates and Forest Service, U. S. Department of Agriculture.
[2] Includes establishments distributed as follows: Connecticut, 24; Delaware, 35; Illinois, 3; Indiana, 2; Iowa, 2; Kentucky, 195; Maine, 25; Massachusetts, 30; New Hampshire, 3; New Jersey, 46; Ohio, 25; Pennsylvania, 193; Rhode Island, 6; Vermont, 3; and West Virginia, 86.

ESTIMATE FOR SHORTLEAF PINE.

An estimate based on the assumption that the rate of cut of each species of southern yellow pine is approximately proportional to the stand would place the total lumber cut of shortleaf in 1913 at 22 per cent of the total southern yellow pine lumber cut, or 3,264,660,000 board feet.

Another estimate may be made by taking 4.1 per cent[1] of the estimated total stand in 1913 (Table 2). This would place the cut at 3,313,784,000 board feet of saw timber, a difference of only 1.5 per cent from the first estimate. A complete calculation would take into account the timber cut for poles, ties, piling, and other uses, although for some of these uses longleaf, because more resinous, is doubtless more extensively used. It is believed that about 3,500,000,000 board feet is a fairly good estimate of the present total annual cut of shortleaf pine.

Certain regional facts throw a good deal of light upon the question. For example, the percentage of shortleaf cut has rapidly increased in some sections of the South through the extension of steam logging roads into the hilly country. Many mills throughout Arkansas and adjoining States which formerly cut a good deal of loblolly pine from the low, flat country are now drawing much of their timber supply from shortleaf growing in the uplands. In the same manner shortleaf in the southern Appalachians is becoming accessible. Further, the cut of second growth in old field stands has increased by leaps during the past five years. In the central Atlantic States a region of heavy lumber production lies over the coastal plain where loblolly pine occurs in heavy stands. Larger areas of shortleaf, however, occur in these same States, although the cut is perhaps lighter than that of loblolly. The yellow pine cut from a large geographical region covering both the Piedmont and the lower slopes of the Appalachians consists almost exclusively of shortleaf pine.

THE WOOD.

PHYSICAL CHARACTERISTICS.

The wood of shortleaf pine is straight fibered, uneven textured with alternate hard and soft concentric rings, resinous, and moderately heavy, hard, and rapid growing. The heartwood is light reddish or orange in color and is clearly defined from the nearly white sapwood.

The weight of oven-dry shortleaf averages about 34 pounds per cubic foot. Air-dry wood (15 per cent moisture) averages about 38

[1] The rate at which southern yellow pine was being cut in 1909.

pounds, but varies in accordance with the moisture content, which ranges from 12 to 18 per cent. Green shortleaf in the log averages 45.5 pounds per cubic foot, with a moisture content of 31 per cent for heart and 88 per cent for sapwood. The loss of weight in drying amounts to about 25 per cent for the heartwood and about 60 per cent for the sapwood. In passing from a green to an oven-dry condition the wood shrinks about 12 per cent in volume, about one-third of which occurs in passing from the green to the air-dry (15 per cent) condition. The density of absolutely dry wood is variable, its specific gravity being from 0.48 to about 0.56.[1] This difference in density seems largely due to the varying conditions of growth over its wide geographic range.

In resin content shortleaf ranks lower than longleaf pine and about the same as loblolly, although all are variable, and the amount of difference has not been definitely determined. When the sapwood of shortleaf is freshly cut limpid resin oozes out freely. Occasionally the heartwood and normally the bases of all large limbs become highly impregnated with resin and furnish "lightwood" and "pine knots," extensively used for firewood. In fuel value shortleaf averages about 12 per cent below longleaf, of which 1 cord is approximately equivalent to a ton of coal. This is largely due to the difference in the average density of the two woods. For woods of the same weight per cord of the two species it is believed there is little difference, if any, in heat producing power.[2]

The wood varies somewhat in hardness, and in some regions is moderately soft. In its southern range it averages about as hard as longleaf pine when there is the same proportion of summer wood in the annual rings. The wood grown in the more northern regions or at higher altitudes in the southern region seems to be softer.

The width of the rings is greatest in early life. Ten to twelve rings to the inch is an average rate of growth during the middle period, say from 60 to 140 years. Within the individual annual ring, the transition from the spring to the summer wood is normally quite abrupt, giving the annual ring the appearance of two sharply defined lines or bands. In young and rapid-growing trees and in those growing where the summers are short, the transition is commonly more gradual.

Since the fibers are straight and do not interlock, the wood is straight grained, easy to split and but slightly subject to warp and check in drying. The wood is easily worked, may be given a good finish, and takes paint and wood preservative well. The contrast

[1] Latter figure not definitely determined.
[2] Forest Products Laboratory, Madison, Wis.

between the hard and soft layers in each annual ring gives the wood a very pleasing figured effect.

Even under a high-power microscope the woods of the important southern pines appear strikingly similar though not identical in structure. With a view of bringing out the features helpful in distinguishing the wood of shortleaf pine from the other important southern pines, a brief summary of characteristics is given in Table 5.

TABLE 5.—*Average physical properties of the important southern pines.*

Species.	Width of sapwood.	Grain (comparative width and number of annual rings per inch).[1]	Resin content.	Weight per cubic foot.			Moisture content.			
				Green.	Air-dry (15 per cent moisture).	Oven-dry.	Green.		Air-dry.[2]	
							Heart.	Sap.	Heart.	Sap.
	Inches.			*Lbs.*	*Lbs.*	*Lbs.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Longleaf pine.	2 to 3	Narrowest (14 rings).	Very abundant.	52.5	43.5	39.0	34.0	95.5	15	15
Slash pine...	3 to 6	Wide.....	.....do.....	52.5	45.0	41.5	32.5	84.0	15	15
Shortleaf pine	3 to 4	Intermediate (11 rings).	Moderate.....	45.5	38.0	31.0	31.0	88.5	15	15
Loblolly pine.	3 to 6	Widest (7 rings).	.....do.....	54.0	39.0	36.0	36.0	82.0	15	15

[1] Variable in all species so that rapid-growing longleaf might be taken for any of the others. This order prevails in the average.

[2] Heart and sap will ultimately reach the same moisture content if thoroughly air dried under the same conditions.

DURABILITY AND PRESERVATIVE TREATMENT.

Shortleaf pine is only moderately durable in contact with the soil. The presence of a large amount of resin, as in "light wood," is commonly thought to increase materially the natural durability of the wood. Sapwood is much less durable than heartwood; it can not ordinarily be expected to last over two or three years, while good heartwood may last seven or eight years. When not in contact with the soil or under conditions particularly conducive to decay, the wood has given good satisfaction.

By proper preservative treatment the durability of short-leaf pine can be very materially increased. Wood preservation is discussed in a number of publications, among which are Forest Service Bulletins 78, 84, 107, 118, and Circular 209.

MECHANICAL PROPERTIES.

The wood of shortleaf pine is strong and stiff and therefore very valuable for structural timber. It often contains the same number of rings per inch and is very similar in wood structure to longleaf pine, which holds first place among the southern pines used for this

F-13191A

FIG. 1.—VIEW THROUGH THE TOPS OF THE TREES SHOWN BELOW.

F-13192A

FIG. 2.—LOWER PORTION OF TRUNKS. TREES 160 YEARS OLD, 20 TO 28 INCHES IN DIAMETER, AND ABOUT 110 FEET IN HEIGHT.

TWO VIEWS OF A GROUP OF MATURE SHORTLEAF PINE TREES, SHOWING THE NARROW CROWN AND STRAIGHT CLEAN BOLE TYPICAL OF THE SPECIES.

F-67319

GROSS CHARACTER OF SHORTLEAF PINE IN CROSS SECTION.

F-15050A

FIG. 1.—A 70-YEAR-OLD SHORTLEAF PINE STAND IN NEW JERSEY, WELL THINNED AND ALL THE THINNINGS FULLY UTILIZED.

F-14610A

FIG. 2.—WASTEFUL LOGGING OF SHORTLEAF PINE IN SOUTH CAROLINA BY LEAVING MUCH HIGH-GRADE MATERIAL IN STUMPS. STRONG MARKET DEMAND FOR EVERYTHING DOWN TO 2 INCHES FOR CORDWOOD.

F-13186A

FIG. 1.—SECOND-GROWTH LIMBY TOP LEFT ON ACCOUNT OF POOR GRADE OF TIMBER.

F-13185A

FIG. 2.—YIELD OF 18,000 BOARD FEET PER ACRE IN 60-YEAR-OLD SHORTLEAF FOREST STAND.

LOGGING SECOND-GROWTH SHORTLEAF PINE.

purpose. Other woods much used for structural timbers are Douglas fir, western hemlock, tamarack, Norway pine, loblolly pine, and western larch. Comparative tests of these in both a green and an air-seasoned condition, and for both structural sizes and small, clear, straight-grained pieces,[1] give shortleaf a relatively high place in all strength values, including bending, compression, and shearing. The values found in the various tests are shown in Table 6:

TABLE 6.—*Average strength values of shortleaf pine, air seasoned, and green structural timbers with ordinary defects, and small, clear specimens cut from them.*[1]

Condition and size.	Rings per inch.	Horizontal shear per sq. in.	Bending.			Compression parallel to grain.			Compression perpendicular to grain.	Shear.
			Fiber stress at elastic limit per sq. in.	Modulus of rupture per sq. in.	Modulus of elasticity per sq. in.	Crushing strength at elastic limit per sq. in.	Crushing strength at maximum load per sq. in.	Modulus of elasticity per sq. in.	Crushing strength at elastic limit per sq. in.	Shearing strength per sq. in.
Air seasoned structural sizes	12.4	*Pounds.* 364	*Pounds.* 4,675	*Pounds.* 6,573	*1,000 lbs.* 1,726	*Pounds.* 4,070	*Pounds.* 6,030	*1,000 lbs.* 1,961	*Pounds.* 796	*Pounds.* .....
Small specimens	.....	.....	7,780	12,120	1,792	.....	6,380	.....	926	1,135
Ratio	.....	.....	60	54	96	.....	95	.....	86	.....
Green structural sizes	12.1	332	3,237	5,548	1,473	2,460	3,435	1,548	351	.....
Small specimens	.....	.....	4,350	7,710	1,395	.....	3,570	.....	400	704
Ratio	.....	.....	74	72	106	.....	96	.....	88	.....

[1] Tables 1, 2, and 10 to 15, Forest Service Bulletin 108, "Tests of Structural Timbers."

Though true longleaf pine averages heavier, stronger, and tougher, many pieces of shortleaf have greater density, strength, and toughness than the average longleaf pine. Also some longleaf pine lacks density and is weaker than the average of the other species, the density or dry weight of the wood being a much better criterion of the strength than the species.

USES.[2]

The general uses of shortleaf pine are as varied as those of longleaf and the two go together without preference or prejudice for many purposes. For heavy building and structural work, however, where the architect desires timber to sustain pressure and withstand shocks, longleaf is usually preferred. Because of a high degree of strength and elasticity, the heavier classes of shortleaf[3] are being substituted for longleaf and are giving practically the same service. This recent

[1] Conducted by the Forest Products Laboratory, Madison, Wis.

[2] Based in part upon State cooperative wood manufacturing studies and Forest Service Bulletin 99, "Uses of the Commercial Woods of the United States: Pines," pages 17 to 20.

[3] Timber having the same density as longleaf.

change is due chiefly to the recognition of the relation between the strength and the density of the wood.

Shortleaf pine is one of the chief house-building materials throughout the eastern and middle western United States. It is used both for house frames and for finish, including ceiling, weather boarding, wainscoting, baseboards, cornice, carved work, railing, panels, sash and doors, window and door frames and casing. The grain is handsome and shows well in natural finish or when stained. Because of its wearing qualities, pleasing appearance, and ready response to oils, wax, and other floor finishes and dressings, a good deal of shortleaf is made into flooring. Many of the large lumber mills of the South, particularly Louisiana, Arkansas, and Texas, advertise shortleaf pine as a specialty for finishing lumber and are producing it in great quantities and in many forms.

Furniture manufacturers find shortleaf an admirable wood for frames for couches, lounges, tables, large chairs, stands, and desks. It is also used for veneer in box, crate, and basket manufacture, and for excelsior and slack cooperage,[1] in agricultural machinery and tools, wagon bottoms and cart beds, hoppers, drawers, boxes, chutes, and compartments in fanning mills, corn shellers, grain drills, and in numerous other labor-saving machines and devices. Large quantities are used in car construction for roofing and siding. Railroad companies buy a large amount, of which the heavier kinds are used, with longleaf, in bridge and trestle work, and the rest for track timber, piling and crossties, usually treated with wood preservatives. As a material for ship and boat building, shortleaf has held a prominent place during the past two centuries not only along the coast within a hundred miles or so of the supply, but in practically all boat building ports east of the Rocky Mountains. It is worked into nearly everything of wood that is required in modern boat building.

The southern pines seem particularly adapted for the manufacture at low cost of strong, brown wrapping, or "kraft" papers.[2] The wood fibers are long and thick walled, and the wood has high specific gravity, implying large yields of pulp per cord. Several species of pine are now used in large quantities for the making of various kinds of wrapping paper, including kraft, and also for the manufacture of white book paper. Small timber and woods and mill waste are used for this purpose. Through recent development

[1] The quantities of shortleaf made into veneer, crates, baskets, excelsior, cooperage, crossties, and piling are not known because the southern yellow pines so used are not listed separately.

[2] The importance of this class of paper is shown by the fact that wrapping paper stands third among the paper products of the United States, the amount and value being less than that of news and book papers only. In 1909 the production of wrapping papers of all kinds aggregated 764,000 short tons, with a value of $42,296,000. The value of wrapping paper imported in 1912 was $846,500.

in Europe, especially Sweden and Norway, of the sulphate process, the superior quality of paper made from resinous woods has brought attention to shortleaf, along with the other southern pines, as an important source of pulp in this country.[1]

With the use of either the sulphate or the soda process, the presence of knots, pitch pockets, and streaks, and remnants of decayed wood and bark is not very objectionable. Mill waste, consisting of slab edgings and trimmings, logs and tops left in the woods, and small logs which are now cut with little or no profit would supply a very large amount of raw material for pulp making. It costs more, however, to handle and prepare slabs and pieces of irregular shape than round pieces. Experiments[2] with longleaf pine have shown conclusively that it is well adapted for the manufacture of natural-color kraft pulps and papers, equal in quality to the imported and domestic kraft papers now on the market. Because of the close similarity of the wood of shortleaf to that of longleaf, it seems quite probable that further experiments will show a like suitability of shortleaf for this class of papers, except perhaps that it may produce less pulp per cord because of the difference in specific gravity of the two pines.

LUMBER INDUSTRY.

LOGGING AND MILLING.

The methods of logging and milling naturally show wide variations over a territory so extensive and representing so many different market conditions. Logging is still done by oxen to a considerable extent in the rougher lands of the southern Appalachians. Here the spring and fall months are usually chosen for operations. Steam skidders are not so much in use in logging shortleaf as in logging longleaf and loblolly pines, which belong to the lower level country. Teams do the majority of the hauling to the temporary logging spurs.

The small mill with a planer, located near some town center and producing timber for building and general construction for the neighborhood, and the portable mill are the most typical forms of manufacture in the great region of second growth in the eastern United States. Such mills usually have a daily capacity of 5 to 10 thousand feet. In the virgin pine country the mills more often represent a good-sized fixed investment and operating capital. The equipment includes logging railroads and buildings, machinery,

[1] Based upon Bulletin 72, U. S. Department of Agriculture, "Suitability of Longleaf Pine for Paper Pulp."

[2] Conducted by Forest Products Laboratory, Madison, Wis.

teams, and other logging appliances. With the retreat of the source of timber farther back into the hills many roads which at the start were purely railroad logging trams have been improved and organized as common carriers. Many mills in the Central South are hauling logs from 50 to 80 miles over their own rails, and some over 100 miles. As a rule the cost of handling prevents the separation of the rough milling from the finishing operations, and practically all of the mills in the Mississippi region manufacture large amounts of the standard forms of finished products. The larger mills commonly have two band saws, and the largest ones employ gang saws in addition. The capacities are mostly from 100 to 150 thousand feet in an ordinary working day, while the largest mills can turn out about 300 thousand feet a day.

COST.

The straight stem, the small crown, the clear and straight-grained character of the wood, and the gregarious habit of the tree make the cost of lumbering shortleaf pine relatively low. Large yields per acre afford opportunity for economy in method and equipment. On the other hand, the occurrence of shortleaf over rolling or hilly lands would tend to increase logging costs and the home of longleaf and loblolly over the low coastal plain affords easier logging and shorter hauls to seagoing transportation for the finished product.

The cost of manufacture in three representative regions—New Jersey, South Carolina, and Arkansas—is given below. A lumbering operation on private land within the Lebanon State Reserve, Burlington County, N. J., costs about 70 cents for cutting, $3.50 for hauling logs 3 miles to the mill, and $4 for milling. With the addition of 60 cents for depreciation the total cost was $8.80 per thousand feet of rough lumber. The timber was mostly 70 to 110 years old.

In the uplands of South Carolina logging and sawing rough pine lumber by portable mills in small tracts often cost not more than from $5 to $7 per thousand feet. The mills are small and most of the output is roughly manufactured.

In the virgin shortleaf forest region from Alabama to Texas—for the past 10 or 15 years the greatest yellow-pine lumbering region of the United States—lumbering is on a comparatively permanent basis. In general, the cost of logging may be placed at from $4 to $7 per thousand feet and milling at $6 to $8, under average conditions and good management in the upland shortleaf regions. In this connection the itemized manufacturing costs of 30 mills cutting shortleaf timber in central and western Arkansas, shown in Table 7, will be interesting. The average cost of logging was $5.47 and milling $7.22, or a total cost of the finished timber aboard the car of

$12.69. The labor is more largely negro than white, logging is in hilly country, with contract team hauling, and usually railroad logging spurs built up the larger depressions or drainage tributaries with rail hauls of 10 to 40 miles.

TABLE 7.—*Average cost of manufacture of shortleaf pine by 30 mills.*[1]

Operation.	Range of costs per M board feet.	Average cost per M board feet.
Logging:	*Dollars.*	*Dollars.*
Cutting	0.28 to 1.00	0.63
Hauling with teams	1.00 to 4.56	2.24
Loading on cars	.17 to 1.50	.48
Railroad haul	1.00 to 5.49	1.94
Overhead charge	.08 to .25	.18
Total		5.47
Milling:		
Sawmill	1.10 to 3.00	1.74
Kiln	.11 to 1.50	.73
Planer	.64 to 3.00	1.46
Hauling with teams	.55 to 3.00	1.42
Loading on cars	.20 to .75	.40
Overhead charge	.35 to 3.82	1.47
Total		7.22
Total logging and milling		12.69

[1] Logging mostly in hilly country and milling by both large and small permanent mills in central and western Arkansas in 1912.

On the National Forests of Arkansas, portable mills with daily capacities of 10 to 20 thousand board feet saw the bulk of the timber. These mills cut about 2 million feet to each set, and thus greatly reduce the high cost of the log haul in rough country. Generally each company has its own planers at the most convenient railroad point, to which the rough lumber is hauled for distances of from 6 to 15 miles. In some sections smaller mills cutting 5 to 7 thousand feet daily are the prevailing type. The capital represented by these mills averages from $5,000 to $8,000 each. The ownership of the land is composite and the government timber is more or less cut up with small private holdings in various stages of development. The logging and milling costs do not vary widely and the present lumber prices are such as to allow net returns of 16 to 22 per cent on the full interest-bearing investment. A careful study of five companies operating on the Arkansas National Forest[1] shows an average total cost, exclusive of stumpage, of $11.07 f. o. b. cars for finished lumber. The costs shown in Table 8 are for one of the representative mills working where the timber is scattered in the hilly portions of western Arkansas. The cost of operation, $10.70 per thousand feet, was next to the lowest for five companies in a region where the highest cost was

[1] Reports by Messrs. Dorr Skeels and Quincy Randles, of the Forest Service, spring of 1913.

about $11.50. The figures indicate the various factors considered in logging and manufacture and the cost of operations in cutting 16 million feet of shortleaf pine during a period of 4 years with 10 settings of a mill having a daily capacity of 20 thousand feet. The timber runs 2 to 3 logs per tree and 8 to 10 logs per thousand, and occurs mostly either in small groups or widely scattered over an area of 18,000 acres divided by a range of low mountains into two natural logging units. The lumber haul to the railroad is from 5 to 11 miles.

TABLE 8.—*Itemized cost of manufacturing shortleaf pine on the Arkansas National Forest.*

	Cost per thousand board feet.	
Cost of rough lumber on kilns at sawmill (distributed below)		$5.47
Investment, depreciation, interest, and labor on logging and sawmill:		
Two sawmills fully equipped and set up, $6,000 at 7 per cent depreciation	$0.10	
Sixteen logging teams, wagons, harness, and chains, $8,000 at 17 per cent depreciation	.30	
Moving sawmill, 10 sets at $300, and 100 miles logging roads at $30 per mile, average yearly investment of $1,500	.38	
Total investment of $15,500: interest at 6 per cent on $13,070[1]	.19	
Felling, bucking, and brush disposal	1.00	
Labor, team maintenance, bucking, loading, log haul 1½ miles	2.00	
Labor, sawing, and smoke-kiln drying	1.50	
Lumber haul, 8 miles partly over rough roads, 3 trips in 2 days		3.13
Planer (distributed as follows: chargeable against 60,000,000 feet annual cut)		1.47
Investment—		
Planer, $10,000; real estate, $3,000; lumber in yards, $4,500; lumber at mills, $1,500; accounts receivable, $6,000; total, $25,000. Interest on $25,000 at 6 per cent, depreciation on $10,000 (value planer) at 7 per cent	.37	
Labor—		
20 men per day (5 counted as lay-off time) at $1.75	1.10	
General overhead charges: Taxes, $600; insurance, $750; superintendence, $1,200; bookkeeper, $900; supplies and repairs, $600; and general office expenses, $200; total, $4,250	.63	
		10.70

The average cost of manufacture, exclusive of stumpage, was $11.07 for five large portable mills averaging 3.5 million feet annually and representing an interest-bearing capital of $33,300 each. This cost of operation plus stumpage averaging $2.59 gives the total

[1] Fifteen thousand five hundred dollars minus one-half the investment retired in 3 years, or $2,430, equals $13,070. Mill cutting 4,000,000 feet per year.

cost of finished lumber as $13.66. At current selling prices (April, May, 1913) of $15.75, this yielded a net profit of $2.09 per thousand feet, or total annual net earnings of $7,315. This represents clear profits of 21 to 24 per cent, or an average of 22 per cent, for the five companies.

WASTE.

The degree of utilization in the logging, manufacture, and general use of shortleaf pine varies widely. On the whole, the utilization is comparatively close throughout its range. In the uplands of the coastal Atlantic and Gulf States practically all of the product finds a ready market. The poorer class of timber is used locally, and the day of clearing off lands by destructive fires ceased in this region long ago. Almost paradoxical, however, is the waste in one particular feature of logging in some of the more progressive regions. As an illustration, in Pickens County, in the upper Piedmont of South Carolina, stumps of mature shortleaf pine were cut from 20 to 34 inches in height (March, 1913), where everything of the smaller sizes down to 2 inches in diameter was being corded and shipped by rail for fuel. Thus, clear and high-priced timber was being left where there was a paying market demand for even the small topwood. The cause for this condition was given by the operator as the impossibility of changing the old-time habits of the negro labor of cutting high stumps. Two stumps, 28 and 30 inches high, shown in Plate III scaled a total of 38 board feet (Doyle log rule) above a stump height of 12 inches, and were worth $0.19 at a stumpage rate of $5 per thousand feet.[1] Measurements on an average acre gave 30 stumps containing an average of 9 board feet each above a maximum stump height of 12 inches, or a value of $1.35 per acre. This represents practically a clear loss due to careless logging of not less than $270 on the tract of 200 acres.

In contrast, the operators of the Mississippi Valley region are cutting to a maximum stump height of 12 inches, and small trees up to 15 inches in diameter are taken mostly at 8 to 10 inches. On the other hand, in very many cases they do not take the log or logs in the crown above about the second limb. Top diameters of 12 to 16 inches were common in representative mature cuttings in Pike County, Ark., in the fall of 1912. In a well-stocked stand, 150 years old, 380 logs were taken and 100 logs left per acre in the tops because of the lower grade of timber. The top logs taken ranged from 16 down to 9 inches and averaged 11.6 inches in diameter at the small end. The diameters of the top logs left in the woods averaged 9.8 inches and ranged from 13 down to 8 inches. The number of logs taken and left per acre, and

[1] A conservative price for clear material in butt logs.

their volume and value at assigned stump prices in logging well-stocked stands of various ages, are shown in Table 9.

TABLE 9.—*Utilization and waste in logging well-stocked forest stands of shortleaf pine in Arkansas.*[1]

Age.	Logs taken.								Logs left.							
	Logs per acre.	Diameter inside bark of top log.			Scribner.		Doyle.		Logs per acre.	Diameter inside bark of top log.			Scribner.		Doyle.	
		Maximum.	Average.	Minimum.	Contents.[2]	Value at $3 per M.	Contents.[2]	Value at $3 per M.		Maximum.	Average.	Minimum.	Contents.[3]	Value at $1.50 per M.	Contents.[3]	Value at $1.50 per M.
Yrs.		*In.*	*In.*	*In.*	*Bd.ft.*	*Dolls.*	*Bd.ft.*	*Dolls.*		*In.*	*In.*	*In.*	*Bd.ft.*	*Dolls.*	*Bd.ft.*	*Dolls.*
65	160	15	9.3	6	7,845	23.54	5,815	17.44	45	10	8.0	7	760	1.14	441	0.66
75	270	11	9.1	7	14,580	43.74	10,856	32.57	75	9	7.8	7	1,160	1.74	637	.96
150	388	16	11.6	9	48,150	144.45	40,290	120.87	100	13	9.8	8	2,640	3.96	1,912	2.87
160	470	15	11.1	8	53,010	159.03	45,090	135.27	70	10	8.7	8	1,840	2.76	1,208	1.81
170	229	16	11.3	7	23,619	70.36	20,133	60.40	63	12	8.6	7	1,680	2.52	1,107	1.66
180	220	21	15.0	8	39,780	119.34	35,906	107.72	84	15	9.7	8	4,096	6.14	3,197	4.80

[1] Measurements taken in November, 1912, on seven plots representing six different age classes.
[2] Ten per cent deducted for defects in logs taken.
[3] Twenty per cent deducted for defects in logs left.

Under the best conditions of market the utilization of top logs runs higher than is shown in Table 9. Where there are log hauls of 50 to 90 miles over railroads, now necessary for many of the larger mills, there is small profit in manufacturing the lower grades. In the flat, easily logged regions, straight and clear boles are taken for saw timber down to as low as 5 inches, and sometimes less. In much private lumbering practically everything straight and clear is taken. As a northern Louisiana operator said, "we take everything that will make two slabs and sawdust." This policy, which removes the chief basis for a second cut, is being pursued for the alleged reason that fire gets what the lumberman leaves. There is a wide difference of opinion in regard to the subsequent damage and loss by fire. Mr. L. J. Witherspoon, Womble, Ark., found by counts that in five years heavily cut tracts lost by all the combined destructive agencies only from 5 to 15 per cent of the trees above 3 inches in diameter.

Inspection and grading that would include as merchantable lumber short lengths down to 4 feet and provide for odd lengths throughout up to 24 feet would result in a very large reduction of present milling waste. Short lengths of the clearest lumber in the tree in the form of slabs now go to making steam because of the present limitations; for the same reason many logs are now left in the tops. In most cases this is the result of haste and a desire to secure quantity rather than quality through careful grading. Better utilization would mean also remodeling plants and adding machinery for remanufacturing the product. The utilization of waste wood by

chemical methods is making rapid progress, particularly in the resinous woods. Stumps and knots of shortleaf often become highly impregnated with resin, though in general its low resin content makes it less valuable than longleaf for use in resinous-wood distillation.

GRADES.

The tall, clean bole of shortleaf pine and relatively low susceptibility to injurious fungi, permit a high percentage of the upper grades of lumber. In the region of heavy production of virgin pine the rough lumber from the saw is commonly thrown into the five grades of clear, and Nos. 1, 2, 3, and 4 common. The lowest qualities come from the small portable sawmills in the farming districts, where the cut is mostly from second growth or culled land. The great bulk of the cut of shortleaf in Mississippi, Alabama, and Georgia as well as Arkansas and Louisiana is probably well represented by the third distribution given in the following table:

TABLE 10.—*Average mill cut by grades of shortleaf pine west of Mississippi River.*[1]

[Percentage of total cut.]

Locality.	Grades of rough lumber.				
	Clear stock "B and better."	No. 1 common.	No. 2 common.	Nos. 3 and 4 common.	Total.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Best timber in most favorable region (Clark County, Ark.)	36.9	45.9	11.0	6.2	100
Good timber along Iron Mountain R. R. (Arkansas).	35	40	19	6	100
Good timber in hilly shortleaf region. Average for 7½ months, March 1 to October 15, 1912 (Pike County, Ark.)	32	39.9	17.3	10.8	100
Small portable mills in farming districts (western Arkansas)	20	48	29	3	100

[1] Based upon information furnished by lumber companies in the region covered.

In general shortleaf cuts from 30 to 35 per cent of clear stock ("B and better"), 40 to 50 per cent of No. 1 common, 15 to 30 per cent of No. 2 common, and 5 to 10 per cent of the two lower grades of common lumber. On account of defects which develop later somewhat less is actually marketed.

In cutting the second-growth stands in the Piedmont region, little attention is given to grading by the small operators. Larger operators, however, find it profitable to grade the stock from the saw. Often two grades, sap and heart pine, are roughly made by the small mills with an assigned difference of $5 to $6 per thousand feet in price.

In the Mississippi Valley the product is graded by the rules of the Southern Pine Association, whose specifications refer closely

to defects, without qualifications in regard to heart. The rules of the North Carolina Pine Association and the Georgia-Florida Sawmill Association govern the bulk of the eastern business. The chief shortleaf pine products of the larger mills and the various grades of each are: Dressed finishing, 3 grades and specials; flooring, 12 grades; ceiling, 4 grades; wagon bottoms, 2 grades; drop siding and bevel siding, 4 grades; partitions, 4 grades; molded casing and base, window and door jambs, 3 grades each; common boards, ship lap, and barn siding, 4 grades; grooved roofing, nearly same as No. 1 of preceding; fencing, 4 grades; dimension and heavy joist, 3 grades; No. 1 common timbers; lath, common and patent; and pickets.

MARKET.

Much confusion exists in the eastern markets regarding the names under which southern pines are sold. Those in use represent essentially, in different degrees, the qualities of weight, strength, and grain or width of annual rings. In general, the names "longleaf" and "shortleaf" are used to designate the harder and softer qualities of southern pine lumber, and this is broadly justified by differences in the species. Longleaf averages the heaviest and closest grain. Shortleaf is clear lumber of high quality and an intermediate number of rings per inch and loblolly has very wide annual rings and thick sapwood. Lumber sold as longleaf often contains more or less of the heavier kinds of shortleaf. Rapid growing longleaf and shortleaf both have wide annual rings and thus might be classed as loblolly. There is no complete separation in the lumber market.

A large amount of the shortleaf lumber produced—estimated by some at as high at one-half—is sold by the manufacturers direct to large consumers, such as railroads, manufacturers of railroad equipment, and those engaged in the construction of buildings and other structures requiring material in large quantities. The remainder of the output is mostly sold direct to wholesalers, brokers, and retailers. Many of the large manufacturers are also retailers, either directly or indirectly, through subsidiary companies. A very large amount of the shortleaf lumber goes into further manufacture and finds its market in the wood-using industries of the various States.

The market for shortleaf pine includes practically all of the United States east of the Rocky Mountains. Within this region, the districts of lightest use are the upper Lake States and New England. In the former region white and red pine and in the latter region loblolly pine, shipped by cargo from the Atlantic coastal plain, are used in large amounts. According to the wood-using industry reports,[1] little shortleaf reaches Massachusetts; Maine uses

[1] This and the following statements are based upon various wood-using industries bulletins published by the individual States in cooperation with the Forest Service.

more than 10,000,000 feet annually of longleaf and loblolly, but practically no shortleaf; in Iowa, shortleaf is second only to white pine in total quantity used; in Illinois in 1912 it stood second in car manufacture, first for sash, door, and blind, and also box manufacture, and entered into the leading classes of wood products. The most intensive market area lies from New York through the northeastern, central, and southern prairie States. The best available estimate of the quantity of shortleaf further manufactured by the wood-using industries of the United States annually during the period of 1910 to 1912 is, in round figures, 3,500,000,000 board feet (Table 11), valued at about $52,740,745 f. o. b. factory. Of this amount about 2,500,000,000 feet were converted into planing-mill products, and the balance largely used for sash, doors, blinds, and general millwork, boxes and crates, car construction, agricultural implements, vehicles and parts, fixtures, furniture, and shipbuilding.

TABLE 11.—*Quantity and value of shortleaf pine used annually by the wood-manufacturing industries of the United States.*[1]

Industry.	Quantity used.	Average value per M feet.	Total value.	Industry.	Quantity used.	Average value per M feet.	Total value.
Planing-mill products and general millwork	*Board feet.* 2,501,189,960	*Dolls.* [2]12.26	*Dolls.* 30,653,669	Fixtures	*Board feet.* 9,864,765	*Dolls.* 30.34	*Dolls.* 299,298
Sash, doors, and blinds	327,830,625	23.30	7,639,295	Furniture	7,651,800	18.38	140,645
Boxes and crates	349,094,714	15.52	5,419,004	Shipbuilding	5,173,762	23.88	123,531
Car construction	212,913,493	25.02	5,327,034	Miscellaneous [3]	79,401,264	23.05	1,830,498
Agricultural implements	37,132,070	26.84	996,653	Total	3,544,751,908	14.88	52,740,745
Vehicles and parts	14,499,455	21.46	311,208	Total exclusive of planing-mill products	1,043,561,948	21.17	22,087,076

[1] This is a tenative table, compiled from the various State wood-using industry reports, published by the State organizations and lumber-trade journals, in cooperation with the Forest Service. Figures are for the period 1910 to 1912, or an average about 1911. Although reported as true shortleaf, it seems likely that the amounts are somewhat high because of the tendency to include some other material than shortleaf under this head.

[2] Very low average due to extensive planing-mill industry of producers in Arkansas, Louisiana, Alabama, North Carolina, Mississippi, and Texas, where supplies are secured without cost for transportation.

[3] Includes chiefly sporting and athletic goods, machine construction, caskets and coffins, wooden ware and novelties, printing material, kitchen cabinets, refrigerators, elevators, frames and molding, tanks, and silos.

LUMBER PRICES.

The average mill-run price of shortleaf pine lumber does not differ much from that of the other southern yellow pines. In the Gulf States it holds closely to that of longleaf and in the central Atlantic States to loblolly. The factors which govern this more than anything else are location, cost of transportation to the larger markets, and average size of mill output. For example, in 1912 the average mill-run of "North Carolina pine" was $14.22, while yellow pine in Arkansas was $14.78. Mississippi, where the percentage of longleaf in the cut is as high as anywhere, showed an average mill-run

value of $14.80, or only 2 cents higher than Arkansas, where no longleaf occurs. Below is shown the average wholesale mill-run value at the mill for southern yellow pine lumber from 1899 to 1914, inclusive.[1] Shortleaf was a heavy contributor and its fluctuations have doubtless been quite similar.

1914	$14.19	1911	$13.87	1908	$12.66	1904	$9.96
1913	15.76	1910	13.29	1907	14.02	1899	8.46
1912	14.36	1909	12.69	1906	15.02		

From 1908 to 1913 a gradual advance in price occurred in common with nearly all coniferous woods. From an average value in 1901 of approximately $9 the price rose to $13.87 in 1911, an increase of 54 per cent in 10 years. The advance in price was strongly upward to the year 1906, when the values reached a high point. Between 1908 and 1913 the advance in price was steady but more gradual, with rather marked variation during 1914 and 1915.

TABLE 12.—*Cost of longleaf, shortleaf, and loblolly lumber used by the wood-manufacturing industries of 16 States.*[1]

Group and State.	Average cost per M board feet f. o. b. factory.			Group and State.	Average cost per M board feet f. o. b. factory.		
	Longleaf.	Shortleaf.	Loblolly.		Longleaf.	Shortleaf.	Loblolly.
Northeastern States:	*Dollars.*	*Dollars.*	*Dollars.*	Southern States:	*Dollars.*	*Dollars.*	*Dollars.*
Connecticut	36.10	23.32	27.00	Florida	11.66	11.60	11.77
Delaware	31.46	18.08	15.56	Georgia	13.30	13.03	10.03
Maine	35.12	31.00	29.71	Mississippi	11.66	11.66	11.24
New Hampshire	33.70	28.86	29.99	Texas	12.71	12.64	11.51
New York	31.49	27.34	20.77	Average for Northeastern States	33.30	27.52	25.21
Vermont	31.91	36.50	28.21	Average for Central States	24.79	22.05	21.49
Central States:				Average for Southern States	12.33	12.23	11.14
Iowa	28.04	29.05	27.45				
Illinois	28.69	26.07	27.72				
Ohio	26.26	25.75	18.32				
Tennessee	20.23	16.18	.....	Average for all States represented	23.47	20.60	19.28
Virginia	20.26	13.26	12.77				
West Virginia	25.26	21.99	21.20				

[1] Compiled from various State wood-manufacturing industry reports in cooperation with the Forest Service. Figures must be considered as approximate since there is no accurate separation of the species in the market.

The lowest average price of pine used by the wood manufacturing industries shown in Table 12, occurs in the large lumber-producing Southern States, where most of the big sawmills manufacture planing-mill products, obtaining their supplies without transportation charges; also a number of these industries use logs, wholly or partly, and reported cost on these instead of on lumber. An increasing

[1] Prices for 1913 are based upon average prices during the last three-quarters of the year from large representative mills in the States of Georgia, Florida, Alabama, Mississippi, Louisiana, Arkansas, and Texas. The 1914 figures are based upon reports of similar representative large mills in 10 States from Virginia to Texas for the complete year. The earlier prices represent reports submitted by miscellaneous operators, both large and small. A question whether these prices are legitimately comparable with the 1913 and 1914 figures may properly be raised.

price will be noted for States more distant from the region of production. The figures thus represent only roughly the average cost of lumber of the various species in the different States and regions shown.

STUMPAGE VALUE.

The value of shortleaf pine stumpage is in general a little below that of longleaf in the Gulf States and above loblolly in the Central Atlantic States. The slightly higher market value of longleaf pine lumber and the distribution of shortleaf pine over the more hilly lands have a tendency to make the stumpage value for shortleaf slightly lower than for longleaf pine. The closer proximity, however, of shortleaf to the markets of the Central and Middle Western States gives it an advantage.

The purchase of "timber rights" in the North Carolina pine region by one company from 1896 to 1908, shown in figure 2, illustrates the

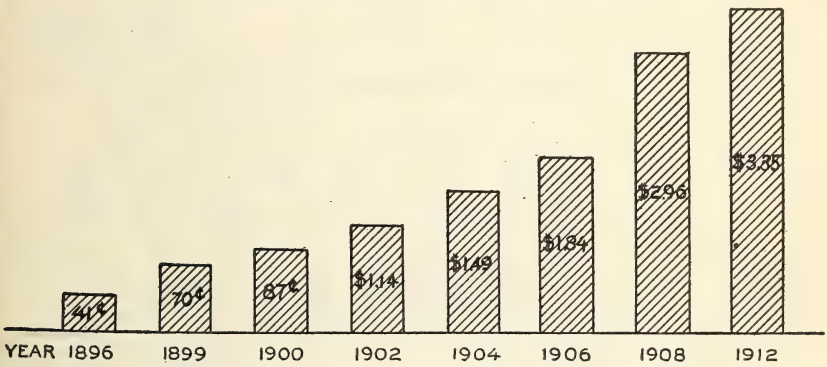

FIG. 2.—Cost of yellow-pine stumpage to one company in North Carolina, from 1896 to 1908 ("The Lumber Industry," Bureau of Corporations, p. 23), and estimate for 1912 (based on average price for North Carolina in 1912, plus increase of price in 1909 over average value for State).

general upward movement of yellow pine stumpage in the eastern market.[1]

In the central Mississippi Valley region the stumpage values are not essentially different from those in North Carolina. In Arkansas stumpage for virgin timber was worth, in round figures, 40 cents in 1890, $1 in 1900, $2.50 in 1907, at the crest of the year's prices, and in 1913 was reported at $3 to $4. Second growth in abandoned fields reaches diameters of 10 to 14 inches in fifty years, with yields of 10 to 20 thousand feet. Such tracts, if located near good local markets with railroad facilities, have stumpage values ranging from 50 cents up to about $1.50, but otherwise values are small, ranging down to a few cents, mostly a potential or holding value.

[1] Prices for 1896 from "The Lumber Industry, Part I," Bureau of Corporations, p. 23.

The demand for standing shortleaf pine timbers in Arkansas is indicated well by the prices offered for Government timber on the Arkansas National Forest. The timber is located mostly in the rougher and more inaccessible portions of the State, and is cut up somewhat by small private holdings. Timber sales in 1914 under competitive bids in this rough region were made at prices ranging from about $2.25 up to $3 per thousand feet.

The stumpage values for shortleaf pine were collected by the Forest Service for the year 1912 from the various States in the form both of reports of sales actually made and estimates of buyers and others qualified to know market prices. The average values reported by lumber companies in 1912 and in 1907 for various States are shown in Table 13.

TABLE 13.—*Stumpage value of southern yellow pine in 1912, with comparison of average values in 1907.*[1]

Group and State.	1912. Average value. Based on estimates.	1912. Average value. Based on sales.	1912. Range of values. Based on estimates.	1912. Range of values. Based on sales.	1912. Basis: Number of reports. Estimates.	1912. Basis: Number of reports. Sales.	Average value in 1907. Average value.	Average value in 1907. Basis: Number of reports.	Rate of increase in 5-year period. Estimates.	Rate of increase in 5-year period. Sales.
Northern Atlantic:									*P. ct.*	*P. ct.*
Delaware	$5.19	$4.50	$4.00- 6.50	$4.00- 5.00	8	2				
Maryland	5.43	5.11	2.00- 8.00	3.00- 7.50	26	9	$4.33	10		
New Jersey	4.25	3.00	3.00- 5.00	3.00- 3.00	4	1	4.20	5		
Pennsylvania	6.12	5.50	3.00-12.00	3.50-10.00	52	16	5.30	37		
Average for group	5.25	4.53					4.61		13.9	— 1.7
Western Appalachian:										
Kentucky	3.36	4.00	1.00- 8.00	4.00- 4.00	21	2	2.36	12		
Tennessee	3.22	3.50	1.50- 5.00	2.00- 5.00	48	24	2.60	15		
West Virginia	3.25	4.00	2.00- 4.00	4.00- 4.00	6	2	3.32	14		
Average for group	3.28	3.83					2.76		18.8	38.8
Southern Atlantic:										
Georgia	2.79	2.68	1.50- 5.00	1.50- 5.00	90	38	2.51	43		
North Carolina	3.07	3.07	1.50- 6.00	1.50- 7.00	167	79	2.73	49		
South Carolina	2.97	2.99	1.00- 6.00	1.75- 5.00	71	29	2.45	25		
Virginia	3.70	3.35	1.00- 6.00	2.00- 5.50	37	17	2.99	60		
Average for group	3.13	3.02					2.67		17.2	13.1
Gulf:										
Alabama	2.39	2.32	1.00- 5.00	1.00- 5.00	122	56	2.29	45		
Arkansas	2.57	2.54	1.25- 5.00	1.50- 5.00	69	40	2.45	65		
Florida	2.96	3.01	1.50- 6.00	1.75- 6.00	80	53	2.91	40		
Louisiana	3.86	3.64	1.50- 7.00	1.50- 6.00	57	34	3.20	32		
Mississippi	3.44	3.59	1.00- 6.50	1.00- 6.50	60	38	2.78	41		
Texas	2.98	3.10	1.00- 5.00	1.00- 5.50	65	43	2.22	35		
Average for group	3.03	3.03					2.64		14.8	14.8
Oklahoma	1.84	1.80	1.00- 4.00	1.00- 3.00	11	5	1.13	4		
Missouri	2.30	2.50	1.00- 6.00	1.50- 6.00	35	14	2.54	13		
Average for Oklahoma and Missouri	2.07	2.15					1.84		12.5	16.8

[1] Figures for 1912 based upon reports of estimates and sales received from lumber companies; the 1907 values are based upon estimates.

In Missouri, Kentucky, West Virginia, and Pennsylvania, neither longleaf nor loblolly pines are known to occur, while in three others—New Jersey, Tennessee, and Oklahoma—loblolly is present only in very small areas. In all except New Jersey and Pennsylvania, shortleaf is the principal yellow pine and dominates the market.

The stumpage value of yellow pine can best be studied by natural groups of States, i. e., those having generally similar density and areas of stands. Thus New Jersey, Pennsylvania, Delaware, and Maryland led with an average stumpage of $5.25 in 1912, as compared with $4.61 in 1907. (Table 13.) West Virginia, Tennessee, and Kentucky came next in order with values of $3.28 and $2.76 for the same years. The group comprising Virginia, North Carolina, South Carolina, and Georgia averaged $3.13 and $2.67, respectively. The States of Alabama, Florida, Mississippi, Louisiana, Arkansas, and Texas, the principal producers of virgin yellow pine, averaged $3.03 for 1912 and $2.64 for 1907. The low figures of $2.07 and $1.84 for Missouri and Oklahoma are probably due to the low yield and quality of pine in Missouri and special features of timber ownership in Oklahoma. The higher stumpage value in the North Atlantic States is undoubtedly due to the strong local demand near large centers of population. Stumpage values are highest in the North and decrease with striking regularity all the way to the southern and western extremity of the yellow-pine belt. The highest rate of increase in value during the period of five years ending in 1912 occurred in the middle of the zone of distribution.

The yellow-pine timberlands of the South constitute one of the two chief timber supply regions of the United States. With an increasing population and diminishing timber supply, the speculative holding of timberlands has become general, and, except for the periodic declines of a temporary character, the general movement of stumpage values of shortleaf in common with the other southern pines is likely to continue in an upward direction.

The practice of cutting and burning timber in clearing lands is still prevalent in some of the southern and Mississippi Valley States. In some of the more remote sections tracts of 20 to 50 acres of pure stands containing from 5 to 25 thousand board feet per acre of second-growth pine are not infrequently cut without thought or comment. The larger trees are usually girdled and the smaller ones cut and burned. Thus are destroyed many stands, the accumulated timber growth of several decades, which would, if left for relatively few years, bring good stumpage prices.

ESSENTIALS OF FOREST MANAGEMENT.

Forest management aims to make the forest continuously productive of the largest quantity and at the same time the most useful or valuable quality of timber. It deals essentially with second growth, including in the South the so-called "old field" stands. The increasing scarcity of virgin timber is daily developing new uses for second growth, and stands formerly considered of no value are now becoming commercial assets. Owners will find it more and more profitable, therefore, to employ intensive methods of handling timberlands.

Under forest management, it is necessary first of all to protect the growing tree crop against fire and other harmful agencies. The age at which the stand should be cut, or the period of rotation, must be determined in advance upon the basis of the size and kind of wood desired. The tree density, or amount of growing stock on the ground, strongly influences the growth and should be regulated by thinning or artificial restocking. Cutting so as to secure complete natural reproduction is of great importance.

PROTECTION.

FIRE.

Owners of southern pine lands now realize that enormous loss and injury result every year from forest fires. They will be interested therefore in methods of preventing fires as far as is possible and of controlling at an early stage those which are started. To be sure, shortleaf pine regenerates vigorously by sprouts during early life when subject to greatest fire injury. The injury caused to older trees, however, by even a surface fire is very often recorded in the entrance of destructive fungi, or "punks," through the fire scars, and retarded growth, due to the removal of the protective layer of leaf litter ("pine straw") and soil enriching humus. The loss of trees by repeated fires during a period of 30 or 40 years and consequent reduction in the yield is surprisingly large. The person starting a fire which spreads to his neighbor's forest is rightfully held responsible for the destruction of property. The best protection lies in the hearty cooperation of all landowners and communities in the enforcement of efficient State fire laws. When rightly planned and constructed, fire lines are very helpful in protecting growing timber, and are proving effective in the yellow pine on the National Forests of Florida and Arkansas. A double furrow stops slowly burning surface fires and is a good base from which to fight others. Fire lines are best constructed by opening one or more furrows on each side of a strip 4 to 8 yards wide and, in favorable weather burning over the intervening ground.

F-13222A

FIG. 1.—ENCROACHMENT OF SHORTLEAF ON SUCCESSIVELY ABANDONED PORTIONS OF COTTON FIELD. STANDS OF SIX DIFFERENT AGES.

F-20687A

FIG. 2.—VERY DENSE STAND OF 9-YEAR-OLD SEEDLINGS, 42,000 TREES PER ACRE. NOTE CLOSE RELATION BETWEEN DENSITY AND DEVELOPMENT.

SHORTLEAF ENCROACHING UPON FIELDS UNDER CULTIVATION.

F-91746

EFFECT OF TREE DENSITY IN 33-YEAR-OLD SHORTLEAF PINE STANDS UPON GROWTH.

On the left, average tree 9 inches, 550 trees per acre; on the right, tree 10 inches in diameter, 370 trees per acre; less yield but better quality.

INSECTS.

The southern pine beetle[1] (*Dendroctonus frontalis* Zimm.) has been the subject of exhaustive study by Dr. A. D. Hopkins, in West Virginia between 1891 and 1901 and in the Southern States from 1902 to the present time. According to these investigations this insect has caused the death of millions of shortleaf and loblolly trees and some longleaf. The loss during the past 20 years due to this insect has been estimated at between 10 and 20 million dollars. From 1890 to 1893 a serious invasion occurred in Virginia and West Virginia. In the season of 1910 the trouble occurred in many places in the Southern States, leading to a special study and demonstration of methods of control by the Bureau of Entomology and the publication of Farmers' Bulletin 476, from which the recommendations for controlling the insect pest are quoted below because of their value and importance to owners of shortleaf stands. It is important, however, that all of Farmers' Bulletin 476 be consulted in case of extensive or serious infestation.

Evidences of infestation.—(1) If in clumps or patches of pine, where there is no plain evidence of serious injury by fire, the foliage fades to pale green and changes to yellowish and pale brown, it indicates that the trees are dying from the attack of the southern pine beetle, and that the bark of such trees is infested with the developing broods of minute white grubs and transforming beetles; therefore such infested trees are a *menace to the living trees.*

(2) If the trees have reddish brown and partially fallen foliage, or if all of the foliage has fallen, it indicates that the broods of beetles have emerged and that such trees are no longer a menace to the living ones.

(3) If the trees die during the period between the 1st of March and the 1st of October they will be abandoned by the broods of beetles within a few weeks after the foliage begins to fade.

(4) If the trees begin to die during the period between the 1st of October and the 1st of December the broods of beetles will remain in the bark until the following March or April.

Essential details in methods of control.—There are certain essential details in the recommended methods of combating the southern pine beetle which must be observed in order to avoid not only serious mistakes but possibly ultimate failure:

(*a*) The principal clumps or patches of *dying* trees which are actually infested by the broods of the destructive beetle, as indicated by the *fading and dying* foliage, or otherwise, should be located and marked during the months of November, December, January, and February. In order to do this work, proper experience or special instruction is required. Therefore some one who has had instructions should have charge of the work in each important area in which control work is to be undertaken.

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[1] "Report on Investigations to Determine the Cause of Unhealthy Conditions of the Spruce and Pine from 1880–1893," Bulletin 56, West Virginia Agricultural Experiment Station, pp. 281–378, 1899, by A. D. Hopkins, Entomologist.

"The Southern Pine Beetle," Bulletin 83, Part I, Bureau of Entomology, U. S. Department of Agriculture, pp. 56–72, 1909, by A. D. Hopkins.

"The Dying Pine in the Southern States: Cause, Extent, and Remedy," Farmers' Bulletin 476, U. S. Department of Agriculture, 15 pages, 4 figures, 1911, by A. D. Hopkins.

(*b*) The *broods of the beetle* in the bark of the *main trunks* of the medium to larger-sized dying infested trees within an area of 8 or 10 square miles or more must be destroyed in order to stop their depredations.

(*c*) The broods may be destroyed by *one* or *more* of the following methods, the work to be done between the 1st of November and the 1st of March:

(1) Removing and burning the infested bark from the trunks of the standing trees; or

(2) Removing and burning the infested bark from the trunks of the trees after they have been cut down; or

(3) Scorching the infested bark or burning the wood with the bark after the trees are cut down; or

(4) Placing the infested portions of the trunks in water; or

(5) *Converting the trunks of the infested trees into cordwood and using the wood for fuel before the beetles leave the bark;* or

(6) *Converting the infested trees into lumber or other products and burning the slabs or bark.*

(*d*) It is not necessary to burn the tops or branches of treated trees or to cut and burn small infested saplings *if the larger infested trees are disposed of.*

(*e*) It is not necessary to remove or destroy the bark on the lower portion of the trunk or on the stumps if it is not infested with the destructive beetle, and it is not necessary to cut or treat dead trees from which the beetles have emerged.

(*f*) It is necessary and essential that the broods of the destructive beetle in the bark of any portion of the main trunks of the medium to larger sized dying infested trees of any given locality should be destroyed.

(*g*) If the wood of the infested trees can be utilized for fuel, lumber, or other purposes, its value should cover the cost of the work. If the work of felling and barking the trees is done at direct expense, the cost will average 10 to 30 cents per tree.

(*h*) The cost of protecting the living timber of any locality with average infestation should not exceed an average of from 1 to 5 cents per acre for the total area of pine-covered land, and if estimated on a basis of volume it should not cost over 2 cents per cord of the living timber protected.

(*i*) The best time to conduct control operations against the southern pine beetle is during the period between November 1 and March 1.

(*j*) If a pine tree standing among or near a grove or woods of living pine is either struck by lightning or felled and barked or split into cordwood during the summer and early fall, it will, as a rule, attract the beetles within a radius of 3 or 4 miles and result in the starting of a new center of infestation and in the death of a large number of trees.

(*k*) The principal owners of pine in each community should cooperate in the disposal of the required infestation, but should not undertake the work until *some one or more of the owners is sufficiently familiar with the essential details of the proper methods.*

The pine tip moth (*Retinia frustrana* Scud.) attacks and deforms the growing tips of branches. In some localities this is the most noticeable cause of injury and is sometimes very abundant for several successive years. There is no practical means of controlling the insect under forest conditions. The injury is least in suppressed parts of trees, or trees growing beneath older forest stands and greatest in thrifty stands of reproduction from 4 to 10 years old growing in old

fields or under full light exposure. Following the unusually wet spring and early summer of 1912, the infestation was general in the Piedmont region and southern Mississippi Valley. In an extreme case of a 9-year-old stand, as high as 90 per cent of the shortleaf saplings showed injury.[1] Some had been attacked by at least two generations of insects during midsummer, and, as a result, developed two sets of adventitious leaders.

Larvæ of the southern pine sawyer, or round-headed borer, *Monohammus titillator* Fab.,[2] develop from eggs laid under the bark of felled or dead trees by the adult beetle. The insect never attacks living trees in the South. If allowed to dry rapidly by removing the bark, or if immersed in water, the wood is little subject to injury by the insect.

FUNGI.

The most practical means of combating the injury and loss of timber by fungi is to prevent, so far as possible, the occurrence of wounds in the tree through which the fungus finds its direct avenue of attack. The most serious cause of the formation of wounds is fire. Infested trees should be selected for cutting, since they are the breeding places for spores or "seed," which are minute in size and produced in vast numbers.

YIELD.

The productiveness of the tree, especially of second growth or young timber, being the basis of management, a knowledge of the yield, or amount of wood produced per acre, is essential in order to decide the time and method of cutting, the probability of success, and other important points in handling the forest crop. Yield tables are particularly valuable for trees like shortleaf pine, which come in extensively in even-aged second-growth stands following the removal of the virgin forest and the abandonment of fields cleared for agriculture. For such stands normal yield tables give the information most needed. These are obtained from measurements taken in fully stocked pure stands, or portions of stands, and show the possibilities of the species at various ages. Yield tables thus made are used as guides in ascertaining the present total volume of the growing stock and period of highest productivity in the life of the stand, and in predicting future yields of the forest at given ages. Many stands or portions of stands, however, are not more than two-thirds to three-quarters fully stocked, because of insufficient seed, direct injury from fires, and losses by insects or fungi. A deduction

[1] Mixed stand in which 610 shortleaf and 330 loblolly had been infested and 70 shortleaf and 10 loblolly showed no injury. (Mt. Vernon, Glenville P. O., Arkansas.)

[2] See Bureau of Entomology Bulletin 58, "Some Insects Injurious to Forests."

must necessarily be made for such stands. The influence of stand density upon yield in saw timber and cordwood is discussed on pages 35 and 36, respectively.

Yields from fully stocked, pure shortleaf stands have been measured in representative regions in the Piedmont uplands of North Carolina, Virginia, and central western Arkansas. In addition, a few yields have been obtained in Georgia, South Carolina, and New Jersey, and are interesting for comparison.

The yield table for the Piedmont region of North Carolina (Table 14) is based upon the measurement of yields of 80 well-stocked stands of various ages up to 80 years. It gives the yields in terms of board feet saw timber, scaled both by the Doyle and the Scribner rules, also cubic feet, for three different qualities of site; also the number of trees per acre, and average height and diameter of the trees. For logs up to 24 inches in diameter the Scribner rule gives higher values, which represent more nearly the actual mill cut than does the Doyle rule. The latter rule is therefore advantageous to the purchaser of standing timber or logs, while it is equally disadvantageous to the seller. For example, at the age of 50 years, on Quality II site, a fully stocked shortleaf pine stand, scaled to include all logs 6 inches and over at the top end, yields an average of 17,000 board feet by the Scribner rule, but only 9,500 feet if scaled by the Doyle rule. The average size of the trees is 57 feet in height by 9.4 inches in diameter, and the stand contains an average of 355 trees per acre, having a total cross section or basal area of 179 square feet at breastheight. The cubic volume, including bark, is 4,360 cubic feet. Table 15 shows that at the age of 50 years, the stand was increasing annually at the rate of 525 board feet per acre, or 106 cubic feet in total stem volume, the average yearly increase during the whole life of the stand (column headed "Mean annual increment") was somewhat less, as might be expected—340 board feet (Scribner), 190 feet (Doyle), or 87 cubic feet per acre.

A similar yield table (Table 16) for fully stocked pure stands of shortleaf in its region of best development west of the Mississippi River is based upon the measurement of 38 sample plots in central western Arkansas. The stands had been protected against frequent fires, and the portions measured were completely stocked, so that the table may be considered as representing fairly well the yields to be expected from protected and managed stands. The number of plots used as a basis for both Tables 16 and 17 is obviously too few, so the tables are tentative, and have been included for the purpose of indicating the character of second-growth stands in Arkansas, with the view of later comparison and revision when additional measurements are available.

TABLE 14.—*Yield*[1] *per acre of fully stocked second-growth shortleaf pine in North Carolina.*[2]

QUALITY I.

Age.	Trees per acre.	Average diameter (breast-high).	Average height.	Total basal area (at breast-height).	Yield of saw timber.		Solid measure.
					Scribner rule.	Doyle rule.	
Years.		*Inches.*	*Feet.*	*Sq. ft.*	*Bd. ft.*	*Bd. ft.*	*Cu. ft.*
20	1,000	5.8	40	158	5,700	2,000	2,120
25	675	6.9	46	175	8,400	3,600	2,730
30	510	7.9	51	188	11,200	5,300	3,350
35	410	8.8	55	198	14,000	7,100	3,950
40	340	9.6	59	205	17,100	8,900	4,570
45	280	10.4	63	211	20,300	10,900	5,200
50	235	11.2	66	215	23,700	12,800	5,840
55	200	11.9	69	218	27,000	14,500	6,450
60	165	12.7	72	220	30,100	16,200	7,020
65	140	13.4	74	222	33,200	17,700	7,570
70	120	14.1	77	224	36,100	19,300	8,100
75	100	14.7	79	226	38,800	20,800	8,600
80	90	15.3	81	227	41,500	22,400	9,110

QUALITY II.

20	1,635	4.6	33	129	3,200	300	1,380
25	1,095	5.6	38	145	5,200	1,700	1,840
30	765	6.5	43	156	7,300	3,200	2,330
35	600	7.3	47	165	9,400	4,700	2,820
40	500	8.0	50	172	11,700	6,300	3,320
45	420	8.7	54	176	14,300	7,900	3,830
50	355	9.4	57	179	17,000	9,500	4,360
55	310	10.0	59	182	19,700	11,000	4,880
60	270	10.6	62	183	22,400	12,500	5,360
65	230	11.3	64	185	25,200	13,900	5,830
70	205	11.8	66	186	27,800	15,300	6,280
75	180	12.4	69	187	30,400	16,700	6,730
80	155	13.0	71	188	32,900	18,100	7,160

QUALITY III.

20	2,450	3.4	26	100	700	----------	650
25	1,880	4.2	31	114	2,100	----------	930
30	1,405	5.0	35	125	3,400	1,100	1,290
35	1,045	5.7	39	133	4,800	2,300	1,670
40	795	6.4	42	138	6,500	3,600	2,070
45	655	7.0	45	142	8,300	4,900	2,470
50	550	7.6	47	144	10,300	6,200	2,880
55	475	8.2	50	145	12,400	7,500	3,300
60	420	8.7	52	146	14,700	8,800	3,700
65	370	9.2	54	147	17,100	10,100	4,100
70	330	9.7	56	148	19,600	11,400	4,490
75	295	10.2	58	149	22,000	12,600	4,860
80	270	10.6	60	149	24,200	13,900	5,230

[1] Based on 80 sample plots in fully stocked stands; total area 21.6 acres. Saw timber scaled to 5.5 inches in top diameter inside bark. Stump height 1 to 1.5 feet. Volume of stem both in board feet and cubic feet, is from 1-foot stump to 6-inch top diameter, including bark. All trees 6 inches and over in diameter breast-high were scaled.

[2] Counties in North Carolina are: Alexander, Burke, Cabarrus, Catawba, Cleveland, Davie, Gaston, Lincoln, McDowell, Rowan, Rutherford, Surry, Wilkes, and Yadkin.

TABLE 15.—*Yearly increment*[1] *per acre of fully stocked second-growth shortleaf in North Carolina.*[2]

PERIODIC ANNUAL INCREMENT.

Age.	Scribner rule.			Doyle rule.			Solid measure.		
	Quality.			Quality.			Quality.		
	I.	II.	III.	I.	II.	III.	I.	II.	III.
Years.	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*
20	500	370	.....	300	.....	.....	112	82	50
25	530	400	240	320	280	.....	117	88	59
30	560	430	275	340	295	.....	121	93	66
35	590	460	310	360	310	240	124	98	72
40	620	485	340	380	315	250	126	101	76
45	650	505	370	400	320	255	127	104	80
50	680	525	400	380	315	255	128	106	82
55	655	540	425	365	310	260	123	104	84
60	625	550	455	350	300	260	117	101	83
65	605	560	475	330	290	260	112	97	81
70	580	545	500	315	280	260	106	92	78
75	560	520	475	300	275	255	100	87	75
80	540	490	445	285	265	250	94	82	71

MEAN ANNUAL INCREMENT.

20	285	175	50	100	15	.....	107	69	32
25	335	205	80	140	65	.....	109	74	38
30	370	240	110	175	105	35	111	78	43
35	405	270	135	205	135	65	113	81	48
40	430	295	160	225	160	90	115	83	52
45	450	320	185	245	175	110	116	85	55
50	470	340	205	255	190	125	117	87	58
55	490	360	225	265	200	135	117	88	60
60	500	375	245	270	210	145	117	89	62
65	510	385	260	275	215	155	116	90	63
70	515	395	275	275	220	165	116	90	64
75	520	405	295	280	225	170	115	90	65
80	520	[3] 410	310	280	225	175	114	90	65

[1] Based on 80 sample plots in fully stocked stands; total area 21.6 acres. Saw timber scaled to 5.5 inches in top diameter inside bark; stump height 1 to 1.5 feet. Volume of stem is from 1-foot stump to 6-inch top diameter, including bark. All trees 6 inches and over in diameter breast high were scaled.

[2] Counties in North Carolina are: Alexander, Burke, Cabarrus, Catawba, Cleveland, Davie, Gaston, Lincoln, McDowell, Rowan, Rutherford, Surry, Wilkes, and Yadkin.

[3] A continuation of these figures indicates a culmination of mean annual increment at about 90 years, with an increment of about 420 board feet.

TABLE 16.—*Yield*[1] *per acre of fully stocked second-growth shortleaf pine in Arkansas.*

QUALITY I.

Age.	Trees, total per acre.	Basal area (breast-height), total per acre.	Average diameter trees 6 inches and over.	Height.	Saw timber.		Solid measure.
					Scribner rule.	Doyle rule.	
Years.	*Number.*	*Sq. ft.*	*Inches.*	*Feet.*	*Bd. ft.*	*Bd. ft.*	*Cu. ft.*
20	639	166	7.5	43	8,000	.....	2,500
25	473	182	8.6	50	12,700	4,200	3,630
30	380	195	9.6	55	17,500	6,600	4,900
35	316	205	10.6	60	22,400	9,700	6,060
40	276	213	11.4	65	27,500	13,400	7,010
45	245	219	12.2	69	32,500	17,600	7,730
50	220	225	13.0	73	37,400	21,800	8,320
55	201	230	13.6	76	42,200	25,600	8,850
60	186	234	14.2	79	46,850	29,000	9,320
65	174	237	14.8	81	51,350	32,100	9,760
70	164	240	15.3	84	55,750	35,000	10,160
75	155	242	15.8	86	.....	37,800	10,520
80	147	243	16.2	88	.....	40,500	10,850

QUALITY II.

20	1,130	125	6.6	35	4,350	.....	1,740
25	784	139	7.5	41	7,450	2,700	2,520
30	595	150	8.3	46	10,600	4,500	3,390
35	479	159	9.1	51	13,800	6,800	4,220
40	404	167	9.9	55	17,000	9,500	4,930
45	351	173	10.7	58	20,200	12,400	5,520
50	308	178	11.3	61	23,450	15,400	6,050
55	277	183	12.0	64	26,850	18,200	6,520
60	249	186	12.5	67	30,600	20,600	6,980
65	229	189	13.1	69	34,050	23,000	7,410
70	214	191	13.6	72	37,500	25,200	7,800
75	197	193	14.1	74	40,850	27,400	8,160
80	184	194	14.5	76	44,000	29,500	8,500

QUALITY III.

20	1,510	.....	.....	.....	.....	.....	.....
25	1,088	95	6.3	33	2,600	1,200	1,390
30	802	105	7.0	37	4,300	2,500	1,870
35	638	113	7.7	41	6,000	3,900	2,360
40	521	120	8.4	44	7,900	5,500	2,850
45	446	126	9.1	47	10,000	7,200	3,310
50	385	131	9.7	50	12,200	9,000	3,760
55	343	135	10.3	53	14,600	10,700	4,210
60	312	138	10.8	55	17,000	12,300	4,650
65	284	140	11.4	57	19,500	13,900	5,070
70	260	142	11.9	59	22,000	15,400	5,450
75	242	143	12.4	61	24,600	16,900	5,810
80	225	143	12.9	63	27,100	18,400	6,150

[1] Based on 38 fully stocked sample plots; area 5.8 acres. All trees 6 inches and over in diameter breast-high were scaled: Top diameter, 5.5 inches; stump height, 1 foot. Table is only preliminary, based upon insufficient measurements but used here for comparison until more complete data are available.

TABLE 17.—*Yearly increment*[1] *per acre of fully stocked second-growth shortleaf pine in Arkansas.*

PERIODIC ANNUAL INCREMENT.

Age.	Scribner rule.			Doyle rule.			Solid measure.		
	Quality.			Quality.			Quality.		
	I.	II.	III.	I.	II.	III.	I.	II.	III.
Years.	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*
20	.....	.....	.....	.....	.....	.....	.....	.....	.....
25	940	620	.....	.....	.....	.....	226	156	.....
30	960	630	340	480	360	260	254	174	96
35	980	640	340	620	460	280	232	166	98
40	1,020	640	380	740	540	320	190	142	98
45	1,000	640	420	840	580	340	144	118	92
50	980	650	440	840	600	360	118	106	90
55	960	680	480	760	560	340	106	94	90
60	930	750	480	680	480	320	94	92	88
65	900	690	500	620	480	320	88	86	84
70	880	690	500	580	440	300	80	78	76
75	.....	670	520	560	440	300	72	72	72
80	.....	630	500	540	420	300	66	68	68

MEAN ANNUAL INCREMENT.

20	400	220	.....	.....	.....	.....	125	85	.....
25	510	300	105	170	110	50	145	100	55
30	585	355	145	220	150	85	165	115	60
35	640	395	170	275	195	110	175	120	65
40	690	425	200	335	240	140	175	125	70
45	720	450	220	390	275	160	170	125	75
50	750	470	245	435	310	180	165	120	75
55	765	490	265	465	330	195	160	120	75
60	780	510	285	485	345	205	155	115	80
65	790	525	300	495	355	215	150	115	80
70	795	535	315	500	360	220	145	110	80
75	.....	545	330	505	365	225	140	110	75
80	.....	[2] 550	340	505	370	230	135	105	75

[1] Based on 38 fully stocked sample plots; total area, 5.8 acres. Saw timber scaled to 5.5 inches in top inside bark. Stump height, 1 foot. All trees 6 inches and over breast-high diameter were scaled.

[2] A continuation of these figures indicates a culmination of mean annual increment at about 100 years with an increment of about 560 board feet.

ROTATION.

It is always desirable to determine in advance the length of the period through which the stand should be allowed to grow. This depends largely upon (1) the age at which the average yearly growth is greatest, (2) the kind of material desired, pulpwood, cordwood, or saw timber, and (3) the total cost of producing the material. The most reliable basis for determining the age at which to cut the stand is the time when the average yearly production is the greatest. This will then be modified in accordance with the kind of timber that is desired. Other factors to be considered are taxes and protection figured on the basis of compound interest, as well as stumpage values and market demand. The age at which the highest net money return will be secured, or the financial maturity of the stand, may

precede or follow the age of greatest annual growth, depending upon demand and market prices.

Yield and growth tables show the relation between age, size of trees, and total yields. They form the basis, therefore, for deciding when to cut in order to obtain any desired quality and size of timber. For example, on Quality II sites the maximum mean annual yield per acre of saw timber in North Carolina for trees 6 inches and over in diameter (scaled by the Scribner log rule) occurs at about 90 years (Table 15, note), with an average yield of about 420 board feet per year. Fully stocked stands in Arkansas for average Quality II sites appear to reach a culmination of yield of 570 board feet produced annually at the age of about 100 years (Table 17, note). Measurements of similar unthinned stands in Virginia[1] show the culmination of annual yield in saw timber at about 57 years, and those of a few pure stands in New Jersey indicate a maximum annual yield there at 45 to 50 years. The age of culmination in annual volume production is thus increasingly later as the region of growth is better.

The production of cubic volume or cordwood without regard to size or quality appears to culminate about 20 to 30 years earlier than the production of saw timber. The maximum mean annual yield in cubic volume for unthinned well-stocked stands in North Carolina is obtained on the best sites at about 50 to 60 years, on medium or second-quality sites at about 65 to 75 years, and on the poorest or third-quality sites at an estimated age of about 85 years. At 80 years, stands on third quality sites were found not yet to have passed their maximum in volume production. The more rapid growth of thinned stands hastens the date of their financial maturity by from 15 to 30 years.

If the aim is to raise saw timber, a rotation of from 80 years on the better sites to 100 years on the poorer sites will apparently give the greatest yield in the shortest time; for cordwood the age of highest production lies mostly between 60 and 80 years.[2] In practice stands will more likely be cut in shorter rotations, or before they reach their maximum rate of growth. Pine is extensively cut for ties at 12 inches breasthigh diameter. This size is reached at 65 years in North Carolina, and the tree is then 70 feet high. Such a tree will make two to four ties, according to the size of the tie desired. The disadvantage of holding charges at compound interest tends strongly to reduce the rotation.

[1] W. W. Ashe, "Shortleaf Pine in Virginia" p. 28), published by the Virginia Department of Agriculture and Immigration.

[2] Scrub and pitch pines are extensively used for firewood and are usually removed from mixed stands with shortleaf because of their inferiority for saw timber.

On the National Forests of Arkansas the Federal Government in its management of shortleaf pine aims to produce the sort of material most needed by the people, which is mostly medium-sized saw timber. A rotation of about 100 years in fully stocked pure stands affords the largest annual yield. The average tree at this age, grown under forest conditions, is 74 feet in height by 16.6 inches in diameter, and contains not less than 270 board feet [1] of merchantable lumber. While the interval between successive cuts is many years, it is well to bear in mind that present cuttings on private holdings in the region are taking very little timber younger than 60 years. Where the stand, whether of pure shortleaf or a mixture of shortleaf and various hardwoods, is moderately open, as is the case over considerable of its range, the culmination in annual yield is earlier. A rotation of 90 years under these conditions will probably give the highest average yearly yield of saw timber on the Arkansas National Forest. Under natural conditions, and without fire protection until very recently, shortleaf pine on the Arkansas National Forest at 90 years measures mostly from 14 to 18 inches in diameter, averaging 15.9 inches, and from 60 to 110 feet in height, averaging 73 feet. The average tree of this size contains 240 feet of saw timber. Judging from the character of similar stands up to 80 years old, pure stands at 90 years on average sites in Arkansas yield from 30 to 40 thousand feet, while completely stocked stands on the same situations contain about 170 trees per acre and yield about 50 thousand feet of saw timber.

THINNINGS.

The extensive areas of shortleaf pine in the younger stages of growth and the quick response of the species to changes in light supply [2] make thinnings very important in its management: their purpose is to admit the right amount of light so far as is possible to each individual tree. The available soil moisture and growing space for the roots must also be considered. Thinnings are made necessary by the dense seeding which usually takes place under protection from fire, in openings, such as abandoned fields or forest clearings. While natural thinning gradually reduces the density of the stand, progress is slow and much time is lost in the production of a mature crop. Fires thin stands, but in a haphazard manner, accompanied always by severe loss and injury. Thinnings made by selecting the proper trees at the right intervals result in an increased yield, a notable improvement in quality, and frequently a higher net money return on the investment.

[1] Table 29 in Appendix.

[2] U. S. Department of Agriculture Bulletin No. 244, "Life History of Shortleaf Pine."

RELATION BETWEEN TREE DENSITY AND YIELD.

A thinning is very desirable between the ages of 10 and 15 years. It should be somewhat earlier for the better than for the poorer sites and regions of growth. Subsequent thinnings should be made at regular intervals of 5 years up to the age of from 40 to 60 years, and thereafter about every 10 years to the close of the rotation. If, for any reason, it is impracticable to repeat the operation so often, the interval may be increased to from 7 to 10 years. Ten years is satisfactory for older stands of timber managed under a longer rotation. It is thoroughly practical to start thinnings even at considerably later ages than those mentioned. The limit has not been definitely determined, but vigorous recovery after suppression has been observed up to 80 and 100 years of age. Perhaps ages of 50 to 60 years on the better situations and best regions of growth are approximately near to the average limit of the period of good recovery. This allows a period of 20 to 30 years prior to the culmination of height and diameter growth. On the drier and thinner soils the corresponding upper limit seems to be reached from 10 to 20 years earlier.

Too heavy thinning stimulates leaf development and wood production over the lower branches, correspondingly reduces the rate of height growth, and is injurious also through the exposure of the soil and humus to the unfavorable action of sun and wind. The ideal thinning removes a sufficient number of the trees to relieve overcrowding without creating large openings in the canopy. Obviously, long intervals between thinnings make necessary the removal of a greater amount of material than shorter intervals, and increase the danger of soil exposures and the development of long dense crowns. It should be borne in mind, however, that young stands which are so open as to be considered understocked may often close up as they grow older and be fully stocked at maturity.

The close relation between the number of trees per acre and the resultant yield of saw timber is indicated by Table 18 derived from seven different portions of a 30-year old shortleaf stand of irregular density. The best yield resulted from a density of 350 trees per acre, with decreasing yields at about the same rate from both understocking and overstocking. Thinnings made in Hanover County, Va., for the accurate determination of the resulting growth in a typical shortleaf stand of similar character and age removed 42 per cent of the trees but only 6 per cent of the total cubic volume of wood.

TABLE 18.—*Relation between tree density and yield of shortleaf pine in board feet per acre.*[1]

Total trees per acre.	Trees 8 inches and over in diameter.	Saw timber.[2]		Average diameter (breast-high).	Total trees per acre.	Trees 8 inches and over in diameter.	Saw timber.[2]		Average diameter (breast-high).
		Scribner rule.	Doyle rule.				Scribner rule.	Doyle rule.	
Number.	*Number.*	*Board feet.*	*Board feet.*	*Inches.*	*Number.*	*Number.*	*Board feet.*	*Board feet.*	*Inches.*
150	130	11,250	6,600	11.5	500	255	15,350	7,900	8.1
200	175	13,500	8,450	10.9	550	235	13,200	6,800	7.7
250	215	16,000	9,700	10.4	600	215	11,250	5,800	7.3
300	260	18,100	10,600	9.8	650	195	9,250	4,450	7.0
350	290	19,400	10,800	9.4	700	180	7,500	3,200	6.6
400	290	19,100	10,200	8.9	750	160	5,900	2,000	6.3
450	260	17,500	9,000	8.5	800	140	4,250	800	6.0

[1] A 30-year old stand of varying densities on good quality site and protected against fire, Montgomery County, Ark.
[2] Yield of trees 8 inches and over in diameter at breast-height.

In a selected old-field stand in Arkansas, 20 years old (Pl. VII, fig. 1) a density of 1,440 trees per acre gave a yield of 1,600 board feet, counting all trees 8 inches and over in diameter, while a normal stocking of 520 trees per acre in the same stand yielded 10,200 feet of saw timber. The overstocked stand contained only 40 trees per acre 8 inches and over in diameter and merchantable for saw timber, the well-stocked stands 200. The relation between number of trees per acre and diameter growth is so regular that it is almost susceptible of expression with mathematical exactness. The sections in Plate VIII represent the average growth in a 33-year-old stand of shortleaf pine coming up under full-light exposure in an opening of about 10 square miles caused by a cyclone. A density of 370 trees per acre gave a yield of 18,000 feet of saw timber, a density of 550 trees per acre 21,800 feet. The trees widely spaced averaged 1 inch larger in breast-high diameter, thus yielding a higher grade of lumber.

The number of trees to be left per acre in thinning shortleaf stands of specified ages varies chiefly with the quality of the situation. Table 19 indicates approximately the number of trees in natural unthinned stands and also the trees left after thinning. The better class is representative of the more southern and western portions of the shortleaf range; the poorer class, of unfavorable local situations in this portion of the range, and the more northern and eastern areas of distribution.

TABLE 19.—*Trees per acre in unthinned and thinned stands of various ages.*[1]

Age.	Trees per acre.				Age.	Trees per acre.			
	Better situations.		Poorer situations.			Better situations.		Poorer situations.	
	Unthinned stands.	After thinning.	Unthinned stands.	After thinning.		Unthinned stands.	After thinning.	Unthinned stands.	After thinning.
Years.	*Number.*	*Number.*	*Number.*	*Number.*	*Years.*	*Number.*	*Number.*	*Number.*	*Number.*
20	1,400	990	2,120	1,460	70	225	195	260	230
30	680	525	990	820	80	200	175	200	190
40	480	380	680	540	90	185	165	185	180
50	340	280	460	380	100	175	160	180	175
60	270	230	340	290					

[1] Represents about an average number based on measurements in 128 well-stocked stands in various portions of the range.

TREES TO BE REMOVED.

For convenience in thinning, trees may be divided into four groups of "dominant," "codominant," "intermediate," and "suppressed." These groups are termed "crown classes," and represent the relative importance of the trees in the composition of the stand. The dominant and codominant trees compose the bulk of the stand, forming the general level of the forest canopy. They receive full light from overhead, and the dominant ones some from the sides also. The codominant trees are somewhat crowded on the sides. The intermediate trees have smaller crowns and are generally below the main level of the stand, where they receive only a small amount of light from above. They clearly belong to the class of trees which is being gradually crowded out. The suppressed trees are the smaller sickly ones completely below the general forest canopy.

Athough there are certain more or less essential rules for thinning average shortleaf pine stands, they will not fit all cases, and the removal of the trees is largely a matter of individual judgment. In general, thinnings should be made primarily for the better development of the dominant and codominant classes. This is accomplished through the removal of the more crowded intermediate and suppressed trees on the lower side and the exceptionally large, overshading or "wolf" trees on the upper side. In the crowded groups it is often necessary to remove as many as one-half, or occasionally two-thirds, of the intermediate trees, together with a few trees of the codominant class. Figure 3 represents an overstocked 30-year-old shortleaf stand and several subsequent thinnings. In ordinary early thinnings the number of trees removed is about one-third of the total stand. The suppressed trees are making exceedingly small growth and exert no appreciable influence upon the stand. Their removal, however, is beneficial in decreasing the fire menace. Large openings should al-

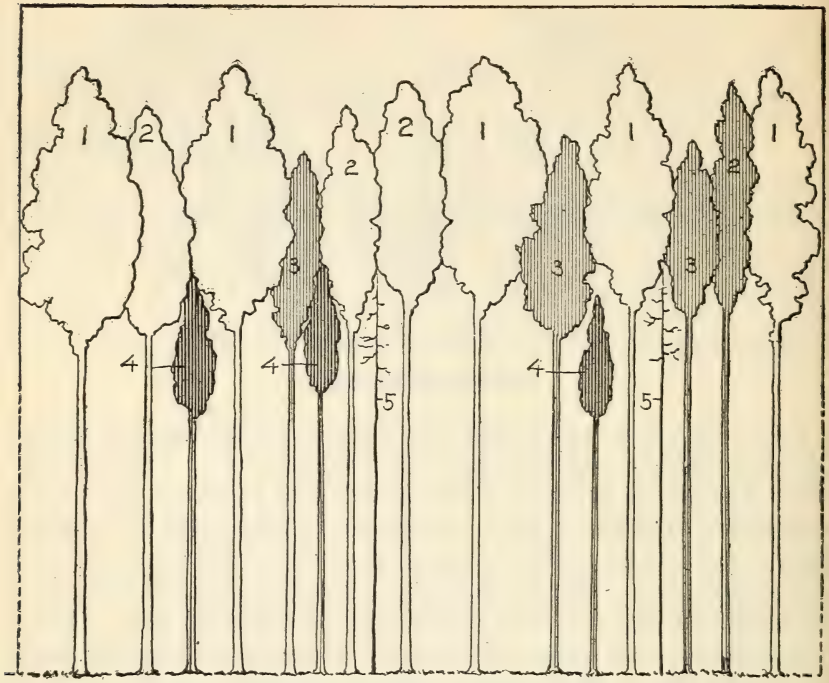


FIG. 3a.—Profile of trees in the original unthinned stand; 15 trees living.

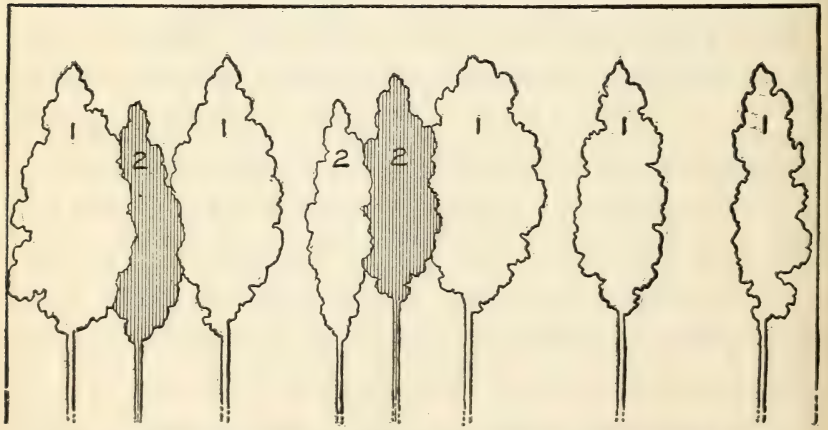


FIG. 3b.—Same stand after first thinning by removing 7 trees; 8 trees living.

FIG. 3.—Successive thinning in an overstocked, even-aged shortleaf stand, 30 years old. mediate; 4, suppressed; 5, dead. Tree outlines in original stand.

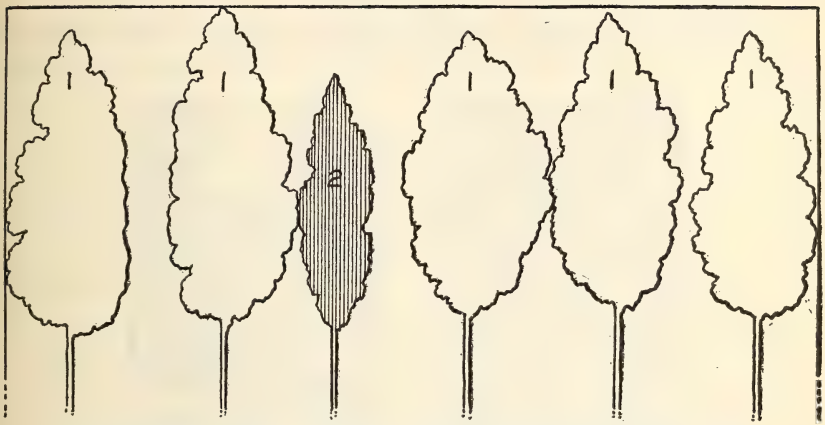


FIG. 3c.—Same stand 7 years later after second thinning; 6 trees living.

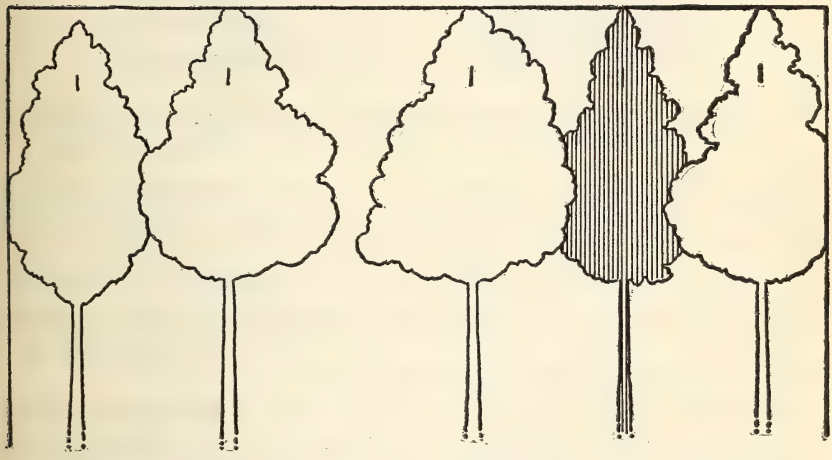


FIG. 3d.—Same stand 8 years later following third thinning; 5 trees living.

Shaded trees to be removed in next thinning. 1, dominant; 2, codominant; 3, intertaken from "Principles of Handling Woodlands," by H. S. Graves.

ways be avoided in order to prevent soil deterioration and the entrance of weeds or undesirable hardwood species. In the absence of other trees over a space larger than about two or more square rods trees of all crown classes should be retained. The trees in a well-stocked thinned stand of shortleaf should maintain a general uniformity in height.

Figure 4 shows graphically the actual appearance of the canopy of a 30-year-old stand and the same after it was thinned by the removal of 9 suppressed and 4 intermediate trees, equivalent to 46.4 per cent of the number of trees, or about 8 per cent of the cubic volume.

In this case thinning was badly needed because of the number of trees in the lower crown classes and overcrowding in the main

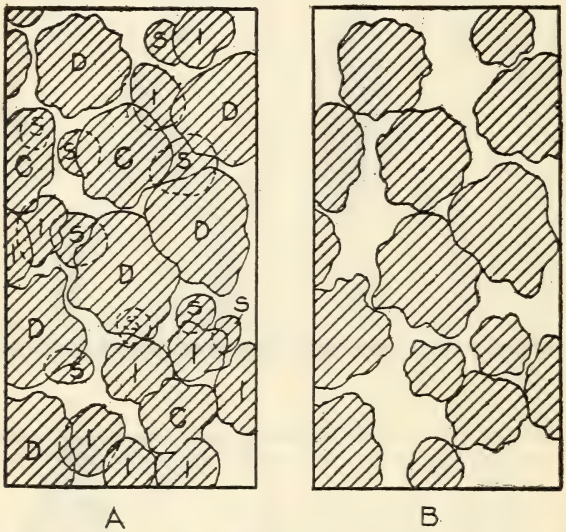


FIG. 4.—Canopy of a crowded shortleaf pine stand 30 years old; (A) before thinning; (B) after thinning. D dominant, C codominant, I intermediate, S suppressed.

canopy. The expansion of the crowns of the remaining trees will rapidly fill openings, making a second thinning necessary in about five years. The selection of trees among the various crown classes for thinning should always be preceded by the removal of unsound and defective trees, such as those with crooked, forked, or short knotty trunks. The presence of "punk," or the fruiting body of a fungus, is certain evidence of a diseased tree.

In mixed stands the pine should be favored at the expense of the hardwoods practically always except on the least favorable situations and extreme outer limits of its range. Artificial thinning will accelerate growth, however, and make the tree successful on situations formerly considered unfavorable. In proportion to the amount of air and soil space occupied shortleaf pine produces more timber

than any of its hardwood associates. In the lower and deeper soils red gum comes close to shortleaf pine in volume production. In general the principles of thinnings stated above for pure stands apply with only minor modifications to mixed pine and hardwood stands.

RETURNS FROM THINNED STANDS.

The relation of cost to financial return is much the same for thinning shortleaf stands as for similar operations with farm crops. The material obtained from thinnings can usually be utilized for cordwood, rails, and other purposes, and often pays for the work from the start. A market for peeled poles can perhaps be developed, especially in view of the success of treating sap pine with wood preservatives. The factors which determine the immediate financial success of thinning an acre of young pine vary widely with age, density, location, and opportunity for using the product.

The results obtained by thinning shortleaf pine in Virginia have been studied by the Forest Service in cooperation with the Department of Agriculture and Immigration of the State of Virginia. The study was made by Mr. W. W. Ashe, of the Forest Service, and the results are embodied in a publication issued in 1913 by the State, entitled "Shortleaf Pine in Virginia—The Increase in Its Yield by Thinnings." The tables and discussion which follow are based upon this report, and may be considered applicable over the northern and central Piedmont region, and with relatively small modifications over the entire region of distribution.

Saw timber.—The largest yield of saw timber is obtained from stands which are periodically and lightly thinned, following an earlier period of moderate crowding. The possibilities of increase in yield of lumber as a direct result of thinning are clearly indicated in Table 20, showing yields for understocked, thinned, and crowded unthinned stands.

TABLE 20.—*Yield*[1] *of saw timber from understocked, crowded, and thinned stands of shortleaf pine in Virginia.*

[Trees 9 inches and over in diameter at breast height.]

Age.	Crowded stands, unthinned.		Fully stocked, thinned stands.		Understocked stands.	
	Trees per acre.	Yield.	Trees per acre.	Yield.	Trees per acre.	Yield.
Years.		*Bd. ft.*		*Bd. ft.*		*Bd. ft.*
30	1,235	200	765	8,400	350	3,800
40	860	6,000	505	16,400	300	5,700
50	535	13,100	355	20,400	150	6,900
60	395	16,800	255	23,000	100	7,800

[1] Yield in terms of mill cut production under close utilization.

The yield in saw timber of a crowded stand 30 years old is very small, because very few trees have attained a merchantable diameter. The largest diameters occur in understocked stands, which yield considerably less, however, than fully stocked thinned stands. If the material derived from the thinnings is of sufficient value to pay for the cutting or to yield a profit, the cost per thousand feet of growing saw timber in fully stocked thinned stands is less than in either crowded or understocked stands. If thinnings do not pay for themselves the cost is greater. At the age of about 48 years, when thinned stands reach their maximum annual yield, the diameter of the average-sized tree is about 9.5 inches breast high, or 11.5 inches on the stump. The average annual yield of saw timber at that time from trees 9 inches and over in diameter is 410 board feet. For similar unthinned stands the maximum annual yield occurs at the age of about 57 years, and the tree averages 8.2 inches at breast height, or 9.8 inches on the stump. The annual increment at different ages from unthinned and thinned stands is shown in Table 21.

TABLE 21.—*Average annual increment per acre of saw timber from thinned and unthinned shortleaf-pine stands in Virginia.*

[Trees 9 inches and over in diameter, measured at breast height.]

Age.	Thinned stand (thinnings neglected).		Unthinned stand.	
	Average annual increment.	Periodic annual increment for each decade.	Average annual increment.	Periodic annual increment for each decade.
Years.	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*
30	280	.....	.....	.....
40	410	800	150	.....
50	408	400	262	710
60	383	260	250	190
70	357	200	238	170

In calculating the cost of growing shortleaf pine saw timber, compound interest on the value of the land, accumulated taxes, and other expenses must be considered. The effect of thinning upon the final yield and upon the cost of growing shortleaf pine are shown in Table 22. The calculation assumes a land value of $5 per acre, taxes and other expenses at the rate of 1 per cent on the land value, and net annual returns of 5 per cent on the investment in land and cost of stocking. The lowest cost for unthinned stands was $6.25 and for thinned stands $2.21 per thousand feet. The age at which the cost is lowest, or the financial maturity of the timber, was 45 years for natural stands and 35 years for the thinned stands.

TABLE 22.—*Cost of growing shortleaf-pine saw timber in thinned and unthinned stands in Virginia.*

Age of stand.	Unthinned stand.			Thinned stand.		
	Accumulated cost of investment.	Yield.	Cost of growing per M.	Net cost per acre of producing crop.[1]	Final yield.	Cost of growing per M board feet.
Years.	*Dolls.*	*Bd.ft.*	*Dolls.*	*Dolls.*	*Bd.ft.*	*Dolls.*
20	11.04	.....	.....	11.04	.....	.....
25	16.46	.....	.....	15.68	900	17.00
30	23.72	200	.....	21.75	8,400	2.59
35	33.43	1,400	23.80	29.64	13,400	2.21
40	46.43	6,000	7.64	40.06	16,400	2.44
45	63.82	10,200	6.25	54.33	18,700	2.90
50	87.10	13,106	6.70	73.70	20,400	3.61

[1] After allowing for profit from thinnings in the form of cordwood.

The total stumpage value of old fields at various ages and the gross returns yielded on the original investment in land are given in Table 23. The investment on which the gross rate of profit is based includes taxes and cost of protection, assumed to be 1 per cent of the land value, here placed at $5 per acre. The material from the thinnings is assumed to cover the cost of cutting without profit or loss.

TABLE 23.—*Interest yielded and total stumpage value per acre of thinned and unthinned stands of shortleaf pine in Virginia.*

Age of stand.	Thinned stand.			Unthinned stand.		
	Yield per acre.	Value of stand neglecting thinnings.[1]	Gross rate per cent yielded on land value.	Yield per acre.	Value of stand.	Gross rate per cent yielded on land value.
Years.	*Bd.ft.*	*Dollars.*	*Per cent.*	*Bd.ft.*	*Dollars.*	*Per cent.*
30	8,400	16.80	4.3	.....	.....	.....
35	13,400	26.80	5.0	.....	.....	.....
40	16,400	32.80	5.0	6,000	12.00	2.5
45	18,700	37.40	4.5	10,200	20.40	3.2
50	20,400	40.80	4.0	13,100	26.20	3.3

[1] Stumpage at $2 per thousand feet.

Cordwood.—Since the yield of cordwood from stands of shortleaf pine depends more upon the number than upon the size of the individual trees on a given area, thinnings are not so profitable for cordwood as for saw timber. At the age of 45 years properly thinned stands show an increase in cordwood of 33 per cent, including thinnings; an increase in saw timber of 80 per cent over natural unthinned stands. In each case regular thinnings are made at intervals of five years. Since there is little increase in the actual volume of unthinned stands after the ages of about 35 to 40 years in Virginia, the rotation for cordwood there is relatively short and the maximum yield is reached much earlier than for the production of lumber.

Tables 24, 25, and 26 show the total yield in cordwood, yearly increment, cost of growing, and the stumpage value per acre, and gross rate of money return on the investment for various ages from thinned and unthinned stands.

TABLE 24.—*Cordwood yield per acre of unthinned and thinned pure stands of shortleaf pine in Virginia.*

[Trees 3 inches and over in diameter breast high.]

Age.	Unthinned stands.		Thinned stands—Yield of thinnings.						
	Volume at different ages.	Average increment.	Volume of stand before each thinning.	Number trees which can be removed in each thinning.	Approximate average diameter of trees removed.	Volume of trees removed in each thinning.	Total of all previous thinnings.	Total thinnings and stand.[1]	Average annual increment, including thinnings.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Years.	*Cords.*[2]	*Cords.*[2]	*Cords.*		*Inches.*	*Cords.*	*Cords.*	*Cords.*	*Cords.*
20	47	2.3	47.0	930	3.3	6.1	.....	47.0	2.3
25	57	2.2	52.0	205	4.5	5.1	6.1	58.1	2.3
30	62	2.1	57.0	150	5.0	5.0	11.2	68.2	2.3
35	64	1.9	60.0	110	5.5	4.8	16.2	76.2	2.2
40	65	1.7	60.0	85	6.0	4.3	21.0	81.0	2.0
45	64	1.3	59.0	68	6.5	4.0	25.3	84.3	1.8
50	63	1.2	57.0	55	7.0	3.6	29.3	86.3	1.7
55	61	1.1	54.5	45	7.6	.....	32.9	87.4	1.6

[1] Column 9 is the sum of colums 4 and 8.
[2] A cord refers to the standard cord of 128 sticked cubic feet, reducible to the long cord by dividing by 1.25. Wood has the bark on and all trees are taken 3 inches and over in diameter.

TABLE 25.—*Cost per cord of growing shortleaf-pine cordwood in unthinned and thinned stands, thinnings included.*

Age.	Unthinned stands.			Thinned stands.					
				Thinnings.			Net cost per acre of producing crops.[4]	Final yield.	Cost of growing per cord.[5]
	Total accumulated cost.[1]	Final yield.	Cost of growing per cord.[2]	Amount.	Assumed value per cord.	Accumulated value.[3]			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Years.	*Dollars.*	*Cords.*	*Dollars.*	*Cords.*	*Dollars.*	*Dollars.*	*Dollars.*	*Cords.*	*Dollars.*
20....	11.04	47	0.23	6.1	0.10	.....	11.04	47	0.23
25....	16.46	57	.28	5.1	.15	0.78	15.68	52	.30
30....	23.72	62	.38	5.0	.20	1.97	21.75	57	.38
35....	33.43	64	.52	4.8	.25	3.79	29.64	60	.49
40....	46.43	65	.81	4.3	.25	6.37	40.06	60	.66
45....	63.82	64	.99	4.0	.25	9.50	54.33	59	.92
50....	87.10	63	1.38	.....	.....	13.40	73.70	57	1.30

[1] Obtained by calculating the interest at 5 per cent, plus 1 per cent for taxes, making a total of 6 per cent, compounded annually on a land value of $5 per acre. Since the land will remain after the timber is sold, its value is not included in the cost of growing.
[2] Obtained by dividing column 2 by column 3.
[3] The product of columns 5 and 6 compounded at 5 per cent every 5-year period. The value of wood removed in thinnings (column 6) is only nominal on account of its small size and the difficulty of making thinnings.
[4] The remainder after deducting column 7 from column 2.
[5] Obtained by dividing column 8 by column 9.

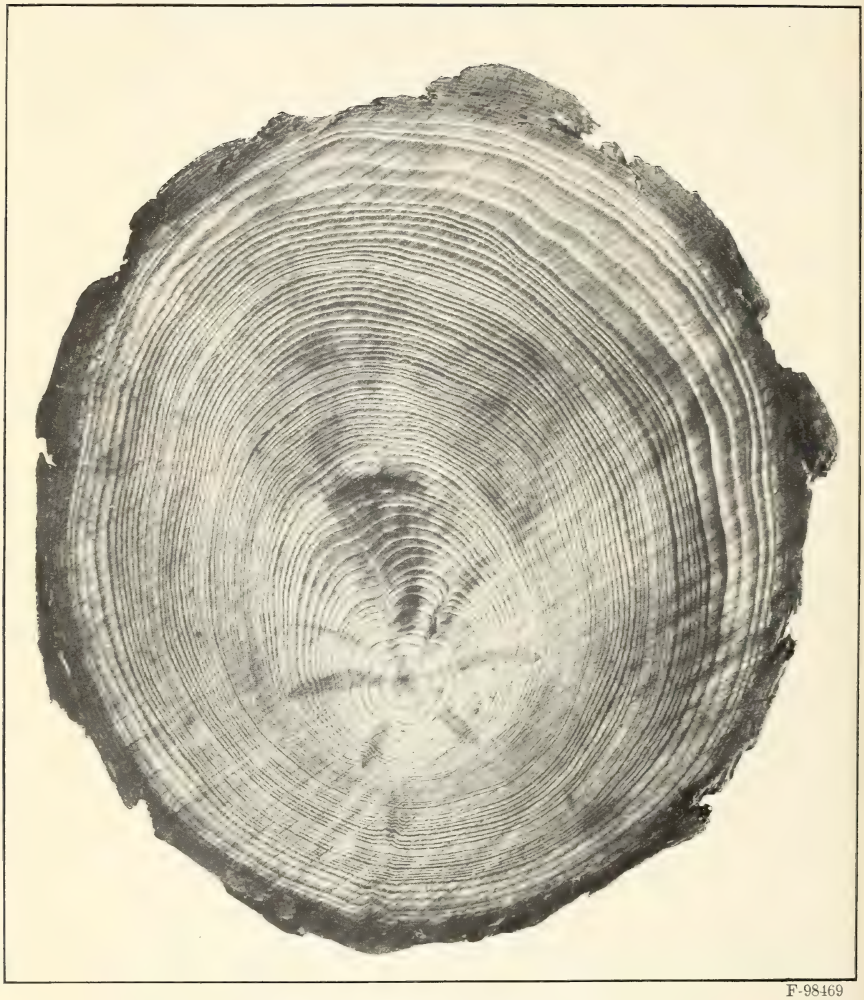
F-15059A

FIG. 1.—SHORTLEAF REPRODUCTION ENTERING AS SECOND STORY IN OPENINGS IN AN EVEN-AGED STAND IN NEW JERSEY.

F-14208A

FIG. 2.—A 30-YEAR-OLD SHORTLEAF STAND IN VIRGINIA PRIOR TO THINNING.

STANDS OF YOUNG SHORTLEAF PINE.



F-98469

TYPICAL INCREASED GROWTH OF A 66-YEAR-OLD SHORTLEAF PINE SINCE LOGGING 5 YEARS AGO. HELLBIG, PIKE COUNTY, ARK. ABOUT 200 PER CENT INCREASE OVER PREVIOUS 5-YEAR PERIOD.

TABLE 26.—*Stumpage value per acre and gross interest yielded on land value from cordwood in old field stands of shortleaf pine in Virginia.*[1]

Age.	Thinned stand.			Unthinned stand.		
	Final. yield.	Total value per acre including accumulated value of thinnings at 4 per cent compound interest.	Gross rate per cent yielded on land value.[2]	Yield per acre.	Value of stand.	Gross rate per cent yielded on land value.
Years.	*Cords.*	*Dolls.*	*Per cent.*	*Cords.*	*Dolls.*	*Per cent.*
20	47	.....	----------	47	11.75	4.3
25	52	13.74	4.0	57	14.25	4.2
30	57	16.08	4.0	62	15.50	3.8
35	60	18.44	3.8	64	16.00	3.5
40	60	19.65	3.6	65	16.25	3.0
45	59	23.94	3.5	64	16.00	2.8
50	57	26.43	3.2	63	15.75	2.5

[1] Cordwood stumpage valued at 25 cents.
[2] Gross interest rate is figured on an investment including cost of protection, and interest on land value assumed to be $5 per acre. Taxes and other costs equal 1 per cent.

CUTTING AND REPRODUCTION.

In forest management the cutting of stands is looked upon as an intermediate step in the continuous process of timber production. The capacity of the species for natural regeneration usually determines the method of final cut. The easy reproduction of shortleaf pine avoids a loss of time between the timber crops and permits of concentration and economy in lumbering. As the seed is small and matures in abundance about every third year, with partial crops in the interval, it is aggressive and takes complete possession of abandoned fields and clearings. (See Pl. V.)

The essential requirements for the formation of fully stocked young stands are (1) an abundance of light, secured by making large-sized openings, and (2) the presence of seed-bearing trees scattered over or near the openings. The method of cutting depends upon whether the stand is pure or mixed. Shortleaf is most productive in pure stands (Pl. IX).

PURE STANDS.

For pure stands some form of the clear-cutting system should be used. Two methods are suggested. One leaves isolated seed trees scattered uniformly over the tract, and is applicable when the bulk of the contents of the stand is to be taken at one lumbering operation. This system may be modified and applied in the form of a strip, group, or compartment. The other is to clear cut in strips.

The first method scatters seed uniformly and leaves a few trees on the ground for local use after the young growth has been established. This is often a convenience on farms or near small settlements. Trees left for seed should have well-developed crowns and

good root systems so as to be windfirm. Such trees may not occur naturally in the stand. In this case it is advisable to make the last thinning in such a manner as to develop from 4 to 10 good seed trees per acre, well distributed over the area. The number will depend upon the age and size of the trees, more being left on elevations than elsewhere. In the case of long-stemmed, slender trees, groups of two to four serve the purpose better than single trees. At least an average of three of these small groups should be selected for each acre. The crowns of the individual trees or groups as a whole should be entirely freed on all sides by the last thinning. Due allowance should be made for old "forest" or "heart" pine trees that may be left along fence rows or along the margin of a stand. These are usually heavy seed producers. It is essential to mark the good seed-producing trees in advance of logging. Blazing or boxing is injurious and should be strictly avoided. Some simple method, such as the use of strips of old sacking or burlap, is effective and inexpensive. Light hacking in the outer bark only, if done carefully on two sides of the tree, is one method of identifying the trees against cutting. All other merchantable trees may be cut, but if the stand is younger than about 35 years many of the small-sized lower crown classes will recover if left after logging. In most stands there are shade-enduring hardwoods, such as persimmon, sassafras, and dogwood, which have entered small openings in the pine. It is desirable to cut these in order to prevent their developing later and overshading the pine saplings.

In unthinned, well-stocked stands good seed trees are not usually developed until the maximum height growth is passed and crown isolation begins to take place, which is at about 40 or 50 years. There are present also many trees of the lower sizes, too small to saw into lumber without a high degree of waste. In such cases the large trees may be logged in a first cutting and the operation repeated after an interval of 5 to 10 years. Groups of seedlings will establish themselves in the successive openings thus left. The remainder of the stand, previously thinned at the time of the second cut, may be removed in a third cutting as soon as a thorough restocking is assured, or they may be held over to form large standards for cutting during the first thinning of the younger stand. In understocked stands a larger per cent of the trees are of a merchantable size and can be taken in the first cut. Seed trees are developed from the smaller trees, which are of less value for saw timber and show rapid development in crown spread and seed production through an increased light supply.

The second method (strip method) leaves alternate strips of clear-cut land and standing timber. The openings may be as wide as four times the average height of the trees and the timber strips one-fourth

the width of the opening. With trees averaging 60 feet in height the relation would be 240 feet of opening to each 60 feet of timber. This would remove four-fifths of the stand and reduce the second cut, or removal of the seed strips, to an operation of small size. If logging costs or market conditions should make such a small cut impracticable the strips should be made of equal width. In case a large tract is being managed to secure a periodic yield, which is sustained, but comparatively small, the strips are cut successively starting from some point or points on the leeward side of the stand. A strip is cut at right angles to the prevailing winds, and another is made to the windward as soon as regeneration is fully secured in the first, and so on. When a strip is being cut, the next one may be thinned by the removal of all the smaller and some of the medium sized trees. This stimulates seed producing within the stand as an aid in restocking the cleared strip. The last remaining strip in the series should be heavily thinned at the time of the preceding cutting and only 15 to 20 of the larger trees left on each acre. These will serve as seed trees, and on account of the rapid crown development following thinning they should fully restock both strips in the course of three to seven years. After this has been accomplished they are removed, as the final cutting of the original stand.

MIXED STANDS.

In mixed stands where shortleaf pine is in competition with various hardwoods it has been found most profitable to encourage the pine, thus bringing about a gradual change in the forest type. Detailed studies carried on by the State in western North Carolina show that this is true in forest management of mixed second-growth oak and pine forests[1] over the Piedmont region from Virginia to Georgia. This is recommended because of the rapid rate of growth and greater general usefulness of the pine timber. Its compact crown and ability to grow with only overhead light enable young shortleaf pine to keep pace with or emerge from the general level of its associates following the coppicing of hardwoods. In brief, the essential steps in accomplishing this desired end are (1) adequate provision for pine seed trees, (2) protection of the young pine in cutting and logging, (3) opening up the forest by the removal of a larger percentage of the hardwoods, and (4) reducing the fire menace. In the mixed stands in the National Forests of western Arkansas and adjacent regions the ranging of hogs in large numbers for many years past has very greatly reduced the natural seeding of the associated nut-bearing oaks and hickories, and by preparing a good seed bed has considerably increased that of shortleaf pine. An advantage is

[1] Bulletin 23, Forest Conditions in Western North Carolina, and Press Bulletins 64 to 84, North Carolina Geologic and Economic Survey.

gained over the hardwoods by cutting them from July to early September, when the sprouting capacity is at its lowest point.

In mixed stands the crowns average larger than in pure stands, with the result of an earlier and larger seed production. The crowns of seed trees should be freed on all sides. Not less than three and usually not more than eight trees, varying with the average seeding capacity, will be needed for each acre. The formation of pure groups on favorable sites, rather than pure stands over larger, variable sites, should be the aim. In some parts of the South scrub pine competes strongly with shortleaf, and on account of its inferior timber should be removed in order to favor shortleaf in seeding up cut-over tracts or abandoned agricultural land.

The selection and clear-cutting methods are alike applicable to mixed and uneven-aged stands. Of these, the selection method is best suited to the prevailing form of mixed stands. The groups of shortleaf pine frequently found among mixed hardwoods are in reality small-sized pure stands and should be handled as such. They are usually even aged, and can be regenerated best by leaving sufficient seed trees to restock the tract completely at an early date. The individual selection of the trees as soon as they have reached the most profitable size is the simplest form of final cutting. This must be modified as required by the dominant aim of increasing the proportion of shortleaf over the less valuable hardwoods. To do this, trees for natural seeding purposes are needed. In many instances much of the shortleaf may profitably be left for the second cutting. It will then have served its purpose of seeding, and a larger amount will be ready for the saw.

CUTTING ON THE NATIONAL FORESTS OF ARKANSAS.

On the two National Forests of Arkansas, where the mixed type prevails, the ultimate aim in the silvicultural management of shortleaf pine is to convert the present more or less uneven-aged forest into even-aged stands. The bulk of the shortleaf pine on these National Forests large enough to cut is from 70 to 175 years old, ranging from over 225 years down to 55 years for trees on the warm slopes. Careful marking of all trees to be cut assures sufficient seed trees. In addition, a minimum diameter limit of 14 inches breast high, equivalent to a stump diameter of 14.9 inches inside bark on a stump 1 foot high, protects the young trees, whose growth and value are increasing at the most rapid rate. It usually provides ample seed trees for restocking and some basis, at least, for a second cut. Growth[1] and volume[2] tables for western Arkansas show a 14-inch

[1] U. S. Department of Agriculture Bulletin No. 244, "Life History of Shortleaf Pine."
[2] Table 29, Appendix.

shortleaf pine to be 70 years old, 69 feet high, and to contain 170 feet of saw timber, scaled by the Scribner rule. If left 30 years for a second cut, the 14-inch tree will be 100 years old, 16.5 inches in diameter, 74 feet high, and scale 270 feet by the Scribner rule.

An area of 18 acres on a typical cut-over tract on the Arkansas National Forest cut to a 14-inch diameter limit contained an average of 21.4 shortleaf pines per acre, of which 12.4 were 10 inches and over, breast-high diameter, and yielded 1,497 board feet per acre. The actual cut of pine on the sale area of 800 acres averaged 2,434 board feet per acre, or almost exactly 62.5 per cent of original stand of 4,000 feet. Table 27 shows the size and number of trees left on a sample 18 acres of this sale:

TABLE 27.—*Shortleaf pine left on 18 acres of typical cut-over tract on the Arkansas National Forest.*[1]

Diameter (breast-high) in 1910.	Trees.					Diameter (breast-high) in 1940.[2]
	Sample tract.[1]			Total.	Average number per acre.	
	1	2	3			
Inches.						*Inches.*
5	1	.....	8	9	0.5	11.0
6	2	4	10	16	.9	12.0
7	2	9	20	31	1.7	12.3
8	3	14	27	44	2.4	12.8
9	14	14	35	63	3.5	13.4
10	4	12	24	40	2.2	14.0
11	24	14	26	64	3.6	14.6
12	16	5	25	46	2.6	15.2
13	12	3	13	28	1.6	16.0
14	5	2	13	20	1.1	16.6
15	3	3	5	11	.6	17.3
16	3	3	3	9	.5	17.8
17	.....	1	.....	1	.1	18.5
18	.....	.....	1	1	.1	19.2
Total.	89	84	210	383	21.4	.....

DIAMETER AND YIELD IN ABOVE STAND.

Diameter groups.	Trees.		Yield.		Diameter groups breast-) high) in 1940.
	Total (18 acres).	Average per acre.	Total (18 acres).	Average per acre.	
Inches.			*Bd. ft.*	*Bd. ft.*	*Inches.*
4 to 9	161	9.0	.....	.....	11 to 13.5
10 to 13	178	10.0	20,980	1,166	14 to 16
14 and above.	44	2.4	5,960	331	16.5 up.
Total...	383	21.4	26,940	1,497	.....

[1] Plots selected and measured by H. D. Burrall, January, 1911, in mixed shortleaf and hardwood stand. Three sample plots of 6 acres each. Stand cut to 14-inch diameter limit.

[2] Based on diameter and growth tables in U. S. Department of Agriculture Bulletin 244, "Life History of Shortleaf Pine."

If a second cut is made in 30 years, the trees now 10 to 14 inches will have reached diameters of 14 and 16.5 inches, respectively. On

this tract there should be at least 10 trees per acre, allowing for a 20 per cent loss in the 30 years. Since shortleaf in forest stands, unless crowded, begins to seed at 30 to 40 years, trees 14 inches and over are at least 3 decades beyond the beginning of seed-bearing age, and probably fully one-third were actual seed producers at the time of the logging. A minimum diameter limit of 14 inches usually provides ample seed trees and a basis of about 10 trees, varying considerably, for a second cut in 30 years. The volume of the 12.4 trees per acre, 10 inches and over in diameter, left on the above cut-over tract, in 30 years will scale 2,675 feet, not counting losses. On the basis, however, of a probable reduction to 10 trees per acre and allowing 20 per cent reduction in scale for defect and breakage, the yield at the end of 30 years will be approximately 2,100 feet or an increase of 40 per cent over the present yield. The factor of accelerated growth, which must be included in the calculation, may safely be counted on to increase the rate at least one-half of the normal, or to a total yield of 2,400 feet. The power of accelerated growth following suppression is definitely known to be retained by shortleaf west of the Mississippi to considerably beyond the age of 70 years. In 7 representative trees, averaging 67 years old (45 to 101 years old), the growth in basal area in the 5 years after logging was 171.4 per cent greater than in the previous 5-year period prior to cutting. (Plate X.) It is believed that the above calculation is conservative.

A 10-inch diameter limit, which represents an average age of 40 years, is about the present minimum commercial diameter limit for the region. If this limit were adopted, it would clearly be necessary in every operation to make special provision for retaining sufficient seed trees. This sort of cutting would result in more uniform conditions on the ground following logging, largely increase the area for incoming reproduction, and thereby gain some ground toward bringing about the desired even-aged form of forest. Wherever the present stand is dominated strongly by pine, in contrast to the mixed pine and hardwoods, and the region is rough or rather inaccessible, it appears that cutting to include the smallest merchantable size will give good results.

The silvicultural principles upon which the marking and logging of shortleaf pine are based are: The high capacity of the species for recovery after suppression, and abundance of seed and demand of the seedlings for light; the possibility, under certain conditions, that shortleaf can profitably be managed on a relatively short rotation; the desirability of growing shortleaf in even-aged pine stands, and at the same time, where necessary, during the first rotation, retaining the younger portion of the stand for a second cut in 30 or more

years. The procedure, in summary, is to (1) protect the vigorous younger growing stock and all pine reproduction against cutting; (2) retain sufficient wind-firm and full-crowned seed trees to provide for completely restocking the area, if possible within the next three years, or natural cycle of full seed production; (3) cut diseased and deformed trees if not needed for seed (leave these for seed only in the absence of better trees); (4) create as full an opening of the forest floor as possible to supply light to the young trees; (5) utilize the hardwoods, favoring white oak over other species because of its greater value; and (6) prevent fires. It is practically certain that shortleaf pine can be profitably extended much more widely within its natural range than it is now by following these suggestions.

REGENERATION BY SOWING AND PLANTING.

Where it can be secured, natural reproduction is of course best, but sometimes it is desirable to start a complete young stand by sowing or planting, especially to fill in blank spaces. The vigor and hardiness of shortleaf pine on well-drained or moderately dry soils make it particularly valuable for reforesting eroded slopes and dry ridges, where, on account of lack of moisture, the growth of hardwoods is retarded. Within its range few other species are so well adapted for reforesting abandoned fields, even those badly gullied, and watersheds supplying water to towns and cities. The work of sowing and planting is especially important because the mature trees which seeded the present old field stands a quarter of a century ago have now become very scarce.

METHODS.

Sowing the seed directly in the field is usually much the cheaper, but transplanting the young trees from nursery beds is the surer method of securing a complete stand.

In direct seeding two methods of preparing the soil are commonly employed. Throwing two or three furrows together reduces the weed competition and prepares a favorable seed bed. Where the surface is rough, steep, or otherwise unfitted for the use of a plow, seed spots are prepared by digging up a space 12 to 18 inches square with a mattock, or, in very loose soil, an ordinary garden hoe. If the soil is loose and reasonably free from weeds, etc., smaller "spots" are sometimes satisfactory. The seeds are then well scattered in the prepared soil and carefully covered. In the plowed furrows seed is sown either in seed spots and covered by using a light mattock or heavy garden hoe or scattered by hand and the strip run over by a brush or spike-toothed harrow. A covering usually of not more than one-quarter of an inch of fine mineral soil is desirable. Too deep covering is unfav-

orable. In dry, loose soil light pressure with the hoe, mattock blade, or shoe sole will aid in checking excessive drying of the surface layer. In order to secure good germination nothing is better than to scatter a half inch or so of fine leaf litter or humus over the surface in addition to the light firming of the mineral soil. A handful of partly decomposed "pine straw" will answer this purpose very well. Early spring is probably the most favorable time for seed sowing, although good results may be expected from fall sowing if the seed is not molested by animals. Fresh seeds will germinate in 15 to 30 days, varying with local climatic conditions.

A spacing of 6 by 6 feet for the seed spots, or 1,210 per acre, is considered about right to provide for a density during early life close enough to stimulate rapid height growth. Regular spacing is not always possible, especially if the tract to be sown contains scattered trees and bushes. A spacing of 8 by 8 feet may be used but does not give quite the desired form development; and closer spacing, for example, 4 by 4 feet, is objectionable, chiefly on account of the additional expense and the need for earlier thinning when the product is insufficient to pay for the labor. Losses of seedlings in considerable numbers because of fungi and animals may be expected during the first one or two years even if protection is afforded. At least 15 to 20 seeds should be sown on each seed spot, allowing for a germination of 40 to 50 per cent for average seed, and the usual destruction of young seedlings during early life. It is desirable that by the end of the germination period each seed spot should contain from five to eight thrifty seedlings. At this rate of sowing and spacing a little over half a pound of seed will be required to sow an acre.[1] Sowing broadcast in plowed furrow strips will usually require a little more seed to obtain the same stand per acre.

Shortleaf pine bears seed abundantly at intervals of from one to three years. The collection of seed is a simple process and not expensive. It is done to best advantage where logging is in progress. The cones are collected from the tops during a period of two to five weeks prior to the time when they would naturally open on the tree. The seed is readily released by applying heat gradually to the cones spread on fine wire mesh, or by exposing them to the drying action of the sun.[2]

Planting nursery-grown seedlings gives more uniform results than field sowing, but is generally more expensive. The seeds are sown in early spring in prepared and protected beds. Beds 4 by 12 feet

[1] This allows for average well-cleaned seed. If the seed contains much cone scale and leaf litter, allowance should be made accordingly. Clean shortleaf pine seeds average sixty thousand to the pound.

[2] For additional directions, see Forest Service Circular 208, "Extracting and Cleaning Forest Tree Seed."

are convenient and are extensively used. Sowing is sometimes done in drills spaced 6 inches apart running crosswise in the beds. This permits of cultivation between the rows. Otherwise seed is sown broadcast over the bed and covered by sifting fine sand to a depth of about one-quarter inch. This method better utilizes space in the seedbed and is therefore cheaper. In the latter case about 300 seeds should be sown on each square foot, or a total of one-quarter of a pound of clean seed on each standard seedbed (4 by 12 feet) in order to obtain a final stand of about 5,000 seedlings. This is about 100 per square foot. Sowing at the rate of 50 seed per linear foot in the drills, less than one-tenth of a pound of seed will be required for each seed bed, on which a stand of 2,000 seedlings is desired. These quantities of seed are based upon a germination vigor of 50 to 60 per cent and the probable natural loss of seedlings during the first few weeks.

One-year-old seedlings are inexpensive to raise and handle and give good results when planted out in favorable situations. Two-year-old stock, either seedlings or one year in the transplant bed, give better results on weedy or otherwise unfavorable sites. For the most unfavorable situations 2-year-old transplants are best. To produce these, 1-year-old seedlings with their roots pruned to about 8 inches in length should be transplanted early in the preceding spring into open nursery beds. A spacing of 3 inches in rows 6 inches apart is recommended. Field planting is done preferably in early spring just before root activity starts. Late fall is also a favorable time, and in case of large operations advantage may be taken of both seasons.

FORM OF PLANTATION.

Shortleaf pine is admirably adapted to pure plantations, which are strongly recommended over any kind of mixture in starting young forest stands. Shortleaf may, however, be planted in mixture with heavier foliaged species of slower growth—for example, sugar maple and such durable and valuable wood as red juniper. This mixture occurs naturally as a two-storied forest in the Piedmont region. Other species suitable for use in mixture are white, chestnut, red, and black oaks, and hickory. All of these except the close-crowned juniper require much larger growing space and greatly decrease the yield of the pine per acre. In the higher portions of the Piedmont plateau and the southern Appalachian range, white pine and shortleaf in mixture have given good results.[1] The shortleaf, unlike the white pine, prunes itself quickly. The red pine and western yellow pine are not successful in mixture with shortleaf because of the at-

[1] Dr. C. A. Schenck, formerly in charge of the forest on the Biltmore Vanderbilt estate.

tacks of *Aecidium pini*, a rust fungus.[1] Pure plantations of shortleaf promise larger financial returns than any other form. Mixed stands afford better protection against large losses from disease and insect ravages, as well as a variety of wood for use on the farm and to supply markets which may offer better returns for such sales.

Plantations of shortleaf now cover several hundred acres on the Vanderbilt estate at Biltmore in western North Carolina. These were planted beginning about 1900 when this estate was placed under intensive forest management. The average growth in height of the 9-year-old shortleaf pine measured on eight different tracts covering an area of 66 acres was exactly 2 feet annually. The stock used was mostly 1-year-old seedlings, and some 2 years old. Shortleaf has been planted in pure stands and in mixture with sugar maple, white pine, walnut, and other hardwoods. The plantations are strikingly uniform in development and have suffered no serious injury. At 9 years old in mixed plantations sugar maple averages about 7 feet in height, shortleaf pine 18 feet, and white pine mostly from 2 to 5 feet less than the shortleaf.[1] For the upper altitudes of 2,200 to 3,000 feet this mixture was successful, although the pure stands are equally so and are to be preferred. The trees were mostly planted 2 feet apart in rows spaced 5 feet,[2] and following the contour of the hills in order to check soil erosion. The small 1-year-old seedlings were planted in holes made with a dibble (wooden spike with a handle). Experimental plantations have been made by New Jersey, South Carolina, and possibly other States, but the planting of shortleaf pine on an extensive scale at Biltmore furnishes the best example of the possibility of artificial reforestation.

PROTECTION.

Protection against fire and cattle is essential until the trees are 2 to 4 inches in diameter and the bark is thick enough to prevent injury from these sources. Shortleaf, however, sprouts freely following fire or cutting during the period up to about 10 years of age. In field seeding, mice, chipmunks, and other forms of animal life frequently cause damage during germination. The best means of combating these is to scatter poisoned grain or seed over the tract about a week before and again at the time of seed sowing.[3] In more remote regions, where stock laws are antiquated or poorly enforced, it may be necessary to exclude hogs, since they sometimes root up seed spots, although they do not eat the small seeds to any extent.

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[1] Dr. C. A. Schenck, formerly in charge of the forest on the Biltmore Vanderbilt estate.

[2] For average conditions this is much too close a spacing.

[3] Formulas for poisoned bait can be obtained upon application to the Bureau of Biological Survey, Washington, D. C.

COST.

The cost of direct seeding varies with the price of labor and size of the operation. From one-half to 1 pound of seed is required for an acre, and one man can sow at the rate of an acre a day. On the basis of $1.50 for labor and $2.50 for seed, the cost is not over $4 per acre. If the soil preparation is by furrow plowing, the item of labor is increased from 50 cents to $1 per acre. To this must be added the value of the land to get the total initial cost of the investment.

The cost of raising 1-year-old seedlings in lots of 50,000 to 200,000 is about $2 per thousand, 2-year seedlings about $2.50, and 2-year-old transplants $3.50 per thousand. The field labor for planting an acre, spaced 5 by 5 feet, requires one man about two days with the 1-year-old seedlings, or three days with the largest-sized transplants. The total cost of plantations is $5 to $8 per acre.

The returns and cost of carrying the investment can be calculated on the basis of the rate of growth, yields at various ages, results from intermittent thinnings, and final cutting, as discussed under the corresponding headings above, the value of the land, the initial cost of establishing plantation, and annual expenses, including taxes and protection, calculated at compound interest.

APPENDIX.

VOLUME TABLES.

Volume tables are usually based on diameter at breastheight and either the total length of the trees or contents of the tree in number of logs of standard length. The contents are most conveniently expressed in cubic feet and board feet of saw timber. It will be noted especially that the contents of the trees scaled by the Doyle rule is very much less than by the Scribner rule. The latter represents much more correctly the actual contents of saw timber in pine stands up to the size of about 24 inches breastheight.

Both volume and taper tables for the Piedmont region are based upon measurements of well-stocked, even-aged second-growth or "old-field" stands in North Carolina taken in 1909, 1910, and 1911. The tables will be found applicable to practically all second-growth shortleaf pine throughout the Piedmont region and lower extension of the Appalachian Plateau. Volume and taper tables for shortleaf pine in Arkansas are based upon the measurements of over 3,000 trees and show the form and average contents of trees of specified diameters in board feet scaled by both the Scribner and the Doyle rules. These tables, although based mostly on measurements taken on the Arkansas National Forest, have been supplemented and found by actual checking to apply in other parts of Arkansas and generally over the southern Mississippi Valley.

TABLE 28.—*Volume in board feet and cubic feet of shortleaf pine of different diameters and heights growing in well-stocked stands in the Piedmont region, North Carolina.*

[Based on taper curves scaled in 16-foot logs, with an additional 8-foot top log in some cases; stump height, 1 foot; diameter inside bark of top, 6 to 8 inches.]

Diameter breast-high.	Total height of tree.								
	40 feet.			50 feet.			60 feet.		
	Scribner rule.	Doyle rule.	Cubic volume.	Scribner rule.	Doyle rule.	Cubic volume.	Scribner rule.	Doyle rule.	Cubic volume.
Inches.	*Bd.ft.*	*Bd.ft.*	*Cu.ft.*	*Bd.ft.*	*Bd.ft.*	*Cu.ft.*	*Bd.ft.*	*Bd.ft.*	*Cu.ft.*
6	1	1	1.2	4	2	1.7	9	3	2.2
7	4	2	3.4	12	4	4.4	20	5	5.3
8	10	5	5.8	20	7	7.3	30	9	8.7
9	18	7	8.2	30	10	10.4	43	14	12.2
10	30	11	10.7	43	16	13.5	57	21	15.9
11	43	18	.....	58	25	16.9	73	33	19.8
12	56	26	.....	73	35	20.0	90	47	24.0
13	.....	.....	.....	89	46	24.0	110	63	28.0
14	.....	.....	.....	106	57	28.0	130	82	33.0
15	.....	.....	.....	.....	.....	.....	150	101	38.0
16	.....	.....	.....	.....	.....	.....	169	122	43.0
17	.....	.....	.....	.....	.....	.....	195	143	48.0
18	.....	.....	.....	.....	.....	.....	220	164	53.0
19	.....	.....	.....	.....	.....	.....	.....	.....	.....
20	.....	.....	.....	.....	.....	.....	.....	.....	.....

TABLE 28.—*Volume in board feet and cubic feet of shortleaf pine of different diameters and heights growing in well-stocked stands in the Piedmont region, North Carolina*—Continued.

Diameter breast-high.	Total height of tree.									Basis.
	70 feet.			80 feet.			90 feet.			
	Scribner rule.	Doyle rule.	Cubic volume.	Scribner rule.	Doyle rule.	Cubic volume.	Scribner rule.	Doyle rule.	Cubic volume.	
Inches.	*Bd. ft.*	*Bd. ft.*	*Cu. ft.*	*Bd. ft.*	*Bd. ft.*	*Cu. ft.*	*Bd. ft.*	*Bd. ft.*	*Cu. ft.*	*Trees.*
6	17	4	2.9	.....	.....	.....	.....	.....	.....	11
7	28	7	6.5	.....	.....	.....	.....	.....	.....	15
8	43	12	10.1	.....	.....	.....	.....	.....	.....	28
9	57	18	13.8	.....	.....	15.5	.....	.....	.....	36
10	72	27	17.8	87	30	20.0	.....	.....	.....	38
11	90	41	22.0	108	49	25.0	.....	.....	.....	51
12	111	58	27.0	134	72	30.0	159	85	35.0	57
13	134	78	32.0	161	97	36.0	192	119	42.0	46
14	158	102	38.0	192	127	43.0	228	157	49.0	35
15	186	128	44.0	225	160	50.0	267	197	56.0	24
16	214	156	50.0	262	196	57.0	310	241	64.0	15
17	243	185	56.0	295	234	64.0	350	285	72.0	6
18	275	217	62.0	334	273	72.0	394	332	81.0	4
19	315	249	70.0	375	313	81.0	438	380	91.0	3
20	348	282	77.0	413	354	90.0	482	428	101.0	2
Total.	.....	.....	.....	.....	.....	.....	.....	.....	.....	371

TABLE 29.—*Volume in board feet of shortleaf pine of different diameters and heights in Arkansas, scaled by the Scribner and Doyle log rules.*

[Based on taper curves; scaled mostly in 16.3-foot logs, with a few shorter logs where necessary; height of stump, 1 foot.]

Diameter breast-high.	Total height of tree.										Diameter inside bark of top.	Basis.
	40 feet.		50 feet.		60 feet.		70 feet.		80 feet.			
	Scribner rule.	Doyle rule.	Scribner rule.	Doyle rule.	Scribner rule.	Doyle rule.	Scribner rule.	Doyle rule.	Scribner rule.	Doyle rule.		
Inches.	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Inches.*	*Trees.*
8	30	7	30	9	40	12	50	15	60	20	6	3
9	40	16	40	20	50	24	60	28	70	33	6	8
10	50	25	60	31	70	36	80	42	90	49	6	17
11	60	35	70	41	80	48	100	56	110	66	6	49
12	70	45	90	53	100	61	120	71	140	83	7	96
13	80	54	100	64	120	74	140	86	170	100	7	180
14	100	67	120	78	150	95	170	110	200	130	7	367
15	110	80	140	98	170	120	200	140	230	160	8	389
16	120	97	160	120	200	140	230	170	270	200	8	401
17	140	120	190	150	230	170	260	210	310	240	8	345
18	160	140	220	170	260	210	300	250	350	290	8	342
19	180	160	250	200	290	240	340	290	400	340	9	266
20	200	190	280	230	330	280	380	330	450	390	9	207
21	.....	.....	310	260	370	320	430	380	500	450	9	164
22	.....	.....	350	300	410	360	480	430	550	510	10	120
23	.....	.....	380	330	450	400	530	480	610	570	10	85
24	.....	.....	.....	.....	490	440	580	530	680	630	10	63
25	.....	.....	.....	.....	530	480	640	590	740	700	10	34
26	.....	.....	.....	.....	580	530	700	650	810	770	11	21
27	.....	.....	.....	.....	.....	.....	750	710	880	840	11	25
28	.....	.....	.....	.....	.....	.....	810	770	960	910	11	9
29	.....	.....	.....	.....	.....	.....	870	840	1,030	990	11	9
30	.....	.....	.....	.....	.....	.....	.....	.....	1,110	1,080	12	2
31	.....	.....	.....	.....	.....	.....	.....	.....	1,180	1,160	12	1
32	.....	.....	.....	.....	.....	.....	.....	.....	1,260	1,240	12	2
33	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12	1
34	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13	.....
Total.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3,206

TABLE 29.—*Volume in board feet of shortleaf pine of different diameters and heights in Arkansas, scaled by the Scribner and Doyle log rules*—Continued.

Diameter breast-high.	Total height of tree.								Diameter inside bark of top.	Basis.
	90 feet.		100 feet.		110 feet.		120 feet.			
	Scribner rule.	Doyle rule.	Scribner rule.	Doyle rule.	Scribner rule.	Doyle rule.	Scribner rule.	Doyle rule.		
Inches.	*Bd. ft.*	*Bd ft*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Inches.*	*Trees.*
8	.....	.....	.....	.....	.....	.....	.....	.....	6	3
9	.....	.....	.....	.....	.....	.....	.....	.....	6	8
10	110	55	120	60	.....	.....	.....	.....	6	17
11	130	75	150	88	.....	.....	.....	.....	6	49
12	160	99	180	120	200	130	230	150	7	96
13	190	120	220	150	240	170	270	190	7	180
14	230	160	260	180	290	210	320	240	7	367
15	270	190	300	220	340	260	370	290	8	389
16	310	230	350	270	390	310	430	350	8	401
17	360	280	400	320	450	370	510	420	8	345
18	400	330	460	380	520	440	580	490	8	342
19	460	390	520	450	590	510	660	570	9	266
20	510	450	590	510	660	580	740	650	9	207
21	570	510	660	580	740	660	830	750	9	164
22	640	580	730	660	830	750	930	840	10	120
23	710	650	810	750	920	850	1,040	950	10	85
24	780	730	900	830	1,020	950	1,150	1,070	10	63
25	860	810	990	930	1,130	1,060	1,280	1,190	10	34
26	940	890	1,090	1,030	1,250	1,170	1,420	1,320	11	21
27	1,030	980	1,190	1,130	1,380	1,290	1,580	1,460	11	25
28	1,120	1,070	1,310	1,240	1,510	1,420	1,740	1,620	11	9
29	1,210	1,170	1,420	1,360	1,660	1,560	1,910	1,780	11	9
30	1,310	1,280	1,540	1,480	1,800	1,710	2,100	1,950	12	2
31	1,420	1,380	1,660	1,610	1,960	1,860	2,290	2,120	12	1
32	1,530	1,490	1,780	1,750	2,120	2,010	2,490	2,300	12	2
33	1,640	1,610	1,920	1,880	2,290	2,180	2,710	2,480	12	1
34	1,740	1,730	2,050	2,020	2,460	2,340	2,920	2,660	13	.....
Total.	.....	.....	.....	.....	.....	.....	.....	.....	.....	3,206

TABLE 30.—*Volume in board feet of shortleaf pine of different diameters and merchantable lengths in 16-foot logs in Arkansas, scaled by Scribner log rule.*

[Based on taper curves; scaled mostly in 16.3-foot logs, with a few shorter logs where necessary; height of stump, 1 foot.]

Diameter breast-high.	Number of 16-foot logs.										Diameter inside bark of top.	Basis.
	1½	2	2½	3	3½	4	4½	5	5½	6		
Inches.	*Bd.ft.*	*Bd.ft.*	*Bd.ft.*	*Bd.ft.*	*Bd.ft.*	*Bd.ft.*	*Bd.ft.*	*Bd.ft.*	*Bd.ft.*	*Bd.ft.*	*Inches.*	*Trees.*
8	30	42	54	68	82	.....	.....	.....	.....	.....	6	3
9	38	50	63	77	93	.....	.....	.....	.....	.....	6	8
10	44	59	74	90	110	120	.....	.....	.....	.....	6	17
11	53	69	87	110	130	150	.....	.....	.....	.....	6	49
12	60	79	100	130	150	170	200	.....	.....	.....	7	96
13	73	96	120	150	180	210	240	.....	.....	.....	7	180
14	80	110	140	170	200	240	270	310	.....	.....	7	367
15	.....	130	160	190	230	270	310	350	.....	.....	8	389
16	.....	140	180	220	270	310	350	400	.....	.....	8	401
17	.....	160	210	250	300	350	400	450	500	.....	8	345
18	.....	180	230	280	340	390	450	510	570	.....	8	342
19	.....	.....	260	320	380	440	500	570	640	.....	9	266
20	.....	.....	290	360	420	490	560	640	720	.....	9	207
21	.....	.....	320	390	470	540	620	710	800	.....	9	164
22	.....	.....	350	430	510	600	690	790	890	990	10	120
23	.....	.....	.....	470	560	660	760	870	980	1,100	10	85
24	.....	.....	.....	520	620	720	830	950	1,080	1,220	10	63
25	.....	.....	.....	560	670	790	910	1,040	1,190	1,340	10	34
26	.....	.....	.....	610	720	850	990	1,140	1,300	1,470	11	21
27	.....	.....	.....	.....	790	920	1,070	1,240	1,420	1,610	11	25
28	.....	.....	.....	.....	840	990	1,150	1,340	1,540	1,760	11	9
29	.....	.....	.....	.....	890	1,060	1,250	1,460	1,670	1,910	11	9
30	.....	.....	.....	.....	940	1,130	1,340	1,570	1,820	2,070	12	2
31	.....	.....	.....	.....	.....	1,210	1,450	1,690	1,950	2,250	12	1
32	.....	.....	.....	.....	.....	1,290	1,540	1,810	2,100	2,420	12	2
33	.....	.....	.....	.....	.....	1,360	1,640	1,940	2,270	2,610	12	1
34	.....	.....	.....	.....	.....	1,450	1,750	2,080	2,430	2,800	13	.....
Total	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3,206

TABLE 31.—*Volume in board feet of shortleaf pine of different diameters and merchantable lengths in 16-foot logs in Arkansas, based on Doyle rule.*

[Based on taper curves; scaled mostly in 16.3-foot logs, with a few shorter logs where necessary; height of stump, 1 foot.]

Diameter breast-high.	Number of 16-foot logs.										Diameter inside bark of top.	Basis.
	1½	2	2½	3	3½	4	4½	5	5½	6		
Inches.	*Bd.ft.*	*Bd.ft.*	*Bd.ft.*	*Bd.ft.*	*Bd.ft.*	*Bd.ft.*	*Bd.ft.*	*Bd.ft.*	*Bd.ft.*	*Bd.ft.*	*Inches.*	*Trees.*
8	9	13	17	22	27	.....	.....	.....	.....	.....	6	3
9	15	21	26	32	38	.....	.....	.....	.....	.....	6	8
10	21	29	36	44	53	65	.....	.....	.....	.....	6	17
11	29	37	47	57	71	85	.....	.....	.....	.....	6	49
12	36	47	60	74	89	110	130	.....	.....	.....	7	96
13	44	59	76	93	110	140	160	.....	.....	.....	7	180
14	53	72	93	120	140	170	200	230	.....	.....	7	367
15	.....	86	110	140	170	200	240	270	.....	.....	8	389
16	.....	110	140	170	200	240	280	320	370	.....	8	401
17	.....	130	160	200	240	280	330	380	430	.....	8	345
18	.....	150	190	230	280	330	380	440	490	.....	8	342
19	.....	.....	220	270	320	380	440	500	570	.....	9	266
20	.....	.....	240	300	360	430	500	570	640	.....	9	207
21	.....	.....	270	340	410	480	560	640	730	.....	9	164
22	.....	.....	300	380	460	540	630	720	820	920	10	120
23	.....	.....	.....	430	510	600	700	800	910	1,020	10	85
24	.....	.....	.....	470	560	670	780	890	1,010	1,130	10	63
25	.....	.....	.....	.....	620	740	860	980	1,120	1,260	10	34
26	.....	.....	.....	.....	680	800	940	1,080	1,230	1,380	11	21
27	.....	.....	.....	.....	740	880	1,020	1,180	1,350	1,530	11	25
28	.....	.....	.....	.....	800	950	1,100	1,280	1,470	1,680	11	9
29	.....	.....	.....	.....	870	1,020	1,190	1,380	1,600	1,830	11	9
30	.....	.....	.....	.....	930	1,100	1,290	1,500	1,740	2,000	12	2
31	.....	.....	.....	.....	.....	1,180	1,390	1,620	1,880	2,170	12	1
32	.....	.....	.....	.....	.....	1,260	1,490	1,740	2,020	2,340	12	2
33	.....	.....	.....	.....	.....	1,350	1,590	1,870	2,190	2,530	12	1
34	.....	.....	.....	.....	.....	1,430	1,690	2,000	2,340	2,730	13	.....
Total	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3,206

FORM TABLES.

The form or taper of shortleaf trees of different diameters and heights is shown in Tables 32 and 33. The points selected are at breastheight (4.5 feet), and successive intervals above the stump of 8 feet plus 0.15 foot, or 3.6 inches for a 16-foot length, allowed for trimming the log. Table 34, giving the butt taper at various heights up to breastheight for trees of different diameters, will be found useful in correlating stump measurements with the standard tables based upon breastheight diameters. The same is true of the double width of the bark at breastheight for trees of different diameters and heights shown in Table 35.

TABLE 32.—*Diameters inside bark at successive 8-foot intervals*[1] *of shortleaf pine of different diameters and heights, growing in well-stocked stands in the Piedmont region, North Carolina.*

[Stump height, 1 foot.]

40-FOOT TREES.

Diameter breast-high.	Height above ground.										Basis.
	4.5 feet.	9.15 feet.	17.30 feet.	25.45 feet.	33.60 feet.	41.75 feet.	49.90 feet.	58.05 feet.	66.20 feet.	74.35 feet.	
Inches.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Trees.*
4	3.5	3.3	2.7	2.2	1.2	.....	.....	.....	.....	.....	2
5	4.4	4.0	3.3	2.7	1.6	.....	.....	.....	.....	.....	.....
6	5.2	4.7	4.0	3.3	1.8	.....	.....	.....	.....	.....	9
7	5.9	5.4	4.7	3.8	2.1	.....	.....	.....	.....	.....	.....
8	6.7	6.1	5.3	4.3	2.4	.....	.....	.....	.....	.....	2
9	7.5	6.8	6.0	4.9	2.7	.....	.....	.....	.....	.....	.....
10	8.3	7.3	6.6	5.4	3.0	.....	.....	.....	.....	.....	.....
Total...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13

50-FOOT TREES.

4	3.4	3.1	2.8	2.6	2.0	1.0	.....	.....	.....	.....	1
5	4.3	3.9	3.6	3.2	2.6	1.5	.....	.....	.....	.....	.....
6	5.2	4.9	4.4	4.0	3.3	2.0	.....	.....	.....	.....	6
7	6.1	5.7	5.2	4.7	4.0	2.4	.....	.....	.....	.....	.....
8	7.0	6.6	6.0	5.4	4.5	2.9	.....	.....	.....	.....	13
9	7.9	7.4	6.7	6.1	5.1	3.3	.....	.....	.....	.....	.....
10	8.8	8.2	7.5	6.8	5.7	3.8	.....	.....	.....	.....	14
11	9.7	9.1	8.3	7.4	6.3	4.3	.....	.....	.....	.....	.....
12	10.7	10.0	9.1	8.1	6.9	4.7	.....	.....	.....	.....	6
13	11.6	10.9	9.9	8.8	7.4	5.1	.....	.....	.....	.....	.....
14	12.5	11.8	10.6	9.4	8.0	5.6	.....	.....	.....	.....	1
Total...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	41

60-FOOT TREES.

6	5.2	5.0	4.7	4.3	3.9	3.3	2.2	.....	.....	.....	2
7	6.2	5.9	5.5	5.1	4.5	3.8	2.6	.....	.....	.....	.....
8	7.1	6.8	6.3	5.8	5.2	4.4	3.0	.....	.....	.....	21
9	8.0	7.6	7.0	6.5	5.9	4.9	3.3	.....	.....	.....	.....
10	8.9	8.5	7.9	7.2	6.5	5.5	3.7	.....	.....	.....	23
11	9.9	9.4	8.7	8.0	7.2	6.0	4.1	.....	.....	.....	.....
12	10.8	10.3	9.5	8.7	7.8	6.5	4.4	.....	.....	.....	14
13	11.8	11.2	10.3	9.5	8.4	7.0	4.7	.....	.....	.....	.....
14	12.6	12.1	11.2	10.2	9.0	7.6	5.2	.....	.....	.....	8
15	13.5	12.9	11.9	10.8	9.7	8.1	5.5	.....	.....	.....	.....
16	14.5	13.8	12.6	11.5	10.4	8.7	5.9	.....	.....	.....	5
17	15.4	14.6	13.4	12.3	11.0	9.2	6.2	.....	.....	.....	.....
18	16.3	15.4	14.2	12.9	11.6	9.7	6.6	.....	.....	.....	1
Total...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	74

70-FOOT TREES.

8	7.2	6.9	6.4	5.8	5.5	5.0	4.2	3.0	.....	.....	7
9	8.1	7.8	7.3	6.6	6.2	5.5	4.7	3.3	.....	.....	.....
10	9.1	8.7	8.1	7.3	6.9	6.2	5.2	3.7	.....	.....	36
11	10.0	9.6	8.9	8.1	7.6	6.8	5.7	4.0	.....	.....	.....
12	10.9	10.4	9.7	8.9	8.4	7.4	6.3	4.4	.....	.....	78
13	11.9	11.4	10.6	9.6	9.1	8.1	6.8	4.8	.....	.....	.....
14	12.7	12.2	11.4	10.3	9.8	8.8	7.4	5.2	.....	.....	46
15	13.7	13.1	12.2	11.1	10.5	9.4	7.9	5.5	.....	.....	.....
16	14.5	14.0	13.1	11.9	11.2	10.1	8.5	5.9	.....	.....	18
17	15.4	14.9	13.9	12.6	11.9	10.7	9.1	6.3	.....	.....	.....
18	16.3	15.7	14.6	13.3	12.6	11.4	9.6	6.6	.....	.....	2
19	17.2	16.5	15.4	14.1	13.3	12.0	10.1	7.0	.....	.....	.....
20	18.0	17.2	16.1	14.8	14.0	12.6	10.6	7.3	.....	.....	1
Total...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	188

[1] Three-tenths foot allowed for trimming on each 16-foot length, or 0.15 foot for each 8-foot length.

TABLE 32.—*Diameters inside bark at successive 8-foot intervals of shortleaf pine of different diameters and heights, growing in well-stocked stands in the Piedmont region, North Carolina*—Continued.

80-FOOT TREES.

Diameter breast-high.	Height above ground.										Basis.
	4.5 feet.	9.15 feet.	17.30 feet.	25.45 feet.	33.60 feet.	41.75 feet.	49.90 feet.	58.05 feet.	66.20 feet.	74.35 feet.	
Inches.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Trees.*
10	9.1	8.8	8.3	7.8	7.3	6.7	5.8	4.7	3.1	.....	2
11	10.1	9.7	9.1	8.6	8.1	7.4	6.5	5.3	3.5	.....	.....
12	11.0	10.6	10.0	9.5	8.9	8.2	7.2	5.8	3.9	.....	9
13	11.9	11.5	10.8	10.2	9.7	8.9	7.9	6.5	4.4	.....	.....
14	12.9	12.3	11.6	11.0	10.4	9.7	8.6	7.1	4.9	.....	24
15	13.8	13.3	12.4	11.8	11.3	10.4	9.2	7.7	5.3	.....	.....
16	14.7	14.1	13.3	12.6	12.0	11.1	9.9	8.3	5.8	.....	14
17	15.6	15.0	14.1	13.4	12.7	11.8	10.6	8.9	6.3	.....	.....
18	16.5	15.9	15.0	14.2	13.5	12.5	11.3	9.5	6.8	.....	2
19	17.4	16.8	15.8	15.1	14.2	13.3	12.0	10.1	7.2	.....	.....
20	18.3	17.7	16.7	15.8	15.0	14.0	12.7	10.7	7.6	.....	1
Total...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	52

90-FOOT TREES.

12	11.0	10.8	10.3	9.8	9.3	8.7	8.0	7.2	6.1	4.5	2
13	12.0	11.7	11.1	10.6	10.1	9.6	8.8	7.8	6.6	4.9	.....
14	12.9	12.6	11.9	11.4	10.9	10.3	9.5	8.5	7.1	5.2	2
15	13.9	13.4	12.8	12.2	11.7	11.0	10.2	9.1	7.6	5.5	.....
16	14.9	14.3	13.6	13.0	12.4	11.8	11.0	9.7	8.1	5.8	2
17	15.7	15.2	14.5	13.9	13.3	12.5	11.7	10.4	8.6	6.2	.....
18	16.7	16.0	15.3	14.6	14.0	13.3	12.4	11.0	9.1	6.5	5
19	17.6	17.0	16.1	15.5	14.8	14.0	13.1	11.7	9.7	6.9	.....
20	18.5	17.9	17.0	16.3	15.6	14.7	13.7	12.3	10.2	7.2	3
Total...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14

TABLE 33.—*Diameters inside bark at successive 8-foot intervals*[1] *of shortleaf pine of different diameters and heights, growing in average stands in Arkansas.*

[Stump height, 1 foot.]

40-FOOT TREES.

Diameter breast-high.	Height above ground.								Basis.
	9.15 feet.	17.3 feet.	25.45 feet.	33.6 feet.	41.75 feet.	49.9 feet.	58.05 feet.	66.2 feet.	
Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Trees.*
6	5.1	4.6	4.1	3.0	.....	.....	.....	.....	.....
7	6.1	5.5	4.9	3.2	.....	.....	.....	.....	.....
8	6.9	6.3	5.5	3.9	.....	.....	.....	.....	.....
9	7.8	7.1	6.4	4.1	.....	.....	.....	.....	.....
10	8.7	8.0	7.0	4.5	.....	.....	.....	.....	1
11	9.6	8.8	7.8	4.9	.....	.....	.....	.....	.....
12	10.4	9.6	8.5	5.4	.....	.....	.....	.....	1
13	11.4	10.5	9.3	5.8	.....	.....	.....	.....	1
14	12.3	11.3	9.9	6.3	.....	.....	.....	.....	.....
15	13.1	12.2	10.7	6.7	.....	.....	.....	.....	.....
16	14.0	13.0	11.4	7.2	.....	.....	.....	.....	.....
Total...	.....	.....	.....	.....	.....	.....	.....	.....	3

[1] Three-tenths foot allowed for trimming on each 16-foot length, or 0.15 foot for each 8-foot length.

TABLE 33.—*Diameters inside bark at successive 8-foot intervals of shortleaf pine of different diameters and heights, growing in average stands in Arkansas*—Continued.

50-FOOT TREES.

Diameter breast-high.	Height above ground.								Basis.
	9.15 feet.	17.3 feet.	25.45 feet.	33.6 feet.	41.75 feet.	49.9 feet.	58.05 feet.	66.2 feet.	
Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Trees.*
6	5.3	5.0	4.5	3.7	2.2	.....	.....	.....	3
7	6.2	5.8	5.2	4.3	2.6	.....	.....	.....	2
8	7.0	6.5	5.9	4.9	3.0	.....	.....	.....	.....
9	8.0	7.4	6.7	5.5	3.5	.....	.....	.....	1
10	8.8	8.2	7.4	6.1	3.9	.....	.....	.....	1
11	9.7	9.0	8.1	6.8	4.3	.....	.....	.....	8
12	10.6	9.8	8.9	7.4	4.8	.....	.....	.....	10
13	11.5	10.7	9.6	8.1	5.1	.....	.....	.....	12
14	12.4	11.5	10.3	8.6	5.7	.....	.....	.....	14
15	13.3	12.3	11.1	9.3	6.0	.....	.....	.....	13
16	14.1	13.0	11.8	9.9	6.5	.....	.....	.....	4
17	15.0	13.9	12.5	10.6	6.9	.....	.....	.....	1
18	15.8	14.7	13.3	11.2	7.4	.....	.....	.....	1
19	16.7	15.5	14.0	11.9	7.9	.....	.....	.....	.....
20	17.5	16.3	14.7	12.5	8.5	.....	.....	.....	.....
Total...	.....	.....	.....	.....	.....	.....	.....	.....	70

60-FOOT TREES.

6	5.5	5.1	4.7	4.3	3.7	2.4	.....	.....	.....
7	6.4	5.9	5.5	5.0	4.3	2.8	.....	.....	.....
8	7.3	6.7	6.3	5.7	4.8	3.2	.....	.....	3
9	8.1	7.5	7.0	6.4	5.5	3.6	.....	.....	4
10	8.9	8.3	7.6	7.1	6.1	4.0	.....	.....	6
11	9.9	9.1	8.4	7.7	6.7	4.5	.....	.....	15
12	10.7	9.9	9.1	8.4	7.3	4.8	.....	.....	38
13	11.6	10.7	9.9	9.1	7.9	5.3	.....	.....	83
14	12.3	11.5	10.6	9.8	8.5	5.7	.....	.....	135
15	13.2	12.3	11.4	10.5	9.0	6.1	.....	.....	114
16	14.0	13.1	12.1	11.1	9.6	6.5	.....	.....	75
17	14.8	13.9	12.9	11.9	10.2	6.9	.....	.....	48
18	15.6	14.7	13.7	12.5	10.7	7.3	.....	.....	33
19	16.5	15.5	14.5	13.2	11.4	7.7	.....	.....	7
20	17.2	16.3	15.2	13.9	11.9	8.1	.....	.....	3
21	18.1	17.1	16.0	14.7	12.6	8.5	.....	.....	1
22	18.8	17.9	16.7	15.3	13.1	8.9	.....	.....	.....
23	19.7	18.7	17.6	16.1	13.7	9.3	.....	.....	.....
24	20.4	19.4	18.2	16.7	14.2	9.7	.....	.....	.....
Total...	.....	.....	.....	.....	.....	.....	.....	.....	565

70-FOOT TREES.

8	7.3	6.8	6.4	6.0	5.5	4.8	3.4	.....	.....
9	8.2	7.7	7.2	6.7	6.2	5.3	3.8	.....	2
10	9.0	8.4	7.9	7.3	6.8	5.8	4.0	.....	4
11	9.9	9.3	8.7	8.1	7.4	6.3	4.4	.....	19
12	10.7	10.1	9.5	8.8	8.1	6.7	4.7	.....	36
13	11.6	10.9	10.2	9.6	8.7	7.3	5.1	.....	62
14	12.5	11.7	11.0	10.3	9.3	7.7	5.4	.....	167
15	13.3	12.5	11.7	11.0	10.0	8.3	5.8	.....	183
16	14.1	13.3	12.5	11.7	10.6	8.7	6.0	.....	199
17	15.0	14.1	13.3	12.5	11.3	9.3	6.5	.....	145
18	15.7	14.9	14.0	13.1	11.9	9.8	6.7	.....	112
19	16.6	15.7	14.8	13.9	12.6	10.3	7.1	.....	78
20	17.3	16.5	15.6	14.6	13.2	10.7	7.4	.....	37
21	18.1	17.3	16.4	15.4	13.9	11.3	7.7	.....	17
22	18.9	18.1	17.1	16.1	14.5	11.8	8.0	.....	5
23	19.7	18.8	17.9	16.8	15.2	12.3	8.3	.....	4
24	20.4	19.6	18.6	17.5	15.8	12.8	8.7	.....	2
25	21.2	20.3	19.4	18.3	16.5	13.4	9.0	.....	.....
26	21.9	21.1	20.1	18.9	17.1	13.8	9.3	.....	.....
27	22.8	21.9	20.9	19.7	17.8	14.4	9.7	.....	.....
28	23.5	22.6	21.6	20.3	18.3	14.8	9.9	.....	.....
Total...	.....	.....	.....	.....	.....	.....	.....	.....	1,072

TABLE 33.—*Diameters inside bark at successive 8-foot intervals of shortleaf pine of different diameters and heights, growing in average stands in Arkansas*—Continued.

80-FOOT TREES.

Diameter breast-high.	Height above ground.								Basis.
	9.15 feet.	17.3 feet.	25.45 feet.	33.6 feet.	41.75 feet.	49.9 feet.	58.05 feet.	66.2 feet.	
Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Trees.*
8	7.3	7.1	6.7	6.2	5.7	5.2	4.5	3.3	.....
9	8.3	7.9	7.5	7.0	6.4	5.8	5.0	3.7	1
10	9.1	8.6	8.2	7.7	7.1	6.4	5.5	4.0	5
11	10.0	9.5	9.0	8.5	7.8	7.0	6.0	4.3	7
12	10.7	10.3	9.7	9.1	8.5	7.6	6.4	4.6	10
13	11.7	11.1	10.6	9.9	9.2	8.2	6.9	5.0	20
14	12.5	11.9	11.4	10.7	9.9	8.9	7.4	5.3	46
15	13.4	12.8	12.2	11.5	10.6	9.4	7.9	5.7	68
16	14.2	13.5	12.9	12.2	11.3	10.1	8.4	6.0	97
17	15.1	14.3	13.7	13.0	12.0	10.7	8.9	6.4	125
18	15.9	15.1	14.4	13.7	12.7	11.3	9.4	6.6	127
19	16.7	15.9	15.2	14.5	13.4	11.9	10.0	7.1	104
20	17.5	16.7	16.0	15.2	14.1	12.5	10.4	7.4	82
21	18.4	17.5	16.8	15.9	14.8	13.1	10.9	7.9	55
22	19.1	18.3	17.5	16.7	15.5	13.7	11.5	8.2	35
23	19.9	19.1	18.3	17.4	16.2	14.4	12.0	8.5	12
24	20.7	19.9	19.1	18.2	16.9	15.0	12.5	8.9	9
25	21.5	20.6	19.8	18.9	17.6	15.7	13.0	9.3	6
26	22.2	21.4	20.6	19.6	18.2	16.2	13.5	9.7	2
27	23.0	22.2	21.4	20.3	18.9	16.9	14.0	10.1	.....
28	23.9	23.0	22.2	21.1	19.5	17.5	14.6	10.4	.....
Total...	.....	.....	.....	.....	.....	.....	.....	.....	811

90-FOOT TREES.

Diam-eter breast-high.	Height above ground.													Basis.
	9.15 feet.	17.3 feet.	25.45 feet.	33.6 feet.	41.75 feet.	49.9 feet.	58.05 feet.	66.2 feet.	74.35 feet.	82.5 feet.	90.65 feet.	98.8 feet.	106.95 feet.	
Inches.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Trees.*
10	9.2	8.8	8.4	8.0	7.5	7.0	6.1	5.0	3.5	1.9	.....	.....	.....	.....
11	10.1	9.7	9.2	8.8	8.3	7.7	6.7	5.5	4.0	2.0	.....	.....	.....	.....
12	10.8	10.4	10.0	9.5	8.9	8.3	7.3	5.9	4.3	2.2	.....	.....	.....	1
13	11.7	11.3	10.8	10.3	9.7	9.0	8.0	6.5	4.7	2.4	.....	.....	.....	2
14	12.5	12.1	11.6	11.0	10.4	9.6	8.6	7.0	5.1	2.7	.....	.....	.....	4
15	13.5	12.9	12.4	11.8	11.1	10.3	9.2	7.5	5.5	2.9	.....	.....	.....	9
16	14.2	13.8	13.2	12.6	11.8	10.9	9.8	8.0	5.8	3.1	.....	.....	.....	19
17	15.1	14.6	14.0	13.4	12.6	11.6	10.4	8.6	6.2	3.3	.....	.....	.....	21
18	15.9	15.4	14.8	14.1	13.3	12.3	11.0	9.1	6.7	3.5	.....	.....	.....	51
19	16.8	16.3	15.6	14.9	14.1	13.0	11.7	9.7	7.0	3.7	.....	.....	.....	48
20	17.5	17.1	16.4	15.7	14.8	13.7	12.3	10.1	7.4	3.9	.....	.....	.....	56
21	18.4	17.9	17.2	16.5	15.6	14.3	12.9	10.7	7.8	4.1	.....	.....	.....	54
22	19.2	18.6	18.0	17.2	16.3	15.1	13.5	11.2	8.2	4.3	.....	.....	.....	41
23	20.1	19.5	18.7	18.0	17.0	15.7	14.1	11.8	8.6	4.5	.....	.....	.....	28
24	20.9	20.2	19.5	18.8	17.8	16.5	14.8	12.3	9.0	4.7	.....	.....	.....	19
25	21.7	21.0	20.3	19.5	18.6	17.2	15.5	12.9	9.5	4.9	.....	.....	.....	12
26	22.5	21.8	20.9	20.2	19.3	17.9	16.1	13.5	9.9	5.1	.....	.....	.....	3
27	23.4	22.6	21.7	21.0	20.0	18.6	16.9	14.1	10.4	5.3	.....	.....	.....	4
28	24.2	23.3	22.5	21.7	20.7	19.3	17.5	14.8	10.8	5.5	.....	.....	.....	1
29	25.1	24.2	23.3	22.5	21.5	20.1	18.3	15.4	11.3	5.7	.....	.....	.....	1
30	25.9	24.9	24.0	23.2	22.2	20.8	19.0	16.0	11.6	5.9	.....	.....	.....	.....
31	26.7	25.7	24.8	23.9	22.9	21.6	19.7	16.7	12.1	6.1	.....	.....	.....	1
32	27.5	26.5	25.5	24.6	23.8	22.3	20.4	17.3	12.5	6.3	.....	.....	.....	.....
33	28.5	27.3	26.3	25.4	24.6	23.2	21.2	17.9	13.0	6.5	.....	.....	.....	.....
34	29.3	28.1	27.0	26.1	25.3	23.9	21.9	18.5	13.5	6.7	.....	.....	.....	.....
Total	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	375

TABLE 33.—*Diameters inside bark at successive 8-foot intervals of shortleaf pine of different diameters and heights, growing in average stands in Arkansas*—Continued.

100-FOOT TREES.

Diameter breast-high.	Height above ground.													
	9.15 feet.	17.3 feet.	25.45 feet.	33.6 feet.	41.75 feet.	49.9 feet.	58.05 feet.	66.2 feet.	74.35 feet.	82.5 feet.	90.65 feet.	98.8 feet.	106.95 feet.	Basis.
Inches.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Trees.*
10	9.3	8.9	8.6	8.3	7.9	7.4	6.7	6.0	5.1	3.7	2.0	.....	.....	.....
11	10.1	9.8	9.4	9.0	8.7	8.1	7.4	6.5	5.5	4.1	2.2	.....	.....	.....
12	11.0	10.6	10.2	9.9	9.4	8.8	8.1	7.1	6.1	4.4	2.4	.....	.....	.....
13	11.9	11.4	11.0	10.6	10.1	9.5	8.7	7.7	6.6	4.8	2.5	.....	.....	.....
14	12.7	12.3	11.9	11.4	10.9	10.2	9.3	8.3	7.1	5.2	2.8	.....	.....	.....
15	13.5	13.1	12.7	12.2	11.6	10.9	9.9	8.8	7.5	5.5	2.9	.....	.....	1
16	14.3	13.9	13.5	13.0	12.4	11.6	10.6	9.5	8.0	5.9	3.2	.....	.....	3
17	15.2	14.7	14.3	13.7	13.1	12.3	11.3	10.1	8.5	6.2	3.4	.....	.....	2
18	16.0	15.6	15.1	14.5	13.8	13.0	12.0	10.7	9.0	6.6	3.5	.....	.....	8
19	16.9	16.3	15.9	15.3	14.6	13.7	12.6	11.3	9.5	7.0	3.8	.....	.....	24
20	17.8	17.2	16.7	16.1	15.3	14.3	13.3	11.7	10.0	7.4	4.0	.....	.....	25
21	18.5	18.0	17.5	16.8	16.0	15.1	14.0	12.5	10.5	7.7	4.3	.....	.....	27
22	19.4	18.8	18.2	17.6	16.8	15.8	14.7	13.1	11.0	8.2	4.5	.....	.....	33
23	20.2	19.6	19.1	18.4	17.6	16.6	15.5	13.7	11.5	8.5	4.7	.....	.....	32
24	21.1	20.5	19.9	19.2	18.3	17.3	16.1	14.3	12.1	9.0	5.0	.....	.....	20
25	21.9	21.3	20.7	20.0	19.1	18.1	16.9	15.0	12.5	9.4	5.2	.....	.....	10
26	22.8	22.2	21.5	20.8	20.0	18.9	17.6	15.6	13.2	9.8	5.6	.....	.....	7
27	23.7	23.0	22.3	21.6	20.7	19.6	18.3	16.3	13.7	10.2	5.8	.....	.....	9
28	24.6	23.9	23.1	22.3	21.5	20.4	19.1	17.0	14.3	10.7	6.1	.....	.....	4
29	25.5	24.7	24.0	23.2	22.3	21.1	19.7	17.7	14.8	11.1	6.3	.....	.....	5
30	26.4	25.6	24.8	24.0	23.1	21.9	20.5	18.4	15.5	11.5	6.6	.....	.....	1
31	27.4	26.4	25.6	24.8	23.9	22.7	21.2	19.1	16.0	12.0	6.9	.....	.....	.....
32	28.3	27.4	26.4	25.6	24.7	23.5	22.0	19.9	16.7	12.4	7.2	.....	.....	.....
33	29.2	28.2	27.2	26.4	25.5	24.3	22.7	20.5	17.3	12.8	7.4	.....	.....	.....
34	30.1	29.1	28.1	27.2	26.3	25.1	23.5	21.3	18.0	13.3	7.7	.....	.....	.....
Total	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	211

110-FOOT TREES.

12	10.9	10.7	10.5	10.1	9.7	9.2	8.6	7.9	7.1	5.8	4.1	2.4	.....	.....
13	11.8	11.5	11.2	10.9	10.5	9.9	9.3	8.6	7.7	6.3	4.5	2.7	.....	.....
14	12.7	12.3	12.1	11.7	11.1	10.5	9.9	9.2	8.3	6.8	4.9	2.9	.....	1
15	13.6	13.2	12.8	12.4	11.9	11.4	10.6	9.8	8.7	7.2	5.3	3.1	.....	1
16	14.4	14.0	13.6	13.2	12.6	12.0	11.3	10.5	9.4	7.7	5.7	3.4	.....	4
17	15.3	14.8	14.4	13.9	13.4	12.7	11.9	11.0	9.9	8.2	6.1	3.6	.....	3
18	16.1	15.6	15.2	14.7	14.1	13.5	12.7	11.8	10.6	8.7	6.5	3.9	.....	10
19	17.0	16.5	16.0	15.5	14.9	14.2	13.4	12.3	11.1	9.2	6.8	4.1	.....	4
20	17.8	17.3	16.9	16.3	15.7	15.0	14.2	13.1	11.7	9.7	7.2	4.3	.....	2
21	18.7	18.2	17.7	17.1	16.4	15.7	14.8	13.7	12.3	10.2	7.6	4.6	.....	9
22	19.5	19.1	18.5	17.9	17.2	16.5	15.6	14.5	12.9	10.8	8.0	4.9	.....	5
23	20.5	19.9	19.3	18.7	18.0	17.2	16.3	15.1	13.5	11.4	8.5	5.1	.....	7
24	21.3	20.8	20.2	19.6	18.9	18.1	17.1	15.8	14.2	11.9	8.9	5.4	.....	11
25	22.3	21.7	21.1	20.4	19.7	18.8	17.9	16.5	14.8	12.4	9.3	5.7	.....	6
26	23.1	22.5	21.9	21.3	20.5	19.7	18.6	17.2	15.4	13.0	9.8	5.9	.....	8
27	24.1	23.4	22.8	22.1	21.4	20.5	19.4	17.9	16.1	13.6	10.2	6.2	.....	11
28	24.9	24.3	23.7	23.0	22.2	21.3	20.1	18.6	16.8	14.1	10.6	6.4	.....	2
29	25.9	25.2	24.5	23.8	23.1	22.1	20.9	19.3	17.3	14.7	11.1	6.7	.....	3
30	26.9	26.2	25.4	24.7	23.9	23.0	21.7	20.1	18.0	15.3	11.5	7.0	.....	1
31	27.9	27.0	26.3	25.6	24.8	23.8	22.4	20.8	18.7	15.8	12.0	7.2	.....	.....
32	28.9	28.0	27.2	26.5	25.7	24.6	23.3	21.5	19.3	16.4	12.5	7.5	.....	1
33	29.8	28.9	28.1	27.4	26.6	25.5	24.0	22.3	20.1	17.1	12.9	7.8	.....	1
34	30.8	29.9	29.0	28.3	27.5	26.3	24.8	23.0	20.8	17.7	13.4	8.1	.....	.....
Total	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	90

120-FOOT TREES

12	11.1	10.9	10.5	10.2	9.8	9.3	8.9	8.3	7.6	6.4	5.1	3.7	2.2	.....
13	12.0	11.6	11.3	10.9	10.5	10.1	9.6	9.1	8.3	7.1	5.6	4.2	2.6	.....
14	12.8	12.4	12.2	11.8	11.3	10.8	10.3	9.7	9.1	7.8	6.2	4.6	2.8	.....
15	13.7	13.3	13.0	12.6	12.1	11.6	11.1	10.5	9.6	8.3	6.7	5.0	3.1	.....
16	14.5	14.2	13.9	13.4	12.9	12.4	11.8	11.2	10.4	9.0	7.3	5.5	3.3	.....
17	15.4	15.0	14.6	14.1	13.7	13.1	12.6	11.9	11.0	9.6	7.9	5.9	3.5	.....
18	16.3	15.9	15.5	15.0	14.5	13.9	13.3	12.6	11.8	10.3	8.4	6.3	3.8	.....
19	17.1	16.7	16.3	15.8	15.3	14.7	14.0	13.4	12.4	10.9	9.0	6.9	4.1	1
20	18.0	17.5	17.1	16.7	16.1	15.5	14.8	14.1	13.2	11.7	9.6	7.3	4.5	2
21	18.9	18.3	17.9	17.4	16.9	16.3	15.6	14.9	13.8	12.2	10.2	7.8	4.7	1
22	19.7	19.3	18.9	18.3	17.7	17.1	16.4	15.5	14.4	12.9	10.8	8.3	5.1	1

TABLE 33.—*Diameters inside bark at successive 8-foot intervals of shortleaf pine of different diameters and heights, growing in average stands in Arkansas*—Continued.

120-FOOT TREES—Continued.

Diameter breast-high.	Height above ground.												
	9.15 feet.	17.3 feet.	25.45 feet.	33.6 feet.	41.75 feet.	49.9 feet.	58.05 feet.	66.2 feet.	74.35 feet.	82.5 feet.	90.65 feet.	98.8 feet.	106.95 feet.	Basis.
Inches.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Trees.*
23	20.7	20.2	19.7	19.1	18.5	17.8	17.2	16.3	15.2	13.6	11.4	8.8	5.4	2
24	21.5	21.1	20.6	19.9	19.3	18.7	17.9	17.1	15.9	14.3	12.0	9.2	5.7	2
25	22.5	22.0	21.5	20.9	20.2	19.4	18.7	17.8	16.7	15.0	12.6	9.7	6.1	.....
26	23.4	22.9	22.3	21.7	21.1	20.3	19.5	18.6	17.4	15.7	13.2	10.3	6.4	1
27	24.3	23.8	23.3	22.7	22.0	21.1	20.3	19.3	18.1	16.4	13.8	10.7	6.6	1
28	25.3	24.8	24.3	23.6	22.9	22.1	21.1	20.1	18.9	17.1	14.7	11.3	7.0	2
29	26.3	25.8	25.2	24.6	23.8	22.8	21.9	20.8	19.5	17.8	15.1	11.7	7.2	.....
30	27.3	26.8	26.3	25.7	24.7	23.8	22.8	21.6	20.4	18.6	15.8	12.2	7.6	.....
31	28.3	27.8	27.2	26.6	25.7	24.7	23.5	22.4	21.1	19.3	16.4	12.7	7.8	.....
32	29.3	28.8	28.3	27.7	26.7	25.7	24.5	23.3	22.1	20.1	17.0	13.2	8.1	1
33	30.3	29.8	29.3	28.5	27.6	26.5	25.3	24.1	22.7	20.9	17.6	13.7	8.4	.....
34	31.4	30.9	30.4	29.7	28.6	27.6	26.3	25.0	23.7	21.5	18.2	14.2	8.8	.....
Total	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14

TABLE 34.—*Butt taper of shortleaf pine of different diameters in Arkansas.*

Diameter breast-high, outside bark.	Height above ground.				Basis.
	1 foot.	2 feet.	3 feet.	4.5 feet.	
Inches.	*Inches.*[1]	*Inches.*[1]	*Inches.*[1]	*Inches.*[1]	*Trees.*
4	4.2	3.8	3.4	3.1	1
5	5.3	4.8	4.4	4.0	.....
6	6.4	5.8	5.4	5.0	3
7	7.4	6.8	6.4	5.9	2
8	8.5	7.8	7.3	6.9	3
9	9.5	8.9	8.4	7.9	8
10	10.6	9.9	9.4	8.9	17
11	11.7	11.0	10.4	9.9	49
12	12.8	12.0	11.5	11.0	96
13	13.8	13.1	12.5	12.0	180
14	14.9	14.2	13.6	13.0	367
15	16.0	15.3	14.7	14.0	389
16	17.1	16.4	15.8	15.0	401
17	18.2	17.4	16.8	16.0	345
18	19.3	18.5	17.9	17.0	342
19	20.4	19.6	18.9	18.0	266
20	21.6	20.7	20.0	19.0	207
21	22.8	21.8	21.0	20.0	164
22	23.9	23.0	22.1	21.0	120
23	25.1	24.1	23.2	22.0	85
24	26.3	25.3	24.2	23.0	63
25	27.5	26.4	25.3	23.9	34
26	28.7	27.5	26.4	24.9	21
27	29.9	28.7	27.5	25.9	25
28	31.1	29.8	28.6	26.9	9
29	32.3	30.9	29.7	27.9	9
30	33.5	32.1	30.8	28.9	2
31	34.7	33.2	31.9	30.0	1
32	35.9	34.4	33.0	31.0	2
33	37.1	35.5	34.2	32.0	1
34	38.4	36.7	35.3	33.0	.....
35	39.6	37.8	36.4	34.0	.....
36	40.9	39.0	37.5	35.1	.....
Total	.....	.....	.....	.....	3,212

[1] Diameter inside bark.

TABLE 35.—*Bark width at breastheight of shortleaf pine of different diameters and heights in Arkansas.*

Diameter breast-high.	Height of tree.									Basis.
	40 feet.	50 feet.	60 feet.	70 feet.	80 feet.	90 feet.	100 feet.	110 feet.	120 feet.	
Inches.	*Inches.*[1]	*Inches.*[1]	*Inches.*[1]	*Inches.*[1]	*Inches.*[1]	*Inches.*[1]	*Inches.*[1]	*Inches.*[1]	*Inches.*[1]	*Trees.*
8	.85	.75	.64	.50	.....	.....	.....	.....	.....	2
9	.92	.82	.71	.59	.....	.....	.....	.....	.....	2
10	.98	.88	.78	.67	.....	.....	.....	.....	.....	10
11	1.04	.94	.85	.75	.....	.....	.....	.....	.....	16
12	1.10	1.00	.91	.81	.74	.....	.....	.....	.....	47
13	1.15	1.06	.97	.87	.80	.....	.....	.....	.....	34
14	1.20	1.11	1.02	.93	.85	.78	.....	.....	.....	49
15	1.25	1.16	1.06	.97	.90	.83	.....	.....	.....	44
16	1.29	1.20	1.10	1.01	.94	.87	.....	.....	.....	53
17	.....	1.25	1.14	1.05	.98	.91	.85	.....	.....	48
18	.....	1.29	1.18	1.08	1.01	.94	.88	.83	.....	44
19	.....	.....	1.21	1.11	1.04	.97	.91	.86	.....	113
20	.....	.....	1.24	1.13	1.06	.99	.94	.88	.....	74
21	.....	.....	1.27	1.16	1.09	1.01	.96	.90	.80	56
22	.....	.....	1.30	1.18	1.11	1.03	.98	.92	.82	36
23	.....	.....	1.33	1.20	1.12	1.05	1.00	.94	.84	47
24	.....	.....	.....	1.22	1.14	1.06	1.01	.95	.86	31
25	.....	.....	.....	1.23	1.15	1.07	1.02	.96	.87	32
26	.....	.....	.....	.....	1.17	1.09	1.03	.97	.89	21
27	.....	.....	.....	.....	1.18	1.09	1.04	.98	.90	25
28	.....	.....	.....	.....	1.19	1.10	1.05	.99	.91	9
29	.....	.....	.....	.....	1.19	1.11	1.06	.99	.92	9
30	.....	.....	.....	.....	1.20	1.12	1.06	1.00	.92	2
31	.....	.....	.....	.....	1.21	1.12	1.06	1.00	.93	1
32	.....	.....	.....	.....	.....	1.13	1.07	1.00	.93	2
33	.....	.....	.....	.....	.....	1.14	1.07	1.00	.94	1
Total.	.....	.....	.....	.....	.....	.....	.....	.....	.....	808

[1] Double width of bark at breastheight.

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